Draft
ENVIRONMENTAL IMPACT REPORT

Richmond Bay Campus
Long Range Development Plan

STATE CLEARINGHOUSE NO. 2013012007

November 15, 2013

Prepared for:
University of California

Prepared by:
Tetra Tech, Inc.

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Acronyms, Abbreviations, and Special Terms

µg/L	microgram per liter
µg/m^3	microgram per cubic meter
AB	Assembly Bill
ABAG	Association of Bay Area Governments
AC Transit	Alameda-Contra Costa Transit
adp	average daily population
ARB	California Air Resources Board
AST	aboveground storage tank
ATCM	Air Toxic Control Measure
BAAQMD	Bay Area Air Quality Management District
BART	Bay Area Rapid Transit
BCDC	San Francisco Bay Conservation and Development Commission
bgs	below ground surface
BMP	best management practice
BP	Before Present
Btu	British thermal unit
Btu/h	British thermal unit hour
CAA	Clean Air Act
CAAQS	California Ambient Air Quality Standards
CalARP	California Accidental Release Prevention
CalEEMod	California Emissions Estimator Model
Cal/EPA	California Environmental Protection Agency
Cal/OSHA	California Division of Occupational Safety and Health
Caltrans	California Department of Transportation
CAP	climate action plan
CBC	California Building Code
CBIA	California Building Industry Association
CCR	California Code of Regulations
CDFW	California Department of Fish and Wildlife
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFC	chlorofluorocarbon
CFR	Code of Federal Regulations
CH_4	methane
CMP	congestion management program
CNDDB	California Natural Diversity Database

Acronyms, Abbreviations, and Special Terms (Continued)

CNEL	community noise equivalent level
CNPS	California Native Plant Society
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CRHR	California Register of Historical Resources
CWA	Clean Water Act
dB	decibel
dBA	A-weighted decibel
DOE	US Department of Energy
DOT	US Department of Transportation
DPM	diesel particulate matter
DTSC	California Department of Toxic Substances Control
EBMUD	East Bay Municipal Utility District
EH&S	Environmental Health and Safety
EIR	environmental impact report
EISA	Energy Independence and Security Act
EPA	US Environmental Protection Agency
EPC	Environmental Performance Criteria
ESA	Endangered Species Act
FSW	Field Sampling Workplan
GHG	greenhouse gas
gpm	gallons per minute
gsf	gross square feet
GWP	Global Warming Potential
HAP	hazardous air pollutant
HCFC	hydrochlorofluorocarbon
HEPA	high-efficiency particulate air
HFC	hydrofluorocarbon
HHRA	human health risk assessment
HMX	octogen
HVAC	heating, ventilation, and air conditioning
I	Interstate
I&I	infiltration and inflow
in/sec	inch per second
IPCC	United Nations Intergovernmental Panel on Climate Change
kBtu	kilo-British thermal unit

kBtu/h	kilo-British thermal unit hour
kv	kilovolt
kW	kilowatt
kWh	kilowatt hour
Labs21	Laboratories for the 21st Century
LBNL	Lawrence Berkeley National Laboratory
LEED	Leadership in Energy and Environmental Design
L_{eq}	equivalent sound level
LID	low-impact development
LOS	level of service
LRDP	Long Range Development Plan
M&O	Management and Operating
MBTA	Migratory Bird Treaty Act
MEPP	Master Emergency Program Plan
MFA	mercury fulminate area
mgd	million gallons per day
mgy	million gallons per year
$MTCO_2e$	metric ton of carbon dioxide equivalent
$MMTCO_2e$	million metric ton of carbon dioxide equivalent
MW	megawatt
MWh	megawatt hour
MWTTP	Main Wastewater Treatment Plant
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NAS	Naval Air Station
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NO_2	nitrogen dioxide
NOP	Notice of Preparation
NOx	nitrogen oxide
NPDES	National Pollutant Discharge Elimination System
NRHP	National Register of Historic Places
NRLF	Northern Regional Library Facility
NWP	nationwide permit
OPR	California Office of Planning and Research
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbon

PCB	polychlorinated biphenyl
PCE	tetrachloroethylene
PFC	perfluorocarbon
PG&E	Pacific Gas and Electric
PM	particulate matter
PM_{10}	inhalable particulate matter
$PM_{2.5}$	fine particulate matter
ppm	part per million
PPV	peak particle velocity
PRC	Public Resources Code
RAW	Removal Action Workplan
RBC	Richmond Bay Campus
RCRA	Resource Conservation and Recovery Act
RDX	cyclotrimethylenetrinitramine
RFD	Richmond Fire Department
RFS	Richmond Field Station
RMSD	Richmond Municipal Sewer District
ROG	reactive organic gas
RPD	Richmond Police Department
RWQCB	Regional Water Quality Control Board
SCR	Site Characterization Report
SB	Senate Bill
SF_6	sulfur hexafluoride
SHPO	State Historic Preservation Officer
SIP	State Implementation Plan
SO_2	sulfur dioxide
TAC	toxic air contaminant
TCE	Trichloroethylene
TDM	Transportation Demand Management
TNT	2,4,6-trinitrotoluene
TPH	total petroleum hydrocarbon
UBC	Uniform Building Code
UC	University of California
UCPD	University of California Police Department
USACE	US Army Corps of Engineers
USC	United States Code
USFWS	US Fish and Wildlife Service

UST	underground storage tank
VMT	vehicle miles travelled
VOC	volatile organic compound
WCCIWMA	West Contra Costa Integrated Waste Management Authority
WCCUSD	West Contra Costa Unified School District
WSA	Water Supply Assessment
WTP	water treatment plant
WWTP	wastewater treatment plant

CHAPTER 1
INTRODUCTION

1.1 PURPOSE OF THIS EIR

This environmental impact report (EIR) evaluates the potential for environmental impacts from implementation of the proposed Richmond Bay Campus Long Range Development Plan (LRDP). The EIR is a public informational document for use by University of California (UC or the University) decision-makers and the public, as it informs the University of California, Board of Regents (The Regents), responsible agencies, trustee agencies, and the public of the proposed project's environmental effects. It is intended to identify, publicly disclose and evaluate potential environmental consequences of the proposed project, to identify mitigation measures that would lessen or avoid significant adverse impacts, and to examine feasible alternatives to the project. The information contained in the EIR is reviewed and considered by the lead agency prior to its action to approve, disapprove, or modify the proposed project.

The University is the lead agency for this EIR that examines the overall effects of implementation of the proposed 2014 LRDP (also referred to herein as the "project" for purposes of the California Environmental Quality Act [CEQA]). At University-owned properties in Richmond, California, the University proposes to establish a new major research campus and rename those properties as the "Richmond Bay Campus" (RBC). The LRDP is a joint proposal of the University of California, as the operating and management contractor of the Lawrence Berkeley National Laboratory (LBNL)[1] and the University of California, Berkeley (UC Berkeley). For the RBC, and throughout this EIR, the "University" is represented by LBNL and UC Berkeley and the staffs of those institutions.

This EIR was prepared pursuant to the applicable provisions of the CEQA and its implementing guidelines (CEQA Guidelines), and the UC Procedures for Implementation of the California Environmental Quality Act (UC CEQA Procedures).

An LRDP is a land use plan that guides overall development of a site. The adoption of an LRDP does not constitute a commitment to, or final decision to implement, any specific project, construction schedule, or funding priority. Rather, the proposed 2014 LRDP guides development of a campus of approximately 5,400,000 gross square feet (gsf) of research, development, and supportive uses.

CEQA requires that, before a decision can be made by a state or local government agency to approve a project that may have significant environmental effects, an EIR must be prepared that fully describes the environmental effects of the project. Pursuant to Public Resources Code Section 21080.09, the University is required to prepare an EIR when an LRDP is prepared or updated.

[1] "LBNL" refers in this document to the Lawrence Berkeley National Laboratory, a national federally funded research and development center, and to the University in its role as the management and operating contractor of the laboratory. LBNL facilities are owned by the Department of Energy (DOE) and are located at the main LBNL site in the Berkeley-Oakland hills and at a number of leased properties, such as the Potter Street facility in Berkeley. The main LBNL site is on land owned by the Regents of the University of California and includes land the federal government leases from the University and on which it constructs federally owned buildings, as well as UC-owned land not leased to the federal government.

CEQA stipulates that the lead agency shall neither approve nor implement a project as proposed unless the significant environmental effects of that project have been reduced to less-than-significant levels, essentially "eliminating, avoiding, or substantially lessening" the expected impacts. If the lead agency approves the project despite residual significant adverse impacts that cannot be mitigated to less-than-significant levels, the agency must state the reasons for its action in writing. This "Statement of Overriding Considerations" must be included in the record of project approval.

This LRDP EIR provides information that will inform California Department of Toxic Substances Control (DTSC) decision-making on a proposed Removal Action Workplan (RAW) addressing historic pollutants on portions of the RBC site proposed for development and currently subject to a site investigation and remediation order.

1.2 PROJECT BACKGROUND

The UC proposes to establish a new major research campus at properties it owns in Richmond, California. This campus would provide for consolidation of biosciences programs of the LBNL and for development of additional facilities for use by LBNL and UC Berkeley, and foster opportunities and synergisms between LBNL, UC Berkeley, and institutional or industry counterparts to conduct energy, environment, and health related research and development. The University proposes to rename the properties as the Richmond Bay Campus.

The University has prepared an LRDP in support of the research and academic goals for this proposed new research campus. An LRDP is defined by statute (Public Resources Code [PRC] 21080.09) as a "physical development and land use plan to meet the academic and institutional objectives for a particular campus or medical center of public higher education." The proposed 2014 LRDP addresses sustainability, land use, access and circulation, utilities and infrastructure, and open space and landscaping, and provides for development of up to 5.4 million square feet of new research, development, and support space at the site and an employee population of 10,000 at full implementation of the LRDP in the year 2050. Design principles in the proposed LRDP feature preservation of the site's important natural open spaces including the San Francisco Bay, marsh, and coastal grasslands. The proposed 2014 LRDP will guide the growth and development of the campus through 2050. The project includes addressing historic contamination at developable portions of the proposed RBC site currently subject to a site cleanup and investigation order; this work would be done pursuant to a proposed RAW if approved by DTSC.

The RBC site would continue to be owned by the University, but some of the facilities developed on the RBC site would be used by LBNL to accomplish the missions and activities assigned and funded by US Department of Energy (DOE). Because the RBC would be a joint use campus, some of the existing buildings as well as new buildings on the RBC site would be occupied by UC Berkeley teaching and research programs. As a result, the laws, regulations, and policies that would apply to design and construction of an individual facility would depend on its funding source, and the laws, regulations, and policies that would apply to the operation of an individual facility would depend on the organization occupying the facility.

The Notice of Preparation (NOP) for this Draft EIR, published in January 2013, included an initial development project at the RBC encompassing approximately 16 acres and a development target of 600,000 gsf. Although that project is no longer proposed, the information and analysis developed for that project informs some of the analysis in this EIR, where noted in the document.

1.3 PROJECT OBJECTIVES

To accomplish the purpose and need, the University has the following project objectives. The project should:

- Be within an approximately 20- to 25-minute commute from the existing LBNL main entrance at Blackberry Gate on Hearst Avenue; or an approximately 20 minute commute from UC Berkeley's main entrance at Oxford and University Avenue.
- Have development capacity for approximately 5.4 million gsf of laboratory, office, and support facilities and related utility and transportation infrastructure to support the University's research, teaching, and public service mission.
- Be in a safe and welcoming community with a positive civic expression of interest in development of the site.
- Be readily accessible to a variety of modes of public transportation, inclusive of local buses, mass transit (Bay Area Rapid Transit [BART], Amtrak, and Alameda-Contra Costa [AC] Transit), and shuttle services, and allow safe bicyclist access from designated bicycle routes.
- Allow for electrical, natural gas, and water utilities for the lowest possible cost.
- Allow consolidation of LBNL bioscience programs.
- Allow for establishment of a design framework for development of a state-of-the-art research campus that will be the location of choice for internationally recognized researchers.
- Foster synergy and collaboration between UC Berkeley and LBNL in and across disciplines and institutions in both the public and private sectors.
- Provide sustainable land use and circulation patterns which maximize density to reduce overall building footprints and conserve open space, and maximize bicycle, pedestrian and shuttle services allow for placement and massing of buildings to maximize shared views.
- Facilitate efficient constructability of facilities (buildings, parking structures, bridges, etc.), infrastructure development (roads, underground utilities, pedestrian walkways, etc.), and open space.
- Foster connectivity with the surrounding community.
- Leverage capital investment for environmental stewardship.

1.4 ENVIRONMENTAL REVIEW PROCESS

On January 4, 2013, the University sent a copy of the NOP for this Draft EIR to governmental agencies, organizations, and interested persons for a 30-day review. The NOP was circulated through the Office of Planning and Research, State Clearinghouse. The University held a public scoping meeting on January 23, 2013, at the Richmond City Hall from 7:00 to 9:00 PM. The public scoping period ended on February 4, 2013. The NOP, comments received on the NOP, and the transcript from the public scoping meeting are attached in Appendix A.

Comments received in the public scoping process were considered during preparation of this Draft EIR. This Draft EIR has been made available for a 60-day public review period. All comments on the Draft EIR should be sent to:

Jeff Philliber
Environmental Planning Group
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

Comments may also be sent by e-mail to: lrdp-eir@lbl.gov (attention: Jeff Philliber).

The 2014 LRDP and this Draft EIR are also publicly available at www.lbl.gov/lrdp (for the duration of this CEQA process) and at the following locations:

Berkeley Lab Main Library
One Cyclotron Road
Building 50, Room 4034
Berkeley, CA 94720

Richmond City Library
325 Civic Center Plaza
Richmond, CA 94804

A public hearing on the adequacy of the Draft EIR will be held at:

Richmond City Hall
450 Civic Center Plaza
Richmond, CA 94804

Following the 60-day public review period, comments on the adequacy of the Draft EIR, submitted within the review period, will be addressed in the Final EIR. The Final EIR will be made available online at http://richmondbaycampus.lbl.gov/ and will include the responses to Draft EIR comments, a mitigation monitoring and reporting program, any changes made to the EIR, and any additional information concerning the project. The Regents will then consider the Final EIR prior to taking any action to approve, modify, or reject the project. Before taking action on the proposed project, The Regents must certify the Final EIR, adopt CEQA Findings, and approve the Mitigation Monitoring and Reporting Program.

1.5 INTENDED USES OF THIS EIR

The Board of Regents is the University's decision-making body and is responsible for approving University LRDPs and any physical facilities to be constructed on University-owned land. The Regents will review and consider for approval both this EIR and the 2014 RBC LRDP. It is anticipated that such an approval decision would be made at an early 2014 Regents meeting after the University has completed and submitted a Final EIR.

This EIR is intended to be used for the following actions and to serve the following purposes:

1) The EIR will provide The Regents with environmental analysis to inform their evaluation of the proposed RBC 2014 LRDP, including information about environmental impacts and any mitigation measures that could avoid those impacts. It will be used as the required CEQA document for The Regents' consideration of the 2014 LRDP, for adoption of CEQA findings, and for any other related Regents' actions in connection with their consideration and possible adoption of the 2014 LRDP.

2) The EIR will be a basis for project tiering and for UC Berkeley, LBNL, or Regent consideration of specific projects pursuant to the 2014 LRDP. Pursuant to CEQA Guidelines Section 15168 and described in Chapter 1 (Introduction), some projects may

be approved as within the scope of this EIR, and other projects may be approved after a second-tier CEQA document is prepared.

3) This EIR will provide information to responsible agencies with permitting or approval authority over projects that may be implemented under the 2014 LRDP pursuant to CEQA Guidelines Section 16168, including the potential approvals listed under "permitting and approvals" below.

4) This EIR is intended to be used by the University, consistent with the provisions of CEQA, in connection with other specific regulatory and procedural actions that may be necessary or desirable to approve and implement the 2014 LRDP.

5) This EIR will be used by DTSC to inform its CEQA determination on the proposed RAW for the developable areas of the Richmond Field Station (RFS) portions of the proposed RBC site.

Regarding item (2) above, LBNL and UC Berkeley projects proposed for implementation under the 2014 LRDP would be evaluated to determine whether the LRDP EIR has fully analyzed the project impacts, or whether additional CEQA review is necessary.

As a program CEQA document, the LRDP EIR sets standards of significance for environmental impacts and evaluates whether construction and operation of the RBC through 2050 would exceed these standards. Under CEQA guidelines for using program EIRs with later activities, if newly proposed activities introduce no new effects that were not previously examined in the program EIR, and no new or substantially more severe significant effects would occur and no new mitigation measures would be required, a program EIR has adequately analyzed the later activities for CEQA purposes, i.e., the later activities are considered within the scope of the program EIR, and no further CEQA review is required.

Use of program EIRs to cover later activities is addressed in CEQA Guidelines Section 15168(c):

> (c) Use with Later Activities. Subsequent activities in the program must be examined in the light of the program EIR to determine whether an additional environmental document must be prepared.
>
> (1) If a later activity would have effects that were not examined in the program EIR, a new Initial Study would need to be prepared leading to either an EIR or a Negative Declaration.
>
> (2) If the agency finds that pursuant to Section 15162, no new effects could occur or no new mitigation measures would be required, the agency can approve the activity as being within the scope of the project covered by the program EIR, and no new environmental document would be required.
>
> (3) An agency shall incorporate feasible mitigation measures and alternatives developed in the program EIR into subsequent actions in the program.
>
> (4) Where the subsequent activities involve site specific operations, the agency should use a written checklist or similar device to document the evaluation of the site and the activity to determine whether the environmental effects of the operation were covered in the program EIR.
>
> (5) A program EIR will be most helpful in dealing with subsequent activities if it deals with the effects of the program as specifically and comprehensively as possible. With a good and detailed analysis of the program, many subsequent activities could be found to be within the scope of the project described in the program EIR, and no further environmental documents would be required.

Evaluation of Local Plans and Zoning

The State of California and its constitutionally created agencies are generally exempt from a city's planning and zoning regulations. Specifically, the UC was established by Article IX, Section 9 of the California Constitution. Section 9 grants the UC Regents broad authority with respect to the management and disposition of its property: "The Regents of [UC] shall have the power to take and hold . . . without restriction, all real and personal property for the benefit of the university or incidentally to its conduct." CAL. CONST. Art. IX, Section 9(f).

Because the RBC will be operated by the UC on UC land for UC purposes, it is exempt from local zoning regulations pursuant to Section 9. However, LBNL and UC Berkeley seek to cooperate with local jurisdictions to reduce any physical consequences of potential land use conflicts to the extent feasible.

The CEQA Guidelines (Section 15125(d)) specify that an EIR shall discuss "any inconsistencies between the proposed project and applicable general plans and regional plans." The general plan of the City of Richmond is not an "applicable" plan, because UC is legally exempt from such plans and those plans do not apply to the conduct of university activities on UC property. The conduct of federal activity is also not subject to such local plans. For public disclosure and CEQA, this EIR, at appropriate points, does summarize the provisions of local land use plans. Section 3.14 of the UC CEQA Guidelines states that UC will seek to cooperate to minimize conflict with local plans where feasible to do so.

Related Approvals and Permits

Approval of the 2014 LRDP and certification of the 2014 LRDP EIR by The Regents is required. Action by other agencies is not required prior to 2014 LRDP adoption or 2014 LRDP EIR certification. Under some circumstances, as individual development projects move forward, outside agency permits and approvals may be required or voluntarily sought by LBNL and UC Berkeley. These may include:

- **San Francisco Bay Conservation and Development Commission (BCDC) Major Permit**. The McAteer-Petris Act was enacted to preserve the San Francisco Bay from indiscriminate filling. The law established the BCDC as the agency to prepare the San Francisco Bay Plan as a guidance and policy document for long-term use of the bay. The BCDC commented on the NOP and made the preliminary determination that a portion of the RBC site is in its jurisdiction. For any activities within the BCDC jurisdictional area, a BCDC permit will be required. Based on the size of the proposed development within the jurisdictional area, it is anticipated that an Administrative Permit from the BCDC will be required.
- **Section 404 Permit:** Implementing the 2014 LRDP could result in the filling of wetlands and other waters of the United States. The US Army Corps of Engineers (USACE) regulates the nation's waterways and wetlands, and it is responsible for implementing and enforcing Section 404 of the federal Clean Water Act. USACE regulations require that any activity that discharges fill material or requires excavation in "waters of the United States," including wetlands, must obtain a Section 404 permit.
- **Section 401 Water Quality Certification**: The State Water Resources Control Board and the Regional Water Quality Control Boards (RWQCB) promulgate and enforce narrative and numeric water quality standards to protect water quality; they also adopt and approve Water Quality Control Plans. The State Board and the RWQCBs regulate discharges of harmful substances to surface waters, including wetlands, under the federal Clean Water Act and the California Porter-Cologne Water Quality Control Act. If

issuance of a Section 404 permit is required, it will be subject to water quality certification under Clean Water Act Section 401.

- **Section 7 Consultation**: The Federal Endangered Species Act requires a federal agency (potentially the Army Corps of Engineers if issuance of a Section 404 permit is required, or the Department of Energy) to seek formal consultation with the U.S. Fish and Wildlife Service (USFWS) for any action that may result in the "take" of any species listed or proposed for listing as threatened or endangered. Based on this consultation, the USFWS may issue a biological opinion determining whether the project is likely to adversely affect or jeopardize the continued existence of a federally listed species, or to result in the destruction or adverse modification of critical habitat proposed to be designated for such species. Section 7 consultation may be required for any project that receives federal funding.
- **Section 10 of the Endangered Species Act**: Section 10 of the Federal Endangered Species Act provides a nonfederal applicant a mechanism to obtain incidental take authorization for federally listed threatened or endangered species.
- **Section 106 Compliance**: For projects involving federal funding or requiring a federal permit, such as a Section 404 permit, the National Historic Preservation Act of 1966 (NHPA), as amended by 16 United States Code section 470 et seq., Section 106, 36 Code of Federal Regulations (CFR) 800, includes provisions for protection of significant archaeological and historical resources. Procedures for dealing with previously unsuspected cultural resources discovered during construction are identified in 36 CFR 800 (for implementing Section 106 processes). The administering agency is the State Historic Preservation Officer (SHPO) and the federal lead agency.
- **Section 1601 Permit**: The California Department of Fish and Wildlife (CDFW) requires notification for any project or activity that will take place in or near a river, stream, lake, or its tributaries. Section 1601 (1603 for private entities) of the Fish and Game Code requires that state or local governmental agencies notify the CDFW before they begin any construction project that will (1) divert, obstruct, or change the natural flow or the bed, channel, or bank of any river, stream, or lake; (2) use materials from a streambed; or (3) result in the disposal or disposition of debris, waste, or other material containing crumbled, flaked, or ground pavement where it can pass into any river, stream, or lake.
- **Section 2081 Compliance:** Section 2081 of the California Endangered Species Act permits the "take" (hunting, pursuit, catching, or killing) of endangered or threatened species, provided that the take is incidental to an otherwise lawful activity, the impacts of the authorized take are minimized and fully mitigated, the take permit is consistent with the CDFW recovery programs, the applicant ensures adequate funding to implement the mitigation and monitoring program, and the action will not jeopardize the continued existence of the species. Substantial information regarding state listed species is in Section 4.3, Biological Resources.
- **NPDES Permits:** The Clean Water Act requires a National Pollutant Discharge Elimination System (NPDES) permit for any discharge of pollutants from a point source to waters of the United States. This law and its regulations apply to stormwater in certain circumstances. In 1987, Congress amended the Clean Water Act to require implementation, in two phases, of a comprehensive national program for addressing stormwater discharges. Phase 1 of the stormwater program requires NPDES permits for stormwater discharge from a large number of priority sources, including small municipal and non-traditional municipal separate storm sewer systems, and several categories of

industrial activity, including construction activity that disturbs an acre or more of land. Phase 1 of the stormwater program requires permits for stormwater discharges from certain small municipal separate storm sewer systems and construction activity generally disturbing between one and five acres. The RBC is subject to Phase 1 regulations.

- **Encroachment Permits and Right of Way Acquisition:** The existing 2.7-acre Regatta Boulevard right-of-way through the RBC site would need to be acquired from the City of Richmond and the right-of-way relocated to develop the RBC. The University is working with the city to acquire this right-of-way parcel and provide road right-of-way for Regatta Boulevard on the western boundary of the proposed campus. Encroachment permits would be required for work within any city right-of-way.
- **Wastewater Discharge Permit:** The existing wastewater discharge permit from Richmond Municipal Sewer District would need to be amended for new construction related to the 2014 LRDP.
- **Internal Combustion Engine Permit:** The Bay Area Air Quality Management District (BAAQMD) requires an air emission permit for operation of stationary internal combustion engines. This would apply to the standby diesel generator proposed for the RBC. Application materials include submittal of the internal combustion engine permit, as well as a health risk screening analysis.

1.6 LEVELS OF SIGNIFICANCE

Determining whether or not a project may result in a significant adverse environmental impact is critical to comprehensive CEQA analysis. Neither CEQA nor the CEQA Guidelines describe specific thresholds of significance or how they may be used. The environmental checklist prompts project reviewers to examine a spectrum of potential environmental effects, but it leaves the determination of significance to the lead agency. Instead of dictating a one-size-fits-all approach, CEQA authorizes local governments to adopt by "ordinance, resolution, rule, or regulation" their own "objectives, criteria, and procedures for the evaluation of projects" (CEQA Section 21082). This enables local governments to adopt thresholds to assist in determining the environmental significance of a project.

The "threshold of significance" for an environmental effect is simply that level at which the lead agency finds the effects of the project to be significant. "Threshold of significance" can be defined as:

> "A quantitative or qualitative standard or set of criteria, pursuant to which the significance of a given environmental effect may be determined."

Ideally, a threshold of significance provides a clear differentiation of whether or not the project may result in a significant environmental effect. More practically, a threshold will assist the lead agency in making this determination. In either case, thresholds do not substitute for the agency's use of careful judgment in determining significance (CEQA Guidelines Section 15064). A threshold may be based on:

- A health-based standard such as air pollutant emission standards, water pollutant discharge standards, or noise levels.
- Service capacity standards such as traffic level of service or water supply capacity.
- Ecological tolerance standards such as physical carrying capacity, impacts on declared threatened or endangered species, loss of prime farmland, or wetland encroachment.

- Cultural resource standards such as impacts on historic structures or archaeological resources.
- Other standards relating to environmental quality issues, such as those listed in the Initial Study Checklist.

Each of these resource areas are addressed with the appropriate level of detail for each resource determined in coordination with UC Berkeley and LBNL staff. These determinations considered the affected environment and the resources that could be impacted by implementation of the 2014 LRDP. For each resource area to be analyzed, the geographic area of the affected environment has been individually determined. In all decisions concerning the boundary of the resource-specific affected environment, available input from local, state and federal agencies has been considered, including CDFW, USFWS, and SHPO.

Determining the affected environment is important for potentially impacted resources and for jurisdictional purposes. The project site is on state land, but there are state and local agencies that exercise land use jurisdiction over resources, such as water or tides, that could affect the project site. For example, the BCDC has state jurisdiction over projects occurring on the San Francisco Bay within 100 feet of the high-tide line. Therefore, BCDC statutes and planning documents, including the San Francisco Bay Plan, have been consulted to ensure that the accurate identification of their jurisdictional boundary is incorporated into the EIR.

1.7 REPORT ORGANIZATION

This Draft EIR is organized to allow the reader to quickly review a summary of the analysis and recommended mitigation measures and to identify the residual environmental impacts after mitigation, if any (Chapter 2, Summary). Those readers who wish to read the Draft EIR in greater detail are directed to Chapter 4, Environmental Setting, Impacts, and Mitigation Measures. The Draft EIR begins with this **Introduction (Chapter 1)**. The chapters following the Introduction are:

- **Chapter 2, Summary**, describes the proposed project, issues of controversy associated with the project, environmental effects of the project, and alternatives to the project (including the No Project Alternative). The Summary includes the Summary of Environmental Impacts and Mitigation Measures table that lists each identified environmental impact, corresponding mitigation measures, and residual level of significance after of mitigation.
- **Chapter 3, Project Description**, provides a detailed description of the project site and location, project objectives, proposed project characteristics, and an outline of the approval process.
- **Chapter 4, Environmental Setting, Impacts, and Mitigation Measures**, contains an analysis of environmental topics. The discussion of each topic is divided into an introductory paragraph describing the scope of the issue under consideration, a Setting section that describes baseline environmental information, an Impacts and Mitigation Measures section that has general standards of significance for potential impacts and describes the project-specific impacts and mitigation measures, and a Cumulative Impacts section that describes the cumulative impacts, if any, of the proposed project, in conjunction with other applicable projects.
- **Chapter 5, Analysis of RFS Contamination**, provides an analysis of the activities proposed to address contamination at the RFS.

- **Chapter 6, Alternatives**, provides an analysis of a reasonable range of alternatives to the proposed project. As required by the CEQA Guidelines, a discussion of the reasons for selecting the alternatives analyzed in this chapter is provided, along with a comparative analysis of each alternative and identification of the "environmentally superior" alternative.
- **Chapter 7, Other CEQA Considerations**, reviews the significant, irreversible effects (if any) and cumulative impacts identified in Chapter 4.
- **Chapter 8, List of Preparers/Organizations Consulted**, lists the firms and staff members that prepared the Draft EIR and persons and agencies contacted during preparation of the Draft EIR.

CHAPTER 2
SUMMARY

2.1 PURPOSE

This EIR evaluates the proposed 2014 LRDP for the RBC site. To determine specific physical impacts that could reasonably be expected from development of the 2014 LRDP, this EIR includes an Illustrative Development Scenario that represents a reasonable iteration of RBC site development under the proposed 2014 LRDP implementation.

If approved, the proposed 2014 LRDP would provide guidance for continuing and projected development and activities at the RBC site through 2050. Under the proposed 2014 LRDP, the total research and support space area at the RBC site would comprise up to approximately 5.4 million square feet. The 2014 LRDP does not assume an increase in space at specific time periods. Rather, it assumes that development would occur as specific LBNL and UC Berkeley research and development needs and market conditions warrant. The average daily population (adp) of the RBC site would increase to approximately 10,000 through 2050.

2.2 PROJECT LOCATION

The approximately 134-acre RBC site is at 1301 South 46th Street in the South Shoreline area of the City of Richmond, approximately 5 miles northwest of the UC Berkeley campus and the LBNL site in Berkeley. The RBC site is composed of two University-owned parcels: a 109.8-acre RFS parcel composed of 96.8 acres of uplands and 13 acres of Western Stege Marsh and a transition zone, and a recently acquired 24.0-acre developed parcel along Regatta Boulevard immediately west of the RFS upland area.[2] The University also owns two other parcels in Richmond that comprise tidal lands and open waters in the San Francisco Bay. Those two parcels are 46.1 and 15.6 acres and would not be part of the RBC.

The proposed RBC property is bounded on the west by a PG&E service station, on the north/northwest by Regatta Boulevard, on the northeast by Meade Street, on the east by South 46th Street, and on the south by the San Francisco Bay. Interstate 580 (I-580) runs parallel to Meade Street along the northeastern boundary of the RBC site.

Land uses surrounding the RBC site include industrial and office uses, a major interstate freeway, and low- to medium-density residential neighborhoods. Regatta Boulevard, along the northern/northwestern boundary of the RBC, is adjacent to a railroad spur and a business complex developed with one- to two-story buildings. Bio-Rad Laboratories, a private research equipment manufacturing company, is immediately west of the RBC site. The adjacent property to the east is the location of former chemical production operations previously owned by several entities, including Stauffer and Zeneca, and is currently owned by Cherokee Simeon Venture I, LLC.

The Marina Bay residential neighborhood, across Meeker Slough and southwest of the RBC site, consists of a mix of multi- and single-family residences. Low- and medium-density residential uses are across I-580, north of the Meade Street boundary of the RBC site.

[2] The two RBC parcels total about 134 acres; however, the city-owned 2.7-acre Regatta Boulevard right-of-way between the Regatta and Richmond Field Station parcels is included in the RBC land use map for the purposes of this analysis. The University is working with the City of Richmond to acquire that roadway parcel and, in return, to provide the City with right-of-way for Regatta Boulevard on the western boundary of the proposed campus. The resulting acreage within the Richmond Bay Campus would remain approximately 134 acres following the proposed realignment of Regatta Boulevard.

2.3 PROJECT DESCRIPTION

The proposed project is development of a University campus at University properties in Richmond in accordance with the proposed 2014 LRDP.

The proposed 2014 LRDP addresses sustainability, land use, access and circulation, utilities and infrastructure, and open space and landscaping. Development and operational activities pursuant to the proposed 2014 LRDP include construction, development, and demolition projects and operational, research, and maintenance activities through the planning year 2050. The proposed LRDP provides for up to 5.4 million square feet of new research, development, and support space at the RBC site and a population at buildout of approximately 10,000. The proposed project includes construction, expansion, or improvement of utility infrastructure and roadway improvements. Past activities have resulted in the deposition of chemical contaminants affecting both soil and groundwater at the part of the proposed RBC site comprised of portions of the University's RFS currently under an investigation and cleanup order issued by the DTSC. The proposed project includes management of these contaminants in accordance with a proposed RAW, including a soil management plan, contingent upon DTSC approval, or in accordance with the existing DTSC investigation and cleanup order for the RFS. These actions are described in detail in Section 3.9 and are evaluated in this EIR for their environmental effects in Chapter 5.

Planning principles in the proposed LRDP feature preservation of the site's important natural open spaces, including the marsh and coastal grasslands. The site plan organizes development into distinctive groupings to promote a sense of community within the site, particularly during initial phases of campus growth. The proposed LRDP includes policies that would guide building design and configuration to maximize opportunities for informal interaction between occupants.

Building heights across the RBC are expected to vary, with lower buildings at the Bay-facing edge and taller buildings farther inland. Four- and five-story buildings are expected to be a common building module, with heights of 100 feet for a five-story building with tall floor-to-floor heights that allow building systems to be easily altered as laboratory uses change. Campus "neighborhoods" may also feature iconic buildings that help establish a sense of place. An example would be Sather Tower (the Campanile) at UC Berkeley that is 303 feet high.

The proposed 2014 LRDP demonstrates commitment to sustainability through site design, building design, and infrastructure. As the RBC site is developed, the campus itself would be open to the community, providing community resources such as auditorium, exhibit, and event space for educational programs. The proposed 2014 LRDP describes and highlights the multiple connections to the RBC site by road, bicycle, and pedestrian path, and it incorporates a robust transportation demand management system to facilitate site access.

The RBC site is in the Southern Gateway and Regatta/Marina Bay change areas of the City of Richmond's South Shoreline Specific Plan Area, envisioned by the City as a revitalized hub of innovation. The proposed RBC 2014 LRDP emphasizes connectivity beyond the site and the importance of the campus as a catalyst for its vicinity.

2.3.1 Anticipated Research Programs

In the near term, existing programs at the site in sustainable transportation and earthquake engineering, among others, will continue; the site will also continue to house important collections of the University library and UC Berkeley museums. New programs under consideration may establish the campus as a hub of joint research in advanced manufacturing, bioscience, and energy storage. In addition, the programs at the RBC will maintain a close connection to the research conducted on the main campuses of LBNL and UC Berkeley. The

RBC will strengthen opportunities for partnerships with private industry. In the longer term, the RBC research would be likely to span the biosciences, energy, environmental sciences and technology, computing sciences, nuclear and particle physics, engineering and materials sciences, chemical sciences, accelerator sciences, climate sciences, and other disciplines. This research would be done on a scale that would be housed in buildings such as those described in Section 3.7, Illustrative Development Scenario. UC Berkeley expects that student research and teaching programs would be housed at the site as part of the educational mission of the campus.

2.3.2 Campus Population Projections

The University projects that the campus population would increase incrementally over time as the RBC is developed over the approximately 40-year planning period of the 2014 LRDP, from approximately 300 in 2012 to approximately 10,000 in 2050.

2.3.3 Building Space Projections

Table 2-1, LRDP Building Space Projections, summarizes the existing building space and the projected building space on the RBC at full 2014 LRDP implementation. Total building space on the RBC is projected to increase from approximately 1,050,000 gsf currently to 5,400,000 gsf at the 2014 LRDP planning horizon year.

Table 2-1
LRDP Building Space Projections

LRDP Use	Existing (2012)	Proposed (2050)	Change
Research, Education, and Support			
Existing Space	1,050,000 gsf	300,000 gsf	-750,000 gsf
New NRLF Space		350,000 gsf	350,000 gsf
New Research, Education, & Support Space		4,750,000 gsf	4,750,000 gsf
Total	**1,050,000 gsf**	**5,400,000 gsf**	**4,350,000 gsf**

gsf Gross square feet
NRLF Northern Regional Library Facility

Of the existing 1,050,000 gsf built space, about 750,000 gsf would be demolished and about 300,000 gsf would be retained. The retained space would include the US Environmental Protection Agency (EPA) building (46,000 gsf) and the Northern Regional Library Facility (NRLF) (254,000 gsf). The new building space would include about 350,000 gsf for the expansion of the NRLF and about 4,750,000 gsf of research, education, and support facilities for occupancy by LBNL, UC Berkeley, and partner institutions.

2.3.4 Sustainability

The University envisions the RBC being a showcase of sustainable design and operations to motivate and inspire staff, the community, the nation, and the world. The RBC would assert and enhance the University's reputation as a hub of energy efficiency research and best practice. RBC facilities would demonstrate building efficiency technology innovations developed by the University and its industry partners in a fully functional laboratory environment.

In August 2011, the University updated its UC Sustainable Practices Policy[3] that set goals to advance environmental practices for both construction and operation in eight areas: green building, clean energy, transportation, climate protection, sustainable operations, waste reduction and recycling, environmentally preferable purchasing, and sustainable food service. All projects at the RBC would meet or exceed the goals defined in this, or any successor, UC sustainability policy.

In May 2011, DOE approved DOE Order 436.1, which defines requirements and responsibilities for managing sustainability in DOE facilities. In addition to satisfying the UC sustainability policy, all DOE-funded projects at the RBC also would meet or exceed the goals defined in this DOE Order.

Energy

Physical development at the RBC would incorporate principles of energy efficiency in all capital projects, renovation projects, operations, and maintenance within budgetary constraints. If the type of facility, such as a laboratory or data center, is not required to meet code requirements for energy consumption, the project would be designed to meet specific energy and carbon performance metrics such as those defined by the "Labs21" (DOE and EPA), "Smart Labs" (UC Irvine), or similar successor programs.

Water

To minimize water use to the extent practicable, the RBC would implement measures such as installing water-efficient landscaping and drip or other efficient irrigation systems, using water-efficient fixtures in new construction, and capturing rainwater and stormwater for irrigation.

Municipal Solid Waste

The RBC would strive for zero waste by creating a robust on-site recycling program for diverting municipal solid waste from landfills.

Materials

Building materials would be selected to reduce embodied energy, maximize building lifespan, and be recyclable or reusable. Material use overall would be minimized, whether in buildings or in other site operations (e.g., paper) and recycled wherever practicable. Materials would be locally sourced and from renewable sources to the degree feasible, including re-used and recycled materials from structures proposed for demolition.

Transportation

In addition to providing shuttle access improvements, the RBC would implement a Transportation Demand Management (TDM) program including alternate mode use incentives, such as discounted transit passes, parking cash-out, Guaranteed Ride Home, and flexible car-share programs.

Landscape

The RBC would support bio-diversity and habitat conservation through using native plant materials wherever possible, using low-impact development design techniques and Bay-Friendly landscape design (see www.stopwaste.org), making stormwater management a site feature, and maintaining natural open spaces.

[3] http://www.universityofcalifornia.edu/sustainability/policy.html

2.3.5 Land Use Plan

The proposed 2014 LRDP identifies two land use designations to form the pattern of development at the RBC: (1) Research, Education, and Support; and (2) Natural Open Space. Definitions for each land use designation are provided below. The land use plan also includes realigning Regatta Boulevard to the western edge of the RBC site.

2.3.6 Research, Education, and Support

The Research, Education, and Support land use designation applies to project site areas that are either currently developed with facilities that would remain in their present form or be expanded, or that would be developed with new facilities. This land use would include approximately 107.6 acres of the RBC site, which is sufficient to meet projected program needs. The types of facilities that would be allowed in designated Research, Education, and Support areas include:

- Laboratory, classroom, office, and administration buildings for researchers, faculty, postdocs, students, and non-University public and private entities.
- Product and process development space for private sector startups, small businesses, and industry counterparts that are synergistic with UC Berkeley and LBNL research areas.
- Support infrastructure and facilities for operations, transportation, utilities, renewable power generation, firefighting, security, safety, hazardous materials management, and corporation yard uses, including vehicle and materials shops and storage. Support facilities for specialized research programs such as plant and animal research facilities, greenhouses, and clinical spaces.
- Community outreach and education resources, including exhibit, lecture and event spaces, and conference facilities and meeting rooms focused on public education.
- Amenities such as dining, short-term accommodation facilities (for visiting researchers), retail, and recreation facilities.
- Transportation-related facilities including parking lots and structures, bus and shuttle stops, and roadways and circulation pathways. Parking structures may house parking administration offices, bicycle support facilities, and utility structures such as distributed central plants.
- Developed open spaces that would be usable by the campus population and visitors, ranging from courtyards, terraces, and quad-like spaces, to walkways, tree groves, and recreational fields. Existing non-native landscaping, such as eucalyptus trees, may be removed and replaced. Open spaces in this zone may be paved or landscaped, with or without seating or other site furnishings. They would range in scale from larger areas for outdoor gatherings to smaller spaces for small group interaction or individual reflection. Stormwater would be managed in these zones with swales and other landscaping. Small structures such as pavilions or overlook platforms may be placed in these areas.
- Transition zones would buffer site buildings from the natural open space areas allowing for maintenance access and minimizing the transference of non-native species or noise or light intrusion. These buffer zones would not allow permanent structures within 25 feet of the natural open space areas. Paving would be pervious wherever practicable and any planting would consist of native or non-invasive species.

2.3.7 Natural Open Space

The RBC site includes natural areas such as the Western Stege Marsh, and coastal grasslands. Human engagement and disruption to these spaces would be limited, with the intent to protect, restore, and maintain these resources in their natural condition. Activities would be limited to

interpretation, education, maintenance, and research. Improvements in this zone would be limited to minor access roads for maintenance vehicles and limited boardwalks or pathways, consistent with conservation goals. Approximately 25 acres would be designated Natural Open Space to encompass those natural areas that the University plans to protect from development and maintain in their natural condition.

2.3.8 RFS Contamination

Historical chemical manufacturing operations at the California Cap Company and industrial operations at neighboring properties released or deposited chemicals onto the uplands, marsh, and transition areas of the RFS site. Under DTSC oversight, the University has undertaken investigation of those contaminated media over several years. In connection with development under the LRDP, the University would conduct environmental actions to ensure there are no unsafe or unwarranted exposures to historic contaminants at the RBC site from former operations at the RFS. Because these actions will be concurrent with the development of certain portions of the RBC site, they are considered part of the proposed project and would be implemented in concert with development under the 2014 LRDP.

The actions would be conducted pursuant to a proposed RAW establishing the remedy for certain portions of the project site that are defined as developable and designated for Research, Education, and Support land use in the 2014 LRDP, if approved by DTSC, or pursuant to the existing DTSC investigation and remediation order that currently applies to those portions of the RBC site. The RAW also includes the remedy for groundwater for the entire RFS portion of the RBC site.

The remedy would also include specific actions: soil excavation at an area with mercury contamination from historic production of mercury fulminate, soil excavation of chemicals of concern at Building 120/Corporation Yard. It would also include site-wide prescriptive requirements consisting of land use controls: deed restrictions and a soil management plan. The remedy would also include specific actions: soil excavation at an area with mercury contamination from historical production of mercury fulminate, soil excavation at select locations with polychlorinated biphenyl (PCB) contamination, and groundwater remediation at Building 280B. Remediation of groundwater impacted by TCE originating from the adjacent former Zeneca property will be addressed under the cleanup order of the adjacent former Zeneca site under the DTSC Site Investigation and Remediation Order (IS/E-RAO 06/07-005). The soil excavation areas are in the southern portion of the site, while the groundwater remediation would occur in the north-central portion of the RBC site. Continued investigation within the Natural Open Space area will continue under the DTSC Order.

2.4 PROJECT NEED AND OBJECTIVES

The LBNL main site is in the Berkeley hills on approximately 202 acres of UC land. The main site comprises approximately 1.6 million gsf in permanent facilities and temporary trailers. Main LBNL site structures are at full occupancy. LBNL currently leases approximately 371,100 gsf of commercial property in eight off-site locations and occupies an additional 47,333 sf of research and administration space on the UC Berkeley campus. The University determined that an additional campus site could provide opportunities to consolidate LBNL biosciences research facilities and accommodate future growth of existing or new LBNL and UC Berkeley programs.

LBNL and UC Berkeley have determined that co-location of UC Berkeley with LBNL at the RBC site would benefit both institutions. The histories of UC Berkeley and LBNL have been intertwined since the founding of the Laboratory by Ernest Orlando Lawrence in 1931, and both have richly benefited from co-location and synergies at their existing sites in Berkeley. Hundreds

of UC Berkeley faculty members hold joint appointments at LBNL; many UC Berkeley undergraduate and graduate students do research at LBNL as part of their degree programs and for employment. The partnership helps both institutions recruit and retain top students and scientists from around the world. The RBC would further build that synergistic relationship for the benefit of both LBNL and UC Berkeley and create resiliency through research partnerships and engagement beyond traditional university bounds.

The proposed 2014 LRDP provides land use designations and identifies developable area to support new research and educational initiatives. It creates a framework to support program expansion through 2050.

The University's vision for the RBC is that it would be "A state-of-the-art, inspirational, sustainable place to produce world-class collaborative science for healthy living and sustainable communities."

The purpose of the new campus and the associated LRDP is to provide for the consolidation of LBNL biosciences programs; to support existing or new LBNL and UC Berkeley program growth; to address constraints on locating new research activities at the LBNL main site; to achieve the UC Berkeley's 2002 working paper goal for creating a premiere research facility supporting and complementing UC Berkeley teaching, research, and public service programs at the Richmond property; to reduce UC Berkeley and LBNL fiscal and programmatic costs related to leasing space and dispersed programs; and to allow for successful facilities development for LBNL, UC Berkeley, and other public and private entities in a manner that supports LBNL and UC missions in a time of funding constraints and that continues their history of successful scientific collaboration.

To accomplish the purpose and need, the University has these project objectives. The project should:

- Be within an approximately 20- to 25-minute commute from the existing LBNL main entrance at Blackberry Gate on Hearst Avenue; or an approximately 20 minute commute from UC Berkeley's main entrance at Oxford and University Avenue.
- Have development capacity for approximately 5.4 million gsf of laboratory, office, and support facilities and related utility and transportation infrastructure to support the University's research, teaching, and public service mission.
- Be in a safe and welcoming community with a positive civic expression of interest in development of the site.
- Be readily accessible to a variety of modes of public transportation, inclusive of local buses, mass transit (BART, Amtrak, and AC Transit), and shuttle services, and allow safe bicyclist access from designated bicycle routes.
- Allow for electrical, natural gas, and water utilities for the lowest possible cost.
- Allow consolidation of LBNL bioscience programs.
- Allow for establishment of a design framework for development of a state-of-the-art research campus that will be the location of choice for internationally recognized researchers.
- Foster synergy and collaboration between UC Berkeley and LBNL in and across disciplines and institutions in both the public and private sectors.

- Provide sustainable land use and circulation patterns that maximize density to reduce overall building footprints and conserve open space, and maximize bicycle, pedestrian and shuttle services to allow for placement and massing of buildings to maximize shared views.
- Facilitate efficient constructability of facilities (buildings, parking structures, bridges, etc.), infrastructure development (roads, underground utilities, pedestrian walkways, etc.), and open space.
- Foster connectivity with the surrounding community.
- Leverage capital investment for environmental stewardship.

2.5 AREAS OF CONTROVERSY KNOWN TO THE UNIVERSITY

According to Section 15123 of the CEQA Guidelines, an EIR shall identify "known areas of controversy to the lead agency, including issues raised by agencies and the public." For the 2014 LRDP, the issues most frequently raised during scoping involved: (1) increasing development among or near sensitive natural communities, and (2) developing in or nearby an area with a history of hazardous materials use and contamination.

Specific areas of controversy raised in NOP comments include:

- Potential impacts to wetlands, including impacts to Western Stege Marsh
- Potential impacts to remaining bay grass habitats and their dependent species
- Impacts from previous uses related to the continued remediation of hazardous materials, and potential hazards to construction and operation of the RBC.
- Impacts to the existing transportation network, including local intersections and transit systems.
- Impacts to the Bay Trail and nearby parks, open space, and recreation areas.
- Applicability of local plans and policies

The EIR includes discussion of these and related areas of controversy. Each resource section in Chapter 4 includes a summary of relevant NOP comments and analysis of each resource area addressing these comments. Mitigation measures, where necessary to address potential impacts, are identified.

2.6 ALTERNATIVES

CEQA requires that an EIR include an evaluation of the comparative effects of "a reasonable range of potentially feasible alternatives." One primary criterion for selecting such alternatives is that they "would feasibly attain most of the basic objectives of the project but would avoid or substantially lessen any of the significant effects of the project" (CEQA Guidelines Section 15126.6(a)). The range of alternatives is governed by the "rule of reason" that requires the EIR to analyze only those alternatives necessary to permit a reasoned choice (CEQA Guidelines Section 15126.6(f)). Evaluation of a No Project Alternative and identification of an environmentally superior alternative are required. The significant effects of the alternatives shall be discussed, but in less detail than the significant effects of the proposed project (CEQA Guidelines Section 15126.6(d)).

Chapter 6 of this EIR considers a full range of alternatives. Alternatives that were considered infeasible and not studied in detail are briefly addressed. The 2014 LRDP alternatives analyzed in detail in Chapter 6 are described in the subsections that follow.

2.6.1 Alternative 1: Alternate Development Program

Under the Alternate Development Program, the 2014 LRDP would be modified to include a future scientific facility with certain unique features, characteristics, and utility demands. Even though this facility would be included in the modified LRDP, the total occupiable space on the RBC would increase in a manner similar to the Proposed Project, from approximately 1,050,000 gsf currently to 5,400,000 gsf at full implementation. The same amount of existing occupiable space as under the proposed project would be demolished and retained. The campus population would increase in the same manner as the Proposed Project from approximately 300 in 2012 to approximately 10,000 in 2050. Under this alternative, approximately 108 acres of the upland parcels on the RBC would be developed, and approximately 25 acres of the upland parcels would be designated as natural open space. Land uses under this alternative would be the same as those under the proposed project.

2.6.2 Alternative 2: Reduced Growth Program

Under the Reduced Growth Program, the 2014 LRDP would be revised to reflect a smaller RBC building program as compared with the proposed LRDP. The amount of occupiable space under the Reduced Growth Program alternative would increase from 1,050,000 gsf currently to 3,600,000 gsf at full implementation of the 2014 LRDP. The total site population would increase from the current population of 300 to an estimated 8,400 at full implementation. Under this alternative, approximately 108 acres of the upland parcels on the RBC would be developed, and approximately 25 acres of the upland parcels would be designated as natural open space. Land uses under this alternative would be the same as those under the proposed project but the density of development within the developed area would be lower.

2.6.3 Alternative 3: Alameda Point Alternative

Under the Alameda Point Alternative, the new campus would be developed in the City of Alameda at Alameda Point (a portion of the former Naval Air Station [NAS] Alameda). The Alameda Point site consists of approximately 124 acres. Development would be guided by an LRDP that would provide for the development of 5,400,000 gsf of occupiable building space at full implementation of the LRDP. The campus population would be approximately 10,000 in 2050. Development at this location would be guided by planning principles and objectives similar to those identified for the proposed project. Under this alternative, almost all 124 acres would be developed. Figure 6-1 shows the development footprint for this alternative.

2.6.4 Alternative 4: No Project Alternative

State CEQA Guidelines require consideration of a No Project Alternative. The No Project Alternative would posit that the 2014 LRDP would not be adopted for any site. The amount of building space and the employee population at the proposed RBC site would remain at their current levels.

Should any development activities be proposed by UC Berkeley or LBNL at the RBC site, any required CEQA documentation would be prepared on a project-by-project basis.

2.7 IMPACT SUMMARY

Table 2-2 on the following pages summarizes the impacts and mitigation measures for each environmental resource. Table 2-3 summarizes the environmental protection practices that could be implemented to reduce the magnitude of less than significant impacts.

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
AESTHETICS AND VISUAL QUALITY			
LRDP Impact AES-1 Development under the 2014 LRDP could substantially degrade the existing visual character and quality of the RBC site and its surroundings.	S	**LRDP MM AES-1:** The University shall develop and implement a Physical Design Framework that protects the visual quality of both the on- and off-campus environments through provisions that address building scale, materials, and color schemes. The Physical Design Framework shall include best management practices and procedures for avoiding or minimizing aesthetic nuisances in demolition, construction, and operational phases of the project. Design review processes for planning of new buildings and development shall be clearly articulated and followed throughout the life of the project. Increased RBC scale and density would be addressed in a number of ways through the Physical Design Framework and subsequent plans: buildings would be restricted in height and height zones would further restrict heights in certain locations. Building facades would be broken up by architectural and design features so as to minimize the appearance of mass and bulk. Reflective material would be restricted, which, would minimize the appearance of the new buildings particularly at greater distances. Trees and other landscaping features would be used to further break up, obscure, or minimize RBC development. Aesthetically objectionable appurtenances such as stacks, machinery, tanks, and HVAC systems on top of buildings would be sheltered from view wherever practical. Demolition debris and long-term construction supplies and equipment would be stored such that – to the extent practicable – they would not be visually intrusive from off-site viewpoints.	LTS
LRDP Impact AES-2 Development under the 2014 LRDP would not adversely affect any scenic vistas at the RBC site and its vicinity.	LTS	None required	LTS
LRDP Impact AES-3 Development under the 2014 LRDP would create new sources of light and glare that would not adversely affect regional day or nighttime views.	LTS	None required	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
RAW Impact AES-1 Implementing the RAW would not have a substantial adverse effect on aesthetics and visual resources.	LTS	None required	LTS
AIR QUALITY			
LRDP Impact AIR-1 Criteria pollutant emissions associated with the construction and demolition activities under the 2014 LRDP would not violate an air quality standard or contribute substantially to an existing or projected air quality violation.	LTS	None required	LTS
LRDP Impact AIR-2 Operational activities associated with development under the 2014 LRDP would result in criteria pollutant emissions that would exceed BAAQMD CEQA thresholds and therefore potentially violate an air quality standard or contribute substantially to an existing or projected air quality violation.	S	**LRDP MM AIR-2:** When the University has developed 1,000,000 square feet of building space on the RBC site, before approving the construction of another building, the University shall prepare and implement an operational emissions minimization program that will be composed of campus-wide programs to minimize emissions from mobile and area sources, and project-specific emissions control measures, based on project-specific analysis, to minimize emissions from area and stationary sources. Campus-wide Control Measures Campus-wide programs would include, but not be limited to, the following: • Implement an enhanced TDM program to minimize vehicular traffic. The TDM program shall include the continued implementation of existing TDM measures such as provision of preferential carpool/vanpool parking; secure bike parking; showers and changing facilities; transit subsidies Guaranteed Ride Home Program; and information to employees and students regarding alternative transportation modes. The TDM program will be expanded, following an evaluation of campus population and trip generation, to incorporate additional measures such as car share services; free transit passes; parking cash-out; daily parking charge; employee telecommuting program; compressed work schedules; infrastructure that allows employees to interact or conduct meetings and business without traveling; and a dedicated transportation	SU

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
		coordinator. • Convert campus fleet to low-emission, alternative fuel, and electric vehicles over time. • Use electric equipment for landscape maintenance. • Implement an educational program for faculty and staff and distribute information to students and visitors about air pollution problems and solutions. • Develop centralized utilities such as a central plant (in place of individual boilers in buildings). <u>Stationary and Area Source Control Measures</u> When the University has developed 1,000,000 square feet of building space on the RBC site, if and when a specific building project is proposed that would add new stationary or area sources of emissions to the RBC site, the University will conduct a project-specific air quality impact assessment. If significant impacts are identified, project-specific mitigation measures will be implemented, which would include, but not be limited to, the following: • Select solar or low-emission boilers. • Select low-emission cooling towers. • Other control measures determined appropriate for the specific project based on project-specific analysis.	
LRDP Impact AIR-3 Construction and demolition associated with development under the 2014 LRDP would not expose people to substantial levels of TACs or expose sensitive receptors to substantial pollutant concentrations in excess of the relevant BAAQMD CEQA thresholds.	LTS	None required	LTS
LRDP Impact AIR-4 Operational activities associated with development under the 2014 LRDP would expose people to	S	**LRDP MM AIR-4:** To reduce the effects from RBC laboratory emissions of formaldehyde and chloroform, the University shall implement one of the following measures in conjunction with every laboratory project that involves the use of these chemicals:	SU

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
substantial levels of TACs or expose sensitive receptors to substantial pollution concentrations in excess of the relevant BAAQMD CEQA thresholds.		• Implement one or more emission control technologies on laboratory fume hoods or stacks. Controls will be limited to portions of the laboratory that involves the use of formaldehyde and chloroform. Controls will be selected specific to the chemical emissions to be controlled (formaldehyde or chloroform or both chemicals), and in the case of laboratory stacks, may include, as appropriate, activated carbon filters, scrubbers, biofilters, flares, catalytic converters, cryogenic condensers, vapor recovery systems, and thermal oxidizers. • Demonstrate that the project's use of formaldehyde and chloroform will be at least 10 percent below that assumed for the LRDP human health risk assessment. In the event that neither measure can be implemented, the laboratory project shall demonstrate by preparing a new human health risk assessment that the maximum acute hazard from project emissions, in conjunction with existing site emissions and future emissions under the 2014 LRDP, will not exceed a hazard index of 1.0.	
LRDP Impact AIR-5 Development under the 2014 LRDP would conflict with or obstruct implementation of the applicable air quality plan.	S	Implement LRDP MM AIR-2	SU
LRDP Impact AIR-6 Development under the 2014 LRDP would not create objectionable odors affecting a substantial number of people.	LTS	None required	LTS
LRDP Impact AIR-7 Development under the 2014 LRDP would not create a carbon monoxide hotspot, an area where the carbon monoxide concentration would exceed the state ambient air quality standards.	LTS	None required	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
RAW Impact AIR-1 Implementation of the RAW would generate emissions of criteria and toxic air contaminants that would not violate an air quality standard or contribute to an existing violation.	LTS	None required	LTS
BIOLOGICAL RESOURCES			
LRDP Impact BIO-1 Development under the 2014 LRDP would not have a substantial adverse effect on special-status plant species.	LTS	None required	LTS
LRDP Impact BIO-2 Development under the 2014 LRDP could adversely affect special-status bird species protected under the Migratory Bird Treaty Act, Endangered Species Act, and/or California Endangered Species Act and result in nest abandonment and reproductive failure.	S	**LRDP MM BIO-2:** Where practical, avoid construction, demolition, or renovation activities in areas adjacent or nearby to marshland nesting bird habitat during the nesting season (March 1 – August 31). If construction, demolition, or renovation were to occur in areas adjacent or nearby to marshland nesting habitat during the nesting season, a nesting bird survey shall be performed by a qualified biologist up to approximately 7 days prior to work commencing, up to 100 feet beyond the project boundary. If no birds or evidence of birds are found, no further action is required, provided work commences within approximately 1 week of the survey to prevent "take" of individual birds that may have begun nesting after the survey. If nesting birds with eggs or young are observed during the pre-construction surveys, construction, demolition, or renovation in the affected project area shall not commence within 100 feet of the occupied nest until after the young have fledged. Engage in ESA Section 7 consultation (formal or informal, as appropriate) with the USFWS for implementation level LRDP components if those components constitute a federal action (approvals or funding) to address any potential impacts on California clapper rail. Develop appropriate measures with USFWS and implement them. Establish a 150-foot-wide temporary "no disturbance" buffer around the wetland/upland boundary	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
		of Western Stege Marsh/Meeker Slough when construction occurs during the breeding season (mid-March to July). This buffer would protect and buffer potential California clapper rail habitat and nesting areas during construction by prohibiting entry into this area. Post interpretative California clapper rail signs in and near Western Stege Marsh/Meeker Slough. Signs should include seasonal use restrictions (e.g., stay on designated trails, pets on leash), to reduce disturbance potential during construction and operations.	
LRDP Impact BIO-3 During the bat breeding season, tree and building removal and other construction activity associated with development under the proposed 2014 LRDP could result in a substantial adverse effect on bats.	S	**LRDP MM BIO-3:** 2014 LRDP implementation projects shall avoid disturbance to special-status bats' maternity roosts during the breeding season in accordance with the following procedures for Pre-Construction Special-Status Bat Surveys and Subsequent Actions. No more than 2 weeks prior to commencement of any concrete breaking or similarly noisy construction/demolition activity during the breeding season (March 1 through August 31), a qualified bat biologist shall conduct pre-demolition surveys of all potential special-status bat breeding habitat in the disturbance vicinity. Depending on the survey findings, the following actions shall be taken to avoid potential adverse effects on breeding special-status bats: 1. If active roosts are identified during pre-construction surveys, a no-disturbance buffer shall be created by the qualified bat biologist, in consultation with the CDFW, around active roosts during the breeding season. The size of the buffer shall take into account factors such as: a. Noise and human disturbance levels at the project site and the roost site at the time of the survey and the noise and disturbance expected during the construction, b. Distance and amount of vegetation or other screening between the project site and the roost, and c. Sensitivity of individual nesting species and the behaviors of the bats. 2. If pre-construction surveys indicate that no roosts of special-status bats are present, or that roosts are inactive or potential habitat is unoccupied, no further mitigation is required. 3. Pre-construction surveys are not required for demolition or construction scheduled to occur during the non-breeding season (September 1 through February 28). 4. Noisy demolition or construction as described above (or activities producing similar substantial increases in noise and activity levels in the vicinity) commencing during the non-breeding season and continuing into the breeding season do not require surveys (as it is assumed that any bats taking up roosts would be acclimated to project-related activities already under way). However, if trees are to be removed during the breeding season, the trees shall be surveyed for roosts prior to their removal, according to the survey and protective action	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
		guidelines 1a through 1c, above. 5. Bat roosts initiated during demolition or construction are presumed to be unaffected by the activity, and a buffer is not necessary. 6. Destruction of roosts of special-status bats and overt interference with roosting activities of special-status bats shall be prohibited. 7. The noise control procedures for maximum noise, equipment, and operations identified in Section 4.10, Noise, shall be implemented.	
LRDP Impact BIO-4 Development under the 2014 LRDP would not have a substantial adverse effect on monarch butterfly.	LTS	None required	LTS
LRDP Impact BIO-5 Development under the 2014 LRDP could have a substantial adverse effect on sensitive natural communities.	S	**LRDP MM BIO-5:** Mitigation for LRDP-related impacts on grasslands will expand as the campus grows. a) Any project proposed under the LRDP, whether in or outside of the Natural Open Space area, shall include a construction and operation management plan to minimize the threat of weeds to these grasslands. b) As initial projects under the LRDP are implemented, proactive (not passive) measures to improve the quality of the native grasslands in the Natural Open Space area shall be funded and undertaken. This may take the form of support for research and education into effective restoration. Possible fund sources include the UC Berkeley Capital Renewal Program, which assesses a four percent fee on all capital budgets (UC Berkeley 2013). c) Once a project that may alter high quality grassland within the Natural Open Space land use zone for minor access roads or structures or to construct boardwalks is proposed, the University shall prepare a grassland management plan to guide conservation and enhancement efforts, as well as the siting of boardwalks and minor access roads and structures in a resource-sensitive manner. The plan shall include weed management actions, annual monitoring and reporting, and adaptive management sufficient to maintain or improve the quality of the grasslands preserved in the designated Natural Open Space. The effectiveness of the plan shall be continually evaluated and the plan adjusted as needed. d) Prior to any action to develop the Northwest Meadow or to develop other designated high	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
		quality grasslands outside of the Natural Open Space land use zone, the University shall plan and implement a program to use the native plant stock from such area to aid enhancement and restoration in Natural Open Space grassland areas not currently designated high quality, and to develop or restore meadow acreage elsewhere. Possible locations include formal landscaped open areas of the RBC, roof tops of buildings at the RBC, demonstration meadows at UC Berkeley or in the city of Richmond that help explain the former extent of regional coastal terrace prairie grasslands.	
LRDP Impact BIO-6 Development under the 2014 LRDP could have a substantial adverse effect on federally protected wetlands.	S	**LRDP MM BIO-6:** **BIO-6a:** 2014 LRDP development projects shall avoid, to the extent feasible, the filling of or discharging to potentially jurisdictional waters. Therefore, during the design phase of any future development project that may affect potentially jurisdictional waters, a preliminary evaluation of the project site shall be made by a qualified biologist to determine if the site is proximate to potentially jurisdictional waters and, if deemed necessary by the biologist, a wetlands delineation shall be prepared and submitted to the USACE for verification. Because the USACE's preferred mitigation for impacts to jurisdictional waters is avoidance, to the extent practicable, 2014 LRDP development shall be located to avoid the filling of or discharging to jurisdictional waters. **BIO-6b:** Any unavoidable loss of jurisdictional waters shall be compensated for through the development and implementation of a project-specific wetland mitigation plan. If a 2014 LRDP development project were to potentially impact jurisdictional waters, impact compensation would be based on the USACE-verified wetlands delineation identified in Mitigation Measure BIO-6a. During the permit application process for specific development projects that would impact jurisdictional waters, the University would consult with the USACE, CDFW, and San Francisco Bay RWQCB. The consultation would be to identify the most appropriate assessment and mitigation methods to adequately address losses to wetland function that could occur from the development projects. A project-specific wetland mitigation plan would be developed prior to project implementation and submitted to permitting agencies for their approval. The plan may include on-site or off-site restoration or creation or purchasing of credits from a wetland mitigation bank. All mitigation work proposed in existing wetlands on- or off-site shall be authorized by applicable permits. **BIO-6c:** To the extent feasible, construction projects that might affect jurisdictional drainages or wetlands shall be scheduled for dry-weather months. Avoiding ground-disturbing activities during	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
		the rainy season would further decrease the potential risk of construction-related discharges to jurisdictional waters.	
LRDP Impact BIO-7 Development under the 2014 LRDP would not have a substantial adverse effect on fish and wildlife movement, migratory corridors, or nursery sites.	LTS	None required	LTS
LRDP Impact BIO-8 Development under the 2014 LRDP would not conflict with any local applicable policies protecting biological resources.	LTS	None required	LTS
RAW Impact BIO-1 Implementing the RAW could have a substantial adverse effect on biological resources.	S	Implement LRDP MM BIO-2, BIO-3, BIO-5, and BIO-6	LTS
CULTURAL RESOURCES			
LRDP Impact CR-1 Development under the 2014 LRDP could result in significant impacts on previously undiscovered, unevaluated, or unrecorded archaeological resources or human remains during construction and clearing.	S	**LRDP MM CR-1:** Prior to any project-related excavation or construction, the University shall adequately survey all relevant disturbance areas for archaeological resources and assess the potential for buried resources based on past land use, site records, and proximity to known resources and landforms. Depending on the resulting level of suspected archaeological sensitivity, archaeological testing shall be done and/or qualified archaeological monitors will be present during ground disturbing activities. Prior to any ground disturbing activities that could disturb potentially existing archaeological resources, the University would prepare a Construction Monitoring and Unanticipated Cultural Resources Discovery Plan to be implemented if an unanticipated discovery is made. At a minimum, the plan would detail the following elements: • Worker and supervisor training in the identification of cultural remains that could be found in	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
		the proposed project area • Worker and supervisor response procedures to be followed if there is an unanticipated discovery, including appropriate points of contact for professionals qualified to make decisions about the potential significance of any find • Identities of persons authorized to stop or redirect work that could affect the discovery, and their on-call contact information • Procedures for monitoring construction activities in archaeologically sensitive areas • A minimum radius (typically a minimum of 50 feet) around any discovery in which work would be halted until the significance of the resource has been evaluated and mitigation implemented as appropriate • Procedures for identifying and evaluating the historical significance of a discovery • Procedures for consulting Native Americans when identifying and evaluating the significance of discoveries involving Native American cultural materials • Procedures to be followed for treatment of discovered human remains per current state law, including appropriate notification and consultation with Native American groups or individuals If any suspected human bone is found during construction, all work should stop and the Contra Costa County coroner should be notified immediately per State law and the Discovery Plan. If the remains are determined to be Native American, the Native American Heritage Commission shall be notified for determination of the most likely descendent and tribal affiliation for disposition. No additional work shall take place near the find until the identified actions have been implemented.	
LRDP Impact CR-2 Development under the 2014 LRDP would result in significant impacts on historic Buildings 150 and 175 through demolition or visual intrusion from new building construction.	S	**LRDP MM CR-2:** Because demolition of Buildings 150 and 175 cannot be avoided, historic documentation would be completed by professionals meeting the Secretary of the Interior's Professional Qualification Standards for architectural history. Recording each structure to the standard established for the National Park Service's Historic American Building Survey or Historic American Engineering Record would include high resolution digital photographs taken of historic buildings in their current condition. Up to 20 archival black and white prints would be prepared as part of the recordation package. Construction or as-built drawings (if available) would be reproduced on archival paper.	SU

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
LRDP Impact CR-3 Development under the 2014 LRDP could result in significant impacts on historic structures that have not been identified or that would become of historic age over the life of the plan.	S	**LRDP MM CR-3:** **CR-3a:** Prior to any project construction or demolition activities, the University shall ensure that all buildings and structures in the construction footprint have been adequately inventoried. If any of the inventoried structures are found to be historically significant and are to be retained, the University shall develop reuse or maintenance plans to identify the historic features of the building and prepare design guidelines based on the Secretary of Interior's Standards and Guidelines for the Treatment of Historic Properties and to ensure that the buildings retain their historic, character–defining features. **CR-3b:** If avoidance of direct or indirect impacts on (as yet unidentified) historic buildings is not possible, the University shall determine site specific mitigation measures. Historic documentation would be completed by professionals meeting the Secretary of the Interior's Professional Qualification Standards for architectural history. Structures would be recorded to the standard established for the National Park Service's Historic American Building Survey or Historic American Engineering Record. This would include high resolution digital photography of historic buildings in their current condition. Up to 20 archival black and white prints would be prepared as part of the recordation package. Construction or as-built drawings (if available) would be reproduced on archival paper.	SU
RAW Impact CR-1 Implementing the RAW could have a substantial adverse effect on cultural resources.	S	Implement LRDP MM CR-1	LTS
GEOLOGY AND SOILS			
LRDP Impact GEO-1 Development under the 2014 LRDP would not expose people and structures to substantial adverse effects from seismic hazards such as ground shaking and earthquake-induced ground failure at the RBC site.	LTS	None required	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
LRDP Impact GEO-2 Development under the 2014 LRDP would result in construction on soils that could be subject to erosion and instability.	S	**LRDP MM GEO-2:** **GEO-2a:** A site-specific, design-level geotechnical investigation shall be completed during the design phase of each new building project and prior to construction approval on the RBC site. This investigation shall be conducted by a licensed geotechnical engineer and shall include an evaluation of potential soils hazards and appropriate measures to minimize these hazards. Geotechnical recommendations shall subsequently be incorporated into building design. **GEO-2b:** Construction under the LRDP shall comply with the Association of Bay Area Government's Manual of Standards for Erosion and Sediment Control Measures, and the California Stormwater Quality Association's Stormwater Best Management Practice Handbook for Construction (CASQA 2003) (or subsequent editions thereof). Construction under the LRDP shall use construction BMPs and standards to control and reduce erosion. These measures could include, but are not limited to, restricting grading to the dry season, protecting all finished graded slopes from erosion using such techniques as erosion control matting and hydroseeding, or other suitable measures. **GEO-2c:** All LRDP construction projects shall include, as appropriate, revegetation of disturbed areas (including slope stabilization projects) using native shrubs, trees, or grasses.	LTS
RAW Impact GEO-1 Implementing the RAW would not have a substantial adverse effect on geology and soils.	LTS	None required	LTS
GREENHOUSE GAS EMISSIONS			
LRDP Impact GHG-1 Development under the 2014 LRDP would generate greenhouse gas emissions that would result in a significant impact on the environment.	S	**LRDP MM GHG-1:** One or more climate action plans would be developed and implemented for the RBC. The climate action plan would include target emission rates per service person that are consistent with AB 32 and Executive Order S-3-05 emissions targets. The climate action plan would also implement specific control measures and programs to achieve these targets. These control measures and programs would be developed specifically for each project based on its siting and design needs, but they will at minimum address these general topics: • Energy Efficiency: minimize energy consumption to the extent possible through measures such as design guidelines for new buildings that require specific levels of energy efficiency, incentive programs for employees or departments to reduce energy use, programs to track energy use and discover opportunities to reduce waste, and landscaping or other features that	SU

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
		provide shade or otherwise help reduce energy use. • Renewable Energy Generation: investigate and develop opportunities for renewable energy generation on campus, whether solar, wind, or other sources. • Vehicle Trip Minimization: encourage the use of carpools, shuttles, bicycles, or public transportation that provide resources for employees to access and use alternative transportation, and provide infrastructure that allows employees to interact or conduct meetings and business without traveling. • Renewable Fuel Vehicles: encourage or require the use of renewable fuel vehicles such as by providing electric vehicle charging and compressed natural gas fueling stations, purchasing renewable fuel vehicles for the campus fleet, and providing preferential parking or other incentives for drivers using renewable fuel or hybrid vehicles. • Waste Reduction: implement waste reduction, aggressive recycling goals with incentives, composting systems for general buildings and dining areas, guidelines for low waste construction and purchasing, and educational programs.	
LRDP Impact GHG-2 Development under the 2014 LRDP would conflict with an applicable plan, policy, or regulation adopted for the purpose of reducing greenhouse gas emissions.	S	**LRDP MM GHG-2:** Implement LRDP MM GHG-1	SU
RAW Impact GHG-1 Implementation of the RAW would generate greenhouse gas emissions that would not result in a significant impact on the environment or conflict with an applicable greenhouse gas plan.	LTS	None required	LTS
HAZARDS AND HAZARDOUS MATERIALS			

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
LRDP Impact HAZ-1 Development under the 2014 LRDP would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials.	LTS	None required	LTS
LRDP Impact HAZ-2 Development under the 2014 LRDP would not create a significant public or environmental hazard through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment.	LTS	None required	LTS
LRDP Impact HAZ-3 Development under the 2014 LRDP would not emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school.	LTS	None required	LTS
LRDP Impact HAZ-4 The RBC would be on a site included on a list of hazardous materials sites compiled pursuant to the California Government Code Section 65962.5, but this would not create a significant hazard to the public or the environment.	LTS	None required	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
LRDP Impact HAZ-5 Development under the 2014 LRDP would not impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan.	LTS	None required	LTS
RAW Impact HAZ-1 Implementing the RAW would not have a substantial adverse effect related to hazards and hazardous materials.	LTS	None required	LTS
HYDROLOGY AND WATER QUALITY			
LRDP Impact HYD-1 Stormwater runoff and dewatering associated with 2014 LRDP-related construction activities could result in a violation of water quality standards.	LTS	None required	LTS
LRDP Impact HYD-2 Development under the 2014 LRDP would not substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level.	LTS	None required	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
LRDP Impact HYD-3 Development under the 2014 LRDP would not substantially alter the existing drainage pattern of the RBC site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site.	LTS	None required	LTS
LRDP Impact HYD-4 Development under the 2014 LRDP would not substantially alter drainage patterns in a manner which would result in flooding on- or off-site.	LTS	None required	LTS
LRDP Impact HYD-5 Development under the 2014 LRDP would not create or contribute runoff water that would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff.	LTS	None required	LTS
LRDP Impact HYD-6 Development under the 2014 LRDP would not place structures within a 100-year flood hazard area which would impede or redirect flood flows or expose people or structures to a significant risk of loss, injury, or	LTS	None required	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
death involving flooding.			
LRDP Impact HYD-7 Development under the 2014 LRDP would not expose people or structures to inundation by seiches, tsunamis, or mudflows.	LTS	None required	LTS
RAW Impact HYD-1 Implementing the RAW would not have a substantial adverse effect on hydrology and water quality.	LTS	None required	LTS
LAND USE AND PLANNING			
LRDP Impact LU-1 Development under the 2014 LRDP would not physically divide an established community.	NI	None required	NI
LRDP Impact LU-2 Development under the 2014 LRDP would not result in development that would conflict with land use plans applicable to the project site or with land use plans for properties adjacent to the project site.	LTS	None required	LTS
RAW Impact LU-1 Implementation of the RAW would not have a substantial adverse effect on land use and planning.	LTS	None required	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
NOISE			
LRDP Impact NOISE-1 Construction activities associated with development under the 2014 LRDP could generate and expose people to noise levels exceeding Richmond Community Noise Ordinance standards.	S	**LRDP MM NOISE-1:** **NOISE-1a:** Where technically and economically feasible, construction activities shall be conducted in such a manner that the maximum sound levels at the surrounding properties shall not exceed the dBA levels set forth in the Richmond Municipal Code Section 9.52.110. **NOISE-1b:** The following measures shall be implemented for all construction equipment in accordance with Richmond Municipal Code Section 9.52.060. Quiet construction equipment, particularly air compressors, shall be used whenever possible. Construction equipment powered by internal combustion engines shall be properly muffled and maintained. Stationery noise-generating construction equipment such as tree grinders and air compressors are to be as far as is practical from existing residences. Unnecessary idling of internal combustion engines shall be prohibited. Sources of impulsive sound and jack hammers shall not be used on Sundays and holidays, except for emergencies. **NOISE-1c:** If after implementing NOISE-1a and -1b, construction noise creates a disturbance or results in noise complaints from adjacent property, additional noise reduction strategies shall be evaluated and the necessary practicable technically and economically feasible noise mitigating measures would be implemented, sufficiently to ensure meeting City Noise Ordinance requirements.	LTS
LRDP Impact NOISE-2 Development under the 2014 LRDP would not generate or expose people to excessive groundborne vibration.	LTS	None required	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
LRDP Impact NOISE-3 Development under the 2014 LRDP could generate and expose people to noise levels exceeding Richmond Community Noise Ordinance standards or result in a substantial permanent increase in ambient project vicinity noise levels.	LTS	None required	LTS
RAW Impact NOISE-1 Implementing the RAW could have a substantial adverse effect on noise.	S	Implement LRDP MM NOISE-1a through NOISE-1c	LTS
POPULATION AND HOUSING			
LRDP Impact POP-1 Development under the 2014 LRDP would incrementally increase the RBC site population over the LRDP's approximately 40-year planning period, but would not induce substantial population growth.	LTS	None required	LTS
RAW Impact POP-1 Implementing the RAW would not have a substantial adverse effect on population and housing.	LTS	None required	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
PUBLIC SERVICES AND RECREATION			
LRDP Impact PS-1 Development under the 2014 LRDP would increase the demand for fire services and could result in the construction of new or expanded fire stations. The impacts from the construction of a fire station would be less than significant.	LTS	None required	LTS
LRDP Impact PS-2 Development under the 2014 LRDP would increase police services demand that could necessitate construction of new police facilities on the RBC site, but such construction would not result in significant environmental impacts.	LTS	None required	LTS
LRDP Impact PS-3 Development under the 2014 LRDP would not result in the need for new or physically altered public school facilities.	LTS	None required	LTS
LRDP Impact PS-4 Development under the 2014 LRDP would not trigger construction, substantially increase demand, or substantially degrade parks and recreational facilities.	LTS	None required	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
RAW Impact PS-1 Implementation of the RAW would not result in a substantial adverse effect on public services and recreational facilities.	LTS	None required	LTS
TRANSPORTATION AND TRAFFIC			
LRDP Impact TRA-1 Development under the 2014 LRDP would conflict with an applicable plan, ordinance, or policy establishing effectiveness measures for circulation system performance and would cause an exceedance of a level of service standard established for the study intersections under 2035 conditions.	S	**LRDP MM TRA-1:** The University shall develop and implement a campus traffic mitigation program, a multi-component program to monitor trip generation, reduce peak-hour trips to the extent feasible, or participate in intersection improvements to mitigate off-site impacts at the intersections affected by the proposed project. Each component of this program is described below. Travel Demand Management. To reduce on- and off-campus vehicle trips and resulting impacts, the University shall develop and implement a TDM program in consultation with the City of Richmond. The program is proposed to be adopted by the University following The Regents' approval of the RBC LRDP. The TDM program will include measures to increase transit and shuttle use, encourage alternative transportation modes including bicycle transportation, implement parking policies that reduce demand, and other mechanisms that reduce vehicle trips to and from the campus. The University shall monitor the performance of RBC TDM strategies through annual surveys. Transit Enhancement. To enhance transit systems serving the campus, the University shall work cooperatively with AC Transit and other local agencies to coordinate service routes with existing and proposed shuttle and transit programs. Sustainability and Monitoring. The University shall review individual projects proposed under the 2014 LRDP for consistency with UC sustainable transportation policy and the RBC TDM program to ensure that bicycle and pedestrian improvements, alternative fuel infrastructure, transit stops, and other project features that promote alternative transportation are incorporated into each project to the extent feasible. Campus Traffic Impact Monitoring. The University shall conduct traffic counts at key RBC gateway locations every 5 years to determine campus-generated traffic. Mitigation Payments. The University shall contribute funding on a fair-share basis, to be determined in consultation with the City of Richmond and Caltrans, for periodic (annual or less frequently, as agreed among consulting agencies) signal warrant analyses at the unsignalized intersections significantly impacted by the project. These signal warrant analyses would be used by the City to	SU

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
		determine when a signal is needed. When these signal warrant analyses show that a signal is warranted and the City determines that the required intersection improvements are needed, the University shall reimburse the City on a fair-share basis for the design and construction of the required mitigation, including new traffic signals and related improvements at the intersection impacted by the project. Should the City determine that alternative mitigation strategies may reduce or avoid the significant impact, the University shall work with the City and Caltrans to identify and implement such alternative feasible measures on a fair-share basis.	
LRDP Impact TRA-2 Development under the 2014 LRDP would conflict with an applicable plan, ordinance. or policy establishing effectiveness measures for circulation system performance and would cause an exceedance of a level of service standard established for the study intersections under existing conditions.	S	LRDP MM TRA-2:Implement LRDP MM TRA-1.	SU
LRDP Impact TRA-3 Development under the 2014 LRDP would conflict with an applicable plan, ordinance, or policy establishing effectiveness measures for circulation system performance and would cause an exceedance of a level of service standard established for Congestion Management Plan facilities (freeways) under 2035 conditions.	S	None available	SU
LRDP Impact TRA-4 Development under the 2014 LRDP would not conflict with an	LTS	None required	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
applicable plan, ordinance, or policy establishing effectiveness measures circulation system performance and would not cause an exceedance of a level of service standard established for Congestion Management Plan facilities (freeways) under existing conditions.			
LRDP Impact TRA-5 Development under the 2014 LRDP would not conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities.	LTS	None required	LTS
LRDP Impact TRA-6 The 2014 LRDP would not increase hazards due to a design feature or incompatible use, create unsafe conditions for pedestrians or bicycles, or result in inadequate emergency access.	LTS	None required	LTS
LRDP Impact TRA-7 Traffic associated with the 2014 LRDP campus facilities construction would temporarily and intermittently adversely affect the road network near the RBC site.	S	**LRDP MM TRA-7:** Prepare a construction traffic management plan for each RBC construction project to reduce construction impacts on traffic and parking. The University shall work with City of Richmond in preparing the plan, which will address: • Proposed truck routes • Hours of construction and limits on number of truck trips during peak commute periods (7:00 to 9:00 a.m. and 4:00 to 6:00 p.m.) if traffic conditions demonstrate the need to reduce construction traffic so as to avoid causing significant delays.	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
		• Parking management plan for construction workers; • Tools to provide safe access for pedestrians, bicyclists, automobiles, and emergency access vehicles. • Identification of alternative routes for temporary closure of streets or paths during construction.	
RAW Impact TRA-1 Implementing the RAW would not have a substantial adverse effect on transportation and traffic.	LTS	None required	LTS
UTILITIES, SERVICE SYSTEMS, AND ENERGY			
LRDP Impact UTL-1 Development under the 2014 LRDP would not result in the need for new or expanded water supply entitlements.	LTS	None required	LTS
LRDP Impact UTL-2 Development under the 2014 LRDP would not require or result in new or expanded water treatment facilities.	LTS	None required	LTS
LRDP Impact UTL-3 Development under the 2014 LRDP would require the construction of new or expanded water delivery systems. The construction of new or expanded water delivery systems would not result in significant environmental effects.	LTS	None required	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
LRDP Impact UTL-4 Development under the 2014 LRDP would require the construction of new or expanded wastewater treatment facilities.	S	**LRDP MM UTL-4:** When a project under the 2014 LRDP is proposed that would increase wastewater flows discharged from the RBC site, the University shall work with the City of Richmond to evaluate the impact of the specific project on both the sewer mains and at the Richmond Municipal Sewer District wastewater treatment plant, and if necessary based on the results of the evaluation, the University will compensate the City for the cost of implementing improvements such as slip-lining sewer pipelines downstream of the project site to reduce infiltration and inflow volumes equivalent to or greater than the incremental volume of wastewater generated by the project, or if necessary would construct underground vaults on the RBC site to detain wastewater to reduce peak flows to sewer mains during wet weather.	LTS
LRDP Impact UTL-5 Development under the 2014 LRDP would require the construction of new or expanded wastewater conveyance systems. The construction of new or expanded wastewater conveyance systems would not result in significant environmental effects.	LTS	None required	LTS
LRDP Impact UTL-6 Development under the 2014 LRDP would require the construction of new or expanded stormwater drainage facilities. The construction of new or expanded stormwater drainage facilities would not result in significant environmental effects.	LTS	None required	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
LRDP Impact UTL-7 Development under the 2014 LRDP would generate solid waste, but not enough to require new or expanded permitted landfill capacity.	LTS	None required	LTS
LRDP Impact UTL-8 Development under the 2014 LRDP would comply with all applicable federal, State, and local statutes and regulations related to solid waste.	LTS	None required	LTS
LRDP Impact UTL-9 Development under the 2014 LRDP would require the construction of new or expanded electrical distribution facilities. The construction of new or expanded electrical distribution facilities would not result in significant environmental effects.	LTS	None required	LTS
LRDP Impact UTL-10 Development under the 2014 LRDP would require the construction of new or expanded natural gas distribution facilities. The construction of new or expanded natural gas distribution facilities would not result in significant environmental effects.	LTS	None required	LTS

Table 2-2
Summary of Impacts and Mitigation Measures

Impact	Impact Significance Before Mitigation	Mitigation Measures	Impact Significance With Mitigation
LRDP Impact UTL-11 Development under the 2014 LRDP would not result in the wasteful, inefficient, or unnecessary energy use.	LTS	None required	LTS
RAW Impact UTL-1 Implementing the RAW would not result in a substantial adverse effect on utilities, service systems, and energy.	LTS	None required	LTS

LEGEND:
SU = Significant and unavoidable impact
S = Significant impact
LTS = Less than significant impact
NI = No impact

Table 2-3
Summary of Environmental Protection Practices

Impact	Environmental Protection Practices
AESTHETICS AND VISUAL QUALITY	
LRDP Impact AES-3 2014 LRDP implementation would create new sources of light and glare that would not adversely affect regional day or nighttime views	**LRDP ENVIRONMENTAL PROTECTION PRACTICE AES-3a:** Lighting for new development projects could be designed to include shields and cut-offs that minimize light spill onto unintended surfaces and minimize atmospheric light pollution. **LRDP ENVIRONMENTAL PROTECTION PRACTICE AES-3b:** To reduce off-site lighting impacts, lighting at the campus could be restricted to areas where it would be required for safety, security, and operation. Exterior lights could be hooded, and lights could be directed on-site so significant light or glare would be minimized. For areas where lighting is not required for normal operation, safety, or security, switched lighting circuits could be provided, allowing these areas to remain dark at most times, minimizing the amount of lighting potentially visible off-site. In parking lots, lights could be equipped with motion sensors that reduce the lights to half of their brightness when no motion is detected. **LRDP ENVIRONMENTAL PROTECTION PRACTICE AES-3c:** As part of the design review procedures, light and glare could be given specific consideration, and measures could be incorporated into the project design to minimize both. In general, exterior surfaces would not be reflective; architectural screens and shading devices are preferable to reflective glass.
BIOLOGICAL RESOURCES	
LRDP Impact BIO-4 Development under the 2014 LRDP would not have a substantial adverse effect on monarch butterfly.	**LRDP ENVIRONMENTAL PROTECTION PRACTICE BIO-4:** The University could develop and implement a successional tree planting plan that would maintain the availability of monarch butterfly wintering habitat at the RBC site.
LRDP Impact BIO-5 Development under the 2014 LRDP could have a substantial adverse effect on sensitive natural communities.	**LRDP ENVIRONMENTAL PROTECTION PRACTICE BIO-5:** Currently, and continuing if the LRDP is adopted, the University would mow open space areas consistent with the 2008 report, Richmond Field Station Remediation and Restoration Project Habitat Restoration Progress Report 2003 – 2007, Appendix 2 "Guidelines for Mowing Harding Grass Within and Adjacent to Coastal Terrace Prairie Habitat at the University of California, Richmond Field Station."

Table 2-3
Summary of Environmental Protection Practices

Impact	Environmental Protection Practices
HAZARDS AND HAZARDOUS MATERIALS	
LRDP Impact HAZ-1 Development under the 2014 LRDP would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials.	**LRDP ENVIRONMENTAL PROTECTION PRACTICE HAZ-1:** In implementing the 2014 LRDP, UC Berkeley and LBNL shall continue the same (or equivalent) health and safety plans, programs, practices and procedures related to the use, storage, disposal, and transportation of hazardous materials and wastes (including chemical, radioactive and bio-hazardous materials and waste) as are currently practiced at the UC Berkeley main campus and at the LBNL hill site. These include, but are not limited to, UC Berkeley and LBNL requirements for safe transportation of hazardous materials; EH&S training programs; the requirement that laboratories have chemical hygiene plans; a chemical inventory; a toxic use reduction program; a spill prevention, control, and countermeasure plan; monitoring of underground storage tanks; a waste minimization program; a biosafety program; a waste management program (including medical and biohazardous waste); a radiation safety and/or protection program; compliance with radioactive air emission regulations (40 CFR 61) and compliance with DOE Orders for LBNL activities; compliance with the National Institutes of Health Guidelines for Research Involving Recombinant DNA Molecules; and compliance with US Department of Agriculture requirements for open-field-based research involving transgenic plants.
UTILITIES, SERVICE SYSTEMS, AND ENERGY	
LRDP Impact UTL-7 Development under the 2014 LRDP campus development would generate solid waste, but not enough to require new or expanded permitted landfill capacity.	**LRDP ENVIRONMENTAL PROTECTION PRACTICE UTL-7:** LBNL and UC Berkeley shall develop and implement a plan to maximize diversion of construction and demolition materials from landfill disposal. The plan would set a goal of a minimum of 75 percent diversion, consistent with the UC Sustainable Practices Policy.

CHAPTER 3
PROJECT DESCRIPTION

This EIR evaluates the potential for environmental impacts from implementation of the proposed RBC 2014 LRDP. The RBC would be a new major research campus at University properties in Richmond, California, more specifically described below. The 2014 LRDP horizon year is 2050.

3.1 OVERVIEW

The University, through LBNL and UC Berkeley, proposes to establish a new major research campus, at properties it owns in Richmond, California, for use by both LBNL and UC Berkeley and synergistic institutional or industry counterparts for research and development focused on energy, environment, and health. The University proposes to rename these properties the RBC. The properties are currently operated by the UC Berkeley campus, and the UC Berkeley campus would continue to have administrative control of the RBC, as described further in the 2014 LRDP. The proposed project consists of development of campus facilities pursuant to the proposed 2014 LRDP, which has been prepared in support of the research and academic goals of the University, as elaborated in the 2014 LRDP. An LRDP is defined by statute (PRC 21080.09) as a "physical development and land use plan to meet the academic and institutional objectives for a particular campus or medical center of public higher education;" in this instance, as elaborated in the 2014 LRDP, the new campus is intended to meet institutional objectives of both UC Berkeley and LBNL.

Development and operational activities pursuant to the proposed 2014 LRDP include construction, development, and demolition projects, and operational, research, and maintenance activities through the planning year 2050. At full implementation, the proposed LRDP provides for up to 5.4 million square feet of new research, development, and support space at the RBC site and an employee population of 10,000. The proposed LRDP addresses land use; access, circulation, and parking; open space and landscape; utilities and infrastructure; sustainability; and safety and preparedness. The proposed project includes construction, expansion, or improvement of utility infrastructure and roadway improvements. Past activities have resulted in the deposition of chemical contaminants affecting both soil and groundwater at the part of the proposed RBC site that includes portions of the University's RFS; this is currently under an investigation and cleanup order issued by DTSC. The proposed project includes management of these contaminants in accordance with a proposed RAW, including a soil management plan, contingent upon DTSC approval, or in accordance with the existing DTSC investigation and cleanup order for the RFS. These actions are described in detail in Section 3.9 and are evaluated in this EIR for their environmental effects in Chapter 5.

Design principles in the proposed LRDP feature preservation of the site's important natural open spaces, including the marsh and coastal grasslands.

This LRDP EIR provides a comprehensive program-level analysis of the RBC 2014 LRDP and its potential impacts on the environment, in accordance with Section 15168 of the CEQA Guidelines. The 2014 LRDP would establish RBC growth parameters through 2050; LRDP amendment(s) or replacement would be required in order to exceed those growth parameters. Subsequent proposals for specific development at the RBC would be reviewed for consistency with the LRDP, its EIR, and any necessary further compliance with CEQA.

UC Berkeley is currently responsible for land use and design process at the University's Richmond properties; UC Berkeley would maintain these responsibilities under the RBC LRDP. RBC implementation would be a cooperative effort of LBNL and UC Berkeley, however. While the entities have a close existing partnership and both are managed under the auspices of The Regents of the University of California, the institutions are distinct administrative entities. Upon determination by The Regents to approve the 2014 LRDP and certify the EIR, LBNL and UC Berkeley expect to establish a joint operating committee to oversee RBC operations. The committee would advise the UC Berkeley Chancellor and the LBNL Director.

3.2 PROJECT LOCATION AND SURROUNDING LAND USES

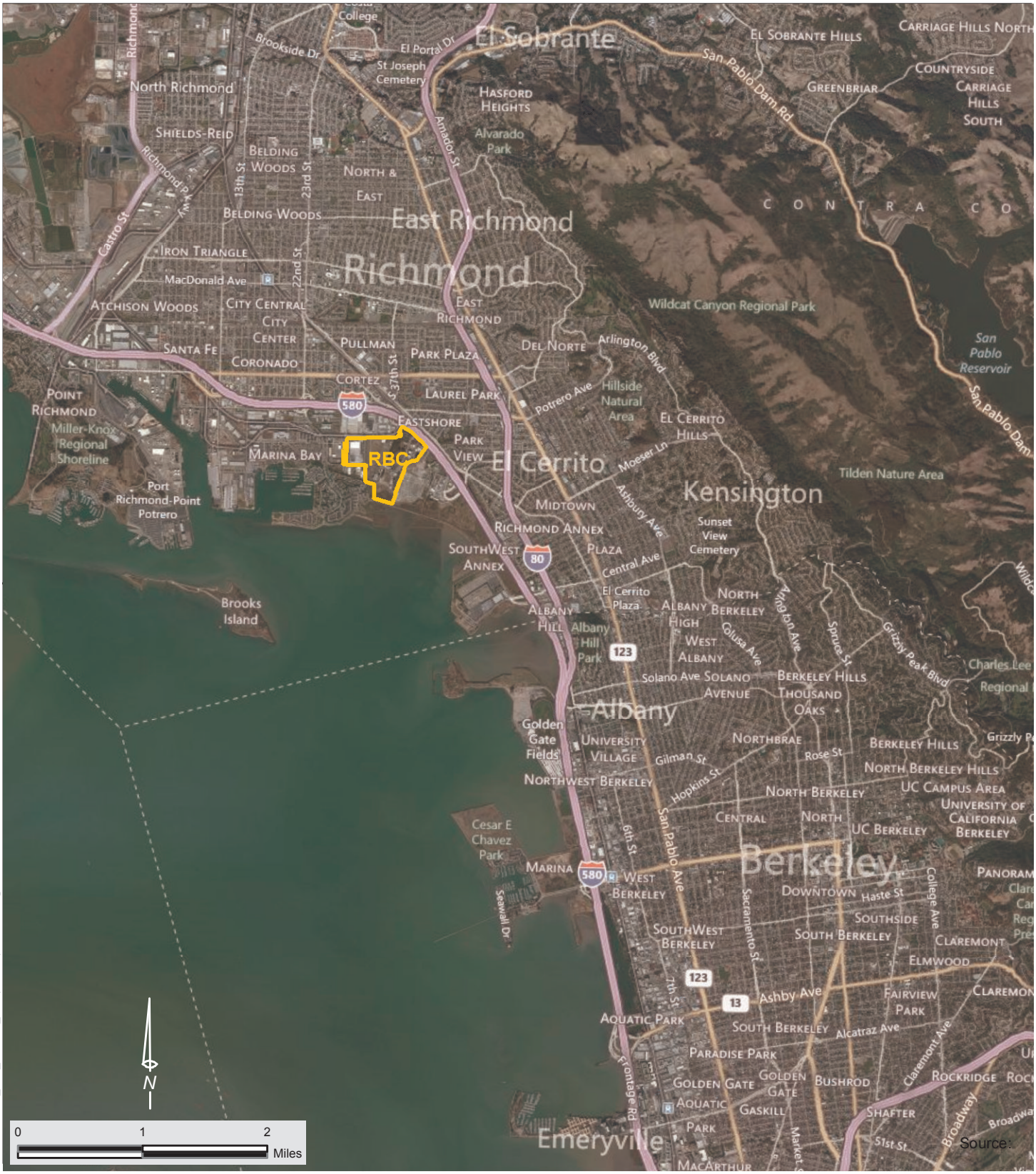
The approximately 134-acre RBC site is located at 1301 South 46th Street in the South Shoreline area of the City of Richmond, approximately 5 miles northwest of the UC Berkeley campus and the LBNL site in Berkeley (Figure 3-1). The RBC site is composed of two University-owned parcels. One parcel is 109.8 acres and is composed of 96.8 acres of uplands at the RFS and 13 acres of the Western Stege Marsh and a transition area at the RFS. The other parcel is a recently acquired 24.0-acre developed property along Regatta Boulevard immediately west of the RFS upland area.[4] The University owns two additional parcels in Richmond that comprise tidal lands and open San Francisco Bay waters. Those two parcels are 46.1 and 15.6 acres and would not be part of the RBC.

The proposed RBC property is bounded on the west by a Pacific Gas and Electric (PG&E) service station, on the north/northwest by Regatta Boulevard, on the northeast by Meade Street, on the east by South 46th Street, and on the south by the San Francisco Bay. I-580 is parallel to Meade Street along the northeastern RBC site boundary.

Land uses surrounding the RBC site include industrial/office uses, a major interstate freeway, and low-/medium-density residential neighborhoods. Regatta Boulevard, along the RBC site northern/northwestern boundary, is adjacent to a railroad spur and a business complex developed with one- to two-story buildings. Bio-Rad Laboratories, a private research equipment manufacturing company, is located immediately west of the RBC site. The adjacent property to the east is the location of former chemical production operations previously owned by several entities, including Stauffer and Zeneca, and is currently owned by Cherokee Simeon Venture I, LLC.

The Marina Bay residential neighborhood, across Meeker Slough, and southwest of the RBC site, consists of a mix of multi- and single-family residences. Low- and medium-density residential uses are also located across I-580, north of the RBC site Meade Street boundary.

[4] The two RBC parcels total about 134 acres; however, the existing 2.7-acre Regatta Boulevard right-of-way between the Regatta and Richmond Field Station parcels is included in the land use map for analytical purposes. The University is working with the City of Richmond to acquire the road right-of-way parcel and to subsequently provide Regatta Boulevard right-of-way on the proposed RBC western boundary. The resulting RBC acreage would remain approximately 134 acres following the proposed realignment of Regatta Boulevard.



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Source:

Regional Location

Richmond, California

TETRA TECH

Figure 3-1

3.3 EXISTING SITE CONDITIONS

3.3.1 Site Conditions

The 134-acre RBC site consists of upland areas developed with buildings that are used for academic and research activities and spaces leased by private and government entities, a north-south oriented eucalyptus tree stand in the site central portion, coastal grasslands, a tidal salt marsh (known as the Western Stege Marsh), and a transition zone between the upland areas and the marsh. About 14 acres of grasslands occur in a number of RBC site meadows. The Bay Trail is south of the site.

The University purchased the original RFS landholdings in 1950. From 1870 to 1950, much of the property belonged to the California Cap Company, which manufactured explosives. The southeast portion of the uplands area was used for explosive manufacturing from the 1870s until 1948. Primarily as a result of historic uses on and around the site, soils, groundwater, and marsh sediments contain levels of contamination that exceed regulatory agency screening criteria. Consequently, several site areas may warrant additional characterization or remedial actions. The main contaminants of concern include metals, volatile organic compounds, and PCBs. The University has been conducting an investigation and remediation of the site in accordance with a DTSC Site Investigation and Remedial Action Order No. I/SE-RAO 06-07-004. On-site contamination and remediation is discussed in many reports completed under the Order, available on the web at rfs-env.berkeley.edu. More information on the actions proposed to address RBC site contamination is presented in Section 3.9 below.

3.3.2 Existing On-Site Land Uses

The RBC site is currently developed with roadways, parking lots, landscaped areas, and 81 one- and two-story buildings, as shown in Table 3-1. The upland RFS area, which has been the location of a variety of industrial enterprises dating back to the mid-19th century, also contains previously disturbed, currently undeveloped open space. Figure 3-2 presents current land uses on the RBC site. The site is currently developed with 1,050,000 gsf of facilities, including more than 500,000 assignable square feet of research space; the NRLF, which serves as an archive for 7.7 million volumes of lesser-used books for the four northern UC campuses; one of the world's largest earthquake shaking tables; test facilities for advanced transportation research; and an EPA regional laboratory. The University purchased the Regatta parcel (former Price Club site) in 2007, which added 24.0 acres to its Richmond properties. The Regatta parcel is developed with a warehouse building and surface parking. The warehouse building currently houses UC Berkeley archives and provides space for other private leased uses.

As of late 2012, the RBC site had a daily population of approximately 300 persons.

3.3.3 Transportation, Circulation, and Parking

The existing RBC site main entrance is at S. 46th Street and the junction of Seaver Avenue and Robin Drive, accessed via the junction of Meade Street and Seaver Avenue. The site is accessible via interstate freeways I-80 and I-580. There are three interchanges on I-580 that provide access to the RBC site—Marina Bay Parkway interchange, Regatta Boulevard interchange, and Bayview Avenue interchange. The Regatta Boulevard and Bayview interchanges are both about 0.35 miles from the main entrance and provide the most direct access between the freeway and the RBC site. The Marina Bay Parkway and Regatta Boulevard interchanges provide the most direct access between the freeway and the Regatta property. Side-street access to the RBC site is provided via overpasses at Bayview Avenue, Regatta Boulevard/Juliga Woods Street, Marina Bay Parkway/S. 23rd Street, Marina Way, Harbor Way, and other streets farther west. Bay Trail access to the

Table 3-1
RBC Site Buildings

Building Number	Year Built	Gross Square Feet	Current Use
100	1950	639	Research
102	1950	6,737	Research
110	1950	1,325	Inactive
111	1987	507	Shop
112	1964	16,949	Office
113	1981	1,800	Storage
114	1950	4,523	Storage
116	1964	967	Shop
117	1950	608	Field Building
118	1950	1,708	Research
120	1967	269	Storage
121	1982	728	Storage
125	1950	1,024	Storage
128	1950	10,287	Storage
149	1982	720	Storage
150	1950	5,410	Research
151	1959	2,629	Research Office
152	1950	4,201	Research
153	1959	3,754	Shop
154	1958	2,731	Research
155	1950	1,896	Office
158	1957	3,343	Research
159	1950	2,366	Research Office
160	1950	1,926	Recreation
161	1950	2,392	Research
162	1976	240	Restroom
163	1950	6,430	Office
164	1950	3,462	Office
165	1996	749	Research
166	2002	5,412	Storage
167	1965	4,092	Shop
175	1950	16,052	Storage
176	1950	672	Research
177	1950	2,969	Research
178	1950	3,950	Office
180	1950	11,008	Office
185	1950	3,165	Storage
190	1950	2,951	Research Office

Table 3-1
RBC Site Buildings

Building Number	Year Built	Gross Square Feet	Current Use
190 TLR	1995	480	Storage
194	1963	1,892	Shop
195	1964	664	Storage
196	1950	2,807	Conference
197	1975	2,419	Vehicle Storage
198	1981	1,800	Storage
275	1956	7,914	Research Lab
276	1958	4,880	Research
277	1966	21,426	Research
280A	1963	13,069	Research Office
280B	1963	15,777	Storage
282	1950	129	Research Lab
300	1992	1,320	Research Office
400	1982	253,660	Library
420	1971	10,635	Storage
421	1970	1,242	Research Lab
445	1968	2,336	Conference
450	1954	6,778	Vehicle Storage
451	1954	7,421	Office
452	1956	7,355	Conference
452 TLR	1995	1,420	Research
453	1956	5,764	Office
454	1963	6,580	Office
460	1968	984	Storage
470	1982	438	Research
471	1988	558	Greenhouse
472	1968	2,633	Research Office
473	1962	3,570	Office
474	1956	342	Storage
475	1993	1,296	Storage
476	1958	997	Storage
478	1958	38,862	Exhibit
479	1954	54	Office
480	1956	7,036	Research
482	1965	1,516	Research
484	1965	14,133	Research Lab
485	1968	429	Research

Table 3-1
RBC Site Buildings

Building Number	Year Built	Gross Square Feet	Current Use
486	1967	8,068	Research Lab
487	1968	543	Inactive
488	1969	175	Storage
491	2002	180	Storage
201	1990	46,000	EPA Building
None	1956	404,098	Regatta Center

RBC for bicyclists and pedestrians is provided via underpasses/overpasses at Central Avenue, Buchanan Street, Gilman Street, University Avenue, the Berkeley bicycle and pedestrian bridge, and others further south. Bay Trail access to the RBC is also provided to bicyclists and pedestrians along the length of the entire South Shoreline Area in the City of Richmond.

The major vehicular circulation routes on the RBC site include east-west oriented Robin Drive and Lark Drive, and north-south oriented Egret Way. The primary vehicular entries into the RBC site are:

- South 46th Street and the junction of Seaver Avenue and Robin Drive,
- South 46th Street at Building 194,
- Regatta Boulevard near South 34th Street, and
- Regatta Boulevard (multiple locations) for the Regatta property.

Parking is accommodated in several surface lots. There are currently 760 on-site parking spaces. UC Berkeley operates a shuttle bus that runs hourly between the UC Berkeley main campus and the RFS.

3.3.4 Utilities and Infrastructure

The RBC site is connected to local utility companies for electrical power, natural gas, water, and telecommunications services and to the City of Richmond wastewater system. PG&E provides electricity to the site through multiple overhead 12-kilovolt electrical lines, with both aerial and underground power lines composing the site's electrical service infrastructure. PG&E also provides natural gas service through multiple high-pressure gas mains, with underground gas lines serving the larger site facilities. East Bay Municipal Utility District (EBMUD) provides potable and fire suppression water via multiple high-pressure water mains, with underground potable and firefighting water lines distributed throughout the site. AT&T provides the site with communications service. Site sanitary sewer discharge flows to the City of Richmond publicly-owned treatment works, located approximately 3 miles to the west on Canal Boulevard.

Existing Land Use

Richmond, California

TETRA TECH

Figure 3-2

3.4 RELATIONSHIP OF THE RICHMOND BAY CAMPUS TO THE US DEPARTMENT OF ENERGY

LBNL[5] is located at 1 Cyclotron Road in Berkeley and is a federal facility managed and operated by the University under a DOE/University contract. The research, public service, and training work conducted at LBNL is within the University's mission and the land is owned by The Regents of the University of California. The federal government leases land at LBNL from The Regents and constructs federally owned buildings on the leased lands. The University has also constructed, and is in the process of constructing, buildings at LBNL to house federal research programs. The University is the LBNL Management and Operating (M&O) contractor, as defined under DOE Acquisition Regulations. As LBNL's M&O Contractor, the University is responsible for providing the intellectual leadership and management expertise necessary and appropriate to manage, operate, and staff LBNL; accomplish the missions and activities funded and assigned to LBNL by DOE; administer the DOE/University contract; and provide University oversight of LBNL's contract compliance and performance.

The RBC site would continue to be owned by the University, but some of the facilities developed on the RBC site would be used by the University, as the operating contractor at LBNL to accomplish the missions and activities assigned and funded by DOE. Because the RBC would be a joint use campus, some of the existing buildings as well as new buildings on the RBC site would be occupied by UC Berkeley teaching and research programs. As a result, the laws, regulations, and policies that would apply to design and construction of an individual facility would depend on its funding source. The laws, regulations, and policies that would apply to the operation of an individual facility would depend on the organization occupying the facility. The proposed joint operating committee would work to sensibly streamline operations that can be handled cooperatively, such as recycling programs, transportation demand management programs, utility operations, maintenance, health and safety, emergency response, when appropriate.

3.5 PROJECT PURPOSE, NEED, AND OBJECTIVES

3.5.1 Project Need

The LBNL main site is located in the Berkeley hills on approximately 202 acres of UC land. The main site comprises approximately 1.6 million gsf in permanent and temporary facilities (LBNL 2012 Annual Lab Plan). Main LBNL site structures are at full occupancy. LBNL currently leases commercial property totaling approximately 371,100 gsf in eight off-site locations and occupies an additional 47,333 gsf of space on the UC Berkeley campus for research and administrative purposes (LBNL 2012 Annual Lab Plan). The University has determined that an additional campus site is needed to consolidate the LBNL biosciences research facilities currently located in off-site leased space. The additional campus would also provide opportunities to accommodate future growth of existing or new LBNL programs, particularly for program activities not requiring routine use of the LBNL national user facilities, (e.g. Advanced Light Source) at the LBNL main site.[6]

[5] "LBNL" refers to the national federally funded research and development center named the Lawrence Berkeley National Laboratory. "University" refers to the University of California, the statewide entity that is the agency affiliation of both the University of California, Berkeley and LBNL. The University is the management and operating contractor of the Lawrence Berkeley National Laboratory.

[6] LBNL national user facilities provide researchers with the most advanced tools of modern science including accelerators, colliders, supercomputers, light sources and neutron sources, and facilities for studying the nanoworld, the environment, and the atmosphere.

LBNL and UC Berkeley have also determined that co-location of UC Berkeley with LBNL at the RBC site would benefit both institutions. The histories of UC Berkeley and LBNL have been intertwined since the founding of the Laboratory by Ernest Orlando Lawrence in 1931, and both have richly benefited from co-location and synergies at their existing sites in Berkeley. Hundreds of UC Berkeley faculty members hold joint appointments at LBNL; many UC Berkeley undergraduate and graduate students conduct research at LBNL as part of their degree programs. The partnership helps both institutions recruit and retain top students and scientists from around the world. The RBC would further build that synergistic relationship for the benefit of both LBNL and UC Berkeley and create resiliency through research partnerships and engagement beyond traditional university bounds.

Past activities have resulted in the deposition of chemical contaminants affecting both soil and groundwater at the part of the proposed RBC site that includes portions of UC Berkeley's RFS. The project would be conducted in accordance with a proposed RAW, including a soil management plan, contingent upon DTSC approval, or in accordance with the existing DTSC investigation and cleanup order for the RFS.

The proposed 2014 LRDP provides land use designations and identifies developable area to support new research and educational initiatives. The 2014 LRDP creates a framework to support program expansion through the year 2050.

The University's vision for the RBC is that it would be "A state-of-the-art, inspirational, sustainable place to produce world-class collaborative science for healthy living and sustainable communities."

3.5.2 Project Purpose

The purpose of the new campus and the associated LRDP is to provide for consolidation of LBNL biosciences programs; to support existing or new LBNL and UC Berkeley program growth; to address constraints on locating new research activities at the LBNL main site; to achieve the UC Berkeley's 2002 working paper goal for creating a premiere research facility supporting and complementing UC Berkeley teaching, research, and public service programs at the Richmond property; to reduce UC Berkeley and LBNL fiscal and programmatic costs related to leasing space and dispersed programs; and to allow for successful facilities development for LBNL, UC Berkeley, and other public and private entities in a manner that supports LBNL and UC missions in a time of funding constraints and that continues their history of successful scientific collaboration.

3.5.3 Project Objectives

To accomplish the purpose and need, the University has these project objectives. The project should:

- Be within an approximately 20- to 25-minute commute from the existing LBNL main entrance at Blackberry Gate on Hearst Avenue; or an approximately 20 minute commute from UC Berkeley's main entrance at Oxford and University Avenue.
- Have development capacity for approximately 5.4 million gsf of laboratory, office, and support facilities and related utility and transportation infrastructure to support the University's research, teaching, and public service mission.

- Be in a safe and welcoming community with a positive civic expression of interest in development of the site.
- Be readily accessible to a variety of modes of public transportation, inclusive of local buses, mass transit (BART, Amtrak, and AC Transit), and shuttle services, and allow safe bicyclist access from designated bicycle routes.
- Allow for electrical, natural gas, and water utilities for the lowest possible cost.
- Allow consolidation of LBNL bioscience programs.
- Allow for establishment of a design framework for development of a state-of-the-art research campus that will be the location of choice for internationally recognized researchers.
- Foster synergy and collaboration between UC Berkeley and LBNL in and across disciplines and institutions in both the public and private sectors.
- Provide sustainable land use and circulation patterns that maximize density to reduce overall building footprints and conserve open space, and maximize bicycle, pedestrian and shuttle services allow for placement and massing of buildings to maximize shared views.
- Facilitate efficient constructability of facilities (buildings, parking structures, bridges, etc.), infrastructure development (roads, underground utilities, pedestrian walkways, etc.), and open space.
- Foster connectivity with the surrounding community.
- Leverage capital investment for environmental stewardship.

3.6 2014 LONG RANGE DEVELOPMENT PLAN

The proposed 2014 LRDP is incorporated by reference into this project description.

3.6.1 Highlights of the RBC 2014 LRDP

The proposed 2014 LRDP addresses land use; access, circulation, and parking; open space and landscape; utilities and infrastructure; sustainability; and safety and preparedness. The LRDP further provides a policy and design framework to guide the development of up to 5.4 million gsf of new research, development, and support space at the site and for an employee population of up to 10,000. Proposed LRDP design principles feature preservation of the site's important natural open spaces, including marsh and coastal grasslands. The site plan organizes development into distinctive groupings to promote a sense of community within the site, particularly during initial campus growth phases. The proposed LRDP includes policies to guide building design and configuration to maximize opportunities for informal interaction.

Building heights across the RBC are expected to vary, with lower buildings at the Bay-facing edge and taller buildings behind them. Four- and five-story buildings are expected to be a common building module, with heights of 100 feet providing for a five-story building with tall floor-to-floor heights that allow building systems to be easily altered as laboratory uses change over time. Neighborhoods within the campus may also feature iconic buildings that help establish a sense of place. An example would be Sather Tower (the Campanile) at UC Berkeley, which measures 303 feet to the top.

The proposed 2014 LRDP demonstrates commitment to sustainability through site, building, and infrastructure planning principles. As the site is developed, the campus itself would be open to the

community, providing community resources such as auditorium, exhibit, and event space for educational programs. The proposed 2014 LRDP describes and highlights the multiple connections to the RBC site by road, bicycle, and pedestrian path, and incorporates a robust transportation demand management system to facilitate site access.

The RBC would be surrounded by the South Shoreline Area of the City of Richmond, envisioned as a revitalized hub of innovation. The proposed RBC 2014 LRDP emphasizes connectivity beyond the site and the importance of the campus as a catalyst for its vicinity.

The following subsections and Section 3.7, Illustrative Development Scenario, provide additional information about the proposed 2014 LRDP.

3.6.2 Anticipated Research Programs

In the near term, existing programs at the site in sustainable transportation and earthquake engineering, among others, will continue; the site will also continue to house important collections of the University library and UC Berkeley museums. New programs under consideration may establish the campus as a hub of joint research in advanced manufacturing, bioscience, and energy storage. In addition, the programs at the RBC will maintain a close connection to the research conducted on the main campuses of LBNL and UC Berkeley. The RBC will strengthen opportunities for partnerships with private industry. In the longer term, the RBC research would be likely to span the biosciences, energy and environmental sciences and technology, computing sciences, nuclear and particle physics, engineering and materials sciences, chemical sciences, accelerator sciences, climate sciences, and other disciplines. The scale and scope of this research would be appropriate for the size and scope of buildings described in Section 3.7, Illustrative Development Scenario. UC Berkeley expects that student research and teaching programs would also take place at the site, as part of the educational mission of the campus.

3.6.3 Campus Population Projections

The University of California projects that the campus population would increase incrementally with development over the 2014 LRDP's approximately 40-year planning horizon, from approximately 300 persons in 2012 to approximately 10,000 persons by 2050.

3.6.4 Occupiable Building Space Projections

Table 3-2 summarizes the existing and projected RBC occupiable building space at the 2014 LRDP horizon year. Total RBC occupiable building space is projected to increase from approximately 1,050,000 gsf at the present time to 5,400,000 gsf at the 2050 horizon year.

Table 3-2
LRDP Occupiable Building Space Projections

LRDP Use	Existing (2012)	Proposed (2050)	Change
Research, Education, and Support			
Existing Space	1,050,000 gsf	300,000 gsf	-750,000 gsf
New NRLF Space	--	350,000 gsf	350,000 gsf
New Research, Education, & Support Space	--	4,750,000 gsf	4,750,000 gsf
Total	**1,050,000 gsf**	**5,400,000 gsf**	**4,350,000 gsf**

Of the site's existing 1,050,000 gsf, about 750,000 gsf would be demolished and about 300,000 gsf would be retained. The retained space includes the EPA building (46,000 gsf) and NRLF (254,000 gsf). The new building space that would be added to the site includes about 350,000 gsf for the expansion of the NRLF and about 4,750,000 gsf of research, education, and support facilities for occupancy by LBNL, UC Berkeley, and partner institutions. LBNL and UC Berkeley would accommodate existing programs housed in space to be demolished, most likely in new RBC facilities.

3.6.5 Sustainability

The University envisions that the RBC would be a showcase of sustainable design and operations to motivate and inspire its staff, the community, the nation, and the world. The RBC would assert and enhance the University's reputation as a hub of energy efficiency research and best practice. The facilities would demonstrate building efficiency technology innovations developed by the University and its industry partners in a fully functional laboratory environment.

In August 2011, the University updated its UC Sustainable Practices Policy,[7] which set environmental practices goals for both construction and operation in eight areas: green building, clean energy, transportation, climate protection, sustainable operations, waste reduction and recycling, environmentally preferable purchasing, and sustainable food service. All RBC projects would meet or exceed the goals defined in this, or any successor, UC sustainability policy.

In May 2011, DOE approved DOE Order 436.1, which defines requirements and responsibilities for managing sustainability within DOE facilities. In additional to satisfying the UC sustainability policy, all DOE-funded projects at the RBC also would meet or exceed the goals defined in this DOE Order.

Energy

RBC physical development would incorporate energy efficiency principles in all construction and demolition projects, renovation projects, operations, and maintenance within budgetary constraints. In cases where certain facility types, such as a laboratories or data centers, are not required to meet energy consumption code requirements, the projects would be designed to meet specific energy and carbon performance metrics such as those defined by the "Labs21" (DOE and EPA), "Smart Labs" (UC Irvine), or similar applicable programs.

Water

In order to practicably minimize water use, the RBC would implement such measures as installing water-efficient landscaping and drip or other efficient irrigation systems, using water-efficient fixtures, and capturing rainwater and stormwater for irrigation use.

Municipal Solid Waste

The RBC would comply with the UC Sustainable Practices Policy for zero municipal solid waste by 2020 by creating a robust on-site recycling program for diverting municipal solid waste from landfills. In additional to satisfying the UC sustainability policy, all DOE-funded projects at the RBC also would meet or exceed the goals defined in DOE sustainability Orders.

Materials

Building materials would be selected to reduce embodied energy, maximize building lifespan, and be recyclable or reusable. Material use overall would be minimized, whether in buildings or

[7] http://www.universityofcalifornia.edu/sustainability/policy.html

in other site operations (e.g., paper), and recycled wherever practicable. Materials would be locally sourced and from renewable sources to the degree feasible, including demolition materials re-use and recycling.

Transportation

In addition to improving shuttle access, the RBC would implement a TDM program that would include alternate mode use incentives such as discounted transit passes, parking cash-out, Guaranteed Ride Home, and flexible car share programs.

Landscape

The RBC would support bio-diversity and habitat conservation by using native plants wherever possible. In addition, the RBC would use low-impact development design techniques and Bay-Friendly landscape design (see www.stopwaste.org) and make stormwater management a site feature. As described below, natural open spaces would also be maintained.

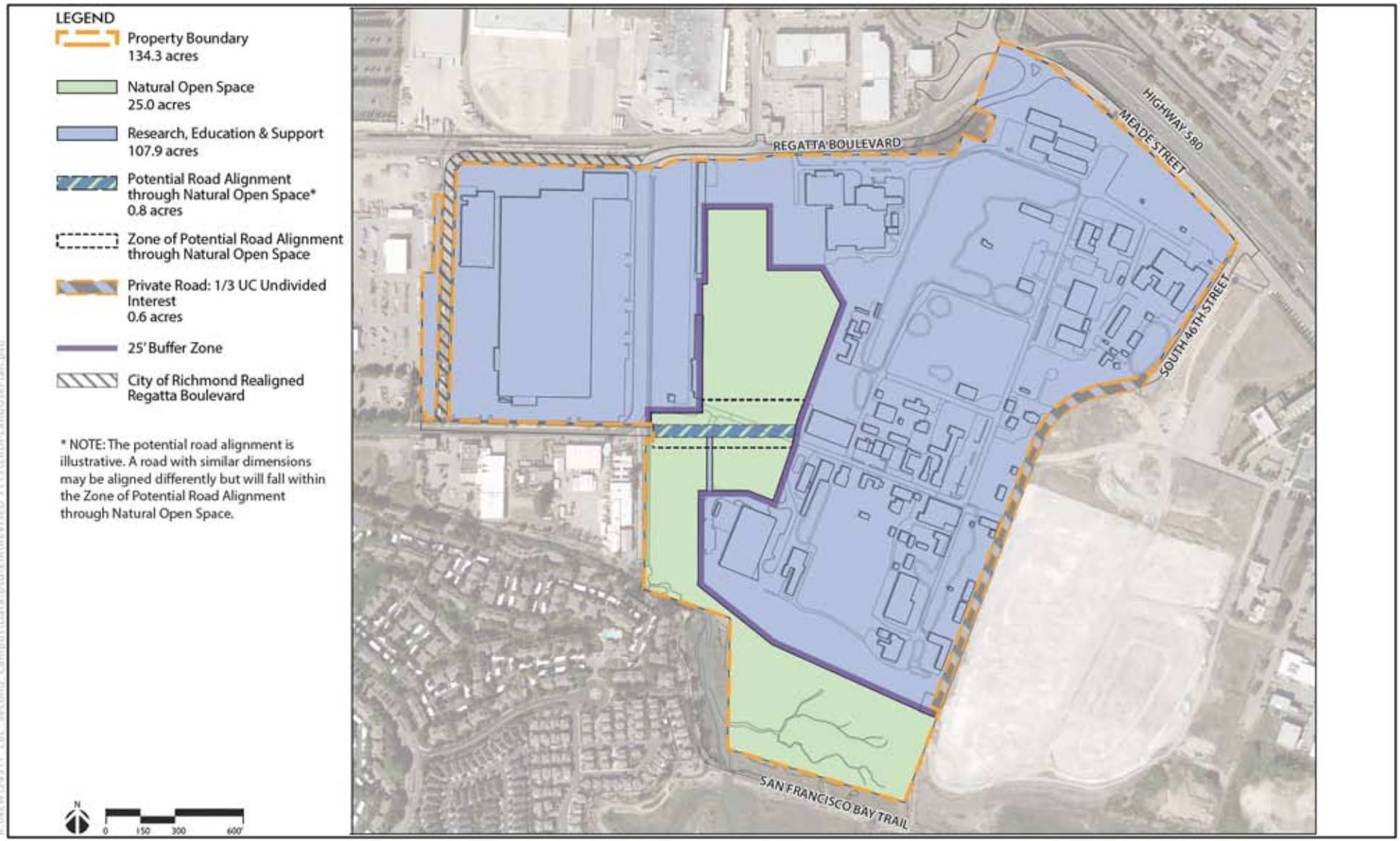
3.6.6 Land Use Plan

The proposed 2014 LRDP identifies two land use designations to inform the pattern of development at the RBC: (1) Research, Education, and Support, and (2) Natural Open Space. Definitions for each land use designation are provided below. Figure 3-3 shows the proposed 2014 LRDP land uses. A possible layout of the site, including realignment of Regatta Boulevard, is shown in Figure 3-4.

Research, Education, and Support

The Research, Education, and Support land use designation applies to RBC site areas that would be developed with new facilities or that would retain existing facilities in their current or expanded form. This land use would include 107.6 acres, which is sufficient to meet projected program needs. The types of facilities that would be allowed in designated Research, Education, and Support areas include:

- Laboratory, classroom, office, and administration buildings for researchers, faculty, postdocs, students, and non-University public and private entities.
- Product and process development space for private sector startups, small businesses, and industry counterparts that are synergistic with UC Berkeley and LBNL research.
- Support infrastructure and facilities for operations, transportation, utilities, renewable power generation, firefighting, security, safety, hazardous materials management, and corporation yard uses, including vehicle and materials shops and storage. Support facilities for specialized research programs such as plant and animal research facilities, greenhouses, and clinical spaces.
- Community outreach and education resources, including exhibit, lecture, and event spaces as well as conference facilities and meeting rooms focused on public education.
- Amenities such as dining, short-term accommodation facilities (for visiting researchers), retail, and recreation facilities.
- Transportation-related facilities including parking lots and structures, bus and shuttle stops, and roads and pathways. Parking structures may house parking administration offices, bicycle support facilities, and utility structures.



LRDP Land Use Plan

Richmond, California

TETRA TECH

Figure 3-3

LRDP Conceptual Layout

Richmond, California

TETRA TECH

Figure 3-4

- Developed, usable open spaces ranging from courtyards, terraces, and quad-like spaces, to walkways, tree groves, and recreational fields. Existing landscaping in these areas, including non-native eucalyptus trees, may be removed and replaced. Open spaces in this zone may be paved or landscaped, with or without seating or other site furnishings. They would range in scale from expansive areas for large, outdoor gatherings to more intimate spaces better suited to small groups and individuals. Stormwater would be managed within these zones in swales, permeable landscaping, and storm drainage systems. Small structures such as pavilions or overlook platforms may be located in these areas.
- Transition zones that would buffer the Natural Open Space areas from site buildings, allowing for maintenance access and minimizing the transference of non-native species or noise or light intrusions. These buffer zones would disallow permanent structures within 25 feet of the Natural Open Space areas. Paving would be pervious wherever practicable and any planting would consist of native or non-invasive species.
- Throughout the RBC, paving would be pervious wherever practicable, stormwater would be carefully managed to protect natural areas, and any planting would consist of native or non-invasive species.

Natural Open Space

The Natural Open Space land use designation applies to natural areas such as the Western Stege Marsh and coastal grasslands, as shown in Figure 3-2. Human encroachment on these spaces would be limited; the LRDP expresses intent to protect, restore, and maintain these resources in their natural condition. Operational activities in these spaces would be limited to interpretation, education, maintenance, and research. Improvements in this zone would be limited to minor access roads for maintenance vehicles and limited boardwalks or pathways, consistent with conservation goals. The LRDP designates 25.2 acres of natural areas as Natural Open Space to protect them from development and maintain their natural condition.

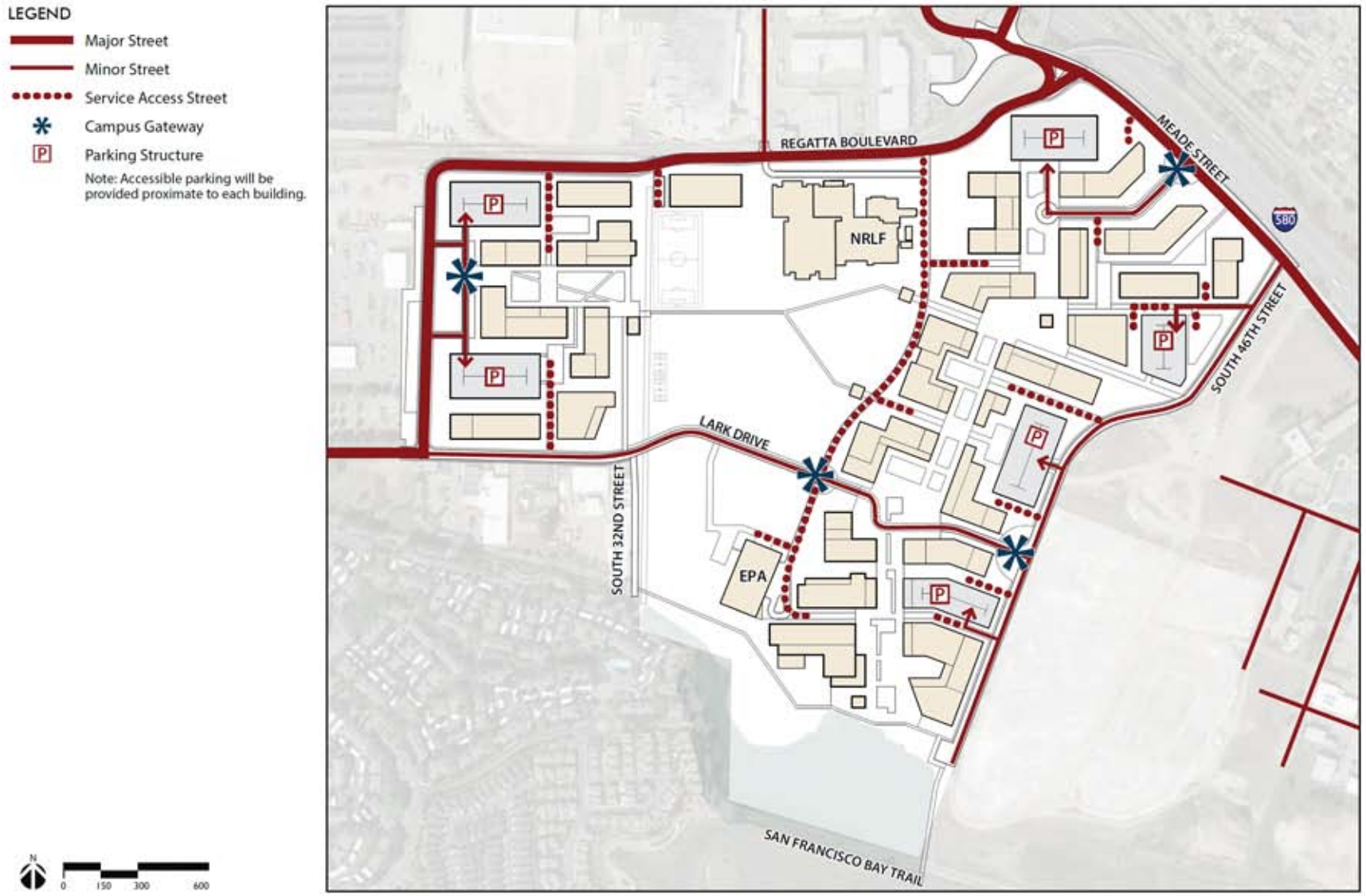
3.6.7 Circulation and Parking

The RBC would model sustainability, including in transportation modes. Prioritizing site access by alternative modes is a key objective for site circulation planning and operation. Transit shuttle facilities and bicycle connectivity improvements would be part of all development phases. A TDM program would promote alternatives to single-occupant commuter vehicles, and an existing on-site hydrogen fueling station could be used to support sustainable transit infrastructure, if vehicles serving the site can one day be hydrogen fueled. Nonetheless, for purposes of the 2014 LRDP environmental impact report, conservative assumptions about mode split and vehicle travel will be made to inform the impact analysis, as outlined below.

Vehicle Access and Circulation

Access to the RBC site is illustrated in Figure 3-5. Vehicle access would continue to be provided from the existing exits off of I-580. The existing entry points to the site would likely remain as primary or service access points. Additional points of entry would be provided from South 46th Street to the east, from Meade Street to the north, and from multiple Regatta Boulevard locations to the west.

RBC internal roadways would provide calm, mixed-use streets for internal circulation. They would serve as vehicle, pedestrian, bicycle, and utility pathways and would provide direct access to buildings. Regatta Boulevard would be rerouted to the west to allow connectivity between the eastern and western portions of the site. Lark Drive would be extended to connect with Regatta Boulevard.



LRDP Circulation Plan

Richmond, California

TETRA TECH

Figure 3-5

Bicycle Circulation

RBC site bicycle access would be via existing overpasses at Bayview Avenue, Regatta Boulevard/Juliga Woods Street, Marina Bay Parkway/S. 23rd Street, Marina Way, Harbor Way, and others further west. Extended Lark Drive would provide bicycle connectivity to downtown Richmond and neighborhoods west of the RBC. Additional RBC site bicycle access would be provided by the Bay Trail; more distant urban connections to the Bay Trail for RBC bicycle commuters would be via existing underpasses/overpasses at Central Avenue, Buchanan Street, Gilman Street, University Avenue, the Berkeley bicycle and pedestrian bridge, and others further south. Bicycle lanes would be provided on all new RBC site roads. A bike sharing system may also be implemented both for internal site circulation and for travel to retail and other points nearby.

Parking

Approximately 690 of the existing 760 vehicle parking spaces located in RBC site surface parking lots would be removed and, as needed over time, replaced in strategic locations. Surface parking would continue to be provided as a short term measure to serve the first few facilities. Later, parking structures would be constructed to provide for the majority of the approximately 6,000 vehicle parking spaces projected for the long term RBC development. The projected change in RBC site parking is shown in Table 3-3. Parking structures would be located in a manner to support a more pedestrian-friendly, vehicle-free district with similarities to a traditional higher education campus. Small surface parking lots would be located adjacent to all new facilities as necessary for disabled access, shipping/receiving, and short-term visitor parking. All parking areas would be provided with an appropriate drainage system designed to treat stormwater runoff from parking areas in conformance with applicable Clean Water Act permits.

Table 3-3
LRDP Parking Projections

Existing Parking Spaces	760
Parking Spaces to be Removed	690
New Parking Spaces	5,930
Total	**6,000**

Bicycle parking would be provided at a rate of at least 20 percent of the RBC population at any given time period, in accordance with Leadership in Energy and Environmental Design (LEED) requirements; this would amount to approximately 2,000 spaces at full LRDP implementation.

New buildings would have indoor secure bicycle parking, showers, and clothes lockers, as well as outdoor bicycle racks, some of which may be secure or covered.

Transit

Two RBC shuttle lines are proposed. The LBNL-UC Berkeley-RBC Shuttle would provide a no-transfer 20-minute ride from LBNL to the RBC with a single intermittent stop at the main UC Berkeley campus. The BART-RBC Shuttle would run routinely between the El Cerrito Del Norte and El Cerrito Plaza BART stations and the RBC, providing a nonstop nine-minute ride from BART to the RBC. The BART stations would also serve as connection points to AC Transit and other bus systems.

3.6.8 Public Services

Increases in campus population and building space would potentially increase demand for public services.

Fire Protection Services

The RBC site is in the jurisdiction of the City of Richmond Fire Department. The closest station is on Bayview Avenue approximately half a mile and four minutes away. It is expected that LBNL and UC Berkeley would continue to use the City of Richmond fire station-based emergency services until required fire safety and emergency assessments and plans indicate the need for additional services. Over the long-term, it may become desirable or necessary to house emergency service equipment and personnel on the campus. The Research, Education, and Support land area includes space for an on-site fire station.

Police Services

The UC Police Department (UCPD) performs all patrol, investigation, crime prevention education, emergency preparedness, and related law enforcement duties for the RBC site. UCPD coordinates closely with the City of Richmond Police Department, operating joint patrol programs in the South Shoreline Area, and coordinating efforts at all levels to ensure the effective provision of police services. The results of required emergency and security assessments and plans may indicate the need for additional services. Over time, these additional services and the associated number of UCPD staff on-site may necessitate expanding or replacing the existing police station. LBNL would retain ultimate responsibility for all security, fire protection, and emergency service requirements for all DOE-funded facilities, assets, and personnel.

3.6.9 Utilities and Infrastructure

The proposed LRDP provides that RBC utility infrastructure would be sustainably designed and implemented and that it would grow over time in carefully planned increments. Nonetheless, for purposes of this EIR, conservative utilities demand assumptions have been made to inform the impact analysis, as outlined below.

The site is currently serviced by a full range of traditional utilities including water, wastewater, natural gas, electricity, and telecommunications utilities providers. The site currently houses a hydrogen fueling station.

The discussion below describes the projected increase in RBC utilities demand under the proposed 2014 LRDP and the types of new facilities or expansions that would likely be required to meet this demand. Table 3-4 presents the current RBC utility demand at the proposed RBC site and the estimated future demands at full 2014 LRDP campus development.

Potable and Firefighting Water

EBMUD provides water to the RBC site for potable, firefighting, central plant, and irrigation uses. Under existing conditions, water consumption is approximately 11 million gallons each year, with an estimated maximum flow rate of 50 gallons per minute (gpm). Following full 2014 LRDP development, the estimated annual water consumption would be about 340 million gallons and the maximum flow rate would be 2,230 gpm. Demand for firefighting water would increase the maximum flow rate by up to 3,000 gpm for a time period of up to 4 hours. The site is currently served by three 8-inch laterals, each connected to 12-inch EBMUD water mains located at South 46th Street, Regatta Boulevard and South 32nd Street, and Regatta Boulevard and South 34th Street. These 8-inch laterals would be upgraded to 12-inch laterals for future potable water delivery. That system would be supplemented and cross-connected by a 12-inch RBC fire water distribution system for future fire water delivery. The underground distribution system would include piping, sectionalizing valves, back-flow preventers, and pressure reducers located generally within 2014 LRDP defined utility corridors. Each new RBC building would feature a water supply isolation valve and meter at its service entry point.

Table 3-4
RBC Utility Demand

Utility	Existing Demand	Projected Demand (2050)
Potable Water	11 million gallons/year (peak demand – 50 gpm)	340 million gallons/year (peak demand – 2,230 gpm)
Firefighting Water	(peak demand – 3,000 gpm)	(peak demand – 6,000 gpm)
Wastewater	9.3 million gallons/year (peak demand – 55 gpm)	273 million gallons/year (peak demand – 2,140 gpm)
Chilled Water	3,513 tons of cooling installed	12,600 tons of cooling installed
Heating Hot Water	281.7 kBTU/h	218,400 kBTU/h
Electrical energy	3,700 megawatt hours/year (peak demand – 500 kW)	142,400 megawatt hours/year (peak demand – 24.7 MW)
Standby Power	peak demand – 400 kW (installed capacity – 3.9 MW)	peak demand –16 MW (installed capacity –20 MW)
Natural Gas	73,600 therms/year (peak demand – 2,700 kBTU/h)	6,600,000 therms/year (peak demand – 240,300 kBTU/h)
Telecommunications	48 strands of fiber optic cable and 300 pairs of copper wire	1,000 strands of fiber optic cable and 3,600 pairs of copper wire

Notes:

gpm gallons per minute
kBTU/h Kilo-British thermal unit hour
kW Kilowatt
MW Megawatt

Wastewater

The Richmond Municipal Sewer District provides wastewater services to the site. The site is currently served by a 15-inch City of Richmond sanitary sewer main line, which connects to several locations at the south end of the developed uplands area. Currently, 9.3 million gallons per year of RBC site wastewater is treated at the City's wastewater treatment plant (WWTP) through the City's sewer system. This would increase to an estimated 273 million gallons per year at full 2014 LRDP implementation. The current peak RBC site sanitary sewer flow rate, which includes some stormwater inflow, is estimated at 55 gpm; this peak flow rate would increase to 2,140 gpm with full 2014 LRDP implementation. The new underground system would include piping and cleanouts located generally within LRDP-identified RBC utility corridors.

Stormwater

The existing site upland area consists of approximately 28 percent impervious and 72 percent pervious surfaces. On-site stormwater currently flows north to south by way of open swales, culverts, underground pipes, and sheet flow into drainages. Runoff from the buildings and other impervious surfaces is directed into storm drains. Currently, there are two main on-site storm drain lines. Stormwater in the western uplands drains overland through open swales or through underground pipes into Meeker Slough and into the transition area north of the Western Stege Marsh. Stormwater in the eastern uplands drains overland through open swales and through underground pipes into the transition area north of the Western Stege Marsh.

The Regatta property is 100 percent impervious surfaces. Runoff from the buildings and other impervious surfaces is directed into storm drains. The eastern portion of the Regatta property drains to the trapezoidal storm drain channel along Regatta Boulevard. The western portion of the Regatta property drains to Meeker Tidal Creek. This trapezoidal drain channel runs north-

south along the western uplands edge; in addition to RBC stormwater, it also carries stormwater collected from portions of the City of Richmond north of the RBC site.

The existing uplands area and Regatta properties combined consist of approximately 42 percent impervious and 58 percent pervious surfaces. With full 2014 LRDP implementation, it is anticipated that the RBC would comprise 43 percent impervious and 57 percent pervious surfaces. The increase in impervious surfaces would be small (about 3 acres). Furthermore, reductions in stormwater runoff would be achieved at the RBC through the incorporation of low-impact development (LID) design techniques that are consistent with NPDES requirements, the UC Sustainable Practices Policy, and LRDP goals that the site model sustainability. Therefore, RBC site stormwater runoff is not expected to increase over existing conditions and is in fact expected to decrease due to the LID and the sustainable design of the new campus.

All construction projects requiring coverage under the State Water Resources Control Board NPDES General Permit for Construction Activities would incorporate stormwater runoff standards. The RBC would also incorporate new open swales, including runoff treatment features and best management practices (BMPs) commensurate with RWQCB requirements to treat stormwater before it is discharged into Western Stege Marsh. In addition, buildings that are constructed using federal funds would also be required to comply with Energy Independence and Security Act (EISA) Section 438 requirements.

Cooling Water

The existing site facilities at the site house water cooling equipment with a combined total capacity of approximately 3,513 tons. The water cooling demand projected for full 2014 LRDP implementation is approximately 12,600 tons. The campus would include individual building heating and cooling systems.

Heating Water

The existing facilities at the site currently house heating equipment with a combined total capacity of approximately 282 kilo-British thermal unit hours (kBtu/h). The heating demand projected for full 2014 LRDP implementation is approximately 218,400 kBtu/h. The campus would include individual building heating and cooling systems.

Electrical Energy

PG&E provides electricity to the site through multiple overhead 12-kilovolt (kv) electrical lines, with both aerial and underground power lines comprising the site's electrical service infrastructure. Under existing conditions, the site has a peak power demand of about 500 kW and consumes approximately 3,700,000 kilowatt hours (kWh) annually. With full 2014 LRDP implementation, RBC peak power demand would be about 25 MW and would consume approximately 142,400 megawatt hours (MWh) annually. The RBC site would continue to be served at 12kv until increased demand made it economical to construct 115kv lines and a 115:12kv substation on the site with a 12kv distribution system. The new substation would include transformers, switchgear, metering, and safety equipment. The Research, Education, and Support land area includes space for a substation prospectively near the junction of Regatta Boulevard and 34th Street. The underground distribution system would include ductbanks, manholes, sectionalizing switches, and additional safety equipment located generally within the utility corridors defined in the 2014 LRDP. Each new major RBC facility would include, as appropriate, adequately sized transformers, switchgear, and standby electrical generators. Whenever possible, generators with the cleanest available technology would be selected.

Natural Gas

PG&E provides the project site with natural gas service through multiple high-pressure gas mains, with underground gas lines serving the larger site facilities. Under existing conditions, site peak demand is about 2,700 kBtu/h and annual consumption is approximately 73,600 therms. With full 2014 LRDP implementation, the RBC would consume approximately 6,600,000 therms of natural gas annually and have a peak demand of about 240,300 kBtu/h. To provide increased natural gas to the proposed project, a new 8-inch gas pipeline would be installed on the RBC eastern portion with three 5- or 6-inch laterals branching off to serve distinct facility clusters. In addition, a new 6-inch gas pipeline would be installed for the western RBC site area. The points of connection to PG&E would include new pressure reducers, meters, vaults, and safety equipment. The underground distribution system would include piping, sectionalizing valves, and additional safety equipment located generally within the 2014 LRDP-defined utility corridors. Each new facility would include a pressure reducer, seismic valve, and meter as required to meet specific operational needs and code requirements.

Telecommunications

AT&T provides project site communications service through telecommunications infrastructure comprising underground and aerial lines. The site is currently served by 48 strands of fiber optic cable and 300 pairs of copper wire. With full 2014 LRDP implementation, the RBC would require approximately 1,000 strands of fiber optic cable and 3,600 pairs of copper wire. The points of connection to AT&T would be located on Meade Avenue and Regatta Boulevard. Each distinct facility cluster would be served by a centralized Main Distribution Frame and a telecommunications distribution system for each individual building. The Research, Education, and Support land area includes space for the Main Distribution Frames. The underground main service and distribution systems would include vaults, conduits, and manholes located generally within the 2014 LRDP-defined utility corridors. Each new RBC facility would include a Building Distribution Frame at its service entry point.

3.6.10 Waste and Recycling

The RBC is intended to model sustainability, and both UC Berkeley and LBNL are working to implement zero waste plans for their respective facilities. The RBC would comply with the UC Sustainable Practices Policy for zero municipal solid waste by 2020. In this EIR analysis, conservative assumptions about waste generation and recycling are used and appear below. In additional to satisfying the UC sustainability policy, all DOE-funded RBC projects also would meet or exceed the goals defined in DOE Orders on sustainability.

Hazardous Waste

Hazardous chemical waste, mixed waste, combined waste, and radioactive waste would be packaged, labeled, and categorized for transport to appropriate permitted and licensed or authorized off-site facilities. Biohazardous waste and universal waste would also be generated and managed at the RBC site. RBC waste collection areas equipped with all required safety features would accommodate collection and management (i.e., consolidation) of hazardous waste and radioactive waste (including mixed waste and combined waste). Hazardous waste and radioactive waste storage areas would be physically separate. The RBC site would also have designated management and storage areas for biohazardous waste (including medical waste) and universal waste.

The storage, handling, use, and disposal of all hazardous materials, hazardous wastes, and other scientific materials within the buildings operated by LBNL would be subject to LBNL Environmental Health and Safety (EH&S) programs. These activities within the UC Berkeley operated buildings would be subject to UC Berkeley EH&S programs.

Municipal Solid Waste and Recycling

All solid waste generated at the RBC would be separated into appropriate waste streams. The non-recyclable and nonhazardous solid wastes from the site would be disposed at a licensed landfill. The recyclable solid wastes from the site would be off-hauled by a licensed contractor.

3.7 ILLUSTRATIVE DEVELOPMENT SCENARIO

To achieve a more detailed understanding of potential project impacts and to allow a more thorough communication of project implications to the public, and also to provide a basis for some of the quantified modeling that has been prepared for the proposed 2014 LRDP and EIR, the University developed an Illustrative Development Scenario that is shown in Figure 3-4.

This Illustrative Development Scenario is a conceptual portrayal of potential development under the LRDP that would be consistent with the proposed 2014 LRDP goals and objectives, the proposed 2014 LRDP Land Use Diagram, and the LRDP's proposed development uses and square footages. The Illustrative Development Scenario is intended to provide a conservative basis for the analysis of environmental impacts.

The actual locations of buildings, configurations, and uses may vary as specific projects are considered for approval in the future. The University's needs and opportunities may change over time at any particular site and the Illustrative Development Scenario is not intended to be a precise representation of the actual development program that would take place over the 40-year planning horizon of the 2014 LRDP.[8]

The EIR uses the Illustrative Development Scenario in the following ways:

1. To illustrate potential development pursuant to the 2014 LRDP based upon a conceptual portrayal of such potential development, and therefore give the reviewer an illustrative sense of the scope and scale of potential development at any particular building site pursuant to the LRDP.
2. To provide a basis for the EIR's project impacts analysis consistent with the *State CEQA Guidelines* provisions for program EIRs, and to provide a similar analytical basis for considering and evaluating future RBC actions after the program EIR has been certified; and
3. To provide a basis for quantified or modeled studies such as the human health risk assessment.

The Illustrative Development Scenario depicts possible siting and dimensions of new buildings, parking garages, and roadway changes, and demolition of existing buildings. Further detail and discussion of these project elements follow in this chapter. Consistent with the proposed 2014 LRDP Land Use Diagram, the Illustrative Development Scenario indicates that development of major new buildings would take place within the Research, Education, and Support zone of the RBC. Parking structures would be sited to support a pedestrian-friendly, vehicle-free environment.

While actual RBC development under the 2014 LRDP would likely not precisely follow the Illustrative Development Scenario layout, the University would consider how each individual

[8] It is not possible to forecast accurately the complex series of development opportunities and decisions, including future building locations, sizes, configurations, uses, construction schedules, etc., that would comprise full implementation of the LRDP program.

project conforms to the assumptions and impact analyses presented in the 2014 LRDP EIR to determine what, if any, further CEQA documentation is necessary at that time. If specific project differences require significant changes to the 2014 LRDP EIR such that the project is not within the scope of the LRDP EIR or the specific impact statements and mitigation measures do not cover the individual project pursuant to CEQA Guidelines Sections 15168(c)(2) and 15168(c)(5), then appropriate, project-specific CEQA analysis would be tiered from this 2014 LRDP EIR in accordance with CEQA Guidelines Sections 15168(d)(1-3). This use of the Illustrative Development Scenario in connection with further approvals is subject to the overall limitations on subsequent review that have been stated elsewhere in this EIR. In particular, any development in excess of a net total of 5,400,000 gsf of occupiable (Research, Education, and Support) space would require an amendment of the LRDP and accompanying CEQA review.

If adopted, the provisions of the 2014 LRDP would become binding land use designations and policies for the University, and later projects carried out by the University would be required to be consistent with the 2014 LRDP (unless the LRDP is amended). In contrast, the descriptions contained in the Illustrative Development Scenario are not binding or governing policies, but the Illustrative Development Scenario would be part of the information that is considered in determining the appropriate form of CEQA review for later approvals of specific projects pursuant to the 2014 LRDP. Thus the scenario is illustrative, and it is provided in this EIR for the purpose of evaluating the development impacts that may occur pursuant to the proposed LRDP. Under the CEQA Guidelines, for later approvals based on a program EIR, the Illustrative Development Scenario may be considered (along with other information, and along with the overall limitations on subsequent review that have been stated elsewhere in this EIR) in determining whether the proposed later approval is within the scope of this EIR's analysis, or whether some level of further analysis is required under CEQA.

The Illustrative Development Scenario assumes ongoing demolition and construction activities over the course of the approximately 40-year planning period. Areas of soil and groundwater contamination at the RBC site would be addressed as part of the proposed project activities; this is further discussed in Section 3.9.

3.7.1 Demolition

In addition to showing new building space, the Illustrative Development Scenario depicts which existing buildings would be potentially demolished and removed; up to 750,000 gsf of outdated or underused facilities are not carried forward in the Illustrative Development Scenario. Demolition is considered for buildings and structures that are not cost-effective to upgrade, no longer suitable for modern science, costly to maintain, and not an efficient use of the site’s buildable space. Most of the existing buildings are more than 40 years old, beyond the effective age of a typical laboratory building, and are relatively small, averaging about 9,600 gsf.

Active demolition project phases would generally proceed as follows: (1) determine any special site or building conditions due to historic contamination; (2) evaluate as necessary soil management, construction activities, and adherence to existing decision documents; (3) characterize building contents; (4) abate building materials hazards, including asbestos-containing materials, lead-based paint, and radioactive contamination, if any are present; (5) identify and remove reusable and recyclable materials; (6) demolish and remove the structure; (7) address hazards, if any, in soils in accordance with established protocols and regulatory oversight; (8) demolish and remove foundation and utilities; and (9) fill any holes, grade the site as necessary, and landscape the site or redevelop it with a new building. Existing concrete may be reduced to rubble and re-used on site to support sustainable redevelopment.

Demolition equipment would include large vehicles, stationary equipment, and hand-held equipment typical of that used in demolition and construction.

Table 3-5 identifies anticipated demolition activity levels under the 2014 LRDP. The table compares anticipated average and peak annual average levels of demolition activity, broken out into principal demolition parameters for analysis. The annual average is derived by dividing the total demolition gsf by a 40-year planning period. The anticipated peak demolition activity is assumed to be demolition of the majority of the existing Regatta property within a 12-month period. The calculation of truck trips assumes 10-ton haul trucks.

Table 3-5
Demolition Activity Levels

	Anticipated Average Demolition Project (12-month peak activity)	Anticipated Site-wide Average Annual Demolition Activity	Anticipated Peak Demolition Activity (12-month period)
Facilities Demolition	9,600 gsf	18,750 gsf	250,000 gsf
Weight (125 lbs/gsf)	600 tons	1,172 tons	15,625 tons
Truck Trips	60 truckloads	117 truckloads	1,563 truckloads

Notes:

gsf gross square feet
lbs pounds

3.7.2 Construction

Large project construction planning includes consideration of each project's environmental and regulatory elements. Construction activities usually include the need for adjacent lay-down areas for equipment, supplies, and fabrication activities, as well as construction-worker parking, typically on or near a job site. Under the 2014 LRDP, it is expected that large construction projects would not often occur simultaneously, although such projects may have some degree of overlap in schedules.

Construction would typically begin with demolition of existing facilities at a site, if necessary, followed by site clearing, soil investigation and management, and excavation work. At the RBC, preliminary steps include determination of any special site or building conditions due to historic contamination that should inform site work. Excavated soil would be adequately characterized and profiled so that it may be shipped off site during this phase, unless the project is a balanced cut-fill excavation. Soil must be evaluated for contamination prior to on-site reuse or off-site disposal. Reuse or disposal of soil would be in accordance with soil management plan requirements in a proposed RAW, if approved by DTSC, or subject to DTSC approval. Foundation work, building frame erection, and building finishing are the three major phases to follow. Under optimal conditions, site work for large RBC projects would typically be scheduled to occur between the months of April through September for optimal weather conditions, although it may occur in any month of the year, and the remaining phases may also take place at any time during any season.

Construction equipment would typically include large vehicles, stationary equipment, and hand-held equipment used on the building site and at nearby staging areas, and would be powered by diesel or gasoline engines or electricity. Such equipment would include cranes, scraper/dozers, spreader/compactors, loaders, drill rigs, haul trucks, cement trucks, bore drillers, rough terrain forklifts, pavers, rollers, and other rigs. All equipment would comply with applicable regulatory standards, including required noise, air emissions, safety, and energy efficiency standards.

For the purposes of this EIR, the term "construction," unless specifically indicated otherwise, includes building new facilities, rehabilitating or modifying existing facilities, demolishing existing facilities, and investigating and remediating contaminated soil. The maximum total new construction and renovation under the Illustrative Development Scenario is proposed to be 7,300,000 gsf. This includes approximately 300,000 gsf of existing space, 5,100,000 gsf of new occupiable building space construction, and 1,900,000 gsf of new parking structures. While parking structures are not considered part of the 2014 LRDP occupiable space totals, they account for potential construction-related impacts and are thus considered in this EIR analysis. Table 3-6 identifies the construction activity level for a typical construction project, divided into the major phases of construction. A 175,000 gsf project is used to represent the average new building size at the RBC. Table 3-6 also compares anticipated average and peak annual levels of construction activity.

Table 3-6
Construction Activity Levels

	Anticipated Average Construction Project (30 months total)	Anticipated Site-wide Average Annual Construction Activity	Anticipated Peak Construction Annual Average
Construction	175,00 gsf	175,000 gsf	600,000 gsf
Excavation & Replacement Volume	15,700 cubic yards	15,700 cubic yards	53,800 cubic yards
Soil Hauling	1,570 truckloads	1,570 truckloads	5,380 truckloads
Foundation	650 truckloads	650 truckloads	2,740 truckloads
Construction	3,400 truckloads	3,400 truckloads	14,380 truckloads
Total Truckloads	5,620 truckloads	5,620 truckloads	22,500 truckloads
Average Daily Truckloads	9 truckloads/day	9 truckloads/day	36 truckloads/day
Peak Daily Truckloads	25 truckloads	25 truckloads	100 truckloads

Note:
gsf gross square feet

The annual averages are approximately equivalent to one typical construction project being underway at all times at the RBC. The averages are derived by combining total project construction elements identified in the Illustrative Development Scenario (e.g., total square footage, footprint square footages, etc.) and then dividing these aggregates evenly over the 40-year planning period. In this way, the peak annual average construction activity level is over three times the annual average, or the equivalent of 3.4 typical construction projects being underway simultaneously. This activity level is intended to represent the maximum anticipated construction activity level for analytical purposes.

The excavation truck trips calculation assumes the use of 10-cubic-yard haul trucks. Project excavation estimates are based on Illustrative Development Scenario building footprints: an excavation perimeter is established 5 feet outside of and around each prospective building and its foundation. This formula is applied to each building or parking structure identified in the Illustrative Development Scenario. The structures were assumed to be an average of 4.5 stories high. While this volume is likely to be exceeded with some projects, others would require less excavation or would be balanced cut-fill excavations. Foundations are assumed to be approximately the area of the building footprints perimeter identified in the Illustrative Development Scenario and up to 10 feet deep. Per the above description, the excavated soil would be hauled in trucks, each assumed to hold 10 cubic yards. An average building project is estimated to require approximately 3,400 truckloads of materials, including rental equipment, concrete, structural steel, siding, building systems equipment, and interior finishing materials.

In accordance with LRDP Policy UI2, proposed development projects would incorporate measures to protect campus facilities from the amount of sea level rise anticipated through 2100. These measures could include raising the base elevation of parcels at the southern end of campus, using natural shore forms where practicable, and maintaining existing offshore wave sheltering structures.

3.8 OPERATIONS

While LBNL and UC Berkeley have a close existing partnership, they are distinct administrative entities of the University. Upon determination by the Regents to approve the 2014 LRDP and certify the associated Environmental Impact Report, UC Berkeley and LBNL are expected to establish a joint committee to oversee operations at the site. The committee would advise the LBNL Director and the UC Berkeley Chancellor on strategic and operational matters. However, UC Berkeley would continue to have ultimate administrative control of, and responsibility for, the Richmond properties (see also the Implementation section).UC Berkeley currently is responsible for land use and design process at the University's Richmond properties and would continue to be under the RBC LRDP. RBC implementation would be a unique cooperative effort of LBNL and UC Berkeley.

New RBC facilities built by either UC Berkeley or LBNL are expected to be operated by the respective institution. New facilities built by private sector entities would be subject to operational oversight by UC Berkeley or LBNL, as determined by the chancellor and director under the advice of the joint operating committee.

3.9 RFS CONTAMINATION

Past activities at the RFS site have resulted in the deposition of chemical contaminants affecting both soil and groundwater. Upon taking ownership of the property, the University became responsible for addressing historic contamination from industrial activities that occurred prior to its ownership. Under the oversight of DTSC, the University has undertaken investigation of those contaminated media over several years. With DTSC's approval, the University would conduct environmental actions to ensure there are no unsafe or unwarranted exposures to historic contaminants at the RBC site from former operations at the RFS. Because these actions are required prior to development of certain portions of the RBC site, they are considered part of the proposed project and would be implemented in concert with 2014 LRDP development. The actions would be conducted under a proposed RAW prepared in accordance with the California Health and Safety Code Section 25356.1(h)(1), if approved by DTSC, or pursuant to the existing site investigation and remediation order. The RAW would establish the remedy for certain portions of the project site that are defined as developable and designated for Research, Education, and Support land use in the 2014 LRDP and groundwater at the RFS.

The remedy would include site-wide prescriptive requirements, consisting of land use controls (deed restrictions and a soil management plan), and specific proposed cleanup actions, consisting of soil excavation at an area with mercury contamination from historical production of mercury fulminate, soil excavation at Building 120/Corporation Yard, soil excavation at select locations with PCB contamination, and groundwater remediation near Building 280B. The soil excavation areas are within the southern portion of the site, while the groundwater remediation would occur in the RBC site's north central portion. Continued investigation within the Natural Open Space areas of the RFS site would continue under the DTSC Order.

Should additional areas of contamination be identified in the RFS portion of the Research, Education, and Support area, they would be managed in accordance with the RAW and soil management plan under the oversight of DTSC.

Any groundwater remediation resulting from with trichloroethylene (TCE) contamination originating from the adjacent Campus Bay site, except for groundwater monitoring and dewatering related to construction, would be undertaken by Zeneca and would be under the oversight of the DTSC cleanup order for that site.

3.9.1 Site-Wide Prescriptive Actions under the Proposed Removal Action Workplan

If approved by DTSC, the prescriptive portion of the RAW would consist of deed restrictions and a soil management plan, which restrict use of the property to ensure against human exposure to contaminated soil, groundwater, or soil gas. These requirements apply to all areas within the Research, Education, and Support land use designation. The land use controls under the RAW would include:

- A recorded deed restriction that (1) prohibits soil excavation or movement unless conducted according to the soil management plan; (2) prohibits groundwater use or extraction, except for dewatering purposes (extracted groundwater would be handled in accordance with all applicable laws); and (3) prohibits residential use of the property.
- An soil management plan that describes soil sampling and management to be conducted prior to any excavation activities. The soil management plan is for property management to prohibit uncontrolled land excavation or disturbance activities that may expose workers and visitors to potentially unsafe exposures of environmental contaminants which may be present at the site. The soil management plan would include requirements and guidance for future environmental investigations including minimum standards for investigation, soil screening, and air monitoring. Sample results would be compared to pre-established screening criteria, and the soil would either be removed for off-site disposal or managed on site.

The soil volume estimated requiring off-site disposal at a Class I solid waste facility is between 1,000 and 5,500 cubic yards.

3.9.2 Specific Remedial Actions under the Removal Action Workplan

The following specific remedial actions consist of soil excavation and groundwater remediation:

- Soil at an area with mercury contamination above mercury commercial screening levels and soil at Building 120/Corporation Yard above commercial screening levels would be excavated and disposed of at an appropriately licensed off-site disposal facility. Excavation would be achieved using conventional excavation equipment such as backhoes and front-end loaders. Site preparation activities, such as clearing utilities, and clearing and grubbing, would be conducted. Excavation depths would not exceed the depth of groundwater. Decontamination facilities for equipment and personnel would be located at a centralized decontamination area. Off-site disposal of soil includes transportation and disposal of contaminated soil at an appropriately permitted landfill facility based on waste characterization sampling results. Clean soil and soil with contamination below the risk-based screening values would be placed and compacted in the excavation. The soil volume estimated requiring off-site disposal at a Class I solid waste facility is between 1,200 and 2,000 cubic yards.
- Soil with concentrations above the applicable PCB screening level would be excavated and disposed of at an appropriately licensed off-site disposal facility. Excavation would be achieved using conventional excavation equipment such as backhoes and front-end loaders. Site preparation activities, such as clearing utilities, and clearing and grubbing, would be conducted. Excavation depths are estimated at less than 2 feet below ground surface. Off-site disposal of soil includes transportation and disposal of contaminated soil

at an appropriately permitted landfill facility based on waste characterization sampling results. Clean soil would be placed and compacted in the excavation. The soil volume estimated requiring off-site disposal at a Class I solid waste facility is 500 cubic yards.

- Groundwater treatment at Building 280B would consist of monitoring natural attenuation processes to reduce the mass of carbon tetrachloride concentrations without active intervention. Monitoring would consist of installing monitoring wells in and downgradient of the carbon tetrachloride and incorporating these monitoring wells in the RFS groundwater monitoring program. Should monitoring reveal unexpected increases in carbon tetrachloride concentrations or carbon tetrachloride detections at unexpected locations, active treatment such as in-situ bioremediation will be evaluated.

CHAPTER 4
ENVIRONMENTAL SETTING, IMPACTS, AND MITIGATION MEASURES

This chapter discusses the environmental setting, impacts, and mitigation measures for the 14 fully evaluated environmental resource areas. The resource areas and individual topic areas that were adequately addressed through the Initial Study are discussed in Section 6.5.

This chapter includes an overview of the cumulative impact analysis process. The cumulative impacts are discussed under each resource area throughout this chapter.

This chapter presents analysis of each resource area identified through preliminary environmental analysis and public scoping as likely to be affected by the proposed 2014 LRDP. This introduction summarizes the analytical approach, including key assumptions and data used in the analysis. The cumulative analysis methodology is included in this introduction, and cumulative impacts are discussed under each resource area throughout this chapter.

Scope of the EIR

The following EIR sections evaluate 14 resource areas identified in the CEQA Environmental Checklist (Appendix G) of the *State CEQA Guidelines*, as amended by Senate Bill 97 (Public Resources Code - Section 21083.0). Based on the input received during the EIR scoping process, as described in Chapter 1, Introduction, this EIR addresses the following resource areas or categories of impact in detail:

- Aesthetics and Visual Quality
- Air Quality
- Biological Resources
- Cultural Resources
- Geology and Soils
- Greenhouse Gas Emissions
- Hazards and Hazardous Materials
- Hydrology and Water Quality
- Land Use and Planning
- Noise
- Population and Housing
- Public Services and Recreation
- Transportation and Traffic
- Utilities, Service Systems, and Energy

For each resource area listed above, the EIR describes the existing and future setting, the potential for the resource area to be significantly impacted by the proposed project, and recommended mitigation measures that may avoid, reduce, or compensate for any significant or potentially significant adverse impacts of the proposed project. A prior Initial Study (included in Appendix A) determined that the 2014 LRDP would not impact agricultural, forest, or mineral resources and would not result in certain specific individual impacts (or topics) for the resource areas that are addressed in this chapter. Each of the resource sections that follows clearly identifies those impacts that were adequately addressed in the Initial Study and are therefore not evaluated further in this EIR.

Definition of Baseline and Year of Analysis

State CEQA Guidelines Section 15125 requires that EIRs include a description of project area physical environmental conditions that exist at the time the NOP is circulated. These "baseline" physical conditions are normally used by the lead agency to measure changes that would result

from project implementation. The NOP for this Draft EIR was issued on January 4, 2013. Therefore, environmental conditions as of January 2013 represent the project baseline for CEQA purposes.

This EIR presents comparisons of anticipated 2014 LRDP development with baseline conditions to help the lead agency determine whether project implementation would substantially degrade or impact resources and/or significantly impact the environment.

Level of Significance

Under CEQA, a variety of terms are used to describe the levels of significance of adverse impacts. The definitions of terms used in this EIR are presented below.

- **Significant and Unavoidable Impact.** An impact that exceeds the defined standards of significance and cannot be avoided or reduced to a less than significant level through implementation of feasible mitigation measures.
- **Potentially Significant Impact.** An impact that exceeds or may exceed the defined significance standard and that can be avoided or reduced to a less than significant level through implementation of feasible mitigation measures.
- **Less Than Significant Impact.** Impacts that are adverse but that do not exceed the specified standards of significance.
- **No Impact.** The project would not impact a specified environmental resource.

Format of Resource Topic Sections

Each resource topic considered in this chapter is addressed under five primary subsections: Introduction, Environmental Setting, Regulatory Considerations, Impacts and Mitigation Measures, and References. An overview of the information included in these sections is provided below.

Introduction

The introduction section describes the topic to be analyzed and the contents of the analysis. It also lists relevant issues and concerns identified by agencies and the public during the Draft EIR scoping process.

Environmental Setting

This section describes the existing site and surroundings and those features or conditions that may be affected by the proposed project (e.g., existing land uses, existing soil conditions, existing traffic conditions, etc.).

Regulatory Considerations

This section presents relevant federal, state, and local laws, regulations, plans, and policies. Only those laws, regulations, and policies that are pertinent to the impact analysis are included.

Impacts and Mitigation Measures

Standards of Significance. Each resource topic included in this section identifies standards of significance used to evaluate impacts derived from Appendix G of the *State CEQA Guidelines* and the UC CEQA Handbook.

CEQA Checklist Items Adequately Addressed in the Initial Study. This subsection identifies and discusses the individual checklist items (also referred to as standards of significance) that are not evaluated in detail in this EIR.

Analytical Methods. This section summarizes the methodology used to estimate and evaluate the impacts. Impacts are evaluated quantitatively where possible and qualitatively where quantification is not feasible.

RBC 2014 LRDP Policies. This section presents the 2014 LRDP policies that are relevant to the resource. Because these policies would be binding on all future RBC projects, they are considered a part of the proposed project; impact significance is evaluated after considering the mitigating effect of the policies.

LRDP Impacts and Mitigation Measures. This section presents the environmental effects from the construction and operation of the 2014 LRDP using the standards of significance. All impacts are numbered (for instance, LRDP Impact AES-1 refers to the first impact under Aesthetics and Visual Quality) and shown in bold type. For each impact, a summary impact statement is presented along with a conclusion with respect to the impact's significance before and after mitigation. Mitigation measures are numbered to correspond to the impact. Impacts and mitigation measures are numbered consecutively within each resource topic. This section also identifies and describes environmental protection practices, essentially measures that could be implemented to further reduce the magnitude of impacts that already fall below the standard of significance. Unlike mitigation measures, these practices are not required to be implemented as part of the project. Projects will, however, be asked to consider and incorporate these measures, and implementation will be monitored in the ongoing mitigation monitoring and reporting program.

Cumulative Impacts and Mitigation Measures. Cumulative impacts that may result from the project are discussed at the end of each resource section. The approach used to evaluate cumulative impacts is summarized in Cumulative Impact Analysis section below.

References

This section lists the references used to prepare the environmental setting and impact analysis for each resource section.

Cumulative Impact Analysis

CEQA Guidelines Section 15355 defines cumulative impacts as two or more individual effects which, when considered together, are substantial or which compound or increase other environmental impacts. A cumulative analysis describes the "incremental impact of the project when added to other, closely related past, present, or reasonably foreseeable probable future projects" which can result from "individually minor but collectively significant projects taking place over a period of time."

Cumulative impacts that may result from or be compounded by the project are discussed in the appropriate Chapter 4 sections. Each Chapter 4 section describes the cumulative setting for the individual resource area along with cumulative growth under specific projects and long-term development plans.

To project a cumulative framework to the LRDP planning year of 2050, the EIR cumulative impact analysis relies on long-range planning and policy documents that forecast population, employment, and land use patterns. This includes all relevant general plans, specific plans, and other long-range planning documents for which a jurisdiction has adopted growth, development, and land use policies. In this case, such documents include the City of Richmond General Plan 2030 and the South Shoreline Specific Plan (under development). This approach is consistent with CEQA Guidelines Sec. 15130(b), which recommends analysis of a "summary of projections

from adopted local, regional, statewide plan, or related planning documents, that describes or evaluates conditions contributing to a cumulative effect."

The Richmond General Plan 2030 includes policies, land use goals, and population, employment, and housing forecasts through 2030. Since full LRDP development is expected to occur through 2050, the cumulative analysis may consider other regional or statewide planning and land use documents that include forecasts through the 2050 timeframe. The South Shoreline Specific Plan tiers off the General Plan 2030 and proposes land use categories and densities to enhance the economic, residential, and recreational vitality of this area. The General Plan is discussed in detail below.

Although local plans project well into the future, they do not correspond to the development time frame of the 2014 LRDP. In many instances, such plans also lack sufficient detail to enable thorough aggregation of area-wide growth and impacts with LRDP growth and impacts. The risk that these plans may become outdated, may no longer be accurate due to changed circumstances, or may be based on a shorter planning horizon must be factored when considering this analysis.

Pursuant to CEQA requirements, the cumulative impacts analysis should also consider relevant past, present, and probable future projects for the 2014 LRDP programmatic project components. The South Shoreline Specific Plan is expected to tier off the General Plan 2030 and propose land use categories and densities to enhance the economic, residential, and recreational vitality of this area.

For the 2014 LRDP, the cumulative setting includes foreseeable development plans and policies in the Richmond Southern Shoreline Planning Area and other areas where plan or specific projects may contribute to the cumulative setting, given the timeframe applicable to development under the LRDP. The cumulative development assumptions include several projects in the vicinity of the RBC site that either are under construction or are approved and awaiting construction. In addition, the cumulative development assumptions include projects anticipated under applicable zoning and development ordinances and provisions and under the land use goals and policies of the previous and current general plans.

Cumulative Plans and Projects

The following is a list of past, present, or reasonably foreseeable plans and projects that comprise components of the cumulative setting that are considered for analysis of the impacts associated with the 2014 LRDP.

Information for Alameda is provided below in support of the impacts analysis of project alternatives presented in Chapter 6.

Richmond

Richmond General Plan 2030. This general plan was adopted by the City of Richmond in 2012. The RBS site is within the Southern Shoreline Planning Area, one of five designated planning areas under the General Plan.

The General Plan 2030 has an approximately 20-year planning horizon. However, the Plan does not anticipate when the development identified in the Plan would occur. In addition, the Plan's designation of a site or area for a certain use does not necessarily mean the site will be built or redeveloped within the next 20 years. Therefore, to determine a more realistic projection for

future development in the City, the Plan's population and job growth estimates use a "regional share" approach assuming that Richmond will capture a particular share of Contra Costa County's projected regional population and employment growth.

According to the General Plan, Richmond's share of regional population growth was 8.39 percent between 1980 and 2005. The Association of Bay Area Governments (ABAG) projects Richmond will capture 10.91 percent of regional population growth through 2030. However, because the goals and policies of the General Plan are geared to stimulate higher intensity development within the City, the General Plan assumes that Richmond will capture 13 percent of the regional population growth through 2030. The number of jobs that would be generated was calculated based on ABAG projected ratio of jobs to population for Richmond in 2030 (0.48 jobs per person). Based upon this methodology, the City estimated that there would be an increase in population of 30,147 and an additional 22,488 jobs under the General Plan. The City also estimated that approximately 15,548 housing units would be added under the General Plan.

The General Plan 2030 designates the RBC site as "Change Area 16: Southern Gateway." The Southern Gateway area is south of Interstate 580 (I-580) and east of Regatta Boulevard. The Southern Gateway area is envisioned as a revitalized area that would include a mixture of high-intensity light industrial and commercial uses anchored by a large-scale research and development campus at the RBC site. The General Plan envisions a vibrant mix of new and existing uses that would harmonize with ecologically-sensitive areas, maximizing Bay views and providing efficient connections to regional transportation routes, including I-80 and I-580, as well as the multimodal San Francisco Bay Trail. The area has been designated Business/Light Industrial consistent with this vision.

South Shoreline Specific Plan. The RBC site is within the Southern Shoreline Planning Area of the City of Richmond General Plan 2030. The South Shoreline Specific Plan is currently under preparation. The Plan area comprises the southeastern portion of the City of Richmond that is west and south of I-580. It includes areas designated for light industrial, commercial, and residential uses, and it includes the entire RBC site and adjacent sites. This plan tiers off the recently adopted City of Richmond General Plan 2030; therefore, it is anticipated that the Specific Plan will include policies promoting higher residential densities as well as policies promoting the continuation of industrial, research, and development uses. Given the location and size of the RBC site within the Specific Plan area, the planning efforts for the 2014 LRDP would be complemented by those for the Specific Plan, which anticipates development of the RBC though 2050.

Bio-Rad Laboratories Office/R&D Lab Upgrade Project. The project would construct one 16,888 square foot building to enclose office, research and development laboratory uses. The project site is located at 3110 Regatta Boulevard, adjacent to the RBC site, and is 3.95 acres in size. The proposed building would replace six existing dilapidated metal structures and accessory buildings with on structure. The new structure would be used for the same activities and sited within the same location on the property.

Marina Bay Ferry Terminal. The Water Emergency Transportation Authority is considering the construction of a ferry terminal on Richmond's south shoreline in the vicinity of Marina Way and Sheridan Point, west of the Ford Assembly Building. The project is currently undergoing environmental review with the City of Richmond.

Marina Bay/Trails Landscaping. The Richmond Public Works Department, in coordination with the Marina Bay Neighborhood Council, Parks and Recreation, and the Harbor Master, is

constructing pathway and public trail improvements that include landscaping, lighting, sidewalks, and parks. These improvements are being implemented in accordance with City's Landscape Management Master Plan.

Officer Bradley A. Moody Memorial Underpass. The Officer Bradley A. Moody Memorial Underpass project would construct a roadway undercrossing in place of the existing grade crossing on Marina Bay Parkway between Regatta Boulevard and Meeker Avenue. With increased rail activity in recent years and forecasts for growth in the future, long trains are more frequently traversing Richmond grade crossings. In the South Richmond Shoreline area, low maximum train speeds result in traffic blockages for 20-30 minutes at a time with no alternate access, as all north-south ingress and egress to this area is impacted at closely-spaced grade crossings.

The underpass at Marina Bay Parkway will reduce traffic congestion and allow emergency vehicles to access the Marina Bay Area unimpeded. Additionally, the project would improve access to proposed Water Emergency Transportation Authority ferries and improve air quality by reducing emissions of idling vehicles.

Ford Building Rehabilitation Project. The Ford Building Rehabilitation Project is redeveloping the former Ford Assembly Plant at the foot of Harbor Way into a mixed-use facility along the Richmond southern shoreline. The proposed mixture of uses would include offices, retail centers, industrial / research and development sites, restaurants, residential areas, the Rosie the Riveter Visitor Center, and the Craneway Pavilion event center. The building size is approximately 460,000 square feet.

Terminal One Development Project. The Terminal One Development Project would redevelop approximately 13.8 acres of shoreline property immediately east of Ferry Point and Miller/Knox Regional Shoreline Park and west of the Richmond Yacht Club and Brickyard Cove. Current development plans include constructing approximately 285 luxury condominiums on approximately 11 acres of the site. In addition, the project would develop an approximately 1.5-acre park and an open space area along the shore adjacent to and including the terminal pier. A new segment of the Bay Trail would be developed as part of this project.

Alameda

City of Alameda General Plan 2010. The general plan establishes the City of Alameda's development policies for the period 1990-2010. Its purpose is to guide residents, businesses, policymakers and elected officials in making choices about public and private activities that shape the City's physical environment. The general plan's policies reinforce five themes:

- Maintain the City's island setting, by making the shoreline more visible and accessible.
- Maintain the City's small town feeling by not constructing tall buildings, freeways, highway commercial strips, or vast tracts of look-alike housing.
- Respect the City's history by emphasizing restoration and preservation as essential to Alameda's economic and cultural environment.
- De-emphasize the automobile by supporting transit improvements, ferry service, reduction of peak-hour use of single-occupant vehicles, and creating enjoyable pedestrian environment.

- Support multi-use development on the Northern Waterfront by priority space for boating activities, retention of seaports and related industries, and extension of an existing residential neighborhood to a new 10-acre park.

The City has updated its general plan in recent years including the Housing Element in 2012 and the Transportation Element in 2011. Alameda Point is an individual element in the general plan.

Alameda Point Element. The cumulative setting for Alameda Point is generally the entire Alameda Point site (formerly NAS Alameda) and areas in the City of Alameda within half a mile of the site. The site has a land use designation of "Mixed Use." Goals and policies in the Alameda Point element are similar to those of the general plan. Additional themes include:

- Transportation—increase accessibility to local and regional transit systems, integrate pedestrian and bicycle usage, and preserve view corridors.
- Open Space, Conservation and Cultural Resources—provide open space and recreational opportunities to serve new residents and employees, and preserve Alameda Point's Historic District, buildings, development patterns, and open spaces.
- Health and Safety (including flood control, fire hazards, environmental cleanup, emergency management)—support improvement programs that address water quality, urban runoff, and flooding; mitigate factors that are conducive to fire hazards and identify effective means of dealing with fire hazards; continue support of cleanup of contaminated lands; and support integration of Alameda Point into the City of Alameda's Emergency Operations Plan.

Most of the former NAS Alameda runway area is now a National Wildlife Refuge. Approximately 50 acres of this area, located in the southwest corner of the current National Wildlife Refuge, are within the City and County of San Francisco. One of the guiding policies of the Alameda Point Element is to help maintain a National Wildlife Refuge that balances natural conservation with public access, education, and ship navigation.

Northern Waterfront General Plan Amendment. The Northern Waterfront General Plan Amendment was adopted in March 2007 to address the redevelopment of the area. It requires that development in the Northern Waterfront is sensitive to the character of Alameda and the unique waterfront setting. Guiding policies for housing are to provide a mix of housing types, densities, and affordability levels throughout the plan area, to support the development of "for-rent" and "for-sale" affordable housing units throughout the plan area, and to encourage and support the development of senior housing in the Northern Waterfront.

The plan also discusses specific policies for commercial development, such as to prohibit drive-through facilities, to encourage maritime and waterfront related job and business opportunities, and to encourage retail uses that offer recreational products and services. Traffic circulation is also an important theme in the plan, which aims to facilitate movement of vehicles, bicycles, and pedestrians.

Encinal Del Monte Master Plan. This master plan is intended to guide the repurposing and redevelopment of the Encinal Terminals, Del Monte Warehouse, and Chipman/Marina Cove II (Chipman) sites consistent with the General Plan Northern Waterfront goals and policies adopted in 2007. In 2009, the Alameda City Council rezoned the Encinal Terminals and Del Monte Warehouse sites for mixed-use development consistent with the General Plan policies for the area. The mixed-use zoning requires preparation of a master plan that will serve as the zoning code for the area and guide the redevelopment of the property consistent with the policies and

goals of the General Plan. This master plan also includes updated standards and requirements for the development of the Chipman site, which was previously planned and rezoned for residential use in 2000 as part of the adjacent Marina Cove neighborhood.

Marina Cove II Subdivision. The City of Alameda proposes to construct a residential subdivision of single family homes and below-market-rate duplexes on an approximately 7-acre waterfront site. The project site is located between the waterfront and Buena Vista Avenue, east of Entrance Road. Four new residential streets would extend across the project site. Each home would have an attached two-car garage and driveways would provide an additional 198 off-street parking spaces. As part of the project, an additional 0.15-acre lot would be developed along the west side of the site as public open space.

Webster Street Vision Plan. The vision plan for Webster Street was proposed by the City of Alameda in 2010. The plan seeks to improve the Webster Street area as a recognized, regional arterial as identified in the general plan. The plan proposes to divide Webster Street – which is currently a single commercial district – into four distinct districts. The four districts are Gateway (Tubes to Atlantic Avenue), Avenue (Atlantic to Lincoln Avenue), Main Street (Lincoln to Central Avenue), and Anchor (Central Avenue to Crab Cove). The plan includes specific recommendations for street improvements, such as curb extensions, pedestrian scale street lights, banners, street trees, and street furniture.

4.1 AESTHETICS AND VISUAL QUALITY

4.1.1 Introduction

This section discusses existing visual resources and analyzes the potential for development under the proposed 2014 LRDP to affect those resources. The physical characteristics of the project site and surrounding areas are discussed briefly. For a more detailed description of land uses, refer to Section 4.9, Land Use and Planning.

Public and agency NOP comments related to aesthetics and visual quality are summarized below:

- The EIR should analyze the effects of additional human activity on the shoreline's aesthetics;
- The EIR should analyze the aesthetic effects of new buildings on this lightly developed shoreline area.

4.1.2 Environmental Setting

The approximately 134-acre RBC site is at 1301 South 46th Street in the City of Richmond South Shoreline area, approximately 5 miles northwest of the UC Berkeley campus and the LBNL site in Berkeley. The City of Richmond is on land that projects into San Pablo Bay, San Pablo Strait, and San Francisco Bay. The San Pablo Potrero Hills rise to 400 feet above sea level along the Richmond shoreline in a northwest direction, abruptly ending just southwest of the Richmond Inner Harbor at Brooks Island. In contrast to the dramatic San Pablo Potrero Hills, most of the Richmond shoreline (including the proposed project site) is in the coastal lowlands.

The project site is bounded on the west by a PG&E service station, Bio-Rad Laboratories, and Meeker Slough; on the north/northwest by Regatta Boulevard; on the northeast by Meade Street; on the east by South 46th Street; and on the south by the San Francisco Bay Trail. I-580 runs parallel to Meade Street along the northeastern site boundary. The RBC site generally consists of upland areas developed with buildings used for academic, research, and privately leased activities; a north-south oriented grove of mature eucalyptus trees in the central portion of the site; coastal grassland areas; a tidal salt marsh (known as the Western Stege Marsh); and a transition zone between the upland areas and marsh. Grasslands occur in a number of meadows and comprise about 14 acres of the RBC site. The Bay Trail is south of the site.

The site is currently developed with 1,050,000 gsf of facilities, including more than 500,000 square feet of research space, the NRLF, and the EPA. The existing upland parcels are currently developed with approximately 80 one- and two-story buildings, roadways, parking lots, and landscaped areas. The majority of the existing buildings are 45 years old or older. The uplands area also contains previously disturbed, currently undeveloped open space. Land uses surrounding the RBC site include industrial and office uses, a major interstate freeway, and low-to-medium-density residential neighborhoods. Regatta Boulevard, along the northern boundary, is adjacent to a railroad spur and a business complex developed with one- to two-story buildings. Bio-Rad Laboratories, a private research equipment manufacturing company, is immediately west of the RBC site. The adjacent property to the east is the location of former chemical production operations previously owned by several entities, including Stauffer and Zeneca, and is currently owned by Cherokee Simeon Venture I, LLC. The Marina Bay residential neighborhood, across Meeker Slough and southwest of the RBC site, consists of a mix of multi- and single-family residences. Low- and medium-density residential uses are also located across I-580, north of the Meade Street boundary.

4.1.3 Regulatory Considerations

Federal

There are no specific federal regulations pertaining to land use consistency or compatibility that would apply to the evaluation of visual resources.

State

California Scenic Highway Program: Section IV of the California Department of Transportation (Caltrans) Guidelines for the Official Designation of Scenic Highways defines a Scenic Corridor as the area of land generally adjacent to and visible from the highway. No California Scenic Highways exist in the project viewshed, so no state regulations pertaining to scenic resources are applicable.

Local

The RBC site is University-owned property where work within the University's mission is performed on land owned or controlled by The Regents. As a state entity, the University is exempt under the state constitution from compliance with local land use regulations, including general plans and zoning. The University seeks to cooperate with local jurisdictions to, the extent feasible, to reduce any physical consequences of potential land use conflicts. The following sections summarize provisions in the Richmond Municipal Code and policies from the City of Richmond General Plan as they relate to visual resources (City of Richmond 2011).

City of Richmond Municipal Code

The Richmond Municipal Code development standards guide City development practices and protect valued scenic corridors and views. The municipal code guidelines aim to create standards encouraging development of new and innovative structures while maintaining established natural and man-made views important to the City of Richmond. Article 15 of the City of Richmond Municipal Code establishes the zoning land use, design guidelines, and development protocols.

City of Richmond General Plan

The City of Richmond General Plan 2030 Land Use and Urban Design Element contains the following policies related to visual quality (City of Richmond 2011):

LU5.3 Land Use Compatibility: Require sufficient visual open space or landscaped screening between industrial operations and adjacent to residential or recreational activities to create adequate buffers.

LU5.B Design Guidelines: Develop design guidelines and standards for all land uses and development prototypes. The guidelines would build on zoning codes to promote high-quality design. Guidelines should also address compatibility between new and existing historic structures and districts, residential and adjacent non-residential uses and urban and natural areas.

LU5.C Industrial Use Buffers: New industrial uses established adjacent to existing residential or commercial uses shall incorporate measures to minimize impacts to residential uses such as enclosure of industrial activities in buildings, use of screening for visually unattractive uses, site design, soundproofing and landscaping.

The 2030 General Plan EIR determined that the effects on aesthetics and visual resources from future development pursuant to the General Plan would be significant and unavoidable. Although development could improve aesthetic quality at a local level, views and scenic vistas could be substantially impacted. No mitigation is available for this impact. New sources of light and glare would be introduced. Mitigation measures would be implemented to reduce light and glare

impacts, but the impacts would remain significant and unavoidable. Cumulative impacts would also be significant and unavoidable.

4.1.4 Impacts and Mitigation Measures

Standards of Significance

The impacts on aesthetics and visual resources from the implementation of the 2014 LRDP would be considered significant if they would exceed the following Standards of Significance, in accordance with Appendix G of the *State CEQA Guidelines* and the UC CEQA Handbook:

- Substantially degrade the existing visual character or quality of the site and its surroundings;
- Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway;
- Have a substantial adverse effect on a scenic vista; or
- Create a new source of substantial light or glare that would adversely affect day or nighttime views in the area.

CEQA Checklist Items Adequately Addressed in the Initial Study

The NOP Initial Study analysis concluded that further analysis of the following issues was not required in the EIR:

- Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway.

The Initial Study determined that the RBC site does not contain scenic resources and is not on or near a state scenic highway. Regional access to the site is by I-80 and I-580. Portions of I-580 are designated as scenic—from its junction with State Route 24 to the San Leandro city limit, and a portion in eastern Alameda County away from the project area. Therefore, no impact would occur to scenic resources within a state scenic highway. The remaining checklist items are analyzed below.

Analytical Methods

Applicable planning documents (including City of Richmond documents) were reviewed to identify the types of land uses intended for the area, along with the guidelines for visual resources protection or preservation. Consideration was given to the existing visual setting in the project viewshed (defined as the geographical area in which the project can be seen). The project's potential visual changes were assessed to determine impact significance, following the CEQA Guidelines checklist questions listed above. Potential project impacts were evaluated using a public viewpoint analysis, among other tools and information sources. Viewpoints representing the most sensitive locations from which the project would be seen were analyzed and simulated. Visual simulations of the proposed development are on Figures 4-1 to 4-7. Once all potential impacts were examined, impact significance was determined based on CEQA standards, and appropriate mitigation measures were identified. Under CEQA, any required mitigation must be feasible and specific to an identified impact. Because perception of aesthetic impacts is inherently subjective to individual observers, a conservative interpretation of the analysis is used in this EIR.

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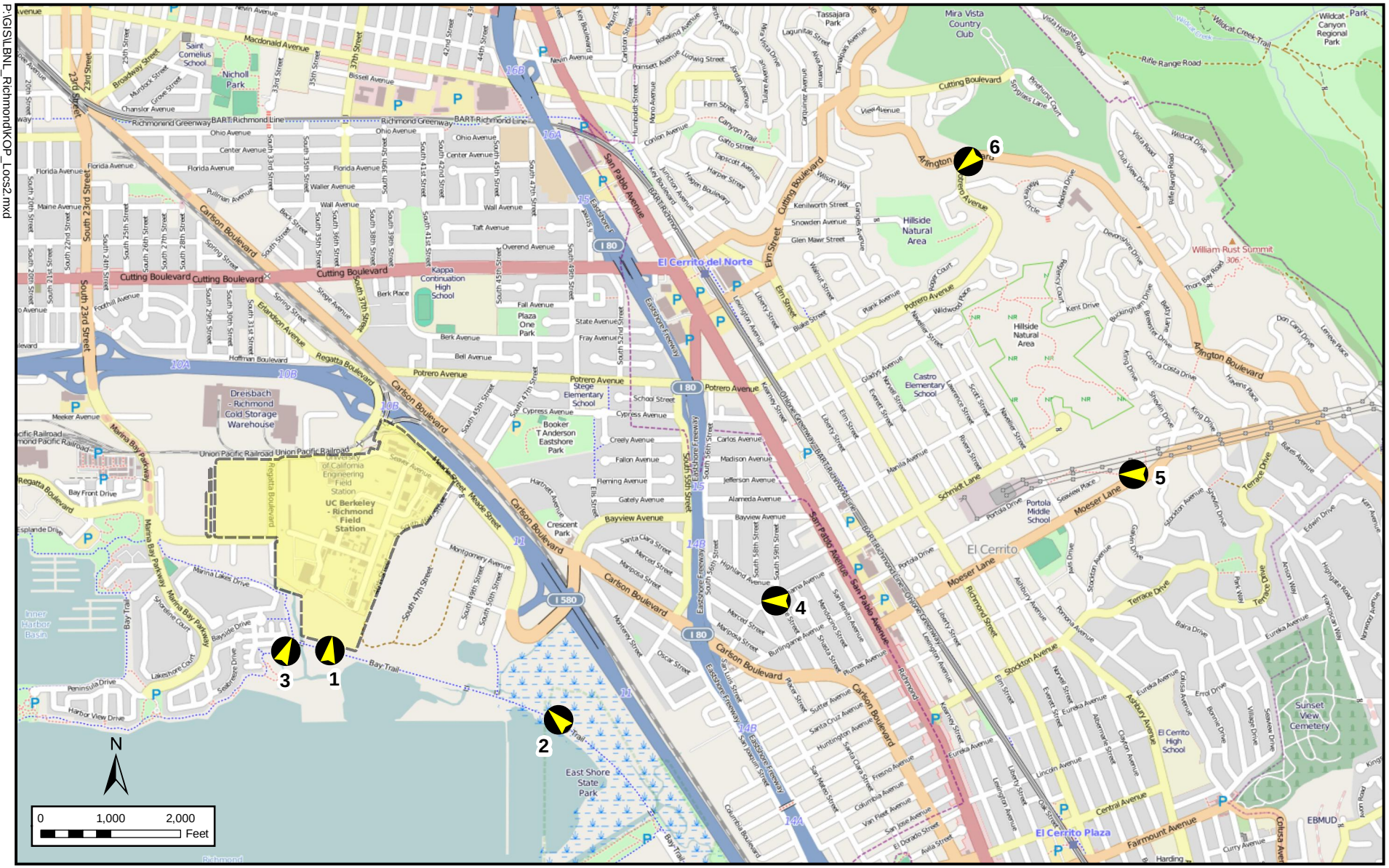

Key Observation Point Locations

Richmond, California

Figure 4-1

TETRA TECH

Source: ArcGIS Online, OpenStreetMap and contributors.

RBC Site, 2013 existing conditions. Northward view from key observation point 1.
(Photograph taken 2/9/2013).

RBC Site, 2050 Illustrative Development Scenario conditions.
Northward view from key observation point 1.
(Conceptual simulation does not depict building articulation or details).

Key Observation Point 1 Visual Simulation

TETRA TECH

Richmond, California

Figure 4-2

RBC Site, 2013 existing conditions. Northwestward view from key observation point 2.
(Photograph taken 2/9/2013).

RBC Site, 2050 Illustrative Development Scenario conditions.
Northwestward view from key observation point 2.
(Conceptual simulation does not depict building articulation or details).

Key Observation Point 2 Visual Simulation

TETRA TECH

Richmond, California

Figure 4-3

RBC Site, 2013 existing conditions. Northeastern view from key observation point 3.
(Photograph taken 2/9/2013).

RBC Site, 2050 Illustrative Development Scenario conditions.
Northeastern view from key observation point 3.
(Conceptual simulation does not depict building articulation or details).

Key Observation Point 3 Visual Simulation

TETRA TECH

Richmond, California

Figure 4-4

RBC Site, 2013 existing conditions. Westward view from key observation point 4.
(Photograph taken 2/9/2013).

RBC Site, 2050 Illustrative Development Scenario conditions.
Westward view from key observation point 4.
(Conceptual simulation does not depict building articulation or details).

Key Observation Point 4 Visual Simulation

TETRA TECH

Richmond, California

Figure 4-5

RBC Site, 2013 existing conditions. Westward view from key observation point 5.
(Photograph taken 2/9/2013).

RBC Site, 2050 Illustrative Development Scenario conditions.
Westward view from key observation point 5.
(Conceptual simulation does not depict building articulation or details).

Key Observation Point 5 Visual Simulation

TETRA TECH

Richmond, California

Figure 4-6

RBC Site, 2013 existing conditions. Southwestward view from key observation point 6.
(Photograph taken 2/9/2013).

RBC Site, 2050 Illustrative Development Scenario conditions.
Southwestward view from key observation point 6.
(Conceptual simulation does not depict building articulation or details).

Key Observation Point 6 Visual Simulation

TETRA TECH

Richmond, California

Figure 4-7

RBC 2014 LRDP Policies

The RBC 2014 LRDP policies related to aesthetics and visual quality resources include the following:

- LU5 – Land Use Policy on Community: The Richmond Bay Campus will be an asset to residents of local East Bay communities.
  - Provide programs and facilities on site that can be used for education and outreach to the local community including an arts program that helps to establish the campus as a visitor destination.
  - Support integration of the campus into the Richmond South Shoreline Area; remove peripheral fencing as adequate population is achieved; and consider adjacent uses in decisions on building siting and design.
  - Allow convenient multi-mode access to the campus and promote public transit, bicycle, and pedestrian transportation modes.
  - Identify Lark Drive and Regatta Boulevard as urban streets where the public realm will be designed to support a pedestrian environment with retail and other amenities to integrate with the neighboring community fabric.
- LU4 – Land Use Policy on Growth: Ensure that the campus grows in a logical and cost-effective manner.
  - Retain existing uses on campus for as long as possible and evaluate opportunities to retain or relocate uses on -site for the long term.
  - Concentrate development to preserve future capacity while maintaining natural areas.
  - Create complete collections of buildings and open spaces as development progresses.
  - Phase growth to create the critical mass of activities and population needed to support amenities.
  - Plan and develop infrastructure to allow logical and cost effective extensions to support future development.
  - Implement LRDP provisions for development undertaken by the private sector for synergistic uses by public or private entities.
- S3 – Sustainability Policy on Site Development: Embody environmental stewardship and respect the unique character of the Richmond Bay Campus in site development.
  - Draw on the neighborhood context and prominently feature the natural assets including climate, wetlands, and proximity to the San Francisco Bay and the Bay Trail.
  - Actively promote sustainability as a core value at the campus and provide practical opportunities for innovation and education in sustainable design.
  - Manage soil contamination as a component of each construction project.

LRDP Impacts and Mitigation Measures

LRDP Impact AES-1: Development under the 2014 LRDP could substantially degrade the existing visual character and quality of the RBC site and its surroundings. (*Potentially Significant; Less than Significant with Mitigation*)

The RBC site has retained its historical industrial character. With the proposed project, existing development would be gradually replaced by a mixture of buildings and facilities with greater massing and density. RBC 2014 LRDP implementation would result in visual and aesthetic changes that could alter the site's character as visible from certain public vantage points. Such viewpoints include those from Regatta Boulevard, South 46th Street, and San Francisco Bay Trail. Changes would be associated with (1) demolition of specific existing buildings, (2) development of new buildings, (3) proposed landscaping and other on-site improvements, and (4) the pattern of clustered development. Implementation of any major new campus development would likely result in the construction of buildings and increased traffic in the area.

Any major new campus projects would be reviewed at each stage of design by the UC Berkeley Design Review Committee. The project provisions would be guided by the RBC 2014 LRDP, the Physical Design Framework for the RBC, and neighborhood concept plans or project specific design guidelines prepared for each such project. They would also be subject to design review and approval by The UC Regents or their designee.

Each neighborhood would have a central space around which concentrations of active uses—dining, meeting rooms, recreation or building lobbies—would be focused. According to the RBC 2014 LRDP, these central spaces might also have an iconic element such as a vertical marker of substantial height, sculpture, fountain, or other landscape element to act as a place-making and orienting device. These spaces would be designed to create a more collegial environment that encourages and facilitates interaction among employees and guests. The specific configuration and design of new development within these neighborhoods would be guided by the Physical Design Framework and concept plans cooperatively developed by LBNL and UC Berkeley.

Approximately 25 acres would be designated Natural Open Space to preserve those areas the University plans to protect from development and maintain in their natural condition. Since new buildings would not be permitted to intrude into such preservation areas, and since new development would have a research character somewhat similar to that in surrounding land uses, the visual changes might not appear significant to some observers. However, such changes might be perceived by other observers as intrusive and substantially altering of the site's scenic background elements.

The site's visual character would continue to appear as buildings among grassland, trees and shrubs, and implementation of the LRDP Principles and Policies would be expected to reduce potential effects on visual character. Some new buildings allowable under the LRDP could be more visually intrusive than others, particularly from certain viewpoints. Many current buildings would be replaced by taller, larger, and/or more massive new buildings. Building heights across the RBC are expected to vary, with lower buildings at the Bay-facing edge and taller buildings behind them. Four- and five-story buildings are expected to be common, with heights of 100 feet for a five-story building. Also, for example, potential development would introduce substantial building massing in the mid-ground, behind the Western Stege Marsh and lowland areas, as viewed from the San Francisco Bay Trail. In addition, Regatta Boulevard and South 46th Street views would include new, larger mid-ground buildings even as the overall visual site character may appear relatively unchanged. As a result, it is anticipated that some observers might perceive

a substantial adverse change in the on-site visual character from construction of the campus or from construction of individual buildings. Because perception of aesthetic impacts is inherently subjective to individual observers, a conservative interpretation of the analysis is used in this EIR: the RBC 2014 LRDP development could alter the site's visual quality and character in a potentially significant manner.

Construction and demolition activities would also create temporary visual changes related to the presence of construction equipment, materials, and workforce, as well as debris and dust.

However, as noted, the site's visual character is of a historically industrial and currently research-institutional nature. Under LRDP development, older industrial and institutional buildings would be replaced by modern buildings of a somewhat similar nature, but the site's overall scale and density would increase over decades of RBC development. It is these latter elements that could potentially be aesthetically objectionable to some off-site viewers. Nevertheless, this project would not be constructed in a single phase or time period, but gradually over several decades. Therefore, the scale of change would not be so sudden as depicted in the "before" and "after" visual simulations in this chapter but would rather occur piecemeal, a single building or a few buildings at a time, over a very long (from a viewer's point of view) period. Even a viewer who spent decades in the site vicinity would be unlikely to experience campus development as a dramatic change, but rather as a series of small changes as older buildings were removed and new buildings were constructed. In addition, LRDP Mitigation Measure AES-1 would ensure that the existing visual character and quality of the RBC site would not be substantially degraded by a project under the LRDP or by development under the LRDP at full implementation. With implementation of LRDP Principles and Policies as well as mitigation measure LRDP MM AES-1, operational and construction-related impacts on visual character and quality would be less than significant.

LRDP MM AES-1: The University shall develop and implement a Physical Design Framework that protects the visual quality of both the on- and off-campus environments through provisions that address building scale, materials, and color schemes. The Physical Design Framework shall include best management practices and procedures for avoiding or minimizing aesthetic nuisances in demolition, construction, and operational phases of the project. Design review processes for planning of new buildings and development shall be clearly articulated and followed throughout the life of the project.

Increased RBC scale and density would be addressed in a number of ways through the Physical Design Framework and subsequent plans: buildings would be restricted in height and height zones would further restrict heights in certain locations. Building facades would be broken up by architectural and design features so as to minimize the appearance of mass and bulk. Reflective material would be restricted, which, would minimize the appearance of the new buildings particularly at greater distances. Trees and other landscaping features would be used to further break up, obscure, or minimize RBC development. Aesthetically objectionable appurtenances such as stacks, machinery, tanks, and HVAC systems on top of buildings would be sheltered from view wherever practical. Demolition debris and long-term construction supplies and equipment would be stored such that – to the extent practicable – they would not be visually intrusive from off-site viewpoints.

LRDP Impact AES-2: Development under the 2014 LRDP would not adversely affect any scenic vistas at the RBC site and its vicinity. (*Less than Significant*)

Views of the RBC site from public viewing points to the north are limited due to the presence of on- and off-site trees and the visual buffer of I-580. The most readily available public viewpoints are from the San Francisco Bay Trail and South 46th Street. Under the 2014 LRDP project, views from the San Francisco Bay Trail observation points would change, but not substantially. Foreground views would continue to comprise the marsh and lowland areas transitioning gently to the developed upland portion of the RBC site. In mid-ground views, anticipated project buildings would be visible; some of these new buildings would be built adjacent to existing structures, while others would replace existing structures. Due to the setback between the Bay Trail and the proposed site, views available to trail users are not expected to change significantly.

The RBC site has natural areas on and near it, such as the San Francisco Bay, Western Stege Marsh, and coastal grasslands. Because the area topography is relatively flat, panoramic views from the RBC site of San Francisco Bay, the Bay Bridge, and the San Pablo Potrero Hills are available in the background, while views of marsh and coastal grasslands are available in the foreground and mid-ground. With implementation of the RBC LRDP, on-site views will remain available from open spaces and plazas, as well as from buildings. Scenic vistas from viewpoints in the hills surrounding the RBC site would remain after campus development. Buildings may be tall enough to be visible, but are expected to alter a very small portion of scenic vistas of the Bay and other natural areas as viewed from these areas. Views would not be obstructed by campus development. Implementation of the RBC LRDP would have a less than significant impact on the view of scenic vistas, and no mitigation would be required.

Mitigation Measure: No mitigation measure is required.

LRDP Impact AES-3: Development under the 2014 LRDP would create new sources of light and glare that would not adversely affect regional day or nighttime views. (*Less than Significant*)

With the inclusion of new buildings and facilities, RBC development could create new sources of light and glare visible from off-site viewpoints. The proposed campus buildings would require on-site nighttime lighting for safety and security. Such new light sources would include exterior building illumination; lighted facilities; parking lots or structures; vehicle headlights; and glare from reflective building, pavement, and vehicle surfaces. Because project lighting would be designed to limit off-site light spill and because the project site is relatively far from residential areas, there is expected to be no appreciable effect on ambient light and glare conditions in sensitive surrounding areas. To the extent that light and glare associated with the project would be visible from off-site, they would be seen in the context of the extensive nighttime lighting that already characterizes the area. Project structures constructed pursuant to the 2014 LRDP would not include large areas of highly reflective material that would produce glare, so the proposed LRDP would not affect the amount of daytime glare in the area. The project site would be in an area planned for research and development with existing similar uses in the vicinity. For these reasons, projects under the RBC 2014 LRDP do not have the potential to create new sources of substantial light or glare that could have adverse impacts on day- or nighttime views.

In the event that nighttime construction activities take place, illumination that meets state and federal worker safety regulations would be required. The majority of nighttime construction work, if any, is anticipated for building interior work following the completion of exterior walls.

Task-specific lighting would be used to the extent practical while complying with worker safety regulations.

LRDP ENVIRONMENTAL PROTECTION PRACTICES AES-3a, AES-3b, and AES-3c are not required but could be implemented to further reduce the magnitude of these less than significant effects.

LRDP ENVIRONMENTAL PROTECTION PRACTICE AES-3a:

Lighting for new development projects could be designed to include shields and cut-offs that minimize light spill onto unintended surfaces and minimize atmospheric light pollution.

LRDP ENVIRONMENTAL PROTECTION PRACTICE AES-3b:

To reduce off-site lighting impacts, lighting at the campus could be restricted to areas where it would be required for safety, security, and operation. Exterior lights could be hooded, and lights could be directed on-site so significant light or glare would be minimized. For areas where lighting is not required for normal operation, safety, or security, switched lighting circuits could be provided, allowing these areas to remain dark at most times, minimizing the amount of lighting potentially visible off-site. In parking lots, lights could be equipped with motion sensors that reduce the lights to half of their brightness when no motion is detected.

LRDP ENVIRONMENTAL PROTECTION PRACTICE AES-3c:

As part of the design review procedures, light and glare could be given specific consideration, and measures could be incorporated into the project design to minimize both. In general, exterior surfaces would not be reflective; architectural screens and shading devices are preferable to reflective glass.

Cumulative Impacts and Mitigation Measures

LRDP Cumulative Impact AES-1: Development under the 2014 LRDP together with regional cumulative development would not result in cumulatively considerable impacts on the area's visual quality and scenic viewshed. (*Less than Significant*)

The RBC site area is designated as a "Change Area" in the City of Richmond General Plan 2030 (City of Richmond 2011). The area is identified as "CA-3 – Ford Peninsula in Marina Bay" in the General Plan. Currently, large industrial and office buildings characterize the Ford Peninsula area. The eastern section of the Ford Peninsula area, about 2 miles from the project site, is envisioned as a mixed-use waterfront district around the marina that takes advantage of the easy access to regional freeways, waterfront location, dramatic views, and nearby employment. A new ferry terminal is proposed in this area. Development of a transit-oriented, high-intensity urban center supporting a ferry terminal within a few miles from the RBC site might contribute to a substantial cumulative aesthetic impact in that area. Views of the high intensity residential, commercial and entertainment uses after the development of the ferry terminal area would be experienced by two sensitive receptors, the San Francisco Bay Trail users and private property owners in the hills. These ferry terminal area improvements would be sufficiently distant so as not to be part of the same viewshed as the proposed RBC project.

Enhancements to the San Francisco Bay Trail are identified in the City of Richmond General Plan 2030 (City of Richmond 2011). Currently, several improvements are being considered along the

shoreline and marina to create a distinctive waterfront promenade. Shoreline development would incorporate a variety of open spaces including parks and plazas accented with native and drought tolerant landscaping. These enhancements would add to the viewshed of the nearby sensitive receptors of the proposed RBC site and would contribute to a beneficial cumulative impact.

Areas to the north and west of the site are largely built out. No substantial new development is proposed in those areas, and much of the surrounding area would remain industrial without much forecasted change. Because other development associated with Marina Bay is not expected to coincide with the RBC LRDP timeframe and is not part of the same viewshed, the cumulative aesthetic effects of the proposed project would be less than significant.

LRDP Cumulative Impact AES-2: Development under the 2014 LRDP together with cumulative development in the region would create new sources of light and glare that would not result in cumulatively considerable impacts on regional day or nighttime views. (*Less than Significant*)

Development of the RBC would add to the existing sources of light and glare in the project site. Exterior and interior lighting associated with buildings, parking lots, and other facilities, combined with illumination of roadways and walkways, would add to the sources of nighttime illumination and glare. As discussed above, these new sources of light and glare would not be substantial and would be mitigated through design measures; they would also be distant from sensitive receptors. They would often not be in the same viewshed as other cumulative light and glare sources in the region. Because of that and because the RBC site is included in the area envisioned to change in the City of Richmond General Plan 2030 (City of Richmond 2011), the project's contribution to this cumulative impact would not be considerable.

4.1.5 References

City of Richmond. 2011. *Richmond General Plan 2030.* August 2011.

University of California. 2013. Richmond Bay Campus Long Range Development Plan, Community Draft. August 12, 2013.

4.2 AIR QUALITY

4.2.1 Introduction

This section discusses existing air quality conditions and analyzes the potential for development under the proposed 2014 LRDP to affect those conditions. Section information and analysis is based on data obtained from BAAQMD and an air quality analysis technical report prepared by Golder Associates, Inc. (Golder Associates, Inc. 2013).

Air quality impacts from the emissions of criteria air pollutants and toxic air contaminants (TAC) are considered in this section. The analysis addresses both temporary emissions from construction and demolition activities on the RBC site and long-term emissions from increased vehicle traffic projected to travel to and from the RBC site and new mechanical equipment that would be installed on the project site as the campus is developed. Greenhouse gas (GHG) emissions are addressed in Section 4.6.

Public and agency NOP comments related to air quality are summarized below:

- The project design should include ways to minimize air quality impacts from vehicle traffic emissions.
- The EIR should address the air quality impacts of hazardous materials remediation, including construction equipment emissions, in a manner consistent with the regulatory requirements.
- The EIR should address the impacts of potential radionuclide releases into air.

These issues are addressed in the sections that follow.

4.2.2 Environmental Setting

Air quality is a measure of the extent to which airborne chemicals are present in quantities sufficient to adversely affect human health and the environment. Common sources of air pollutants are motor vehicles, machinery and equipment, and commercial and industrial processes (such as smelting and dry cleaning). Natural processes such as volcanic eruptions and the decomposition of plant matter also contribute to air pollution. In addition to harming human health, air pollutants can cause effects such as reducing visibility (dust and smog) and contributing to climate change.

Because outdoor air continuously moves and mixes, outdoor air quality is generally assessed at a regional rather than local level. Pollutants released to outdoor air are more concentrated near an emissions source, but over time they disperse and have a regional impact. Pollutant movement in air is influenced by conditions such as wind, topography, and temperature.

The proposed RBC site is in the San Francisco Bay Area Air Basin (Air Basin). The primary factors that determine the Air Basin's air quality are air emissions' source locations, quantities, and types. Meteorological and topographical conditions also are important factors. Meteorological conditions, such as wind speed, wind direction, and variations in the air temperature at different heights above the ground, interact with the physical features of the landscape affecting the movement and dispersal of air pollutants.

Criteria Pollutants

Common air pollutants include carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NOx), ozone, lead, and particulate matter (PM). The US Environmental Protection Agency (EPA) refers to these as criteria pollutants and uses them as indicators of air quality. Air quality in

the basin is assessed by comparing concentrations of criteria pollutants to federal and state standards. The federal standards are known as the National Ambient Air Quality Standards (NAAQS). California has adopted similar and generally more stringent standards known as the California Ambient Air Quality Standards (CAAQS).

For each criteria pollutant an Air Basin is designated as attainment or unclassified if pollutant concentrations are below the standard for that pollutant, and as nonattainment if concentrations exceed the standard. The Air Basin is designated as nonattainment for the federal 8-hour ozone and 24-hour fine particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) standards. The Air Basin is designated as nonattainment for the state ozone, inhalable particulate matter less than 10 microns in diameter (PM_{10}), and $PM_{2.5}$ standards. The Air Basin is designated as attainment or unclassified for the other NAAQS and CAAQS (BAAQMD 2013a). The state and national standards and the Air Basin's attainment status are presented in Table 4.2-1.

BAAQMD monitors air quality in the Air Basin by collecting and analyzing air samples at monitoring stations throughout the region. Each station monitors selected pollutants based on local and regional conditions. Data from these stations provide an indication of air quality in the area. The data may or may not be indicative of air quality at the RBC site due to the distance from the site to the monitoring stations and differences in weather and topography between the two. The monitoring station nearest the RBC site is the Richmond station 2.8 miles northwest. The next nearest stations are San Pablo 3.3 miles northwest and Oakland West 7.3 miles southeast. Recent monitoring data from these stations are presented in Table 4.2-2.

Toxic Air Contaminants

A group of pollutants that are known or suspected to cause cancer or other serious adverse health effects are referred to as TACs. TACs are defined in the California Health and Safety Code Section 39655(a) as air pollutants "which may cause or contribute to an increase in mortality or in serious illness, or which may pose a present or potential hazard to human health." The Clean Air Act (CAA) refers to TACs as hazardous air pollutants. TACs are emitted by fuel combustion sources such as the exhaust from motor vehicle engines, by industrial processes such as manufacturing, and by commercial processes such as dry cleaners and gasoline stations. TACs are less pervasive in the atmosphere than criteria pollutants, and there are no ambient air quality standards for TACs.

BAAQMD inventories TAC emissions, conducts new source reviews, and determines TAC control and reduction strategies. BAAQMD's 2010 inventory of TAC emissions in Contra Costa County is provided in Table 4.2-3.

A TAC of particular concern in Richmond is diesel particulate matter (DPM). DPM is particulate matter emitted in the exhaust of diesel engines. DPM is known to cause cancer and respiratory illnesses and increase the risk of heart disease (California Air Resources Board [ARB] 2007). According to the City of Richmond General Plan, "DPM per square mile per year released in Richmond is six times higher than the [Contra Costa] County average and 40 times higher than the state average. More than 60 percent of the diesel pollution in Richmond comes from ships and commercial vessels, about 20 percent from diesel locomotives, and about 10 percent each from heavy duty trucks and construction equipment" (City of Richmond 2011).

Sensitive Receptors

Sensitive receptors are individuals or groups that are more susceptible to air pollution effects than the population at large. While the ambient air quality standards are designed to protect public health and are generally regarded as conservative for healthy adults, there is greater concern to

Table 4.2-1
State and National Ambient Air Quality Standards and Attainment Status

Pollutant	Averaging Time	California Concentration	California Attainment	National Concentration	National Attainment
Ozone	8 hours	0.070 ppm (137 µg/m^3)	Nonattainment	0.075 ppm	Nonattainment
	1 hour	0.09 ppm (180 µg/m^3)	Nonattainment	None	Not applicable
Carbon Monoxide	8 hours	9.0 ppm (10 mg/m^3)	Attainment	9 ppm (10 mg/m^3)	Attainment
	1 hour	20 ppm (23 mg/m^3)	Attainment	35 ppm (40 mg/m^3)	Attainment
Nitrogen Dioxide	1 hour	0.18 ppm (339 µg/m^3)	Attainment	0.100 ppm	Unclassified
	AAM	0.030 ppm (57 µg/m^3)	Unclassified	0.053 ppm (100 µg/m^3)	Attainment
Sulfur Dioxide	24 hours	0.04 ppm (105 µg/m^3)	Attainment	0.14 ppm (365 µg/m^3)	Attainment
	1 hour	0.25 ppm (655 µg/m^3)	Attainment	0.075 ppm (196 µg/m^3)	Attainment
	AAM	None	Not applicable	0.030 ppm (80 µg/m^3)	Attainment
Particulate Matter (PM_{10})	AAM	20 µg/m^3	Nonattainment	None	Not applicable
	24 hours	50 µg/m3	Nonattainment	150 µg/m^3	Unclassified
Fine Particulate Matter ($PM_{2.5}$)	AAM	12 µg/m3	Nonattainment	15 µg/m^3	Attainment
	24 hours	None	Not applicable	35 µg/m^3	Nonattainment
Sulfates	24 hours	25 µg/m^3	Attainment	None	Not applicable
Lead	Calendar quarter	None	Not applicable	1.5 µg/m^3	Attainment
	30 day average	1.5 µg/m^3	Attainment	None	Not applicable
	Rolling 3-month average	None	Not applicable	0.15 µg/m^3	Unclassified
Hydrogen sulfide	1 hour	0.03 ppm (42 µg/m^3)	Unclassified	None	Not applicable
Vinyl Chloride (chloroethene)	24 hours	0.010 ppm (26 µg/m^3)	Unclassified	None	Not applicable

AAM = annual arithmetic mean; ppm = parts per million; mg/m^3 = milligrams per cubic meter; µg/m^3 = micrograms per cubic meter

Source: BAAQMD 2013a

Table 4.2-2
Data from Nearby Air Quality Monitoring Stations

	2010			2011		
	RH	**SP**	**OW**	**RH**	**SP**	**OW**
Ozone						
Maximum 1-hour concentration (ppb)	--	97	--	--	78	57
Days exceeding the state 1-hour standard	--	1	--	--	0	0
Maximum 8-hour concentration (ppb)	--	81	--	--	58	48
Days exceeding the state 8-hour standard	--	1	--	--	0	0
Days exceeding the national 8-hour standard	--	1	--	--	0	0
Carbon monoxide						
Maximum 1-hour concentration (ppb)	--	--	2.7	--	1.9	3.5
Maximum 8-hour concentration (ppb)	--	--	1.7	--	1.0	2.7
Days exceeding the national or state standard	--	--	0	--	0	0
Nitrogen dioxide						
Maximum 1-hour concentration (ppb)	--	--	68.6	--	51	62
Maximum 24-hour concentration (ppb)	--	--	16	--	10	16
Days exceeding the national or state standard	--	--	0	--	0	0
Sulfur dioxide						
Maximum 1-hour concentration (ppb)	26.0	--	--	20.7	14.4	19.3
Maximum 24-hour concentration (ppb)	6.5	--	--	3.2	6.0	3.8
Days exceeding the national or state standard	0	--	--	0	0	0
PM_{10}						
Annual average ($\mu g/m^3$)	--	--	--	--	19.7	--
Maximum 24-hour concentration ($\mu g/m^3$)	--	--	--	--	73	--
Days exceeding the national standard	--	--	--	--	0	--
Days exceeding the state standard	--	--	--	--	1	--

RH = Richmond; SP = San Pablo; OW = Oakland West; ppb = parts per billion; $\mu g/m^3$ = micrograms per cubic meter; -- = no data

Raw data (i.e., data that have not yet been checked by BAAQMD for accuracy) for $PM_{2.5}$ are available for the Oakland West and San Pablo stations from January to early October 2013. As the data has not been verified, it is not reported in the table. The average $PM_{2.5}$ concentration at Oakland West during this time period was 12 $\mu g/m^3$, and the maximum concentration was 104 $\mu g/m^3$. At the San Pablo monitoring station, the average concentration was 11 $\mu g/m^3$, and the maximum was 68 $\mu g/m^3$.

Source: BAAQMD 2013b, 2013c

protect adults who are ill or have long-term respiratory problems, young children whose lungs are not fully developed, and older people. According to the ARB, sensitive receptors include children less than 14, persons over 65, and people with cardiovascular and chronic respiratory diseases.

BAAQMD identifies these land uses that may contain a high concentration of sensitive receptors: long-term health care facilities, rehabilitation centers, convalescent centers, retirement homes, residences, schools, playgrounds, child care centers, and athletic facilities. BAAQMD considers the relevant zone of influence for health risk assessment to be the area within 1,000 feet of the project boundary. The only sensitive receptors within 1,000 feet of the project boundary are the residences to the southwest of the RBC site in the Marina Bay neighborhood that are approximately 150 feet from the RBC development boundary.

Table 4.2-3
2010 Toxic Air Contaminant Emissions Inventory for Contra Costa County

Toxic Air Contaminant	Contra Costa County Emissions (pounds per year)	Toxic Air Contaminant	Contra Costa County Emissions (pounds per year)
Acetaldehyde	1,278.93	Hydrochloric acid mist	14,291.32
Acrolein	0.01	Hydrofluoric acid mist	4,616.70
Acrylamide	0.34	Hydrogen chloride	114,146.03
Acrylonitrile	20.17	Hydrogen fluoride	7208.63
Ammonia	1,134,465.74	Hydrogen sulfide	13,074.93
Arsenic	5.12	Isopropyl alcohol	17,742.69
Benzene	41,136.32	Lead	20.80
Benzyl chloride	0.07	Manganese	220.24
Beryllium	0.18	Mercury	248.33
Butadiene, 1,3-	139.01	Methyl alcohol	13,933.00
Cadmium	8.81	Methyl cellosolve	201.55
Carbon tetrachloride	2603.36	Methyl tertiary-butyl ether	26.09
Cellosolve acetate	40.07	Methylene chloride	18,507.77
Chlorine	1,983.64	Methylenedianiline	0.02
Chlorobenzene	317.55	Naphthalene	2,263.49
Chloroform	2,084.16	Nickel	270.36
Chromium (hexavalent)	7.15	Polycyclic aromatic hydrocarbons (benzo[a]pyrene equiv)	475.93
Cresol	4.96	Perchloroethylene	27,957.38
Dichlorobenzene	165.91	Phenol	1,078.36
Diesel engine exhaust particulate	6,192.09	Polychlorinated biphenyl	0.59
Diethanolamine	1,343.02	Propylene	1,815.72
Dioxane, 1,4-	19.47	Propylene glycol monomethyl ether	80.72
Ethyl chloride	116.06	Selenium	0.13
Ethylbenzene	3,601.61	Styrene	17,706.48
Ethylene dibromide	15.58	Sulfuric acid mist	10,279.75
Ethylene dichloride	94.84	Tetrachloroethane, 1,1,2,2-	0.12
Ethylene glycol	147.54	Toluene	53,250.81
Ethylene oxide	0.35	Trichloroethane, 1,1,1- (without dioxane)	541.04
Ethylidene chloride	20.34	Trichloroethane, 1,1,1- (with dioxane)	960.77
Formaldehyde	110,354.35	Trichloroethylene	968.99
Glutaraldehyde	84.16	Vinyl chloride	894.42
Hexachlorobenzene	0.02	Vinylidene chloride	28.37
Hexane	3,778.90	Xylene	43,743.70

Source: BAAQMD 2010

4.2.3 Regulatory Considerations

Federal

Criteria Pollutants

The federal CAA requires the EPA to establish and periodically review the NAAQS to protect public health and welfare. National standards have been established for seven air pollutants: ozone, CO, nitrogen dioxide (NO_2), SO_2, PM_{10}, $PM_{2.5}$, and lead.

The CAA requires each state to identify areas that have ambient air quality in violation of federal standards. States are required to develop, adopt, and implement a State Implementation Plan (SIP) to achieve, maintain, and enforce federal ambient air quality standards in these nonattainment areas. Deadlines for achieving the federal air quality standards vary according to air pollutant and the severity of air quality problems. The SIP must be submitted to and approved by the EPA. SIP elements are developed on a pollutant-by-pollutant basis whenever one or more air quality standard is being violated.

Hazardous Air Pollutants

Regulation of hazardous air pollutants (HAPs) under federal regulations is achieved through federal, state, and local controls on individual sources. Federal law defines HAPs as noncriteria air pollutants with short-term (acute) and/or long-term (chronic or carcinogenic) adverse human health effects. HAPs include both hazardous chemicals and radioactive materials. The 1990 federal CAA Amendments offer a comprehensive plan for achieving significant reductions in both mobile and stationary source emissions of HAPs. Under the 1990 CAA Amendments, a total of 189 chemicals or chemical families were designated HAPs because of their adverse human health effects. Title III of the 1990 federal CAA Amendments amended Section 112 of the CAA to enact an entirely new technology-based program. Under Title III, the EPA must establish maximum achievable control technology emission standards for all new and existing "major" stationary sources through promulgation of National Emission Standards for Hazardous Air Pollutants (NESHAP). Major stationary sources of HAPs are required to obtain an operating permit from BAAQMD pursuant to Title V of the 1990 CAA Amendments (a major source is defined as one that emits at least 10 tons per year of any one HAP or at least 25 tons per year of all HAPs combined).

NESHAP regulations promulgated by the EPA regulate both radioactive and non-radioactive emissions of HAPs. Subpart H of 40 CFR Part 61 established standards for emissions of radionuclides (other than radon) from facilities owned and operated by DOE. Some DOE facilities emit a wide variety of radionuclides in various physical and chemical states. The purpose of subpart H is to limit radionuclide emissions from DOE facilities so that no member of the public receives an effective dose equivalent to more than 10 millirem per year. Subpart H requires emissions sampling, monitoring, and dose calculations to determine compliance with the standard. Emissions measurement categories are determined by the greatest potential effective dose equivalent from airborne radionuclide emissions that could be received by a maximally exposed individual which is defined as a member of the public at an off-site point where there is a residence, school, business, or office. Standards for emissions of radionuclides from federal facilities not operated by DOE are covered in Subpart I of 40 CFR Part 61.

State

Criteria Pollutants

In California, air quality regulation is a joint responsibility between the ARB and local air quality management agencies. The ARB manages air quality, regulates mobile emissions sources, and oversees the activities of California counties and regional air districts. The ARB regulates local air quality indirectly by establishing CAAQS and vehicle emissions standards and by conducting research, planning, and coordination. California has adopted ambient standards that are more stringent than the federal standards for the seven criteria air pollutants. The CAAQS are established under the authority of the California Clean Air Act, which is patterned after the CAA.

The CAA and the California Clean Air Act require that SIPs be developed for areas designated as nonattainment (with the exception of areas designated as nonattainment for the state PM10 standard). On September 15, 2010, BAAQMD, in cooperation with the Metropolitan Transportation Commission (MTC) and the Association of Bay Area Governments, adopted the 2010 Clean Air Plan. The 2010 Clean Air Plan updates the Bay Area 2005 Ozone Strategy in accordance with the requirements of the California Clean Air Act to implement all feasible measures to reduce ozone; provide a control strategy to reduce ozone, particulate matter, TACs, and GHGs in a single, integrated plan; and establish emission control measures. The primary goals of the 2010 Clean Air Plan are to:

- Attain air quality standards,
- Reduce population exposure and protecting public health in the San Francisco Bay Area, and
- Reduce GHG emissions and protect the climate.

The 2010 Clean Air Plan represents the Bay Area's most recent triennial assessment of the region's strategy to attain the state one-hour ozone standard. The plan includes stationary-source control measures to be implemented through BAAQMD regulations; mobile-source control measures to be implemented through incentive programs and other activities; and transportation control measures to be implemented through transportation programs in cooperation with the MTC, local governments, transit agencies, and others.

Toxic Air Contaminants

California's TAC program was implemented in 1983 with the passage of the Toxic Air Contaminant Identification and Control Act, also known as the Tanner Bill. It was amended in 1992 to include the federal NESHAP hazardous air pollutants as state TACs. Another component of California's TAC program is the Air Toxics "Hot Spots" Information and Assessment Act of 1987 (Assembly Bill [AB] 2588) that regulates all of the TACs regulated by the Tanner Bill and additional TACs. AB 2588 includes requirements for certain facilities to quantify and report TAC emissions to the local air pollution control district that can require that the facility perform a human health risk assessment. BAAQMD regulates TACs through a permitting program and compliance with Air Toxic Control Measures (ATCM). ATCMs regulate a variety of sources of TACs including diesel engines and generators and operations that disturb naturally-occurring asbestos. The RBC site is not in an area where naturally-occurring asbestos is likely to be present (California Department of Conservation 2000).

Local

BAAQMD

BAAQMD is the agency with local air quality management authority in the nine-county San Francisco Bay Area Air Basin. BAAQMD has primary responsibility for most air quality regulatory programs, with the ARB exercising oversight responsibilities. The ARB directly implements statewide regulatory programs for motor vehicles, portable equipment, and hazardous air pollutants. BAAQMD is responsible for ensuring that federal and state air quality standards are met by monitoring ambient air pollutant levels throughout the air basin and implementing strategies to attain the standards.

BAAQMD CEQA Guidelines. BAAQMD has published CEQA Air Quality Guidelines that include thresholds of significance to assist lead agencies in evaluating the air quality impacts of projects and plans proposed in the San Francisco Bay Area Air Basin. BAAQMD's original CEQA Air Quality Guidelines were published in 1999. Revised thresholds of significance were adopted in June 2010 and a revised version of the guidelines was adopted in May 2011. The California Building Industry Association (CBIA) filed a lawsuit alleging that BAAQMD had violated CEQA by failing to review the potential environmental impacts of the revised thresholds before adopting them. On March 5, 2012, the Alameda County Superior Court issued a judgment finding that BAAQMD had failed to comply with CEQA when it adopted the June 2010 thresholds of significance. However, that decision was appealed by BAAQMD, and on July 13, 2013, the court of appeal ruled that adoption of the thresholds was not subject to CEQA.

BAAQMD Rules and Regulations. Specific rules and regulations have been adopted by BAAQMD that limit emissions that can be generated by various uses or activities. These rules regulate not only the emissions of the state and federal criteria pollutants, but also the emissions of TACs. The rules are also subject to ongoing refinement by BAAQMD. A few of the primary BAAQMD rules applicable to the project include the following:

- Regulation 2, Rule 1 (General Requirements): This rule requires new and modified sources of air pollution to acquire permits (e.g., Authority to Construct, Permit to Operate) in order to monitor stationary source emissions within BAAQMD's jurisdiction. The rule also includes a list of equipment and processes that would be exempt from permitting requirements. Among others, these include cooling towers and boilers with a heat input rating less than 10 million BTU/h fired exclusively with natural gas, liquefied petroleum gas, or a combination, and laboratories located in a building where the total number of fume hoods within the building is fewer than 50 or the total laboratory space is less than 25,000 square feet, provided that responsible laboratory management practices are used.
- Regulation 8, Rule 3 (Architectural Coatings): This rule sets limits on the reactive organic gas (ROG) content in architectural coatings sold, supplied, offered for sale, or manufactured within BAAQMD's jurisdiction. The rule also includes time schedules that specify when more stringent ROG standards are to be enforced. The rule applies during the construction phase of a project. In addition, any periodic architectural coating maintenance operations are required to comply with this rule.
- Regulation 8, Rule 15 (Emulsified and Liquid Asphalts): This rule sets limits on the ROG content in emulsified and liquid asphalt used for maintenance and paving operations. The rule includes specific ROG content requirements for various types of asphalt (e.g., emulsified asphalt, rapid-cure liquid asphalt, slow-cure liquid asphalt). This rule applies during the construction phase of a project. In addition, any future asphalt maintenance of a project's roads would be required to comply with the ROG standards set in Rule 15.

- Regulation 9, Rule 6 (Nitrogen Oxide Emission from Natural Gas-Fired Water Heaters): This rule sets a limit on the NOx emissions from natural gas-fired water heaters. The rule applies to natural gas-fired water heaters manufactured after July 1, 1992, with a heat input rating of less than 75,000 BTU/h. Water heaters subject to the rule must not emit more than 40 nanograms of NOx per joule of heat output.

City of Richmond

The proposed RBC site is a University of California property where work would be conducted within the University's mission on land that is owned or controlled by The Regents. As a state entity created by Article IX, Section 9 of the California State Constitution, the University is exempt under the state constitution from compliance with local land use regulations, including general plans and zoning. The University seeks to cooperate with local jurisdictions to reduce any physical consequences of potential land use conflicts to the extent feasible. The RBC site is in the city of Richmond. The following sections summarize objectives and policies from the City of Richmond General Plan 2030 and local ordinances as they relate to air quality.

The City of Richmond 2030 General Plan Energy and Climate Change Element (City of Richmond 2012) contains the following policy related to air quality:

- **Policy EC5.3—Air Quality:** Support regional policies and efforts that improve air quality to protect human and environmental health and minimize disproportionate impacts on sensitive population groups. Work with businesses and industry, residents and regulatory agencies to reduce the impact of direct, indirect and cumulative impacts of stationary and non-stationary sources of pollution such as industry, the port, railroads, diesel trucks and busy roadways. Ensure that sensitive uses such as schools, childcare centers, parks and playgrounds, housing and community gathering places are protected from adverse impacts of emissions.

  Continue to work with stakeholders to reduce impacts associated with air quality on disadvantaged neighborhoods and continue to participate in regional planning efforts with nearby jurisdictions and BAAQMD to meet or exceed air quality standards. Support regional, state and federal efforts to enforce existing pollution control laws and strengthen regulations.

The following action is related to this policy:

- **Action EC5.C—Air Quality Monitoring and Reporting Program:** Work with BAAQMD and other government agencies to establish and identify funding for a citywide air quality monitoring and reporting program. The air quality monitoring and reporting program would assess the cumulative impact of air pollution and toxins on human and environmental health and monitor exposure of sensitive uses such as schools, childcare centers, parks and playgrounds, housing and community gathering places.

  Collaborate with the County Health Services Department, BAAQMD, and state agencies to establish baseline exposures and to the extent feasible, document health effects associated with monitored baseline exposures and develop provisions to hold businesses and operations financially accountable for their impacts on the environment or community due to air pollution exceeding legal thresholds.

The 2030 General Plan EIR determined that the effects on air quality from future development pursuant to the General Plan would be significant and unavoidable. Future development could introduce new sources of air emissions that would contribute substantially to an existing or projected air quality violation or conflict with implementation of the Clean Air Plan. Mitigation

measures would be implemented to minimize potential impacts, but the impact would remain significant and unavoidable. Other impacts would be less than significant with mitigation. For example, development under the General Plan would not expose sensitive receptors to concentrations of carbon monoxide or toxic air contaminants in excess of the established thresholds. It would not expose a large number of people to odors. Cumulative impacts would be cumulatively considerable for potential air quality violations and conflicts with the Clean Air Plan but less than significant for exposure to carbon monoxide, toxic air contaminants, and odors.

4.2.4 Impacts and Mitigation Measures

Standards of Significance

Air quality impacts from campus development under the 2014 LRDP would be considered significant if they would exceed the following Standards of Significance, in accordance with Appendix G of the *State CEQA Guidelines* and the UC CEQA Handbook:

- Violate any air quality standard or contribute substantially to an existing or projected air quality violation
- Conflict with or obstruct implementation of the applicable air quality plan
- Expose sensitive receptors to substantial pollution concentrations
- Expose people to substantial levels of TACs, such that the exposure could cause an incremental human cancer risk greater than 10 in one million or exceed a hazard index of one for the maximally exposed individual
- Create objectionable odors affecting a substantial number of people
- Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)

The UC CEQA Handbook states that where available, the significance criteria established by the applicable air district may be used to make significance determinations.

As noted above, the significance thresholds under BAAQMD's CEQA Air Quality Guidelines were challenged by the CBIA. However, in July 2013, the court of appeal ruled that adoption of the thresholds was not subject to CEQA. Although this decision may be appealed by the CBIA, the University has determined that in this circumstance it will use the methodological approach and emissions thresholds in the BAAQMD guidelines to evaluate the impacts of the proposed project. The thresholds for the evaluation of air quality impacts from the BAAQMD CEQA Air Quality Guidelines are presented in the sections that follow.

Criteria Pollutant Emissions

Impacts from construction or direct or indirect operational emissions associated with the proposed project would be considered significant if they exceeded the following thresholds:

- 54 pounds per day of ROGs or volatile organic compounds (VOCs), NOx, or $PM_{2.5}$; or
- 82 pounds per day of PM_{10}.

The BAAQMD CEQA thresholds are the same for construction and operational emissions of criteria pollutants.

Local Community Risk and Toxic Air Contaminant Emissions

Local community risk and hazard impacts are associated with TACs and $PM_{2.5}$ because emissions of these pollutants can have significant health impacts at the local level. The proposed project would result in a significant impact if its emissions of TACs or $PM_{2.5}$ resulted in either:

- Non-compliance with a qualified risk reduction plan; or
- An incremental increase in cancer risk of more than 10 in 1 million, an increase in non-cancer risk (i.e., chronic or acute) as measured by a hazard index greater than 1.0, or an increase in $PM_{2.5}$ emissions greater than 0.3 micrograms/cubic meter ($\mu g/m^3$) annual average.

Odors

For impacts associated with odors, BAAQMD considers project operations that result in five confirmed complaints per year averaged over three years to have a significant impact.

Local Carbon Monoxide Concentrations

When sources of CO emissions are concentrated in an area, such as a large volume of vehicles at a congested intersection, a CO "hotspot" can result, meaning that CO concentrations in a localized area could exceed state or federal standards. The impact from CO emissions is considered significant if the emissions would contribute to a violation of the state standards for CO (9.0 part per million [ppm] averaged over 8 hours and 20 ppm over 1 hour).

Federal regulations and the BAAQMD CEQA Air Quality Guidelines contain a list of conditions under which a CO hotspot might be created and require a CO hotspot analysis when these conditions are met.

BAAQMD recommends CO modeling for a plan or a project in which: (1) project vehicle emissions of CO would exceed 550 pounds per day; (2) project traffic would affect intersections or roadway segments operating at level of service (LOS) E or F, or would cause a decline to LOS E or F;[9] or (3) project traffic would increase traffic volumes on nearby roadways by 10 percent or more (unless the increase in traffic volume is less than 100 vehicles per hour). Intersections are determined to operate at an LOS between A and F (LOS A being the best and LOS F being the worst) according to congestion or delay time, demand/capacity ratio, and relative flow of traffic at the intersection. Intersections that are determined to operate at LOS F or E have the potential to cause a CO hotspot (i.e., exceedance of the CAAQS). Indirect CO emissions are considered significant if they contribute to a violation of the state standards for CO (9.0 ppm averaged over 8 hours and 20 ppm over 1 hour).

If necessary, a simplified CO modeling analysis, described in the BAAQMD CEQA Air Quality Guidelines, may be used to determine localized CO concentrations. If modeling demonstrates that the source would not cause a violation of the state standard at existing or reasonably foreseeable receptors, the motor vehicle trips generated by the project would not have a significant impact on local air quality. The traffic study prepared for the proposed project indicates that six intersections would operate at an LOS of E or F, so a CO analysis is required for project operation. Under 40 CFR 93.123(c)(5) and the BAAQMD CEQA Air Quality Guidelines, a CO hotspot analysis is not required for temporary construction emissions and therefore was not conducted for project construction.

[9] Levels of service (LOS) range from A (least congested) with a condition of free flow with low volumes and high speeds to F (most congested) with stop and go, low-speed conditions with little or poor maneuverability.

Cumulative

The project would have a cumulatively considerable impact if:

- The project's criteria pollutant emissions exceed the BAAQMD CEQA thresholds.
- The project's TAC emissions, when combined with the cancer and human health risk from existing sources, result in an increased excess cancer risk of more than 100 in 1 million, an increase in non-cancer risk (i.e., chronic or acute) as measured by a hazard index greater than 10, or an increase in $PM_{2.5}$ emissions greater than 0.8 $\mu g/m^3$ annual average.

CEQA Checklist Items Adequately Addressed in the Initial Study

The NOP Initial Study deferred analysis of the project's air quality impacts to the LRDP EIR. All of the standards of significance listed above are addressed in the following analysis.

Analytical Methods

Construction and demolition activities would generate air pollutant emissions including airborne dust known as fugitive dust, emissions from the operation of on- and off-road construction equipment and vehicles, worker trips, architectural coatings such as paint, and paving off-gasses.

Operational activities would include instituting or operating several new emissions sources, including natural gas-fired boilers, cooling towers, emergency generators, laboratory chemicals use, and vehicle trips. Natural gas-fired boilers would heat buildings and cooling towers would be used to cool them. Emergency generators would serve as a back-up electricity source if there was a power failure. Laboratory chemicals would be used to support a variety of research purposes resulting in the potential for chemical emissions to be released to the atmosphere through lab hood vents on building roofs. Operational emissions would also come from delivery trucks transporting supplies to the RBC site and removing waste, additional employee vehicles, and shuttle buses traveling to and from the RBC site.

These air emission sources were estimated and analyzed in an air quality analysis technical report that was prepared for the project (Golder Associates, Inc. 2013). Air quality impacts from criteria pollutant emissions and TACs were quantitatively assessed for construction, operation, and cumulative conditions of the 2014 LRDP development. Model inputs were based on project description information. A detailed description of the analytical methods, models, and assumptions used to develop the quantitative analysis are in the report, included as Appendix B.

The estimated emissions and calculated risk values were compared to the BAAQMD CEQA thresholds listed above. Impacts are considered significant if they exceed the BAAQMD CEQA thresholds. Potential odor impacts were assessed qualitatively.

RBC 2014 LRDP Policies

The following policy from the 2014 LRDP applies to air quality.

- S3 – Sustainability Policy on Site Development: Embody environmental stewardship and respect the unique character of the Richmond Bay Campus in site development.
    - Control construction dust by implementing the BMPs defined in the BAAQMD CEQA Air Quality Guidelines.

LRDP Impacts and Mitigation Measures

Criteria Pollutants

LRDP Impact AIR-1: Criteria pollutant emissions associated with the construction and demolition activities under the 2014 LRDP would not violate an air quality standard or contribute substantially to an existing or projected air quality violation. (*Less than Significant*)

Construction and demolition associated with RBC development under the 2014 LRDP would generate air pollutant emissions including airborne dust known as fugitive dust and emissions from the operation of on- and off-road construction equipment and vehicles, worker trips, architectural coatings such as paint, and paving off-gasses. As discussed in further detail below, large construction projects would generally not occur simultaneously, although such projects may have some degree of schedule overlap.

Construction would typically begin with any necessary demolition, followed by site clearing and excavation. Soil-disturbing activities such as site excavation, elevation, and grading and placement of infrastructure and structural foundations would generate fugitive dust emissions that would contribute particulate matter to the local atmosphere.

Preliminary construction would include determining any special site or building conditions due to historic site contamination. If excavation is involved, soil that is certified clean may be shipped off site unless the project is a balanced cut-fill excavation that would reuse the soil on site. Contaminated soil would be excavated and removed by truck. Foundation work, building frame erection, and building finishing are the three major phases to follow.

Construction equipment would typically include large vehicles, stationary equipment, and hand-held equipment used on the building site and at nearby staging areas. They would be powered by diesel or gasoline engines or electricity. Such equipment would include cranes, scrapers, dozers, spreaders, compactors, loaders, drill rigs, haul trucks, cement trucks, bore drillers, rough terrain forklifts, pavers, rollers, and other rigs.

The air quality analysis considered emissions from construction equipment during each phase of construction based on the number of pieces of equipment and the duration of their use. It also considered the number of truck trips to deliver supplies and equipment, to transport soil for site grading, and to remove contaminated soil. Vehicle trips by construction workers were also considered. Construction and demolition emissions are estimated using the California Emissions Estimator Model (CalEEMod), version CalEEMod.2011.1.1. Details concerning the construction emissions estimates are in the air quality analysis technical report (Appendix B). The estimated construction emissions are presented in Table 4.2-4.

The LRDP construction emissions in Table 4.2-4 represent a typical annual level of construction and demolition that is expected to occur on the project site based on the total amount of building space that would be constructed under the 2014 LRDP.

Fugitive dust would be generated by construction activities such as excavation, site elevation, and grading. BAAQMD does not have a quantitative threshold for fugitive dust emissions from construction activities, but rather states that BMPs should be employed to control such fugitive dust emissions. Since there is no quantitative threshold for construction fugitive dust, these emissions were not quantified.

Table 4.2-4
LRDP Construction Emissions (pounds per day)

	On-site Stationary (Exhaust)	On-site Mobile (Exhaust)	Off-site Mobile (Exhaust)	Total Construction Emissions	BAAQMD CEQA Threshold
ROG/VOC	--	0.48	1.12	1.59	54
NOx	--	3.42	9.18	12.6	54
CO	--	2.56	8.14	10.7	NE
PM_{10}	--	0.16	0.29	0.45	82
$PM_{2.5}$	--	0.16	0.27	0.42	54

Note: all table units are pounds per day, rounded to two decimal places. Minor discrepancies between the totals reported in column 4 and the sum of individual values in columns 1 through 3 are a result of rounding.

-- = not evaluated; BAAQMD = Bay Area Air Quality Management District; CEQA = California Environmental Quality Act; CO = carbon monoxide; NA = not applicable; NE = not established; NOx = nitrogen oxides; $PM_{2.5}$ = fine particulate matter; PM_{10} = inhalable particulate matter; ROG = reactive organic gases; VOC = volatile organic compounds

Source: Golder Associates, Inc. 2013

As stated in the LRDP Policy S3, fugitive dust from construction activities would be controlled by implementing the construction BMPs recommended in the BAAQMD CEQA Air Quality Guidelines. The BMPs relevant to controlling fugitive dust are:

- All exposed surfaces (e.g., parking areas, staging areas, soil piles, graded areas, and unpaved access roads) shall be watered two times per day.
- All haul trucks transporting soil, sand, or other loose material off-site shall be covered.
- All visible mud or dirt track-out onto adjacent public roads shall be removed using wet power vacuum street sweepers at least once per day. The use of dry power sweeping is prohibited.
- All vehicle speeds on unpaved roads shall be limited to 15 miles per hour (mph).
- All roadways, driveways, and sidewalks to be paved shall be completed as soon as possible. Building pads shall be laid as soon as possible after grading unless seeding or soil binders are used.

All excavated soils would be managed to prevent dust, spills to the ground or water, disposal into drains, and exposure risk to people or the environment. Excavation, transportation, and handling of all soil would be required to result in no visible dust at the fence line of the excavation. Any soil material proposed to be placed as fill, whether from an off-site source or on-site source, would be kept covered or moist to facilitate eventual compaction and to control dust during earthwork operations. A water truck, water tank, or hydrant would be available to supply water in sufficient quantity on the job site while earthwork operations are underway. Sufficient water would be applied to suppress dust while exercising care to avoid generating runoff to any area outside the project boundary. Dust control measures would be implemented, as appropriate and necessary, beginning with site mobilization and continuing during all phases of the construction activities. Water would not be applied if there was a possibility of spreading contaminated soil or leaching contaminants from the soil, or if it resulted in hazardous working conditions.

Construction emissions associated with RBC development under the 2014 LRDP would not exceed the BAAQMD CEQA thresholds (Table 4.2-4), and BMPs would be implemented to control fugitive dust, resulting in a less than significant impact.

Mitigation Measure: No mitigation measure is required.

LRDP Impact AIR-2: Operational activities associated with development under the 2014 LRDP would result in criteria pollutant emissions that would exceed BAAQMD CEQA thresholds and therefore potentially violate an air quality standard or contribute substantially to an existing or projected air quality violation. (*Potentially Significant; Significant and Unavoidable*)

Operational activities associated with RBC development under the 2014 LRDP would include instituting or operating several new sources of criteria pollutant emissions, including natural gas-fired boilers, cooling towers, emergency generators, and vehicle trips. Emissions from each of these sources were calculated and included in the air quality analysis, as presented below:

- Natural gas-fired boilers would heat buildings and cooling towers would be used to cool them. Natural gas boilers would primarily produce NOx and TAC emissions. Cooling towers would produce emissions of particulate matter and sodium bromine (if used as a biocide), a TAC. (The human health impacts from the operational emissions of TACs from boilers and cooling towers are analyzed in LRDP Impact AIR-4 below.)
- Emergency generators would serve as a back-up electricity source if there was a power failure. Routine emissions of criteria pollutants would be associated with the maintenance testing of the emergency generators. Emergency generators would primarily produce SO_2 and DPM emissions. Emergency generators were assumed to meet EPA Tier 4 emission standards or better. This is a reasonable assumption for new generators because Tier 4 standards will be in full effect by 2015. (DPM emissions are TACs. The human health impacts from the operational emissions of DPM from emergency generators are analyzed in LRDP Impact AIR-4 below.)
- Chemicals used in the RBC laboratories would produce ROG/VOC and TAC emissions. (The human health effects from ROG/VOC and TAC emissions from laboratories are analyzed in LRDP Impact AIR-4 below.)
- Vehicle trips were also considered in the analysis. Delivery trucks would transport supplies to the RBC site and remove waste. Employees would travel by motor vehicles to and from the RBC site. Vehicle trips would result in emissions on and off site from fuel combustion and fugitive dust from tire friction that causes particles of dust on roads to become airborne. Although the RBC would provide facilities for alternative fuel vehicles such as electric and compressed natural gas vehicles, the air quality analysis assumes a typical mix of vehicle types (i.e., does not assume a higher percentage of alternative fuel cars than would normally be assumed) in order to provide a conservative analysis. Shuttle buses that would provide service to and from the RBC site would also generate emissions. (The human health effects from ROG/VOC and TAC emissions from motor vehicles are analyzed in LRDP Impact AIR-4 below.)

To the extent feasible, the estimates of operational emissions of criteria pollutants were developed taking into account proximity of retail uses to the RBC site and emissions-reducing project features included in the LRDP. These features include:

- Providing shuttle service to and from the site;
- Implementing low emission generators and compressors or equip them with supplementary exhaust pollution control systems where practical and feasible;
- Providing complete streets and bicycle facilities on the RBC site; and

- Orienting buildings to take advantage of solar heating and natural cooling and use passive solar designs.

The estimated LRDP emissions are based on the anticipated average annual activity levels assuming full development of the RBC under the 2014 LRDP. Details concerning the operational emissions estimates are in the air quality analysis technical report (Appendix B). The estimated operational emissions are presented in Table 4.2-5.

Table 4.2-5
LRDP Operational Emissions (pounds per day)

	On-site Stationary (Exhaust)	On-site Mobile (Exhaust)	On-site Fugitive Dust	Off-site Mobile (Exhaust)	Off-site Fugitive Dust	Total Operational Emissions	BAAQMD CEQA Threshold
ROG/VOC	90.10	9.38	--	36.14	--	***135.62***	54
NOx	47.20	10.50	--	52.90	--	***110.60***	54
CO	213.20	110.60	--	483.70	--	807.50	NE
PM_{10}	71.21	0.90	26.102	43.24	101.10	***242.56***	82
$PM_{2.5}$	50.20	0.83	6.400	18.21	24.82	***100.46***	54

Bold italics = exceeds Bay Area Air Quality Management District (BAAQMD) California Environmental Quality Act (CEQA) threshold

Note: all table units are pounds per day rounded to two decimal places. Minor discrepancies between the totals reported in column 6 and the sum of individual values in columns 1 through 5 are a result of rounding.

-- = not evaluated; CO = carbon monoxide; NA = not applicable; NE = not established; NOx = nitrogen oxides; $PM_{2.5}$ = fine particulate matter; PM_{10} = inhalable particulate matter; ROG = reactive organic gases; VOC = volatile organic compounds

Source: Golder Associates, Inc. 2013

As shown in Table 4.2-5, operational emissions of four criteria pollutants would exceed the BAAQMD CEQA thresholds, resulting in a significant impact. The greatest contributors of criteria pollutant emissions causing these projected exceedances are:

- ROG/VOC: exhaust emissions from employee vehicle trips and emissions from laboratories;
- NOx: exhaust emissions from employee vehicle trips and natural gas boilers; and
- PM_{10} and $PM_{2.5}$: particulate matter emissions from cooling towers and road dust from employee vehicle trips on on-site roadways, city roadways, and the freeway.

The estimated emissions that exceed the BAAQMD thresholds would result when all of the building space (up to 5.4 million square feet) is developed at RBC and the campus has a daily population of 10,000 persons. As the relationship between building space and population and the mass emission rate of criteria pollutant emissions is essentially linear, in the early stages of campus development, emissions would be substantially lower. In fact, based on an evaluation of the total projected criteria pollutant emissions, the development of up to 1,500,000 square feet of building space and associated increase in population at RBC would not result in emissions of criteria pollutants that would exceed BAAQMD CEQA thresholds.

Nonetheless, at full development of the campus, the total emissions of four criteria pollutants would exceed the applicable thresholds. As noted earlier, the 2014 LRDP includes policies requiring the University to provide shuttle service to and from the RBC site, implementation of low emissions generators and compressors (or fitting them with supplemental pollution control systems where practical and feasible), and orientation of new buildings to maximize solar heating

and natural cooling and reduce energy use associated with heating and cooling. The plan also provides for complete streets/sidewalks and commits to secure bike parking and shower changing facilities. LRDP MM AIR-2 would be implemented to minimize the impact from operational emissions. Additional reductions in operational emissions would be achieved with the implementation of LRDP MM GHG-1 (see Section 4.6), LRDP MM TRA-1 (see Section 4.11), and compliance with the new LBNL policy on sustainable building construction. However, because the benefits from each element of LRDP MM AIR-2 are difficult to quantify, and there is uncertainty whether these measures would reduce emissions of NOx, PM_{10} and $PM_{2.5}$ below the BAAQMD CEQA thresholds, it is conservatively concluded that even with mitigation, the impact would remain significant and unavoidable.

LRDP MM AIR-2: When the University has developed 1,000,000 square feet of building space on the RBC site, before approving the construction of another building, the University shall prepare and implement an operational emissions minimization program that will be composed of campus-wide programs to minimize emissions from mobile and area sources, and project-specific emissions control measures, based on project-specific analysis, to minimize emissions from area and stationary sources.

Campus-wide Control Measures

Campus-wide programs would include, but not be limited to, the following:

- Implement an enhanced TDM program to minimize vehicular traffic. The TDM program shall include the continued implementation of existing TDM measures such as provision of preferential carpool/vanpool parking; secure bike parking; showers and changing facilities; transit subsidies; Guaranteed Ride Home Program; and information to employees and students regarding alternative transportation modes. The TDM program will be expanded, following an evaluation of campus population and trip generation, to incorporate additional measures such as car share services; free transit passes; parking cash-out; daily parking charge; employee telecommuting program; compressed work schedules; infrastructure that allows employees to interact or conduct meetings and business without traveling; and a dedicated transportation coordinator.
- Convert campus fleet to low-emission, alternative fuel, and electric vehicles over time.
- Use electric equipment for landscape maintenance.
- Implement an educational program for faculty and staff and distribute information to students and visitors about air pollution problems and solutions.
- Develop centralized utilities such as a central plant (in place of individual boilers in buildings).

Stationary and Area Source Control Measures

When the University has developed 1,000,000 square feet of building space on the RBC site, if and when a specific building project is proposed that would add new stationary or area sources of emissions to the RBC site, the University will conduct a project-specific air quality impact assessment. If significant impacts are identified, project-specific mitigation measures will be implemented, which would include, but not be limited to, the following:

- Select solar or low-emission boilers.
- Select low-emission cooling towers.
- Other control measures determined appropriate for the specific project based on project-specific analysis.

Toxic Air Contaminants

LRDP Impact AIR-3: Construction and demolition associated with development under the 2014 LRDP would not expose people to substantial levels of TACs or expose sensitive receptors to substantial pollutant concentrations in excess of the relevant BAAQMD CEQA thresholds. (*Less than Significant*)

Human health effects from TAC emissions that would occur in association with construction and demolition activities under the 2014 LRDP were analyzed in a human health risk assessment. The assessment calculated the estimated cancer risk, chronic and acute health hazards, and $PM_{2.5}$ concentrations that would be experienced at the maximally exposed individual on the project site as well as off-site in the nearby residential and non-residential areas. Table 4.2-6 presents the results of this analysis compared to the BAAQMD CEQA thresholds.

As shown in Table 4.2-6, construction and demolition TAC emissions under the 2014 LRDP would not result in human health risks or $PM_{2.5}$ concentrations for the maximally exposed individual that would exceed the BAAQMD CEQA thresholds, and therefore the impact would be less than significant.

As Table 4.2-6 indicates, potential cancer risk, and chronic and acute hazard indices were not calculated for the on-site worker. The human health effects from TACs emitted by future construction activities under the LRDP on on-site workers at the RBC cannot be reasonably analyzed at this time for a number of reasons. Human health impacts are dependent on the relationship between the TAC source and the receptors. The sequence in which future buildings would be constructed on the site is not known at this time. Although Figure 3-4, LRDP Conceptual Layout, provides a general representation of the likely arrangement of future buildings on the RBC site, it is not known at this time which buildings will be constructed and occupied first and which ones will be constructed subsequently, and therefore under what circumstance there could be a receptor near a construction site and downwind of the construction activities. Furthermore, the scale of the construction project that could be located close to an occupied building, and therefore the magnitude of TAC emissions, cannot be predicted at this time. The relative location of the receptor and the scale and size of the construction project are essential data without which the human health effects cannot be evaluated without undue

Table 4.2-6
Health Risk Assessment for LRDP Construction

Assessment	Maximally Exposed Individual	BAAQMD CEQA Threshold
Cancer Risk		
Off-site Resident	3.3 in a million	10 in a million
Off-site Worker	2.6 in a million	10 in a million
On-site Worker	--	10 in a million
Chronic Hazard		
Off-site Resident	0.003	Hazard Index less than 1.0
Off-site Worker	0.06	Hazard Index less than 1.0
On-site Worker	--	Hazard Index less than 1.0
Acute Hazard		
On-site	--	Hazard Index less than 1.0
Off-site	--	Hazard Index less than 1.0
$PM_{2.5}$ Annual	0.018 µg/m^3	0.3 µg/m^3

-- = not evaluated; $PM_{2.5}$ = fine particulate matter; µg/m^3 = micrograms per cubic meter; Bay Area Air Quality Management District (BAAQMD) California Environmental Quality Act (CEQA)

Source: Golder Associates, Inc. 2013

speculation. Consistent with CEQA requirements, when future construction projects are proposed at the RBC, they will be evaluated for their potential to result in significant health effects on nearby receptors, including on-site workers.

However, it is unlikely that TACs emitted during construction of future buildings on the RBC site would result in significant human health impacts on on-site workers. Previously, a Phase 1 development program was proposed on the RBC site involving the grading of about 16 acres in the southern portion of the RBC site and the construction of approximately 600,000 square feet of building space. That project would have been immediately adjacent to and upwind of existing on-site worker receptors at the RBC site. The analysis of the human health effects of the construction TACs associated with the Phase 1 development program was completed before the project was discontinued. That analysis showed that human health impacts from Phase 1 construction activities on the nearby existing worker receptors immediately north and northeast of the Phase 1 site would have been less than significant.

Mitigation Measure: No mitigation measure is required.

LRDP Impact AIR-4: **Operational activities associated with development under the 2014 LRDP would expose people to substantial levels of TACs or expose sensitive receptors to substantial pollution concentrations in excess of the relevant BAAQMD CEQA thresholds. (*Potentially Significant; Significant and Unavoidable*)**

Non-radioactive Toxic Air Contaminants

Potential impacts to human health from exposure to the operational TAC emissions associated with RBC development under the 2014 LRDP were analyzed in a human health risk assessment.

The risk assessment included TAC emissions from a variety of sources that are anticipated to be developed on the RBC site under the 2014 LRDP. TAC sources and types of TACs that would be emitted by operational activities include the following:

- Boilers: benzene, toluene, propylene, formaldehyde, toluene, xylenes, lead, and mercury;
- Cooling towers: bromine;
- Generators: DPM;
- Laboratories: 44 laboratory chemicals (see air quality analysis technical report in Appendix B for a listing of chemicals);
- Vehicles: acrolein, benzene, toluene, ethylbenzene, xylenes, methanol, naphthalene, n-hexane, lead, and propylene.

TAC emissions from natural gas-fired boilers, cooling towers, emergency generators, and vehicles were quantified using methods described above under LRDP Impact AIR-2. TAC emissions from chemical use in laboratories were also quantified. Laboratory chemicals would be used for a variety of research purposes resulting in the potential for the TAC emissions to reach the atmosphere through lab stacks on building roofs. To estimate wet lab emissions, as a first step, LBNL and UC Berkeley reviewed chemical use in existing labs at the LBNL campus and the UC Berkeley main campus and prepared lists of chemicals that are anticipated to be used in the future wet labs at RBC. For the identified lab chemicals, emissions were estimated using methodologies followed by LBNL and UC Berkeley in previous health risk assessments prepared for their respective main sites. These methodologies are based on either annual chemical use data or emission factors for laboratory chemicals related to square footage of laboratory space. A full list of the TACs and operational emissions estimates, including a discussion of the methodologies, are found in the air quality analysis technical report in Appendix B.

The estimated emissions were then modeled using a dispersion model to estimate TAC concentrations and the estimated concentrations were used in conjunction with appropriate toxicity factors (including age sensitivity factors) and length of exposure assumptions to estimate potential cancer and non-cancer health effects on on-site worker receptors and off-site residential and worker receptors. The assessment calculated the estimated cancer risk, chronic and acute health hazards, and $PM_{2.5}$ concentrations that would be experienced at the maximally exposed individual on the RBC site (on-site worker) as well as the maximally exposed individual (both off-site resident and off-site worker) off-site in the nearby residential and non-residential areas. Table 4.2-7 presents the results of this analysis compared to the BAAQMD CEQA thresholds.

As shown in Table 4.2-7, the lifetime excess cancer risk, chronic health hazard, and the off-site acute health hazard associated with RBC development under the 2014 LRDP would be below the applicable BAAQMD CEQA thresholds. However, two values in Table 4.2-7 exceed the thresholds. The estimated acute hazard index for on-site worker (1.06) exceeds the applicable threshold, and the annual $PM_{2.5}$ concentration of 0.89 $\mu g/m^3$ (which would occur off-site) also exceeds the applicable threshold. Therefore, TAC emissions from operational activities associated with RBC development under the 2014 LRDP would result in a significant impact. The greatest contributors to the exceedance of the acute hazard index on site are formaldehyde and chloroform emissions from laboratories, and formaldehyde and nitrogen dioxide emissions from boilers and motor vehicle exhaust. The greatest contributors to the $PM_{2.5}$ exceedance off-site are emissions from employee vehicle trips and natural gas boilers.

The estimated TAC emissions that result in the exceedance of the BAAQMD thresholds would result when all of the building space (up to 5.4 million square feet) is developed at RBC and the campus has a daily population of 10,000 persons. As the relationship between building space and

Table 4.2-7
Health Risk Assessment for LRDP Operations

Assessment	Maximally Exposed Individual	BAAQMD CEQA Threshold
Cancer Risk		
Off-site Resident	8.9 in a million	10 in a million
Off-site Worker	3.1 in a million	10 in a million
On-site Worker	4.9 in a million	10 in a million
Chronic Hazard		
Off-site Resident	0.07	Hazard Index less than 1.0
Off-site Worker	0.27	Hazard Index less than 1.0
On-site Worker	0.36	Hazard Index less than 1.0
Acute Hazard		
On-site	***1.06***	Hazard Index less than 1.0
Off-site	0.89	Hazard Index less than 1.0
$PM_{2.5}$ Annual	***0.89 µg/m³***	0.3 µg/m³

Bold italics = exceeds BAAQMD CEQA threshold

$PM_{2.5}$ = fine particulate matter; µg/m³ = micrograms per cubic meter

Source: Golder Associates, Inc. 2013

population and the mass emission rate of TAC emissions is essentially linear, in the early stages of campus development, TAC emissions would be substantially lower and the impacts identified in Table 4.2-7 would not occur.

Nonetheless, at full development of the campus, the total TAC emissions would have the potential to result in an acute hazard index that exceeds 1.0, and $PM_{2.5}$ concentrations that exceed the applicable thresholds. LRDP MM AIR-2 (described above) would be implemented to minimize the impact from $PM_{2.5}$ emissions. Because the benefits from each element of LRDP MM AIR-2 are difficult to quantify, there is uncertainty whether the mitigation measure would adequately reduce $PM_{2.5}$ emissions below the BAAQMD CEQA threshold. Therefore, it is assumed that the impact would remain significant and unavoidable.

LRDP MM AIR-2 would also minimize emissions from on-site boilers and reduce the significant impact to on-site workers. In addition, LRDP MM AIR-4 is proposed to minimize TAC emissions from RBC laboratories, which would reduce the impact to the on-site workers to a less than significant level.

Radioactive Materials

The future wet labs at the RBC are expected to involve the use of some radioactive materials. As with other hazardous materials, the most probable potential pathway for public or environmental exposure to radioactive material would be air emissions from routine use of these materials inside the labs. Based on historical data from LBNL laboratory operations at a number of other locations, exposure to airborne radionuclides at the RBC would be less than 0.1 percent of EPA and DOE regulatory limits and less than 0.001 percent of the threshold below which risks of health effects are considered either too small to be observed or are nonexistent (Health Physics

Society 2010). Furthermore, all labs owned and operated by the DOE at the RBC will be subject to standards in Subpart H of the NESHAP regulations. Subpart H limits radionuclide emissions from DOE facilities so that no member of the public receives an effective dose equivalent of more than 10 millirem per year. Subpart H also requires emissions sampling, monitoring, and dose calculations to determine compliance with the standard. Based on the most recent evaluation of emissions from the UC Berkeley Central Campus (UC Berkeley 2012 Annual Radiation Safety Report), the radiation dose to the maximally exposed member of the public resulting from the use of licensed radioactive materials in the UC Berkeley RBC laboratories would be expected to be much less than the Central Campus, which had a calculated maximum dose of less than 5 percent of the 10 millirem/year dose limit imposed by the EPA. For these reasons, the emissions from the use of radioactive materials in RBC laboratories developed pursuant to the proposed 2014 LRDP would have a less than significant impact.

LRDP MM AIR-4: To reduce the effects from RBC laboratory emissions of formaldehyde and chloroform, the University shall implement one of the following measures in conjunction with every laboratory project that involves the use of these chemicals:

- Implement one or more emission control technologies on laboratory fume hoods or stacks. Controls will be limited to portions of the laboratory that involves the use of formaldehyde and chloroform. Controls will be selected specific to the chemical emissions to be controlled (formaldehyde or chloroform or both chemicals), and in the case of laboratory stacks, may include, as appropriate, activated carbon filters, scrubbers, biofilters, flares, catalytic converters, cryogenic condensers, vapor recovery systems, and thermal oxidizers.
- Demonstrate that the project's use of formaldehyde and chloroform will be at least 10 percent below that assumed for the LRDP human health risk assessment.

In the event that neither measure can be implemented, the laboratory project shall demonstrate by preparing a new human health risk assessment that the maximum acute hazard from project emissions, in conjunction with existing site emissions and future emissions under the 2014 LRDP, will not exceed a hazard index of 1.0.

Other Air Quality Impacts

LRDP Impact AIR-5: Development under the 2014 LRDP would conflict with or obstruct implementation of the applicable air quality plan. (*Potentially Significant; Significant and Unavoidable*)

The 2010 Clean Air Plan is the plan that would be applicable to the proposed project. The BAAQMD suggests that in order to evaluate whether a project or a plan is consistent with the 2010 Clean Air Plan, the lead agency can evaluate three questions: 1) Does the project support the primary goals of the 2010 Clean Air Plan, which includes the attainment of air quality standards? 2) Does the project include applicable control measures from the 2010 Clean Air Plan? And 3) Does the project disrupt or hinder implementation of any 2010 Clean Air Plan control measures? RBC development pursuant to the 2014 LRDP is evaluated relative to these three questions below.

Support Primary Goals of the 2010 Clean Air Plan

As discussed under LRDP Impact AIR-1, construction associated with RBC development under the 2014 LRDP would result in emissions that do not exceed BAAQMD CEQA thresholds. Therefore the emissions would not hinder the attainment of air quality standards. However, as discussed under LRDP Impact AIR-2 above, emissions from RBC operational activities would exceed the BAAQMD CEQA thresholds. Therefore, 2014 LRDP implementation would conflict with the 2010 Clean Air Plan, and the impact would be significant.

LRDP MM AIR-2 would be implemented to minimize this impact. Because the benefits from the elements of LRDP MM AIR-2 are difficult to quantify and there is uncertainty whether the emissions would be reduced below the BAAQMD CEQA threshold, it is assumed that the impact would remain significant and unavoidable.

Include Applicable 2010 Clean Air Plan Control Measures

The 2010 Clean Air Plan contains 55 control measures aimed at reducing air pollution in the Bay Area. The 2014 LRDP includes policies to guide RBC development to be sustainable. These policies are consistent with the applicable Clean Air Plan Land Use and Local Impact measures, Energy and Climate measures, Mobile Source measures, and Transportation control measures included in the 2010 Clean Air Plan. In addition, LRDP MM AIR-2 and LRDP MM GHG-1 include a range of measures that are consistent with the Clean Air Plan control measures. Therefore, the proposed project would not conflict with the 2010 Clean Air Plan under this criterion.

Hinder Implementation of 2010 Clean Air Plan Control Measures

The proposed project does not include any element that would hinder the implementation of any of the Clean Air Plan control measures. Therefore, the proposed project would not conflict with the 2010 Clean Air Plan under this criterion.

In summary, although RBC development under the proposed LRDP would not conflict with the 2010 Clean Air Plan under three criteria provided by the BAAQMD, it would nonetheless result in emissions of criteria pollutants that would exceed BAAQMD CEQA thresholds even after mitigation and would therefore interfere with the attainment of air quality standards. The impact would be significant and unavoidable for reasons presented above.

Mitigation Measure: Implement LRDP MM AIR-2.

LRDP Impact AIR-6: Development under the 2014 LRDP would not create objectionable odors affecting a substantial number of people. (*Less than Significant*)

Construction Emissions

Construction activities at the RBC could generate temporary odors from fuel combustion, paving, and architectural coatings. These odors would be temporary and limited to the immediate project area and would be unlikely to affect a substantial number of people in the surrounding area. Therefore, the impact on air quality from construction-phase odors would be less than significant.

Operational Emissions

Land uses primarily associated with odorous emissions include waste transfer and recycling stations, wastewater treatment plants, landfills, composting operations, petroleum operations, food and byproduct processes, factories, and agricultural activities, such as livestock operations. The proposed project does not include any of these types of land uses. In addition, the proposed project would not be sited near any of these recognized sources of odors. Operational activities at

RBC that could generate odors would be the use of laboratory chemicals and preparation of food in the food service areas. These odors would be controlled by ventilation systems and fume hoods and limited to the immediate area around the source. Therefore, the impact on air quality from odors generated by operational activities would be less than significant

Mitigation Measure: No mitigation measure is required.

LRDP Impact AIR-7: Development under the 2014 LRDP would not create a carbon monoxide hotspot, an area where the carbon monoxide concentration would exceed the state ambient air quality standards. (*Less than Significant*)

Construction Emissions

Under 40 CFR 93.123(c)(5) and the BAAQMD CEQA Air Quality Guidelines, a CO hotspot analysis is not required for construction emissions as construction activities are short term and are considered unlikely to result in a CO hotspot. Therefore such an analysis was not conducted.

Operational Emissions

Operational activities at the RBC would generate increased vehicle traffic on area roads. The traffic study prepared for the proposed project indicates that under 2035 conditions with full development of the RBC under the 2014 LRDP, six intersections would operate at an LOS of E or F. A CO analysis was performed for these intersections to determine if CO emissions generated by project-related traffic would contribute to a violation of the state standards for CO (9.0 ppm averaged over 8 hours and 20 ppm over 1 hour). The analysis was performed using a simplified spreadsheet version of the CALINE4 model with EMFAC2007 CO vehicle emissions factors and background CO concentrations from the San Pablo monitoring station (the nearest monitoring station where CO data are collected). The maximum CO concentrations at the study intersections would be 2.4 ppm averaged over 1 hour and 1.3 ppm averaged over 8 hours. Because these concentrations are well below the state 1-hour and 8-hour standards (see Table 4.2-1), carbon monoxide impacts on air quality from operational activities would be less than significant.

Mitigation Measure: No mitigation measure is required.

Cumulative Impacts and Mitigation Measures

LRDP Cumulative Impact AIR-1: Development under the 2014 LRDP would result in a cumulatively considerable increase in criteria pollutant emissions for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors). (*Potentially Significant; Significant and Unavoidable*)

BAAQMD's CEQA Air Quality Guidelines state that if a project's criteria pollutant emissions exceed the CEQA thresholds, then that project's impacts would also be cumulatively considerable. As shown in Table 4.2-4, the project's criteria pollutant emissions during RBC construction would be less than the BAAQMD CEQA thresholds. However, as shown in Table 4.2-5, operational emissions would exceed the applicable thresholds. Because the project's operational criteria pollutant emissions would exceed BAAQMD CEQA thresholds, the RBC at full development under the 2014 LRDP would make a cumulatively considerable contribution to the significant cumulative impact on regional air quality, and the impact would be significant.

LRDP MM AIR-2 would be implemented to minimize this impact. Because the benefits from each element of LRDP MM AIR-2 are difficult to quantify and there is uncertainty whether this would reduce emissions below the BAAQMD CEQA thresholds, it is assumed that the impact would remain significant and unavoidable.

Cumulative MM AIR-1: Implement LRDP MM AIR-2.

LRDP Cumulative Impact AIR-2: **Development under the 2014 LRDP would not result in an increase in non-cancer risk (i.e., chronic or acute) as measured by a hazard index greater than 10, but would result in a cumulatively considerable increase in cancer risk of more than 100 in 1 million and an increase in $PM_{2.5}$ concentration greater than 0.8 µg/m^3 annual average. (*Potentially Significant; Significant and Unavoidable*)**

BAAQMD's CEQA Air Quality Guidelines include standards and methods for determining the significance of cumulative health risk impacts. A cumulative health risk determination first considers the health risks from existing permitted sources and major roadways near a project (i.e., within a 1,000-foot radius of the source, also considered the zone of influence for health risks). That health risk is then added to the health risk estimated for the proposed project to determine whether the cumulative health risk thresholds would be exceeded.

Table 4.2-8 presents existing sources of TACs within 1,000 feet of the RBC site boundary to establish the cumulative setting for analysis of human health impacts. All of the sources listed in the table are within 1,000 feet of the RBC site boundary. The data reported in the table are from the BAAQMD database.

Construction TAC Emissions

Table 4.2-9 presents the results of the cumulative health risk assessment and the annual increase in $PM_{2.5}$ concentrations from anticipated annual construction activities at the RBC under the 2014 LRDP.

As shown in Table 4.2-9, if estimated human health risk from LRDP construction TAC emissions is added to the risk from existing sources in the area, the cumulative cancer risk and chronic health risk would be below the BAAQMD CEQA thresholds. However, the annual increase in $PM_{2.5}$ concentrations from the cumulative projects, including the proposed project, would exceed the BAAQMD CEQA thresholds for construction under cumulative conditions. As the table shows, the total $PM_{2.5}$ concentration from existing sources (1.47µg/m^3) already exceeds the BAAQMD CEQA threshold. The project's construction activities would make a very small incremental contribution to the existing significant cumulative impact. The primary RBC sources of $PM_{2.5}$ are exhaust emissions from on- and off-road construction vehicle travel and construction equipment use.

The numbers reported in Table 4.2-9 were calculated using the methodology provided in the BAAQMD CEQA Air Quality Guidelines which is a simplified method of estimating cumulative health effects without conducting detailed modeling of the emissions from existing sources in the area. In the event that results obtained from the simplified method exceed thresholds, a lead agency can conduct detailed modeling of the emissions from the existing sources and the proposed project together to estimate the cumulative impact. The University conducted such an

Table 4.2-8
Existing Sources Within 1,000 Feet of the RBC Site Boundary

ID	Name	Address	Cancer Risk (in a million)	Chronic Hazard Quotient	$PM_{2.5}$ ($\mu g/m^3$)
5462	Bio-Rad Laboratories	3110 Regatta Boulevard	36.1	0.374	0.028
G9842	RFS	1301 South 46th Street	0[a]	0[a]	NA[a]
15755	Grace Baking	3200G Regatta Boulevard	0.0576	0.00002	0.53
G7543	Pacific Gas and Electric Company	1100 South 27th Street	1.1	0.0016	NA
17029	Verizon Wireless, Richmond	South 27th Street and Pierson Avenue	8.5[b]	0.003[b]	0.002[b]
93	Safeway Stores, Inc. Bakery Plant	905 South 34th Street	0.03	0.00001	0.617
G7555	Stop and Shop	800 Carlson Boulevard	2.37	0.0034	NA
15508	Wareham Property Group EPA Laboratory	1337 South 46th Street, Building 201	19[b]	0.0067[b]	0.34[b]
851	I-580 (East/North of Freeway)	300 feet from maximally exposed individual	50.4	0.041	0.279
		Total	91.1[c]	0.42	1.47

ID = identification number; NA = not applicable; $PM_{2.5}$ = fine particulate matter; RFS = Richmond Field Station; $\mu g/m^3$ = micrograms per cubic meter

[a] The BAAQMD database reports zero values for the RFS under existing conditions. However, the RFS currently contains a few boilers, emergency generators, laboratories, and a gasoline filling station. While most of these existing sources at RFS will be removed in conjunction with new development under the 2014 LRDP, some of these existing sources are expected to remain on the RBC site in the foreseeable future. Human health effects from the sources expected to remain are reported in Tables 4.2-13 and 4.2-14.

[b] The data reported for sources 17029 and 15508 are for emergency generators at a distance of more than 280 meters from the maximally exposed individual. BAAQMD guidance allows these results to be multiplied by 0.04 (diesel generator attenuation factor), greatly reducing their contribution to the total.

[c] The total includes the risk from sources 17029 and 15508 after attenuation.

Source: Golder Associates, Inc. 2013

an analysis for LRDP construction $PM_{2.5}$ emissions using $PM_{2.5}$ emissions data for existing sources and default release parameters provided by the BAAQMD. The analysis revealed that the cumulative annual increase in $PM_{2.5}$ concentrations from existing sources plus the LRDP construction activities would be 0.30 µg/m3, instead of 1.49 $\mu g/m^3$ as reported in Table 4.2-9 above. Therefore, based on detailed modeling, the cumulative impact from LRDP construction $PM_{2.5}$ emissions would be less than significant.

Table 4.2-9
LRDP Cumulative Construction Health Risk Assessment

Source	Construction		
	Cancer Risk (in a million)	**Chronic Hazard Quotient**	**$PM_{2.5}$ ($\mu g/m^3$)**
Existing Sources within 1,000 feet of RBC Site Boundary (Table 4.2-12)	91.1	0.42	1.47
Existing Sources on the RBC Site	0.3	0.001	0,00
LRDP Emissions	3.3	0.003	0.02
Cumulative Emissions	94.7[a]	0.42	***1.49***
BAAQMD CEQA Threshold	100	10	0.8

Bold italics = exceeds BAAQMD CEQA threshold

$PM_{2.5}$ = fine particulate matter; RBC = Richmond Bay Campus; $\mu g/m^3$ = micrograms per cubic meter

[a] The TAC sources at Verizon Wireless (ID 17029 in Table 4.2-12 above) and at the EPA Lab (ID 15508) are emergency generators. The BAAQMD human health risk assessment guidelines note that cancer risk from emergency generators attenuates with distance and the guidelines provide a generator distance multiplier of 0.04 to be applied to the maximum impact value for emergency generators. That multiplier was applied to these two sources in estimating the total cancer risk under cumulative conditions.

Source: Golder Associates, Inc. 2013

Although the refined analysis above demonstrates that the cumulative $PM_{2.5}$ impacts would be less than significant, and pursuant to LRDP Policy S3, the University has committed to implementing the construction mitigation measures recommended by the BAAQMD to minimize all construction emissions, which will ensure that the LRDP construction emissions of $PM_{2.5}$ will not make a cumulatively considerable contribution to a significant $PM_{2.5}$ impact, the University nonetheless conservatively concludes that the cumulative impact related to $PM_{2.5}$ emissions from LRDP construction would be significant and unavoidable.

Operational TAC Emissions

Table 4.2-10 presents the results of the cumulative health risk assessment and the annual increase in $PM_{2.5}$ concentrations from anticipated annual operational activities at the RBC under the 2014 LRDP.

As shown in Table 4.2-10, if human health risk from LRDP operational TAC sources is combined with the risk from existing TAC sources in the area, the cumulative chronic health risk would be below the BAAQMD CEQA threshold. However, the cumulative cancer risk and the annual increase in $PM_{2.5}$ concentrations from the cumulative projects, including the proposed project, would exceed the BAAQMD CEQA thresholds, resulting in a significant impact. The primary RBC contributors to the cancer risk are natural gas boilers and diesel generators, while the primary RBC contributors to the $PM_{2.5}$ exceedance are road dust from employee vehicle trips and natural gas boilers.

Table 4.2-10
LRDP Cumulative Health Risk Assessment

Source	Operation		
	Cancer Risk (in a million)	**Chronic Hazard Quotient**	**$PM_{2.5}$ ($\mu g/m^3$)**
Existing Sources within 1,000 feet of RBC Site Boundary (Table 4.2-12)	91.1	0.42	1.47
Existing Sources on the RBC Site	2.4	0.00	0.0
LRDP Emissions	8.9	0.07	0.89
Cumulative Emissions	***102.4***[a]	0.49	***2.36***
BAAQMD CEQA Threshold	100	10	0.8

Bold italics = exceeds BAAQMD CEQA threshold

$PM_{2.5}$ = fine particulate matter; RBC = Richmond Bay Campus; $\mu g/m^3$ = micrograms per cubic meter

[a] The TAC sources at Verizon Wireless (ID 17029 in Table 4.2-12 above) and at the EPA Lab (ID 15508) are emergency generators. The BAAQMD human health risk assessment guidelines note that cancer risk from emergency generators attenuates with distance and the guidelines provide a generator distance multiplier of 0.04 to be applied to the maximum impact value for emergency generators. That multiplier was applied to these two sources in estimating the total cancer risk under cumulative conditions.

Source: Golder Associates, Inc. 2013

The analysis above is considered highly conservative because the cumulative results are obtained by simply adding the maximum impacts from all existing sources and are not obtained by modeling the TAC emissions from existing sources (i.e., the maximum impact at any location). The results conservatively add the maximum value for each source together and do not provide for any attenuation of risk that occurs with distance from the source to the maximally exposed individual receptor for the project. As noted in Table 4.2-10 above, a distance multiplier was applied only to generators and to none of the other sources. If a similar distance multiplier is applied to all existing sources (most of which are greater than 500 meters from the maximally exposed individual receptor) and the incremental cancer risk from the project site is added in, the maximum cancer risk at the maximally exposed individual receptor would be 64.4 in a million, well below the BAAQMD CEQA threshold for cancer risk.

Furthermore, studies conducted by the ARB showed that due to programs and controls that were put in place and increasing regulation especially of diesel emissions, statewide human health risks from existing sources decreased by 45 percent between 1990 and 2000 (ARB undated). Additional reductions are projected in the future to result from the ARB's Diesel Risk Reduction Plan, ARB's implementation of ACTMs, the BAAQMD's Air Toxics Program, and its implementation of NESHAPs.

The information above notwithstanding, the University is committed to minimizing its impact on the local community and the environment. Therefore, it will implement LRDP MM AIR-2 to minimize $PM_{2.5}$ and vehicle TAC emissions, and Cumulative MM AIR-2b to ensure that as new TAC sources are added to the RBC site, the site's impact on the community is evaluated and appropriate TAC controls are added to the projects or existing sources retrofitted so that the RBC site does not contribute substantially to a significant human health effect on or in the vicinity of the RBC site. Compliance with the performance standard included in Cumulative MM AIR-2b will ensure that the project will not result in a significant impact related to cancer risk. However, there remains uncertainty whether the University will be able to control its $PM_{2.5}$ emissions

adequately to render its contribution to the cumulative $PM_{2.5}$ impact cumulatively not considerable (i.e., less than significant). Therefore the University concludes that the impact related to $PM_{2.5}$ concentrations would be significant and unavoidable.

Cumulative MM AIR-2a: Implement LRDP MM AIR-2 to minimize $PM_{2.5}$ and vehicle TAC emissions.

Cumulative MM AIR-2b: When the University has developed 500,000 square feet of R&D building space on the RBC site, before approving the construction of another R&D building, LBNL and UC Berkeley will prepare an updated human health risk assessment (HHRA) that will estimate and report the human health effects of RBC operations on on-site and off-site receptors. If the HHRA indicates that there would be no significant health effects from RBC operations (project level or cumulative, based on significance thresholds applicable at that time), no further action is required.

In the event that significant human health effects are indicated, LBNL and UC Berkeley will implement control measures to minimize TAC emissions from laboratories, parking garages, other stationary sources, or other measures to reduce the human health effects from RBC TAC emissions to levels below applicable significance thresholds.

Control measures for new or existing laboratories could include, but would not be limited to, the measures listed in LRDP MM AIR-4.

Control measures for parking structures could include, but would not be limited to, the following:

- Locate parking structures to be as distant as possible from receptors to the north of the campus;
- Control parking structure emissions through a collection and bag house system.

LRDP Cumulative Impact AIR-3: **Under cumulative conditions, development under the 2014 LRDP would not create a carbon monoxide hotspot, an area where carbon monoxide would exceed the state ambient air quality standards. (*Less than Significant*)**

Construction Emissions

Under 40 CFR 93.123(c)(5) and the BAAQMD CEQA Air Quality Guidelines, a CO hotspot analysis is not required for temporary construction emissions and therefore was not conducted.

Operational Emissions

The maximum CO concentrations at the six intersections that would operate at LOS E or F would be 2.4 ppm averaged over 1 hour and 1.3 ppm averaged over 8 hours. Because these concentrations are below the state 1-hour and 8-hour standards, cumulative air quality impacts from the proposed project's operational emissions of CO would be less than significant.

Mitigation Measure: No mitigation measure is required.

4.2.5 References

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4.3 BIOLOGICAL RESOURCES

4.3.1 Introduction

This section presents existing RBC site biological resources and analyzes the potential for development under the 2014 LRDP to affect those resources. Information and analysis in this section is based on California Natural Diversity Database (CNDDB) searches (CNDDB 2012), several previous reports including RFS Habitat Assessment Report and RFS Constraints Analysis (WRA and Jane Valerius Environmental Consulting 2011a, 2012), the RFS Remediation Project IS (URS 2003), UC Richmond Field Station's Remnant Coastal Terrace Prairie (Amme 2005), RFS Grasslands Constraints Analysis (WRA and Jane Valerius Environmental Consulting 2013), The Manual of California Vegetation (Sawyer et al. 2009), and Richmond Field Station Remediation Project Biological Assessment Report (Blasland, Bouck, and Lee, Inc. 2003). A Tetra Tech biologist and professional wetland scientist conducted a site visit and general biological survey on January 4, 2013 (Tetra Tech 2013a). Tetra Tech biologists delineated wetlands on February 13 and 15, 2013 (Tetra Tech 2013b).

The biological resources discussed in this section are vegetation communities, wildlife habitats, wildlife movement corridors, common wildlife, special-status plant and wildlife species, and sensitive natural communities, including wetlands.

Public and agency NOP comments related to biological resources are summarized below:

- Conduct a thorough biological site survey;
- Analyze project impacts on all biological resources;
- The site contains remnant native coastal prairie grasslands that occur in very few locations, possibly only at this site;
- Native coastal prairie grasslands should be preserved on-site, and direct and indirect impacts should be prevented during construction and subsequent operations, including by use of buffer zones;
- Remnant California poppy (*Eschscholzia californica*) and Rancheria clover (*Trifolium alborpurpureum*) populations should be preserved in landscaping plans;
- Specify a weed management plan for the project, including controlling threats to the native grasslands, controlling invasive species such as Italian fennel and pampass grass in the marsh;
- Use local-endemic ecotypes wherever native plants are prescribed;
- Demolition, tree removal, construction, and restoration activities may impact wildlife;
- Impacts on species listed under the US or California Endangered Species Act, including California clapper rail, may require mitigation and permitting;
- Implement measures to reduce impacts on wildlife: minimize outdoor lighting, restrict human presence near sensitive habitats, control trash, reduce construction and operating noise, use bird-safe building standards, avoid structures that could serve as raptor perches near the shoreline, and provide setbacks from the shoreline;
- The project area is adjacent to recently restored wetlands; and
- Comply with local and regional land use laws, regulations, and plans.

4.3.2 Environmental Setting

Vegetation Communities

The project site has five general vegetation communities: native grasslands, non-native grasslands, ornamental/landscaping, eucalyptus stands, and tidal salt marsh (Figure 4-8).

Native Grassland

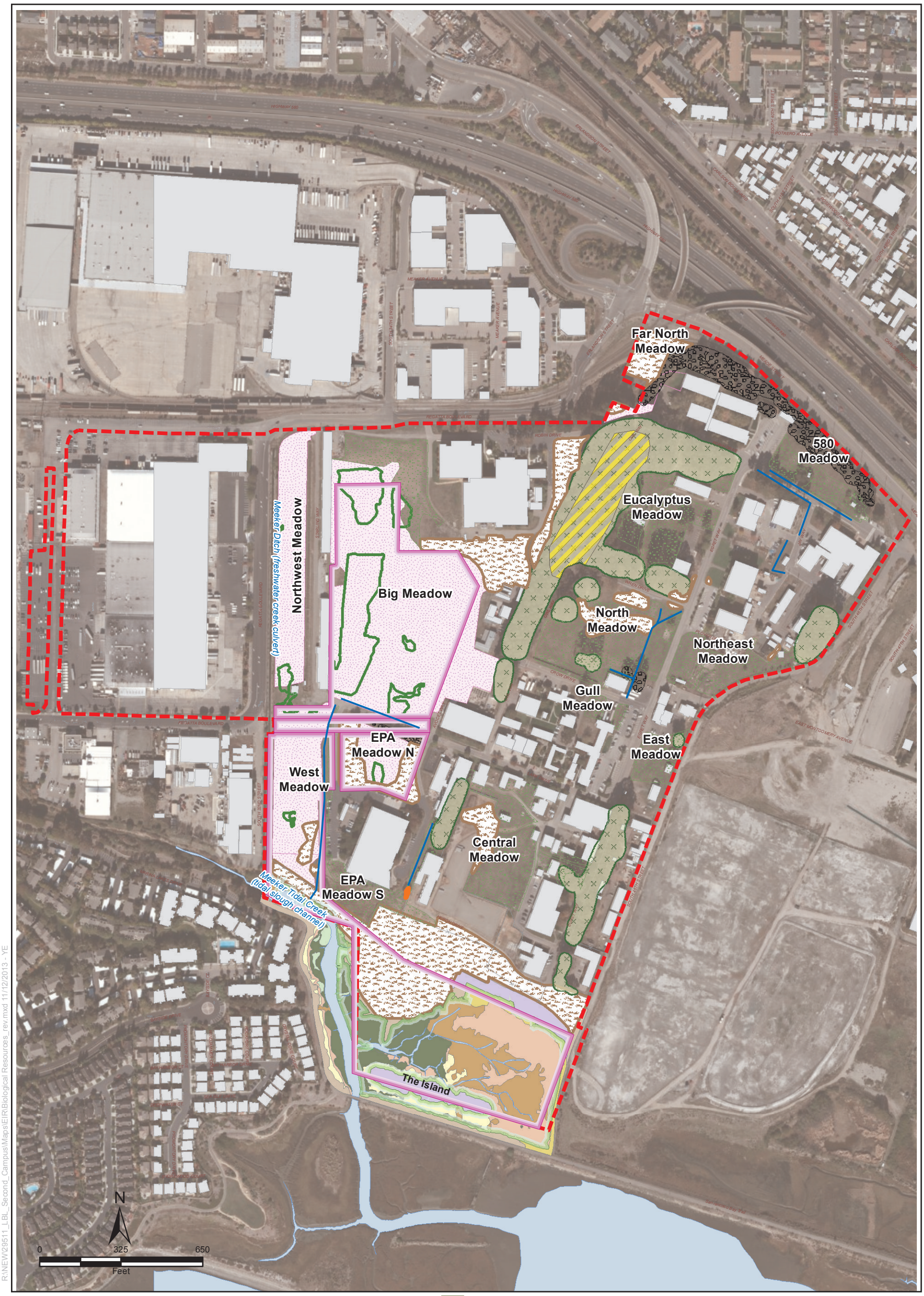
Native grassland communities include California oatgrass and purple needlegrass alliances. California oatgrass grassland is dominated by California oatgrass (*Danthonia californica*). Other species noted in this community includes soft chess (*Bromus hordaceus*), Italian ryegrass (*Lolium multiflorum*), English plantain (*Plantago lanceolata*) and bristly ox-tongue (*Picris echioides*). This community has been reported in all meadows except the Far North Meadow (URS 2007) (Figure 4-8). Harding grass (*Phalaris aquatica*), a non-native species, has invaded much of the oatgrass grassland areas and some areas are slowly transitioning into coastal scrub by the invasion of coyote brush (*Baccharis* pilularis) (URS 2007).

Purple needlegrass grassland also occurs in several areas. Purple needlegrass (*Nasella pulchra*) is typically found in deep soils with high clay content. Nonnative species are also common in this community type and include rattail fescue (*Vulpia myuros*), sixweeks fescue (*Vulpia bromoides*), silver European hair grass (*Aira caryophyllea*), ripgut brome (*Bromus diandrus*), soft chess, and red brome (*Bromus madritenisis*). This community has been reported in all meadows except the Far North Meadow (URS 2007).

California "coastal prairie" or "coastal terrace prairie" are "communities," or conglomerations of native perennial and/or annual grasses that inhabit moist, temperate areas of the California coastal region. Such grasslands occurring along the north and central California coast experience a milder climate than interior grasslands, with weather mediated by fog. These grasslands are typically dense or tall and may be naturally patchy, reflecting differences in soils and moisture availability. Although none of the species found in a coastal prairie are necessarily rare or endangered, the grassland community itself is an uncommon configuration of species. As noted in Table 4.3-1 below, there are no known occurrences of special status (endangered or rare) plant species occurring at the RBC site. However, some plants occurring at the site are uncommon locally.

A 1999 report estimated that moist grasslands occur on about 7,000 acres in the San Francisco Bay Area, a decline from approximately 60,000 acres in historic times (Goals Project 1999). Coastal terrace prairie may be characterized by different species; the oatgrass and purple needlegrass community at the RFS makes up an even smaller portion of the remaining moist grasslands. In addition to occurrences at the RFS, coastal prairie grasslands occur in the vicinity at portions of the San Pablo Peninsula, such as Point Molate (City of Richmond 2013). Coastal prairie grasslands also occur on Brooks Island (Goals Project 1999).

The RFS occurrence of coastal terrace prairie is considered unique as "the only Coastal Terrace Prairie in lowland clay soils in the greater East Bay Area." This soil type comprises the majority of the RBC site upland area (Amme 1993). A 1993 study concluded that "the remnant coastal prairie grassland at Richmond Field Station is scientifically and ecologically invaluable, and virtually impossible to recreate" (Amme 1993). In August of 1996, then-UC Berkeley Chancellor Chang-Lin Tien wrote then-Assembly member Tom Bates proposing, subject to approval, a commitment to incorporate a wetland and grassland reserve into long range plans at the Richmond Field Station. The letter identified approximately 8.7 acres of coastal grasslands at the RFS site, setting this acreage aside as a reserve. This acreage is at the core of the Natural Open Space proposed in the LRDP (Figure 4-8).



This figure depicts existing conditions across the RBC site and the area designated as Natural Open Space in the 2014 LRDP.

- Drainage Swale
- Natural Open Space Designation
- RBC Site Boundary
- Wetlands
- Marsh Boundary
- Building
- Monarch Butterfly Roosting Area
- Coastal Terrace Prairie
- Disturbed Coastal Terrace Prairie
- Non-Native Dominated Grassland on Fill
- Ornamental Trees
- Eucalyptus
- Surface Water
- Cordgrass (*Spartina foliosa*)
- Salty Susan (*Jaumea carnosa*)
- Bulrush (*Scirpus americanus*)
- Saltgrass (*Distichlis spicata*)
- Pickleweed (*Salicornia virginica*)
- Ecotone
- Restored Native Upland
- Non-Native Transitional Upland
- Mud
- Seasonal Freshwater Wetlands

Biological Resources

Richmond, California

Figure 4-8

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community.
Biological resources - RFS Current Conditions Report 2008.

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UC Berkeley has maintained its commitment through passive preservation of the grasslands. However, since 1996 the grasslands have also been the subject of some restoration effort (Watershed Project 2007) and of academic study at UC Berkeley.

Grasslands are a dynamic resource, and human understanding of coastal prairie grasslands has evolved over time. Based upon its reserve status, the RFS reserve areas were left undisturbed and mowing of them was discontinued beginning in the 1990s. Stewards have since learned that native grasslands should not go untouched, but instead are sustained by disturbances such as mowing, fire, grazing and burrowing that help reduce competition from non-native species. Native grasslands have been shown to benefit from types of disturbance that help to limit invasion by non-native species, or limit invasion by successional species (Immel-Jeffery et al. 2013). In the 1993 study of the RFS, the area west of Building 280 at the RFS was not identified as coastal terrace prairie grassland. Known as the Northwest Meadow, it was mowed routinely, and today exhibits characteristics of a high quality coastal terrace prairie grassland (WRA and Jane Valerius 2013). Meanwhile other areas have deteriorated (RFS 2012 Restoration Report, ESPM 187, p. 6; page 22). In 2007, mowing protocols for the reserve areas were re-instituted and are followed today.

Since 1993 the effort to protect grasslands in the city of Richmond has expanded. The East Bay chapter of the California Native Plant Society has designated the entirety of the Richmond shoreline as a botanical priority protection area. CNPS is an advocacy organization with not-for profit status; members of CNPS include biologists and horticulturists as well as amateur enthusiasts. CNPS has developed a "Rare Natural Communities Initiative" stating that "of key importance to CNPS are those vegetation communities that are, in and of themselves, rare" including "high quality stands of native north coastal terrace prairie" (CNPS Undated).

The science of restoration, once thought to be "nearly impossible" (Stromberg et al. 2007) has progressed and evidence of restoration can be seen at the RBC site as well as elsewhere in California (e.g., CNPS Undated, Kraft et al. 2007, Watershed Project 2007). Restoration can be a very detailed and resource intensive process; it requires a detailed management strategy for many years after initial project implementation (Stromberg et al. 2007, Kraft et al. 2007).

The coastal terrace grassland community on the RBC site is composed of valley needlegrass grassland (also known as purple needlegrass alliance) and California oatgrass bunchgrass grassland alliance. The community at the site is considered to be a "sensitive natural community of limited distribution" under protocols prepared by CDFW (CDFG 2009).

It is common for grasslands to be variable in quality and species composition. This is the case for the grasslands at the RBC site as described below. The highest quality meadows on the site are identified here as the "sensitive natural community."

WRA and Jane Valerius Environmental Consulting (2013) evaluated the condition of these grasslands in spring 2012 to update the previous condition assessment by URS (2007). Their goal was to rank the quality of coastal-terrace prairie grassland habitat based on presence of absolute cover of purple needlegrass (5%) and/or California oatgrass (greater than 25%), as described by the membership rule of the series in the Manual of California Vegetation (Sawyer et al. 2009); the quality ranking was not dependent on the presence of other native plant species. The rankings used to classify the RBC meadows are:

- *High Quality*: California oatgrass (>50%) or purple needlegrass (>20%),
- *Medium Quality*: California oatgrass (25-50%) or purple needlegrass (5-19%), and
- *Low Quality*: California oatgrass (0-24%) or purple needlegrass (0-4%).

Further qualitative evaluation of the coastal-terrace prairie grass was based on:

- Consideration of nearby populations and total species distribution,
- The consideration of nearby occurrences of special-status communities and natural community distribution, and
- Analysis of potential threats, including those from invasive species, to the plants and natural communities.

The evaluation concluded that there are 22 acres of high quality coastal terrace prairie grassland habitat at the RBC site (WRA and Jane Valerius Environmental Consulting 2013).

The grasslands that support high-quality coastal terrace are in the Big Meadow, West Meadow, Northwest Meadow, and EPA North Meadow in the central-western portion of the RBC site (WRA and Jane Valerius Environmental Consulting 2013). The Big Meadow represents the only known coastal-terrace prairie grassland on lowland clay soils (Clear Lake-Cropley and Capay-Rincon soil types) in the greater East Bay Area (Amme 2005). The coastal-terrace prairie grassland community in the Big Meadow, West Meadow, and other meadows supports populations of plant species with very limited distribution in Contra Costa and Alameda Counties (EBCNPS 2004).

Non-Native Annual Grassland

Non-native annual grasslands on the RBC site are primarily dominated by Harding grass, wild oats (*Avena* sp.), ripgut brome, soft chess, Italian ryegrass, and hare barley (*Hordeum murinum* ssp. *leporinum*) along with non-native forbs such as English plantain, geraniums (*Geranium dissectum* and *G. molle*), black mustard (*Brassica nigra*), chicory (*Cichorium intybus*), and teasel (*Dipsacus fullonum*) (WRA and Jane Valerius Environmental Consulting 2011a). Non-native annual grasslands are dispersed throughout much of the RBC site.

Portions of the annual grassland habitat were noted to include wetland plants such as umbrella sedge (*Cyperus eragrostis*), Dallis grass (*Paspalum dilitatum*), bristly ox-tongue (*Picris echioides*) and bird's- foot trefoil (*Lotus corniculatus*).

Ornamental/Landscaped

Areas around buildings include landscaping and ornamentals such as cotoneaster (*Cotoneaster* sp.), firethorn (*Pyracantha* sp.), blackwood acacia (*Acacia melanoxylon*), wax myrtle (*Myrica californica*), Monterey pine (*Pinus radiata*), and olive (*Olea Europa*) (WRA and Jane Valerius Environmental Consulting 2011a).

Eucalyptus Stands

The eucalyptus stands are dominated by blue gum (*Eucalyptus globulus*). Understory is limited under the blue gum trees and is composed of non-native annual grasses and forbs. The eucalyptus stands occur in the central portion of the RBC site and run from north to south (WRA and Jane Valerius Environmental Consulting 2011a) (Figure 4-8). A majority of the trees were planted more than a century ago by the California Cap Company to create a blast barrier between the cap company and the adjacent properties. Recent tree failures have shown the stands are infected with heart rot, a fungal disease that causes the decay of wood at the center of the tree. Heart rot is a major factor in the economics of logging and the natural growth dynamic of many older forests. As the fungi grow, they decay more wood and the tissue becomes increasingly soft and weak. The trees will continue to grow around the decayed heart wood because the live wood is not affected; however the extensive decay makes the tree more susceptible to broken branches and causes sudden failure of the tree. Increased failures of the eucalyptus trees at the RBC site have been occurring over the last 10 years (Shackleton 2013).

Salt Marsh

Western Stege Marsh on the southern portion of the RBC site includes high marsh, low marsh, tidal mudflat, and open water slough habitats (Blasland, Bouck, and Lee, Inc. 2003) (Figure 4-8). The high marsh is dominated by inland saltgrass and the low marsh is dominated by pacific cordgrass (*Spartina foliosa*). Inland saltgrass is typically found in temperate grassland with sparse shrub layer. The areas that are now Western Stege Marsh and the transition area just north of the marsh were historically intertidal mudflats. Offshore breakwaters constructed in the 1930s and the rerouting of Meeker Creek from further west to its current location resulted in soil deposition and transition of the mudflats to the tidal marshland which exists today.

Wetland and Aquatic Features

Western Stege Marsh and Meeker Slough, in the Natural Open Space in the southern portion of the RBC site, include high marsh, low marsh, tidal mudflat, and open water slough habitats (Blasland, Bouck, and Lee, Inc. 2003; Tetra Tech 2010). They are all jurisdictional wetlands (Figure 4-8). The primary hydrologic feature in the area is the approximately 40- to 50-foot wide Meeker Slough. The high marsh is dominated by inland saltgrass and the low marsh is dominated by pacific cordgrass. Inland saltgrass is typically found in temperate grassland with sparse shrub layer. Habitats can be irregularly flooded or permanently saturated with shallow water table in haline or saline water chemistry (WRA and Jane Valerius Environmental Consulting 2011a). Western Stege Marsh is considered a sensitive natural community. The saltmarsh habitat provides high quality wildlife habitat for numerous special-status species and also functions to reduce erosion and sedimentation.

Prior to the RBC site's ownership by UC, historical industrial operations on it and adjacent properties caused sediment contamination in the Western Stege Marsh (Tetra Tech 2010). UC Berkeley undertook Western Stege Marsh remediation beginning in 2002 in response to the October 2001 San Francisco Bay RWQCB Order (No. 01-102) issued to UC Berkeley and Zeneca. Remediation was conducted in three phases during 2002, 2003 and 2004. Five years of remediation monitoring was completed in 2010.

Other than Western Stege Marsh and Meeker Slough, additional small areas of wetland could be present on the RBC site. Most of the site has not yet been delineated. Ponded water has been observed in annual grassland habitat for extended periods throughout the rainy season and may constitute potentially jurisdictional seasonal wetlands. These ponded areas were noted to include wetland plants, such as umbrella sedge, Dallis grass, bristly ox-tongue, and bird's-foot trefoil. Given the low-lying aspect of the grassland areas and adjacency to the tidal salt marsh, some of the depressional areas in the grassland may qualify as jurisdictional wetlands.

A wetland delineation (Tetra Tech 2013b) was conducted for the southeastern portion of the RBC site in February 2013. One 300-square foot herbaceous wetland swale was identified and delineated downstream of a drainage channel, approximately 50 feet east of the southeastern corner of the EPA Building (Figure 4-8).

The most common plant species observed in the wetland swale were brown-headed rush (*Juncus phaeocephalus*), followed by Harding grass. Clay loam soils with characteristics indicative of hydric soils are present. The wetland swale water source is largely from the drainage channel from the north. To the east, a second culvert appears to also convey water, as indicated by the location of known underground water conveyances. Water is conveyed southward from the wetland swale through a third culvert where it flows to another open swale for approximately 20 feet. Beyond this point, there is very little evidence of an open swale. Another underground culvert carries water off the RBC site to Western Stege Marsh. Due to topographic variation (gradual sloping to the southeast) below the third culvert and lack of sufficient moisture, the

wetland swale does not appear to be directly hydrologically connected to navigable waters of Meeker Slough; as a result, the wetland swale does not appear to be jurisdictional and is periodically maintained as a drainage ditch. USACE has not yet made its formal jurisdictional determination, but during an inspection of the site, USACE staff commented that the features do not appear to be jurisdictional for these reasons.

Wildlife Habitats

Grasslands

Grassland habitat, including native and non-native grasslands, provides primary habitat, such as nesting and foraging, and secondary habitat, such as movement corridors. Small species using this as primary habitat include reptiles and amphibians, such as southern alligator lizard (*Gerrhonotus multicarinatus*), western fence lizard (*Sceloporus occidentalis*), and Pacific slender salamander (*Batrachoseps attenuatus*). These grasslands may also attract seed-eating and insect-eating birds and mammals. The site's low-growing, sparse vegetation may provide nesting substrate for a variety of birds that prefer nesting open lands, such as killdeer (*Charadrius vociferus*) (WRA and Jane Valerius Environmental Consulting 2011a).

Saltmarsh

The Richmond Inner Harbor and associated saltmarsh in Western Stege Marsh is on the RBC site southern boundary. Species occurring in the salt marsh habitat include great blue heron (*Ardea herodius*) and great egret (*Ardea alba*). They forage in the salt marsh and nest in nearby riparian areas. Shorebirds, such as black-necked stilt (*Himantopus mexicanus*), willet (*Catoptophorus semipalmatus*), and American avocet (*Recurvirostra americana*), use salt marshes for foraging on crustaceans and arthropods. Waterfowl use saltmarshes for feeding and resting during the winter and spring migrations along the Pacific Flyway. Feral cats and red fox (*Vulpes vulpes*), both non-native species, have become a recent threat to mammalian and avian species using salt marshes and other wetlands. Saltmarsh habitat provides important foraging and drinking areas for bats such as *Myotis* species and pallid bat (*Antrozous pallidus*). Several special status wildlife species are unique to this habitat, including California clapper rail (*Rallus longirostris obsoletus*) that has been reported in Western Stege Marsh (WRA and Jane Valerius Environmental Consulting 2011a).

Eucalyptus Stands

RBC site eucalyptus stands are shown on Figure 4-8. The monarch butterfly (*Danaus plexippus*) is known to form tight aggregations during the winter months, often in eucalyptus trees, for cover and thermal regulation. Monarchs historically depended on native California trees but, due to land development, logging, and land management, have had to rely more on non-native eucalyptus trees in the last century. Potential negative impacts of eucalyptus trees on monarch butterflies are not well understood. Eucalyptus appears to offer less protection to butterflies and birds from wind and precipitation than native pines, cypress, and redwood (Stock et al. no date; Williams 2002). The eucalyptus trees provide cover and potential nesting habitat for raptors and songbirds. Because of the physical characteristics of these trees, nests are more likely to be shaken out of eucalyptus trees by the wind. Thus, eucalyptus may provide habitat for monarchs and birds, and be a sink, attracting these species to a habitat that can be harmful. Because any large tree has some potential for roosting bats, especially those with hollows or loose bark, bats could roost in these trees. The lack of understory minimizes the use of this habitat by insects and invertebrates (WRA and Jane Valerius Environmental Consulting 2011a).

Developed

There are several structures on the RBC site (Figure 4-8). Bird species that potentially use these structures include passerines (songbirds), such as barn swallow (*Hirundo rustica*) and black

phoebe (*Sayornis nigricans*), and raptors, such as barn owl (*Tyto alba*). These species have adapted to the disturbances associated with human settlements and will nest and forage near humans. In general, the nesting season for both passerines and raptors typically begins at the end of February and may last up to mid-August.

Buildings also provide bat roosting habitat. Because bats show high roost fidelity, it is possible for older structures to provide roost habitat for decades. Not all buildings available to bats provide the temperature, humidity, and other requirements for bats. As a result, not all buildings provide suitable roost habitat (WRA and Jane Valerius Environmental Consulting 2011a).

Wildlife Movement Corridors

Wildlife movement includes migration (*i.e.*, usually one way per season), inter-population movement (*i.e.*, long-term genetic flow) and small travel pathways (*i.e.*, daily movement corridors in an animal's territory) (McCullough 1996). While small travel pathways usually facilitate movement for daily home range activities such as foraging or escape from predators, they also provide connection between outlying populations and the main corridor, permitting an increase in gene flow between populations.

Overall, the RBC site provides a mosaic of habitats that are accessible to mobile wildlife species, particularly birds. The site offers foraging, nesting, and roosting habitats for many species. Movement corridors in the RBC site include the Western Stege Marsh to the south, Meeker Slough that runs along the western border and the meadows in the western portion of the site (Figure 4-8). The eucalyptus stands provide movement corridors for those species that require cover, such as wild turkey (*Meleagris gallopavo*) and California towhee (*Pipilo crissalis*). The developed habitat provides a potential area for movement for common mammalian species, such as raccoon (*Procyon lotor*), skunk (*Mephitis mephitis*), and opossum (*Didelphis virginiana*).

Wildlife

Wildlife resources at the RBC site and vicinity include invertebrates, fish, reptiles, amphibians, birds, and mammals (including bats). Developed areas provide little habitat value to most wildlife species; therefore, wildlife on the property consists of species that have adapted to the human-influenced landscape. The general lack of understory growth does not provide much habitat for insects and invertebrates and in turn, there are few reptiles (which feed upon insect prey). In general, wildlife species are not expected to be found in any consistent numbers at the RBC site and the available habitat would mainly be used for cover or resting. Small mammal species may be found on the property such as the cottontail (*Sylvilagus bachmani*), black-tailed hare (*Lepus californicus*), house mouse *(Mus musculus*), deer mouse (*Peromyscus maniculatus*), pocket gopher (*Thomomys bottae*), and squirrel species such as *Spermophilus beecheyi*. Striped skunk, and red fox (*Vulpes vulpes*) prey on the smaller mammal species.

Other species may pass through or fly over the property. Typical bird species include gulls (*Larus* spp.), swallows (*Hirundo* spp.), northern mockingbird (*Mimus polyglottos*), European starling (*Sturnus vulgaris*), American crow *(Corvus brachyrhynchos*), western meadowlark (*Sturnella neglecta*), belted kingfisher (*Ceryle alcyon*), western bluebird (*Sialia mexicana*), Saltmarsh common yellowthroat (*Geothylpis trichassinuosa*), Alameda song sparrow (*Melospiza melodia pusilla*), and the western meadowlark (*Sturnella neglecta*).

There are numerous RBC site structures that may be used by various passerine bird species, such as barn swallow and black phoebe, and raptor species, such as barn owl. These species have adapted to the human disturbance and nest and forage near humans. In general, the nesting season for passerines and raptors typically begins at the end of February and may last to mid-August.

The conclusion of the nesting season varies according to species; certain bird species can produce up to three broods each year (WRA and Jane Valerius Environmental Consulting 2011a).

The state of California considers the monarch butterfly (*Danaus plexippus*) to be restricted in its distribution, declining throughout its range, or associated with declining habitats in California. This species is well known for its long migrations. They travel between 1,200 and 2,800 miles or more from the United States and Canada to central Mexican forests where they overwinter. The mountain forests provide areas for hibernation and the less extreme climate gives them a better chance to survive. Monarchs seasonally occur in the RBC site eucalyptus stands and landscaped areas. They use the eucalyptus trees for cover and for thermal regulation during the winter months as described in the earlier Eucalyptus Stands section (WRA and Jane Valerius Environmental Consulting 2011a). Surveys of the coastal-terrace prairie grasslands for moth and butterfly species in the early 1990s found five or six species not known to occur in the East Bay previously. These species are rare in the East Bay area but not special status species.

Special-Status Species

The analysis addresses all special-status species with the potential to occur on the RBC site. For this EIR, special-status species are those that are legally protected by CDFW, USFWS, or the Migratory Bird Treaty Act (MBTA). State and federally listed species known or that have the potential to occur are listed in Table 4.3-1. Legally protected species include those that are federally listed as endangered, threatened, or candidate species; that are state listed as endangered, rare, threatened, California fully protected, or species of special concern; or that are listed in the MBTA. Protected species include those plant species listed as 1A or 1B on the California Native Plant Society (CNPS) plant list (CNDDB 2012). The 1A list is for plants presumed to be extinct in California, and the 1B list is for plants that are rare or endangered in California and elsewhere. Special-status species that have been confirmed at the RBC site or have potential to occur there (WRA and Jane Valerius Environmental Consulting 2011a) are listed in Table 4.3-1.

Birds

The RBC site vegetation communities offer perching and roosting opportunities for a variety of avian species including raptors. Many bird species, including all raptors, are protected under the MBTA. Passerine birds such as the Allen's (*Selasphorus sasin)* or Anna's hummingbird (*Calypte anna*) (also MBTA protected) may occur as they feed on the flower nectar in the developed, horticultural landscaped areas. Raptors such as the American kestrel (*Falco sparverius*), osprey (*Pandion haliaetus*), and northern harrier (*Circus cyaneus*) likely roost, forage, and nest in the eucalyptus. A variety of other bird species may nest at the RBC site, including on existing site buildings. Bird species that may nest on and in the buildings include cliff swallow (*Petrochelidon pyrrhonota*), barn swallow, black phoebe, barn owl, and American kestrel.

The marsh provides habitat for open water species, including pied-billed grebe (*Podilymbus podiceps*), double-crested cormorant (*Phalacrocorax auritus*), caspian tern (*Sterna caspia*), and a variety of duck species, all of which are protected under MBTA. The federal and state endangered California clapper rail is known to nest and forage in Western Stege Marsh and Meeker Slough. Other marsh birds with the potential to occur are the Saltmarsh common yellowthroat and the Alameda song sparrow, both protected as a California Species of Concern and under MBTA. Overall, there is moderate potential for passerines to nest in the RBC project site and for saltmarsh shorebirds to occur or possibly nest in the saltmarsh. Raptors are likely to occur in buildings and other roost sites.

Table 4.3-1
Special Status Species That Could Occur at the RBC Site

Common Name	Scientific Name	Federal/State/ CNPS Status	Habitat	Likelihood of Occurrence / Notes
Invertebrates – None. No suitable habitat present for special status insects.				
Fish – None. No suitable habitat present for special status fish.				
Amphibians				
California red-legged frog	*Rana aurora draytonii*	FT/CSC/--	Lowlands and foothills in or near permanent sources of deep water, with dense, shrubby, or emergent riparian vegetation. Requires 11-20 weeks of permanent water for larval development.	None. No suitable habitat present.
Reptiles				
Western pond turtle	*Clemmys marmorata*	--/CSC/--	Ponds, marshes, rivers, streams, and irrigation ditches with aquatic vegetation. Needs basking sites and upland habitat for egg-laying.	None. No suitable habitat present.
Alameda whipsnake	*Mastiocophis lateralis euryxanthus*	FT/ST/--	Chaparral and scrub habitats, adjacent grasslands, oak savanna and woodland habitats.	None. No suitable habitat present.
Birds				
Burrowing owl	*Athene cunicularia hypugea*	--/ST/--	Open, dry grasslands, deserts, prairies, farmland and scrublands with abundant active and abandoned mammal burrows. Prefers short grasses and moderate inclined hills.	Low: Reported adjacent to the site to the east.
Saltmarsh common yellowthroat	*Geothylpis trichas sinuosa*	--/CSC/--	Nests in fresh and salt marshes in tall grasses, tule patches and willows. Prefers thick cover for foraging and dense vegetation for nesting.	Present. Observed in Western Stege Marsh.
California black rail	*Laterallus jamaicensis coturniculus*	--/ST/--	Freshwater marshes, wet meadows, and shallow margins of saltwater marshes bordering larger bays.	Low. Suitable salt marsh habitat present. No observations.
Alameda song sparrow	*Melospiza melodia pusilla*	--/CSC/--	Found in tidal sloughs in the Salicornia marshes. Nests in Grindelia bordering slough channels.	Present. Reported from Western Stege Marsh. Habitat occurs in Western Stege Marsh.
California clapper rail	*Rallus longirostris obsoletus*	FE/SE/--	Salt water and brackish marshes in vicinity of tidal sloughs. Associated with pickleweed growth.	Present. Has been documented in Western Stege Marsh.
Black phoebe	*Sayornis nigricans*	--/--/--	Nests in manmade structures on ledges and in buildings. Nest made of mud pellets, dry grasses, weed stems, plant fibers and hair.	Present. Suitable habitat present in buildings.

Table 4.3-1
Special Status Species That Could Occur at the RBC Site

Common Name	Scientific Name	Federal/State/ CNPS Status	Habitat	Likelihood of Occurrence / Notes
Allen's hummingbird	*Selasphorus sasin*	--/--/--	Nests in wooded areas, meadows, or thickets along shaded streams, on a branch low down on stem, although placement height varies between 10 inches and 90 feet.	Moderate. Suitable habitat present in aquatic and landscaped areas.
Western meadowlark	*Sturnella neglecta*	--/--/--	Nests in grasslands removed from trees and shrubs. Nest is domed in structure.	Moderate. Suitable grassland habitat present.
Barn owl	*Tyto alba*	--/--/--	Nests in tree cavities, crevices between the fronds of palm trees or small caves in cliffs or banks and in buildings. Nests are typically 10 feet above ground.	Moderate, Suitable habitat occurs in buildings.
Mammals				
Pallid bat	*Antrozous pallidus*	--/CSC/--	Day roosts include rock outcrops, mines, caves, buildings, bridges, and hollows and cavities in a wide variety of tree species. High reliance on oak woodland habitat in many portions of its range in California.	Moderate. Potentially suitable habitat present in buildings and large trees.
California myotis	*Myotis califiornicus*	--/--/--	Roosts in caves, mine tunnels, crevices in rocks and buildings, generally near forested areas. Feeds low among trees or over shrubs.	Moderate. Potentially suitable habitat present in buildings.
Small-footed myotis	*Myotis ciliolabrum*	--/--/--	Roosts in caves, mine tunnels, crevices in rocks and buildings, generally near forested areas. Feeds around canopy, often low to the ground, higher in open habitat.	Moderate. Potentially suitable habitat present in buildings.
Long-eared myotis	*Myotis evotis*	--/--/--	Day roosts in hollow trees under exfoliating bark, and crevices in rock outcrops. Found roosting under bark of small black oaks in northern California. Found throughout California.	Low. Potentially suitable habitat present in buildings and trees.
Fringed myotis	*Myotis thysanodes*	--/--/--	Roosts in colonies in caves, cliffs and attics of old buildings. Will also use trees as day roosts.	Moderate. Potentially suitable habitat present in buildings and trees.
Yuma myotis	*Myotis yumanensis*	--/--/--	Roosts colonially in cares, tunnels and buildings. Inhabits arid regions.	Moderate. Potentially suitable habitat present in buildings.

Table 4.3-1
Special Status Species That Could Occur at the RBC Site

Common Name	Scientific Name	Federal/State/ CNPS Status	Habitat	Likelihood of Occurrence / Notes
Salt-marsh harvest mouse	*Reithrodontomys raviventris*	FE/SE/--	Prefers dense cover of native pickleweed (*Salicornia virginica*). Will use upper zone of peripheral halophytes (salt-tolerant plants) to escape the higher tides, and also move into the adjoining grasslands during the highest winter tides.	Low. Saltmarsh on-site may provide habitat.
Brazilian free-tailed bat	*Tadarida brasiliensis*	--/--/--	Roosts in large aggregations, primarily in buildings, caves, mines, and bridges. May remain in SF Bay Area during winter, active during dry/warm periods.	High. Potentially suitable habitat present in buildings.
Salt-marsh wandering shrew	*Sorex vagrans halicoetes*	--/CSC/--	Occupies tidal marshes that provide dense cover, abundant food (primarily invertebrates), suitable nesting sites, and fairly continuous ground moisture. Occupies "medium high marsh," about 6 to 8 feet above sea level, and in lower- lying marsh not regularly inundated.	Low. Saltmarsh on-site may provide habitat.
Plants				
Bent-flowered fiddleneck	*Amsinckia lunaris*	--/--/1B	Woodlands and grasslands between 50 and 500 meters elevation.	Low. No occurrences in project area. Not seen in surveys.
Pallid manzanita	*Arcostaphylos pallida*	FT/SE/1B.1	Coastal bluff scrub, cismontane woodland, valley and foothill grassland. Flowers from March to June.	Low. No occurrences in project area. Not seen in surveys.
Alkali milk-vetch	*Astragalus tener* var. *tener*	--/--/1B	Low ground, alkali flats, and flooded lands; in annual grassland, playas, or vernal pools between 1 and 170 meters elevation.	Low. Not known to occur in project area. Not seen during surveys.
Round-leaved filaree	*California macrophylla*	--/--/1B.1	Cismontane woodland, valley and foothill grassland on clay soils. Flowers from March to May.	Low. No occurrences in project area. Not seen in surveys.
Coastal bluff morning-glory	*Calystegia purprata ssp. saxicola*	--/--/1B.2	Coastal dunes, coastal scrub, North Coast coniferous forest. Flowers from May to September	Low. No occurrences in project area. Not seen in surveys.
Point Reyes bird's-beak	*Cordylanthus maritimus* ssp. *palustris*	--/--/1B	Coastal salt marsh with *Salicornia* spp., *Distichlis* spp., and *Spartina* spp. between 0 and 15 meters (49 feet) elevation.	Low. No occurrences in project area. Not seen in surveys. Believed to be extirpated in Alameda and

Table 4.3-1
Special Status Species That Could Occur at the RBC Site

Common Name	Scientific Name	Federal/State/ CNPS Status	Habitat	Likelihood of Occurrence / Notes
				Contra Costa Counties.
Fragrant fritillary	*Fritillaria liliaceae*	--/--/1B.2	Cismontane woodland, coastal prairie, coastal scrub, valley and foothill grassland. Often found in serpentine soils. Flowers from February to April.	Low. No occurrences in project area. Not seen in surveys.
Santa Cruz tarplant	*Holocarpha macradenia*	FT/SE/1B.1	Coastal prairie, coastal scrub, valley and foothill grassland, often on clay or sandy soils. Flowers from June to October.	Low. No occurrences in project area. Not seen in surveys. Believed to be extirpated in Alameda and Contra Costa Counties.
Robust monardella	*Monardella villosa ssp. globosa*	--/--/1B.2	Openings in broadleaf, upland forest and chaparral, cismontane woodland, coastal scrub, valley and foothill grassland. Flowers from June to July.	None. No suitable habitat present.
California seablite	*Suaeda californica*	FE/--/1B	Restricted to the upper intertidal zone of coastal salt marsh along the perimeter of a bay.	Low. No occurrences in project area. Not seen in previous surveys. Believed to be extirpated in Alameda and Contra Costa Counties.

Source: WRA and Jane Valerius Environmental Consulting 2011a

Federal Status
FE = Endangered. Species in danger of extinction throughout all or significant portion of its range.
FT = Threatened. Species likely to become endangered in foreseeable future throughout all or a significant portion of its range.
FPD = Proposed delisting.

California State Status
SE = Endangered. Species whose continued existence in California is jeopardized.
ST = Threatened. Species, although not presently threatened with extinction, that is likely to become endangered in the foreseeable future.
CNPS = California Native Plant Society
CSC = Species of Concern.
RBC = Richmond Bay Campus
SFP = State Fully Protected under Sections 3511 and 4700 of the Fish and Game Code.
SR = State Rare
CFP = California Fully Protected

California Native Plant Society
1A = Plants presumed extinct in California
1B = Plants that are rare or endangered in California and elsewhere.

Salt-Marsh Harvest Mouse

The salt-marsh harvest mouse (*Reithrodontomys raviventris)* is both federally and state endangered. It occurs in saltmarshes and may potentially be found in the RBC site marshland, which provides suitable habitat. It inhabits tidal and non-tidal salt and brackish marshes around the San Francisco Bay. Optimal habitat typically contains a dense mat of vegetation cover and open areas composed of pickleweed (*Sarcocornia pacifica [Salicornia virginiana*]) or other salt marsh species, such as fat hen, salt grass, annual grasses, baltic rush, and alkali heath, with no pickleweed present (WRA and Jane Valerius Environmental Consulting 2011a). This species also can move into adjoining grasslands during high winter tides. Development has removed much of the salt marsh harvest mouse habitat and few mice are considered to survive in created wetlands without peripheral halophyte (salt tolerant upland species) zone.

There is a low potential for saltmarsh harvest mouse to move into the upland habitat during high tides. This species could, but is unlikely, to occur at the RBC site. A saltmarsh harvest mouse survey in Western Stege Marsh in November 2001 found the potential for them to occur to be unlikely. Shellhammer noted that the marshes in the southeastern Richmond Shoreline area are historically new and that previous surveys at the neighboring Hoffman Marsh were also negative.

Bats

Bats use a wide variety of natural and man-made roost sites. Natural roost sites include caves, tree hollows, rock crevices, and exfoliating tree bark. Some species roost only in caves or rock crevices, others only in trees, and others are not as selective. Buildings are important for many bat species and provide significant bat roosting habitat. Bats show high roost fidelity; older structures in particular may have provided roost habitat for decades. Bats select buildings based on a variety of factors that vary by species. Selection factors may include temperature, humidity, building design, materials, location, and proximate human activity. Buildings provide day roosting opportunities in crevices and cavities that afford protection and retain heat during night-roosting hours. Bats are affected by roost disturbance; bats roosting in buildings become habituated to noise from human activity. Typically, if the protection afforded by the roost is sheltered from wind, light, or other disturbances, bats will take up residence in large numbers in structures. More than one bat species can use a structure at one time if it is large enough, and the same structure can be used differentially either daily (i.e., day or night roost), or seasonally (i.e., overwintering [hibernacula] or dispersal roost), or by reproductive status (maternity roost). Old structures provide particularly suitable roost habitat for bats due to the construction materials, design, and often open condition of the surfaces that permit easy entry and exit. Most of the RBC site's potentially occurring bat species live in California year-round and likely change roosts seasonally from hibernacula in the winter to day roosts, night roosts, and maternity roosts in the summer (WRA and Jane Valerius Environmental Consulting 2011a). Because of the variety of locations and patterns that these bats can use, bat use of buildings and trees on site cannot be ruled out for any season.

Special-status bat species with the potential to occur in the existing buildings include the Brazilian freetailed bat (*Tadarida Brasiliensis*), the most common species in the area as there is suitable building habitat on site; also the pallid bat (*Antrozous pallidus*), Townsend's big eared bat (*Corynorhinus townsendii townsendii*), California myotis (*Myotis californicus*), small footed myotis (*Myotis ciliolabrum*), fringed myotis (*Myotis thysanodes*), and Yuma myotis (*Myotis yumanensis*) (WRA and Jane Valerius Environmental Consulting 2011a).

Critical Habitat

Critical habitat is designated by the USFWS. Critical habitat is a specific geographic area determined to be essential for conservation of a threatened or endangered species and possibly requiring special management or protection. There is no critical habitat for any listed species in

or adjacent to the RBC site (WRA and Jane Valerius Environmental Consulting 2011a; USFWS 2012).

4.3.3 Regulatory Considerations

Federal

Endangered Species Act of 1973

The Endangered Species Act (ESA) (16 USC, 1531-1543) and subsequent amendments establish legal requirements for the conservation of threatened and endangered species and the ecosystems on which they depend.

ESA Section 7 requires federal agencies, in consultation with the Secretary of the Interior or the Secretary of Commerce, to ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of threatened or endangered species or to destroy or adversely modify critical habitat for these species. The USFWS and National Marine Fisheries Service share responsibilities for administering the ESA. Section 7 regulations governing interagency cooperation are in 50 CFR, Part 402. Federal agencies are required to consult with the USFWS or National Marine Fisheries Service on actions that may affect listed species. A resulting Section 7 biological opinion may include a statement authorizing a take (i.e., to harass, harm, pursue, hunt, wound, kill) that might occur incidental to an otherwise legal activity. The LRDP is not a federal action, and is not subject to Section 7 of the ESA. Individual projects implemented under the LRDP would be subject to ESA Section 7 if they were associated with a federal action; in such cases, the federal lead agency is responsible for undertaking the Section 7 process.

Section 9 of the ESA lists prohibited actions, including "take" of listed species of fish and wildlife without special exemption. Take is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct." "Harm" includes significant habitat modification or degradation that kills or injures a listed species by significantly impairing behavioral patterns, such as breeding, feeding, or sheltering. "Harass" is defined as actions that significantly disrupt a listed species' normal behavior patterns, including breeding, feeding, and sheltering.

Section 10 of the ESA provides a nonfederal applicant a mechanism to obtain incidental take authorization for federally listed threatened or endangered species.

Clean Water Act

The Clean Water Act (33 USC, 1251-1376) establishes legal requirements for restoring and maintaining the chemical, physical, and biological integrity of the nation's waters.

Section 401 requires an applicant for a federal permit to discharge into waters of the United States to first obtain state certification that the discharge would comply with other Clean Water Act provisions. The RWQCBs administer the certification program in California.

Section 404 establishes a permit program, administered by the USACE, regulating dredge or fill material discharge into waters of the US, including wetlands. Under Clean Water Act Section 404, a wetland is determined by hydric soils, hydrophytic vegetation, and wetland hydrology.

The USACE's Section 404 implementing regulations are in 33 CFR, Parts 320-330. Implementation guidelines, referred to as the Section 404(b)(1) Guidelines, were developed by the EPA and the USACE (40 CFR, Part 230). The guidelines allow the discharge of dredged or

fill material into an aquatic system only if there is no practicable alternative that would have less adverse impact.

To be protected under Sections 404 and 401 of the Clean Water Act, wetlands and other waters of the US must be one of the following:

- Traditional navigable waters;
- Wetlands next to traditional navigable waters;
- Nonnavigable tributaries of traditional navigable waters that are relatively permanent, where the tributaries typically flow year-round or have continuous flow at least seasonally (e.g., typically three months); or
- Wetlands that directly abut the tributaries described in the previous bullet (USACE 2008).

The USACE would decide jurisdiction over the following waters, based on a fact-specific analysis, to determine whether they have a significant nexus with a traditional navigable water:

- Nonnavigable tributaries that are not relatively permanent;
- Wetlands next to nonnavigable tributaries that are not relatively permanent; or
- Wetlands next to but that do not directly abut a relatively permanent nonnavigable tributary.

Migratory Bird Treaty Act

The MBTA (16 USC, 703-711) is a treaty signed by the United States, Canada, Mexico, and Japan that makes it unlawful at any time, by any means or in any manner, to pursue, hunt, take, capture, or kill migratory birds. The law applies to the removal of nests (such as swallow nests on bridges) occupied by migratory birds during the breeding season. The MBTA makes it unlawful in the United States to take these species, their nests, their eggs, or their young.

Noxious Weed Act of 1974

This act provides for the control and management of nonindigenous weeds injurious or potentially injurious to agricultural and commercial interests, wildlife resources, or the public health. Under this act, the Secretary of Agriculture has the authority to designate plants as noxious weeds and to inspect, seize, and destroy products and to quarantine areas, if necessary, to prevent the spread of such weeds.

Fish and Wildlife Conservation Act, 16 USC 2901

This Act encourages all federal departments and agencies to use their statutory and administrative authority, to the maximum extent practicable and consistent with each agency's statutory responsibilities, to conserve and promote conservation of nongame fish and wildlife and their habitats.

Executive Order 13112 – Invasive Species

Federal agencies are directed to use their authorities to prevent, detect, eradicate, and control invasive species in a cost effective and environmentally sound manner. Agencies should not authorize or fund activities that would introduce and spread invasive species in the US unless the activity benefits would clearly outweigh the harm and all feasible and prudent measures to minimize the harm would be taken.

Executive Order 13186 – Responsibilities of Federal Agencies to Protect Migratory Birds

Federal agencies whose actions are likely to negatively impact migratory bird populations are directed to develop and implement with USFWS, within two years, a memorandum of understanding that promotes migratory bird populations. To support the migratory bird conventions, federal agencies should:

- Integrate bird conservation principles, measures, and practices into agency activities;
- Avoid or minimize, to the extent practicable, adverse impacts on migratory bird resources when conducting agency actions; and
- Restore and enhance migratory bird habitat.

State

California Environmental Quality Act

CEQA (PRC. 21000 et seq.) was enacted in 1970 to fully disclose environmental impacts prior to state and local public agency discretionary action such as project approval or permit issuance. With regard to biological resources, CEQA considers other plants to be "sensitive" (or "special status"), in addition to federally or state listed species (14 CCR, Chapter 3, Article 20), Section 15280). Sensitive species include plants on the CNPS List 1A (presumed extinct), List 1B (rare, threatened, or endangered in California and elsewhere; eligible for state listing), or List 2 (rare, threatened, or endangered in California but more common elsewhere; eligible for state listing). To be conservative, CNPS List 3 (plants for which more information is needed) and List 4 (plants of limited distribution) are also considered sensitive. Sensitive wildlife species include federally or state listed species as well as CDFW-listed wildlife species of special concern.

California Endangered Species Act

The California Endangered Species Act (CESA) (Fish and Game Code 2050 et seq.) establishes the policy of the state to conserve, protect, restore, and enhance threatened or endangered species and their habitats. CESA mandates that state agencies not approve projects that would jeopardize the continued existence of threatened or endangered species if reasonable and prudent alternatives are available. There are no state agency consultation procedures under CESA. For projects that affect a species listed under both CESA and the federal ESA, compliance with the federal ESA would satisfy CESA if the CDFW were to determine that the federal incidental take authorization is consistent with CESA under Fish and Game Code Section 2080.1. For projects that would result in a take of only a state listed species, the applicant must apply for a take permit under Section 2081(b).

Native Plant Protection Act

California's Native Plant Protection Act (Fish and Game Code, 1900-1913) requires all state agencies to use their authorities to conserve endangered and rare native plants. Provisions of the Native Plant Protection Act prohibit the taking of listed plants from the wild and require a land owner to notify the CDFW at least 10 days in advance of any change in land use where the CDFW has notified the land owner of the presence of rare or endangered plants. This allows the CDFW to salvage listed plant species that would otherwise be destroyed. The applicant is required to conduct botanical inventories and consult with the CDFW, as appropriate, during project planning to comply with the provisions of this act and sections of CEQA that apply to rare or endangered plants.

Streambed Alteration Agreements, Fish and Game Code, Sections 1600-1616

Under the Fish and Game Code, CDFW jurisdiction occurs in any natural river, stream, or lake water body. The term stream, including creeks and rivers, is defined in Title 14, California Code

of Regulations (CCR), Section 1.72. An applicant is required to notify CDFW before constructing any project that would divert, obstruct, or change the natural flow, bed, channel, or bank of any river, stream, or lake. Preliminary notification and project review typically occur during the environmental process. When a fish or wildlife resource may be substantially adversely affected, CDFW is required to propose reasonable project changes to protect the resource. These modifications are formalized in a Streambed Alteration Agreement that becomes part of the plans, specifications, and bid documents for the project.

Fish and Game Code, Sections 3511, 4700, 5515, and 5050

The Fish and Game Code states that fully protected species "...may not be taken or possessed at any time and no provision of this code or any other law would be construed to authorize the issuance of permits or licenses to take any fully protected species, although take may be authorized for necessary scientific research." This "fully protected" designation was the strongest and most restrictive regarding the take of these species. In 2003, the code sections dealing with fully protected species were amended to allow the CDFW to authorize take resulting from recovery activities for state-listed species.

Fish and Game Code, Sections 3503 and 3513

Section 3503 prohibits the take and possession of any bird egg or nest, except as otherwise provided by this code or subsequent regulations. Section 3513 provides for the adoption of the MBTA's provisions. As with the MBTA, this state code offers no statutory or regulatory mechanism for obtaining an incidental take permit for the loss of nongame migratory birds. The administering agency for these sections is the CDFW.

Local

The proposed RBC site is University-owned property where work within the University's mission is performed on land owned or controlled by The Regents. As a state entity, the University is exempt under the state constitution from compliance with local land use regulations, including general plans and zoning. However, the University seeks to cooperate with local jurisdictions to reduce any physical consequences of potential land use conflicts to the extent feasible. The RBC site is in the city of Richmond. The following sections summarize objectives and policies from the City of Richmond General Plan and the Eastshore State Park General Plan as they relate to biological resources.

City of Richmond 2030 General Plan

The City of Richmond 2030 General Plan – Conservation, Natural Resources and Open Space (City of Richmond 2012) contains the following goals, policies, and actions related to biological resources:

GOAL CN1: Preserved and Restored Natural Habitat and Biodiversity. Continue to preserve and restore natural habitat and associated plants and wildlife including wetlands, baylands, riparian areas, oak woodlands and other sensitive biological resources. Take restoration efforts such as controlling invasive species, re-establishing natives, daylighting creeks and reclaiming priority conservation areas to maintaining critical habitat and biodiversity. Carefully balance natural lands, habitat and protection of multiple species with the need to accommodate development.

The following policies (more detail is available in the plan) are outlined in relation to Goal CN1:

- **Policy CN1.1 – Habitat and Biological Resources Protection and Restoration.** Natural habitat is essential to ensuring biodiversity and protecting sensitive biological resources.
- **Policy CN1.2 – Local Native Plant Species.** Promote the use of locally propagated native plant and tree species and remove and control the spread of invasive exotic plant species.
- **Policy CN1.3 – Urban Creek Restoration.** Encourage the restoration of urban creeks and coordinate with property owners and local interest groups in the restoration efforts.

The following actions (more detail is available in the plan) are outlined in relation to this Goal CN1:

- **Action CN1.A – Habitat Conservation.** Work closely with Contra Costa County, the East Bay Chapter of the CNPS, and the East Bay Regional Park district to develop habitat conservation plans.
- **Action CN1.B – Priority Conservation Areas.** The City will identify areas of the City with significant natural habitat, open space and recreation resources and promote conservation, preservation and environmental rehabilitation.
- **Action CN1.C – Creek Access Easement.** Identify and create access easements, where practical, for creek maintenance and public access to creekside amenities.
- **Action CN1.D – Creek Corridor Performance Standards.** Establish performance standards for creek corridors.
- **Action CN1.E – Habitat Restoration.** Work with other jurisdictions, public and private property owners to restore sensitive habitat that has been degraded, but has potential for rehabilitation including brownfield and contaminated sites.
- **Action CN1.F – Special Status Species Protection Methods.** Implement the special status survey methods of the CDFW, USFWS, Contra Costa County Department of Agriculture and CEQA requirements.
- **Action CN1.G – Landscape Design Guidelines.** Update and implement the City's Landscape Design and Development Guidelines to conform to bay friendly landscape standards.
- **Action CN1.H – Urban Creek Restoration.** Where feasible, restore creek corridors in urban areas. Creeks currently diverted in culverts or hardened channels should be restored to their natural state.

GOAL CN2: Conserved Open Space. Conserve open space to ensure that Richmond's expansive shoreline, network of parklands, trails, hillsides and undeveloped natural areas remain viable in supporting biological communities and providing sanctuary for future generations. Conserve open space, expand public access to open space, where appropriate, and acquire additional lands where feasible. Continue to protect surrounding hills and viewsheds as character-defining features that provide scenic backdrops and publicly accessible trails and vistas.

The following policies (more detail is available in the plan) are outlined in relation to Goal CN2:

- **Policy CN2.1 – Open Space and Conservation Areas.** Preserve open space areas along the shoreline, creeks, and in the hills to protect natural habitat and maintain the integrity of hillsides, creeks and wetlands.
- **Policy CN2.2 – Richmond Shoreline.** Conserve, protect and enhance natural and cultural resources along the Richmond shoreline.
- **Policy CN2.3 – Natural Topography and Hillside Protection.** Protect natural topography to preserve and enhance Richmond's natural beauty and require developers to concentrate residential development below the 400 foot elevation.
- **Policy CN2.4 – Agricultural Lands.** Preserve agricultural lands for sustained crop production, grazing and farming.
- **Policy CN2.5 – Access to Large-Scale Natural Areas.** Improve access to large-scale natural areas in the City including regional parks along the shoreline and in the hills.
- **Policy CN2.6 – Protect Soil and Reduce Erosion.** Minimize soil depletion and erosion. Prevent erosion caused by construction activities. Retain natural vegetation and topography and minimize grading of hillsides.
- **Policy CN2.7 – Parkland Preservation.** Maintain high quality parklands and play areas to serve current and future residents. Require new development and redevelopment projects to provide additional parkland or funding to purchase and maintain parklands.
- **Policy CN2.8 – Mineral Resources.** Preserve mineral resources in undeveloped areas that have been classified by the State Mining and Geology Board as having statewide or regional significance for possible future extraction.

The following actions (more detail is available in the plan) are outlined in relation to Goal CN2:

- **Action CN2.A – Transfer of Development Rights Program.** Develop a program that targets areas for Transfer of Development Rights (TDR) which exchange development privileges from natural areas to parts of the City with infill or redevelopment potential.
- **Action CN2.B – Open Space Easements.** Consider opportunities for establishing open space easements where natural resources may be protected or accessed on private property.
- **Action CN2.C – Parkland Dedication Ordinance.** Update the parkland dedication ordinance that requires new development and redevelopment projects to provide adequate park and recreation opportunities to maintain the 3.0 acres per 1,000 population standard in applicable planning areas through a combination of park types as defined in the Parks and Recreation Element (to be updated and refined in the parks master plan).
- **Action CN2.D – Open Space Plan.** Develop and implement an open space plan to enhance public open space in the City.

The remainder of the goals, policies, and actions in the plan that could indirectly affect biological resources include Goal CN3 – Improved Water Quality, Goal CN4 – Improved Air Quality, Goal CN5 – Environmental Sustainability, and Goal CN6 – A Healthy Urban Environment.

The 2030 General Plan EIR determined that biological resources impacts from future development pursuant to the General Plan would be less than significant. Future development would not significantly impact special status species either directly or through habitat modification. It would not significantly interfere with the movement of native resident or

migratory fish or wildlife species or have a significant adverse effect on wetlands, riparian habitat, or other sensitive natural communities. It would not conflict with any local policies or ordinances protecting biological resources. No mitigation measures would be required. Cumulative impacts would be less than significant.

Eastshore State Park General Plan

The Eastshore State Park General Plan was adopted to guide future efforts to balance recreation and conservation, protect and enhance the natural resource base, and expand opportunities for public enjoyment of the shoreline setting of the park. Policies that apply to the South Richmond shoreline portion of the state park are:

- **PI/SR-7:** Removal of invasive exotic plant species and re-vegetation with native plant species in Hoffman Marsh and along South Richmond shoreline.
- **PI/SR-8:** Coordinate with the owners of the adjacent tidal marsh, mudflat, subtidal, and upland habitat areas to ensure adequate protection of this valuable natural area.
- **PI/SR-9:** Explore the possibility of adding one or two new vista point seating areas along the Bay Trail north of Point Isabel.
- **PI/SR-10:** Incorporate interpretive panels into the vista points and other key points along the Bay Trail that explore the natural, cultural and social history of this portion of the park project.
- **PI/SR-11:** Provide fencing along the Bay Trail where necessary to protect tidal marshes, tidal mudflats, and water birds from disturbance.

4.3.4 Impacts and Mitigation Measures

Standards of Significance

The impacts on biological resources from campus development under the 2014 LRDP would be considered significant if they would exceed the following Standards of Significance, in accordance with Appendix G of the *State CEQA Guidelines* and the UC CEQA Handbook:

- Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Wildlife or US Fish and Wildlife Service;
- Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Wildlife or US Fish and Wildlife Service;
- Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means; or
- Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites;
- Conflict with any local applicable policies protecting biological resources.

CEQA Checklist Items Adequately Addressed in the Initial Study

The analysis in the Initial Study prepared for the project and circulated with the NOP concluded that further analysis of the following issue was not required in the EIR:

- Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other applicable habitat conservation plan.

The RBC site and its vicinity is not known to be subject to or designated for any adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved conservation plan. Further analysis is not required.

Analytical Methods

Methods used to evaluate biological resources impacts included CNDDB searches (CNDDB 2012), several biological reports documenting surveys and assessments conducted at the RFS, both specifically for this project and for previous projects. These include the RFS Habitat Assessment Report and RFS Constraints Analysis (WRA and Jane Valerius Environmental Consulting 2011a, 2012), the RFS Remediation Project IS (URS 2003), UC Richmond Field Station's Remnant Coastal Terrace Prairie (Amme 2005), the RFS Grasslands constraints Analysis (WRA and Jane Valerius Environmental Consulting 2013), and Richmond Field Station Remediation Project Biological Assessment Report (Blasland, Bouck, and Lee, Inc. 2003). Methods included consultation with experts on California grasslands at UC Berkeley. Tetra Tech conducted a general biological survey (Tetra Tech 2013a) in January 2013. This survey assessed the current conditions of the southeastern portion of the RBC site existing habitats, and included identification of potential wetland areas. Tetra Tech conducted a wetland delineation survey in February 2013 to identify potential wetland boundaries in the same area (Tetra Tech 2013b).

RBC 2014 LRDP Policies

The RBC 2014 LRDP policies related to biological resources include the following:

- LU1 – Land Use Policy on Development Capacity: Provide for development of up to 5,400,000 square feet of facilities.
    - Maximize density to reduce overall building footprints, conserve open space, and share attractive views.
- OSL1 – Open Space and Landscape Policy on Primacy of Landscape: The landscape of the Richmond Bay Campus, its unique location at the edge of San Francisco Bay, and the coastal prairie grasslands will be protected and featured in the daily experience of the campus.
    - Feature ornamental landscaping at the public realm and entry points to create a more welcoming and vibrant campus; the palette will be selected for non-invasives and with sensitivity to protection of natural open spaces.
    - Implement feasible means to effectively remove and stop the spread of invasive species from sensitive marsh and grasslands.
    - Establish buffers, setbacks, and procedures to review new plantings to protect and enhance coastal plant communities and wildlife habitat on the site.
    - Provide visual connections to the bay, surrounding hills, and natural features of the site and incorporate interpretive elements, public art, and signs into the open space areas to create educational opportunities.

    - Refer to the site's natural features and employ ecologically-sensitive native plantings in the site's landscape design.

- OSL3 – Open Space and Landscape Policy on Sustainability: New landscapes will be consistent with "Bay-friendly" design.
    - Design landscaping that does not rely on irrigation from potable water after an initial establishment period. Specify native species where practical and foster biodiversity which supports and enhances local ecosystems. Coordinate landscape design and maintenance efforts with the surrounding community where possible.
- S9 – Sustainability Policy on Health and Wellness: Richmond Bay Campus development will promote health and wellness of the community, including employees, visitors, and ecosystems associated with the site.
    - Provide walkways with signs interpreting the ecological value of the grassland and marsh areas.

LRDP Impacts and Mitigation Measures

LRDP Impact BIO-1: Development under the 2014 LRDP would not have a substantial adverse effect on special-status plant species. *(Less than Significant)*

The RBC site includes natural areas such as the Western Stege Marsh and coastal grasslands (Figure 4-8). While these areas provide potential habitat for some special-status plant species (Table 4.3-1), no special-status plants have been observed in these habitats during site surveys.

As shown in Figure 4-8, the proposed 2014 LRDP designates approximately 25 acres of the RBC site as Natural Open Space. This designation encompasses those areas the University plans to protect from development and restore and/or maintain in their natural condition. Disturbance of these natural areas would be limited under the LRDP. Minor disturbance from maintenance, research, and educational activities would be expected on occasion. Improvements in these zones would be limited to minor access roads for maintenance vehicles and interpretive boardwalks or pathways, consistent with conservation goals.

Because no special-status plant species have been documented on the site during extensive botanical surveys (Amme 1993, Lidicker et al. 2003, URS 2007, WRA and Jane Valerius Environmental Consulting 2011a) or by the CNDDB, it is unlikely that protected species are present. Because the areas with the most suitable habitat for special-status plant species would be protected from development and no special-status species have been documented, impacts on special-status plant species are not likely to occur from LRDP implementation. Effects on sensitive natural communities are described under LRDP Impact BIO-5.

Mitigation Measure: No mitigation measure is required.

LRDP Impact BIO-2: Development under the 2014 LRDP could adversely affect special-status bird species protected under the MBTA, ESA, and/or CESA and result in nest abandonment and reproductive failure. ***(Potentially Significant; Less than Significant with Mitigation)***

The RBC site includes natural areas such as the Western Stege Marsh and coastal grasslands and numerous older, wooden buildings that could be nesting or roosting sites for various bird species (Figure 4-8). These areas provide potential nesting habitat for special-status bird species (Table 4.3-1). There is a high potential for nesting passerines, protected by the MBTA, to occur in multiple RBC site habitats. These include saltmarsh common yellowthroat and Alameda song sparrow in Western Stege Marsh; black phoebe on man-made structures; and western meadowlark in grasslands. California clapper rail, listed as endangered under the ESA and CESA, has been documented in Western Stege Marsh. Burrowing owl and California black rail, state threatened species, have not been documented on-site, but the site does contain potential owl (grasslands) and clapper rail (marsh) habitat. Raptors, protected by the MBTA and California Code Sections 3503 and 3503.5, are likely present as described in Section 4.3.2.

Because the RBC site provides suitable nesting habitat for MBTA, ESA, and/or CESA-protected birds, loud noise within 100 feet of nests during the nesting period (approximately March 1 through August 15) could result in nest abandonment and "take" of young. Such noise could be from building demolition and construction, site preparation, utilities rerouting, and tree removal during construction.

The construction footprint would be outside of clapper rail habitat and thus minimize potential noise impacts. Nevertheless, noise and other human disturbance—especially related to construction and demolition activities—near the marsh could affect avian use and result in flushing, avoidance, or nest abandonment.

The projected campus population increase from 300 to 10,000 by 2050 could cause indirect impacts on nesting birds. This population increase would have the potential to result in long-term adverse impacts on special status species birds from operations. More people on the site would increase the probability of humans and pets walking into or near sensitive habitats such as Western Stege Marsh, which could alter bird behavior. Although not likely, disturbance of nesting birds, including the endangered California clapper rail, could decrease reproductive success. Also indirect disturbance from nearby operational noise sources could occur. Because campus facilities would not be located within the Natural Open Space areas, there are not likely to be direct effects on Western Stege Marsh.

Implementing LRDP MM BIO-2 would reduce potential impacts on special-status birds from construction and operations to less than significant.

LRDP MM BIO-2: Where practical, avoid construction, demolition, or renovation activities in areas adjacent or nearby to marshland nesting bird habitat during the nesting season (March 1 – August 31).

If construction, demolition, or renovation were proposed to occur in areas adjacent or nearby to marshland nesting habitat during the nesting season, a nesting bird survey shall be performed by a qualified biologist up to approximately 7 days prior to work commencing, up to 100 feet beyond the project boundary. If no birds or evidence of birds are found, no further action is required, provided work commences within approximately 1 week of the

survey to prevent "take" of individual birds that may have begun nesting after the survey.

If active nests or young are observed during the pre-construction surveys, construction, demolition, or renovation in the affected project area shall not commence within 100 feet of the occupied nest until after the young have fledged.

Engage in ESA Section 7 consultation (formal or informal, as appropriate) with the USFWS for implementation level LRDP components if those components constitute a federal action (approvals or funding) to address any potential impacts on California clapper rail. Develop appropriate measures with USFWS and implement them.

Establish a 150-foot-wide temporary "no disturbance" buffer around the wetland/upland boundary of Western Stege Marsh/Meeker Slough when construction occurs during the breeding season (mid-March to July). This buffer would protect and buffer potential California clapper rail habitat and nesting areas during construction by prohibiting entry into this area.

Post interpretative California clapper rail signs in and near Western Stege Marsh/Meeker Slough. Signs should include seasonal use restrictions (e.g., stay on designated trails, pets on leash), to reduce disturbance potential during construction and operations.

LRDP Impact BIO-3: **During the bat breeding season, tree and building removal and other construction activity associated with development under the proposed 2014 LRDP could result in a substantial adverse effect on bats.** ***(Potentially Significant; Less than Significant with Mitigation)***

Several bat species may occur at the RBC site (Table 4.3-1). Brazilian free-tailed bat is the most likely to occur. No bat species federally or state-listed as threatened or endangered are likely to occur. One species, pallid bat, is a California species of concern. Bats may inhabit abandoned RBC buildings or exfoliating tree bark crevices or hollow tree cavities. This would most likely occur in the site's perimeter areas. Tree and building removal could result in direct bat mortality. Construction noise and human disturbance could cause maternity roost abandonment and subsequent death of young. With implementation of LRDP MM BIO-3, the proposed project would not result in a substantial adverse effect on bats, and the effect would be reduced to less than significant. This measure would apply to all project sites containing trees and buildings suitable for bat roosts.

LRDP MM BIO-3: 2014 LRDP implementation projects shall avoid disturbance to special-status bats' maternity roosts during the breeding season in accordance with the following procedures for Pre-Construction Special-Status Bat Surveys and Subsequent Actions. No more than 2 weeks prior to commencement of any concrete breaking or similarly noisy construction/demolition activity during the breeding season (March 1 through August 31), a qualified bat biologist shall conduct pre-demolition surveys of all potential special-status bat breeding habitat in the disturbance vicinity. Depending on the survey findings,

the following actions shall be taken to avoid potential adverse effects on breeding special-status bats:

1. If active roosts are identified during pre-construction surveys, a no-disturbance buffer shall be created by the qualified bat biologist, in consultation with the CDFW, around active roosts during the breeding season. The size of the buffer shall take into account factors such as:
    a. Noise and human disturbance levels at the project site and the roost site at the time of the survey and the noise and disturbance expected during the construction,
    b. Distance and amount of vegetation or other screening between the project site and the roost, and
    c. Sensitivity of individual nesting species and the behaviors of the bats.
2. If pre-construction surveys indicate that no roosts of special-status bats are present, or that roosts are inactive or potential habitat is unoccupied, no further mitigation is required.
3. Pre-construction surveys are not required for demolition or construction scheduled to occur during the non-breeding season (September 1 through February 28).
4. Noisy demolition or construction as described above (or activities producing similar substantial increases in noise and activity levels in the vicinity) commencing during the non-breeding season and continuing into the breeding season do not require surveys (as it is assumed that any bats taking up roosts would be acclimated to project-related activities already under way). However, if trees are to be removed during the breeding season, the trees shall be surveyed for roosts prior to their removal, according to the survey and protective action guidelines 1a through 1c, above.
5. Bat roosts initiated during demolition or construction are presumed to be unaffected by the activity and a buffer is not necessary.
6. Destruction of roosts of special-status bats and overt interference with roosting activities of special-status bats shall be prohibited.
7. The noise control procedures for maximum noise, equipment, and operations identified in Section 4.10, Noise, shall be implemented.

LRDP Impact BIO-4: Development under the 2014 LRDP would not have a substantial adverse effect on monarch butterfly. *(Less than Significant)*

The monarch butterfly is not listed as threatened or endangered under either the ESA or CESA, but it is considered by the state of California to be either restricted in its distribution, declining throughout its range, or associated with declining habitats in California. This butterfly has been documented at the RBC site and occupies the eucalyptus stands and the developed, horticultural landscaped areas (Figure 4-8). This species uses the eucalyptus trees during the winter months

for cover and thermal regulation. Eucalyptus tree removal would reduce the available habitat for monarch butterflies. As described earlier (Section 4.3.3, Eucalyptus Stands subsection), eucalyptus creates habitat that attracts monarchs, but that habitat may act as a "sink" - attracting monarchs to a habitat that can be harmful to the species. Therefore, eucalyptus removal would have a mixed effect that is neither exclusively adverse nor beneficial. The LRDP's impacts on the monarch butterfly would not be considered substantial adverse effects on the monarch butterfly because it is not a special-status species. LRDP ENVIRONMENTAL PROTECTION PRACTICE BIO-4 could be implemented to further reduce the magnitude of these effects.

LRDP ENVIRONMENTAL PROTECTION PRACTICE BIO-4:

The University could develop and implement a successional tree planting plan that would maintain the availability of monarch butterfly wintering habitat at the RBC site.

Mitigation Measure: No mitigation measure is required.

LRDP Impact BIO-5: Development under the 2014 LRDP could have a substantial adverse effect on sensitive natural communities. ***(Potentially Significant; Less than Significant with Mitigation)***

Campus development under the 2014 LRDP could have adverse effects on the RBC site coastal-terrace prairie grassland habitat. Construction and operational activities and a campus population increase would potentially increase risk of adverse impacts on the high quality grasslands. Direct impacts, such as soil compaction, could occur from people driving vehicles through the grasslands. Indirect impacts include increased potential weed intrusion due to construction-related soil perturbation and unintentional seed distribution from the increased numbers of people and vehicles. This potential effect is addressed below.

There are 22 acres of high quality grassland habitat, considered a sensitive natural community, at the RBC site. These are within the Big Meadow, Northwest Meadow, West Meadow, and EPA Meadow North (WRA and Jane Valerius Environmental Consulting 2013). In 15 of the 22 high quality grassland acres, comprising the majority of the area within the Big, West, and EPA North Meadows, direct impacts from the LRDP would be minimal, as these acres would be part of the 25-acre Natural Open Space area. The purpose of this open space would be to retain these resources in their natural condition. The activities that would occur in protected coastal terrace prairie grassland habitat would be limited to maintenance, field research, and education. Improvements in this zone would be limited to minor access roads and structures, and boardwalks or pathways to facilitate maintenance, field research, and education. There would be a buffer between grasslands and new buildings (see Figures 3-3 and 3-4).

As noted, the LRDP designates 15 of 22 high quality grassland acres as part of the 25.2-acre Natural Open Space. Approximately seven acres of high quality grassland, including the Northwest Meadow and outside edges of the Big Meadow, would be within the Research, Education and Support Area as indicated on Figure 4-8. The Northwest Meadow is newly identified as "high quality" as the result of a recent study (WRA and Jane Valerius Environmental Consulting 2013). This study found that, "Only four of the seven listed plant species were Rank A or B so this area did not meet the URS criteria for defining high quality grassland habitat. However, since 2007 the presence of California oatgrass and purple needlegrass has increased in this area making it a high quality grassland habitat based on the membership rules as defined by the Manual of California Vegetation (Sawyer et al. 2009)." The Northwest Meadow and the additional high quality grassland habitat acreage within the Research, Education and Support area may be developed as defined in the LRDP for the Research, Education and Support land use

designation. Campus researchers have noted that the coastal terrace prairie on the RFS site is today threatened by invasives (Sousa and Suding 2013). Invasive plants and Harding grass in particular have been spreading rapidly. In 1984 exotic annuals comprised 22 percent of the standing crop, and a 2007 report concluded that Harding grass covered over 40 percent of the grassland (RFS 2012 Restoration Report, ESPM 187). Implementation of the 2014 LRDP and the mitigation measures below would result in a net benefit to the quality and continuing preservation of the sensitive natural coastal terrace prairie community at the project site, over existing conditions.

LRDP ENVIRONMENTAL PROTECTION PRACTICE BIO-5

Currently, and continuing if the LRDP is adopted, the University would mow open space areas consistent with the 2008 report, Richmond Field Station Remediation and Restoration Project Habitat Restoration Progress Report 2003 – 2007, Appendix 2 "Guidelines for Mowing Harding Grass Within and Adjacent to Coastal Terrace Prairie Habitat at the University of California, Richmond Field Station."

With implementation of the LRDP, including the mitigation measures described below, indirect impacts from individual construction projects and operations on high quality grasslands would be less than significant. Direct impacts on high quality grasslands would also be less than significant.

LRDP MM BIO-5: Mitigation for LRDP-related impacts on grasslands will expand as the campus grows.

a) Any project proposed under the LRDP, whether in or outside of the Natural Open Space area, shall include a construction and operation management plan to minimize the threat of weeds to these grasslands.

b) As initial projects under the LRDP are implemented, proactive (not passive) measures to improve the quality of the native grasslands in the Natural Open Space area shall be funded and undertaken. This may take the form of support for research and education into effective restoration. Possible fund sources include the UC Berkeley Capital Renewal Program, which assesses a four percent fee on all capital budgets (UC Berkeley 2013).

c) Once a project that may alter high quality grassland within the Natural Open Space land use zone for minor access roads or structures or to construct boardwalks is proposed, the University shall prepare a grassland management plan to guide conservation and enhancement efforts, as well as the siting of boardwalks and minor access roads and structures in a resource-sensitive manner. The plan shall include weed management actions, annual monitoring and reporting, and adaptive management sufficient to maintain or improve the quality of the grasslands preserved in the designated Natural Open Space. The effectiveness of the plan shall be continually evaluated and the plan adjusted as needed.

d) Prior to any action to develop the Northwest Meadow or to develop other designated high quality grasslands outside of the Natural Open Space land use zone, the University shall plan and

implement a program to use the native plant stock from such area to aid enhancement and restoration in Natural Open Space grassland areas not currently designated high quality, and to develop or restore meadow acreage elsewhere. Possible locations include formal landscaped open areas of the RBC, roof tops of buildings at the RBC, demonstration meadows at UC Berkeley or in the city of Richmond that help explain the former extent of regional coastal terrace prairie grasslands.

LRDP Impact BIO-6: Development under the 2014 LRDP could have a substantial adverse effect on federally protected wetlands. ***(Potentially Significant; Less than Significant with Mitigation)***

Campus development under the 2014 LRDP could result in adverse impacts on potentially jurisdictional RBC site waters, including drainages and wetlands (Figure 4-8). Wetlands and potential wetlands are described in Section 4.3.2. Most development projected under the 2014 LRDP would have no potential to impact jurisdictional waters. However, some specific development could fill in or create a potential for accidental discharges to jurisdictional waters. Any campus development project resulting in permanent or temporary fill of jurisdictional waters would most likely be subject to provisions of Sections 401 and 404 of the Clean Water Act, Sections 1600 through 1616 of the California Fish and Game Code, and the Porter Cologne Act. Such projects may qualify for a nationwide permit (NWP) issued by the USACE. The most likely applicable NWP for RBC projects would be NWP 39, *Residential, Commercial, and Institutional Developments*. Although nationwide permit specifications vary, NWP 39 typically applies where jurisdictional waters are less than 0.5 acre in area and no more than 300 linear feet of intermittent or perennial stream are to be filled. Even if these limitations are met, the USACE has discretion under certain circumstances to require a more stringent individual permit.

Any project requiring USACE authorization also must obtain a Section 401 RWQCB certification or waiver of certification. These must be obtained prior to project implementation and would stipulate approval conditions designed to minimize adverse effects on wetland resources. Acquisition of these permits is a regulatory requirement and is not considered mitigation for loss of waters of the US. However, the processes for obtaining any state or federal wetlands permits involve the development of compensatory actions similar to CEQA-derived mitigation in scope and intent. In addition to the acquisition of necessary permits, implementation of the mitigation measure LRDP MM BIO-6 would reduce potential impacts on jurisdictional waters to less than significant levels.

With respect to other wetlands within or near the RBC site, including the Western Stege Marsh and Meeker Slough, no development is planned in the marsh or the slough, so there would be no direct impacts. Indirect impacts on wetlands in these areas would be minimized with measures described in LRDP MM BIO-6.

LRDP MM BIO-6: **BIO-6a:** 2014 LRDP development projects shall avoid, to the extent feasible, the filling of or discharging to potentially jurisdictional waters. Therefore, during the design phase of any future development project that may affect potentially jurisdictional waters, a preliminary evaluation of the project site shall be made by a qualified biologist to determine if the site is proximate to potentially jurisdictional waters and, if deemed necessary by the biologist, a wetlands delineation shall be prepared and submitted to the USACE for verification.

Because the USACE's preferred mitigation for impacts to jurisdictional waters is avoidance, 2014 LRDP development shall be located to avoid the filling of or discharging to jurisdictional waters to the extent practicable.

BIO-6b: Any unavoidable loss of jurisdictional waters shall be compensated for through the development and implementation of a project-specific wetland mitigation plan.

If a 2014 LRDP development project were to potentially impact jurisdictional waters, impact compensation would be based on the USACE-verified wetlands delineation identified in Mitigation Measure BIO-6a. During the permit application process for specific development projects that would impact jurisdictional waters, the University would consult with the USACE, CDFW, and San Francisco Bay RWQCB. The consultation would be to identify the most appropriate assessment and mitigation methods to adequately address losses to wetland function that could occur from the development projects. A project-specific wetland mitigation plan would be developed prior to project implementation and submitted to permitting agencies for their approval. The plan may include on-site or off-site restoration or creation or purchasing of credits from a wetland mitigation bank.

All mitigation work proposed in existing wetlands on- or off-site shall be authorized by applicable permits.

BIO-6c: To the extent feasible, construction projects that might affect jurisdictional drainages or wetlands shall be scheduled for dry-weather months. Avoiding ground-disturbing activities during the rainy season would further decrease the potential risk of construction-related discharges to jurisdictional waters.

LRDP Impact BIO-7: Development under the 2014 LRDP would not have a substantial adverse effect on fish and wildlife movement, migratory corridors, or nursery sites. (*Less than Significant*)

The primary RBC site wildlife movement corridors are the Western Stege Marsh to the south, Meeker Slough along the western border, and the grassy meadows on the western portion of the site (Figure 4-8). The eucalyptus stands also provide movement corridors for those species that require more cover, such as wild turkey, brown towhee, and raccoon. The existing developed areas provide less cover and fewer foraging opportunities, so they have limited value as wildlife movement corridors. Common species that frequent human-altered landscapes, such as raccoons, skunks, opossums, and some songbird species, may move through these areas.

In the short-term, wildlife movement at the RBC site, may be affected by noise, dust, and the presence of people and machinery during construction. Most of these types of impacts would occur in the site's already developed areas and would affect species that are the least sensitive to human activity, such as raccoons, skunks, opossums, and some common songbird species. These effects would primarily be changes in movement patterns. Birds might flush due to noises and movements and temporarily avoid using the area.

More sensitive species and habitats occur in the marsh and slough and in the high quality coastal-terrace grasslands that are outside the development footprint, and in areas that would be designated as Natural Open Space. Thus, in the short-term, these areas would not be directly affected during construction. Noise, dust, and movement associated with construction activities adjacent to the Natural Open Space, could have minor short-term effects by altering behavior during construction.

In the long-term, there would be minor adverse effects on wildlife movement corridors due to the presence of additional people and vehicles on the RBC site. Common wildlife species that frequent human-altered habitats would continue to use the developed portions of the site for movement, potentially in fewer numbers due to increased density of buildings. Wildlife movement through the grasslands and marsh that would be part of the Natural Open Space would continue. The frequency of wildlife being disturbed from human presence in these areas would likely increase slightly due to more people being present. Measures described previously, including lighting aimed away from Natural Open Space and interpretative signs, would help minimize disturbance of wildlife movements.

Effects on wildlife movement at the RBC site would not be substantial because the primary corridors would remain intact, although narrowed due to the potential development of the Northwest Meadow, and be protected via the Natural Open Space designation. Most of the construction and activity from operations would occur in areas that would primarily affect species adapted to human landscapes. For these reasons, impacts on wildlife movement would be less than significant.

Mitigation Measure: No mitigation measure is required.

LRDP Impact BIO-8: Development under the 2014 LRDP would not conflict with any local applicable policies protecting biological resources. (*Less than Significant*)

2014 LRDP campus development projects would not conflict with Richmond 2030 General Plan policies related to biological resources protection. While not specifically implementing these General Plan measures, the LRDP is consistent with GOAL CN1: Preserved and Restored Natural Habitat and Biodiversity and the following policies and actions:

- Policy CN1.1 – Habitat and Biological Resources Protection and Restoration. Natural habitat is essential to ensuring biodiversity and protecting sensitive biological resources.
- Policy CN1.2 – Local Native Plant Species. Promote the use of locally propagated native plant and tree species and remove and control the spread of invasive exotic plant species.
- Action CN1.B – Priority Conservation Areas. The City will identify areas of the City with significant natural habitat, open space and recreation resources and promote conservation, preservation and environmental rehabilitation.

The LRDP is also consistent with Richmond 2030 General Plan GOAL CN2: Conserved Open Space and the following policy:

- Policy CN2.1 – Open Space and Conservation Areas. Preserve open space areas along the shoreline, creeks, and in the hills to protect natural habitat and maintain the integrity of hillsides, creeks and wetlands.

The impact would be less than significant.

Mitigation Measure: No mitigation measure is required.

Cumulative Impacts and Mitigation Measures

LRDP Cumulative Impact BIO-1: Development under the 2014 LRDP together with cumulative development in the region would not result in significant cumulative impacts on biological resources. (*Less than Significant*)

This section evaluates whether development under the 2014 LRDP, in combination with other past, present, and reasonably foreseeable future LBNL, UC Berkeley, and non-UC projects, would result in significant cumulative biological resources impacts. In addition, this analysis includes cumulative growth impacts potentially resulting from City of Richmond General Plan 2030 implementation. Future plans and projects include the South Shoreline Specific Plan, Bio Rad Laboratories Office/R&D Lab Upgrade Project, Marina Bay Ferry Terminal, Marina Bay/Trails Landscaping, Officer Bradley A. Moody Memorial Underpass, Fort Building Rehabilitation Project, and the Terminal One Development Project.

The cumulative setting, or region of influence, for biological resource analysis, includes the 134-acre RBC site and the City of Richmond Southern Shoreline Planning Area.

This analysis evaluates whether the proposed LRDP impacts, together with cumulative development impacts, would be significant (based on the significance criteria at the beginning of the biological resources section). For any significant cumulative impacts identified, the analysis assesses whether the LRDP contribution would be considerable. Both conditions—significant cumulative impact and considerable LRDP contribution—must apply for the project's cumulative impacts to be considered significant (Title 14, CCR, Article 5, Section 15064).

Development of projects under the 2014 LRDP and Richmond 2030 General Plan residential development in the region of influence outlined above would collectively reduce open space and available habitat for both common and special-status wildlife and plants. However, open space currently comprises a large portion of the region of influence. Future projects would combine new development with some created open space. Most of the RBC site's ecologically sensitive habitats would be retained and protected as open space. Loss of any high quality grassland areas under the LRDP would represent a loss of a sensitive community; however, loss of the community is occurring with existing passive management strategies and may be inevitable without proactive management techniques.

Cumulative effects of development on biological resources are measured largely against the extent to which those resources are protected in plans and during specific project implementation. The City of Richmond 2030 General Plan and other plans listed above (not including the LRDP), contain policies and guidelines for protecting natural resources, including special-status species, sensitive natural communities, and jurisdictional waters. Development would be subject to federal, state, and local laws that require avoiding and minimizing impacts to special-status species, sensitive natural communities, jurisdictional waters, and wildlife migratory corridors and nurseries through a variety of means including resource-specific management planning and mitigation requirements. Mitigation measures and BMPs applied to specific projects would minimize the potential for substantial adverse impacts on biological resources from other projects. Therefore, cumulative impacts on biological resources resulting from the proposed LRDP and the other projects considered in this section would be less than significant.

4.3.5 References

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4.4 CULTURAL RESOURCES

4.4.1 Introduction

This section presents information on known and potentially existing cultural resources at the RBC site and analyzes the potential for development under the proposed 2014 LRDP to affect those resources. Information and analysis in this section is based on previous archaeological surveys (see Section 4.4.5) and those conducted for the current project: *Cultural Resources Inventory Report for the Richmond Bay Campus, Alameda County* (GANDA 2013) and *Historic Properties Survey Report for Richmond Bay Campus* (Tetra Tech 2013).

Cultural resources can be prehistoric, Native American, or historic. Prehistoric resources are artifacts from human activities that predate written records; these are generally identified in isolated finds or sites. Prehistoric resources are typically archaeological and can include village sites, temporary camps, lithic scatters, roasting pits/hearths, milling features, petroglyphs, rock features, and burial plots.

Historic resources are properties, structures, or built items from human activities that coincide with the epoch of written records. Historic resources can include archaeological remains and architectural structures. Historic archaeological sites include townsites, homesteads, agricultural or ranching features, mining-related features, refuse concentrations, and features or artifacts associated with early military and industrial land uses. Historic architectural resources can include houses, cabins, barns, lighthouses, other constructed buildings, and bridges. Generally, architectural resources that are over 50 years old are considered for evaluation for their historic significance.

Public and agency NOP comments related to cultural resources are summarized below:

- For construction activities proposed in a state right-of-way, Caltrans requires that project environmental documentation include results of a current Northwest Information Center archaeological records search.
- A private individual proposes that the Berkeley and Albany waterfront, grouped together, is eligible for inclusion in the National Register of Historic Places (NRHP) under 36 CFR 800.16 as a Cultural Landscape under the federal criteria for listing.

4.4.2 Environmental Setting

Archaeological

Prehistoric Context

Archaeological investigations in Central California and elsewhere seek to explain past human behavior, cultural continuity, and change. Archaeological interpretation of material remains can address many aspects of human behavior, including when and at what time of year people occupied an area; the technological and natural resources available; social organization; settlement patterns; trade, competition, and conflict relationships with neighboring groups; ceremonial systems; and external environmental issues affecting indigenous populations. Current archaeological research seeks to answer a wide array of questions regarding prehistoric human culture and adaptive responses.

Archaeological research throughout the Central Valley and Central California regions has resulted in the documentation of numerous prehistoric habitation sites. These early archaeological sites were typically near the shoreline of lakes, marshes, creeks, and rivers. Archaeologists now

recognize three general patterns of cultural adaptation throughout the Central Valley Region based on artifact assemblages and mortuary practices during the period between 5,000 Before Present (BP)[10] and 200 BP. The three primary time periods are the Early Period (5000–2500 BP), the Middle Period (2500–1300 BP), and the Late Period (1300–200 BP or contact). Fredrickson (1973, 1974, and 1994) delineated distinct time-period divisions based on general economic, technological, and mortuary traits. He introduced three cultural patterns, the Windmiller, Berkeley, and Augustine Patterns, and he correlated them respectively to the Early, Middle, and Late horizons of the California Central Taxonomic System (Rosenthal et al. in Jones and Klar 2007:154). A brief description of each:

The Early Period/Windmiller Pattern (5000–2500 BP) is divided into the Early, Middle, and Late Windmiller, named for the Windmiller Pattern first identified in the Sacramento–San Joaquin Delta as the oldest archaeological complex (Lillard et al. 1939). The Windmiller Pattern is thought to be composed of a mixed economy of game procurement and the use of wild plant foods. The archaeological assemblages of this period contain numerous projectile points, with large obsidian concave base and stemmed points; rectangular *Olivella* beads; and a wide range of faunal remains (Erlandson and Jones eds. 2002). The Windmiller Pattern reflects a seasonal adaptation in which valley sites were occupied during the winter months and foothill camps were inhabited in the summer (Rosenthal et. al. in Jones and Klar 2007:154; Moratto 1984:201-207).

The Middle Period/Berkeley Pattern (2500-1300 BP) shifted to a more specialized adaptation called the Berkeley Pattern that spanned approximately 1,200 years. Fredrickson (1974) defined the Berkeley Pattern based on the economic adaptive strategies developed around the area's extensive and rich resources. Deeply stratified midden deposits, developed over generations of occupation, are common to Berkeley Pattern sites exemplified by the Emeryville Shellmound (CA-ALA-309) southwest of the project area on the east shore of the San Francisco Bay. These middens contain numerous milling and grinding stones for food preparation. Early representations of the Berkeley Pattern resemble the Windmiller Pattern but shift to larger occupation sites near water sources with the presence of projectile points and atlatls (Rosenthal et. al. in Jones and Klar 2007:156; Hughes 1994; Moratto 1984:207-211).

The Late Period/Augustine Pattern (1300 BP–contact) followed the Berkeley Pattern. The Augustine Pattern exhibits elaborate ceremonial and social organization and the development of social stratification. Exchange became well developed. A more intensive emphasis was placed on acorn usage, as evidenced by the archaeological record of shaped mortars and pestles and numerous hopper mortars. Other Augustine Pattern traits include the introduction of pre-interment burning of offerings in a grave pit during mortuary rituals, increased village sedentism, population growth, and an incipient monetary economy in which beads were used as a standard of exchange (Rosenthal et. al. in Jones and Klar 2007:157; Moratto 1984:211-214).

Ethnographic Context

The project site is in the area ethnographically attributed to the Ohlone (also known as Costanoan). The term "Costanoan" derives from the Spanish word Costaños or "coast people." It refers to an ethno-linguistically distinct people who lived along the San Francisco peninsula before contact with European Americans. Ethnographic and ethnohistoric information about the Ohlone derives primarily from the accounts of early explorers and missionaries. The territory of

[10] "Before Present (BP)" is a dating metric often used in archaeology, geology, and other scientific disciplines. Past events are measured counting back a specified number of years from the originating date of January 1, 1950. So, for example, the Central Valley Region Early Period of 5,000—2500 BP correlates to 2,500—550 BC under the Gregorian or Western calendar system.

the Ohlone is purported to have extended from the Central Coast Ranges between San Pablo Bay in the north to Monterey in the south. The Ohlone tribal territory eastern boundary is not precisely known but is understood to extend to the Mount Diablo Range (Kroeber 1925:462; Moratto 1984:225).

The Ohlone language is one of the eight major linguistic subdivisions of Miwok-Costanoan, which belonged to the Utian family in the Penutian language family (Shipley 1978:82-84). Linguistic evidence suggests that the Ohlone entered the San Francisco and Monterey Bay areas about 1,500 BP (Levy 1978:486). The Ohlone were politically organized by tribelets, each having a designated territory. A tribelet consisted of one or more villages and camps in a physiographically defined territory. Tribelets generally had 200 to 250 members (Levy 1978:485; Margolin 1978:1). Each tribelet consisted of villages every three to five miles (as noted by early Spanish explorers) that contained an average of 60 to 90 persons (Milliken 1995:19). The project site is in the *Huchiun* triblet ethnographic territory, where *Chochenyo*/*East Bay Costanoan* was the common spoken language (Levy 1978:485; Margolin 1978:2).

The acorn was among the most important food resources for Ohlone, who preferred the area's abundant tanbark oak, valley oak, and California black oak. The large oak tree stands created a readily accessible staple. These could be stored in granaries and used through the winter months. Acorns were ground into meal and leached to remove tannins. Other important food resources were buckeye nuts, leached and made into a mush, and the seeds of dock, gray pine, and tarweed, all of which were roasted in baskets with hot coals before being eaten. The Ohlone gathered berries and fruits including gooseberries, blackberries, madrone, and wild grapes along with root resources such as wild onion, cattail, and wild carrot (Levy 1978:491).

Shellfish and marine mammals were important Ohlone dietary resources, particularly for coastal populations. Shellmound midden throughout the Bay Area attest to the importance of shellfish in the Ohlone diet. The Emeryville Shellmound (CA-ALA-309; documented by Nels Nelson in 1909), once a complex of mounds, is approximately 2.5 miles southwest of the project site on the San Francisco Bay eastern shoreline. Terrestrial mammals, including rabbits, black-tailed deer, Tule elk, and pronghorn sheep, were important to coastal and inland Ohlone populations. These were hunted and trapped using drive and snare methods. Hunting parties were communal, often bulk harvesting meat for immediate consumption or for winter storage for the various village groups (Lightfoot and Parrish 2009:212). Migratory waterfowl, particularly geese, ducks, and coots, the most important avian resources, were captured with nets; local quail were caught in traps. The Ohlone fished for salmon, sturgeon, and lampreys, and built Tule balsas (rafts) to move about the waterways. The Ohlone traded with surrounding tribes such as the Miwok (to the northeast), and the Northern Valley Yokuts (to the east). Mussels, abalone shells, dried abalone, and salt were exchanged for piñon nuts with the Yokuts. *Olivella* shells (the shell of a small predatory sea snail) were traded with the Sierra Miwok. Bows were traded with the Plains Miwok (Levy 1978:488).

Historic Period

In 1772, Europeans arrived in what would become Contra Costa County when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[11] Though subsequent Spanish expeditions passed through the region, the Spanish did not appear to settle in the Richmond area during the Mission Period of 1769 through 1833. In the 1820s and 1830s, the Mexican government began granting large tracts

[11] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[12] Americans began farming in Contra Costa County in the late 1830s, and by 1882, two-thirds of the cultivated land in the county was devoted to wheat production.[13]

In 1852 and 1853, Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo adjacent to the San Francisco Bay; this eventually became the southern portion of the City of Richmond.[14] In the 1860s, a wharf and produce warehouse were constructed to ship agricultural produce from Rancho San Pablo and Quilfelt Ranch to San Francisco markets. German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. A town named Stege formed on Richard Stege's holdings, and by the early twentieth century it boasted several industries, including the California Cap Works (located on the RBC site), the United States Briquette Company, the Stauffer Chemical Works, and the Stege Lumber Manufacturing Company.[15] Richmond incorporated in 1905, and by 1917 it was the largest city in Contra Costa County.[16]

California Cap Company

In 1877, William Letts Oliver, who was born in Chile to English parents, established the Tonite Powder Company adjacent to the Stege Ranch. Oliver was a mining engineer who developed an explosive called "*Tonite*" that could be used at high heat and was instrumental in construction of the Sutro Tunnel in the Comstock Lode.[17] This drainage tunnel allowed access to deeper mineral exploration. Mine flooding and inadequate pumps had inhibited some exploration activities up to that time.

To ensure a steady supply of blasting caps, otherwise imported from Europe, Oliver and partner Freeborn Fletter founded the California Cap Company.[18] The California Cap Company occupied a 160-acre parcel adjacent to the bay at the southern end of the Stege Ranch.

The California Cap Company, which operated on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege continued to reside on the ranch and contracted with Tonite Powder and California Cap to transport their products to the railroad.[19] The California Cap Company was on the parcel that is currently the RFS. The Tonite Powder Company appears to have been to the east of the RFS on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.[20]

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[12] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[13] J.P. Munro-Fraser, *History of Contra Costa County, California,* W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[14] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[15] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[16] Hulanski p. 288.

[17] Oliver, p. 1.

[18] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

[19] Nilda Rego, "Enterprising Stege lost all and died without a penny," Time Out, March 27, 1994, p. 2, column 4.

[20] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.

The Tonite and California Cap factories, the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety. [21] Eventually the Tonite factory was incorporated into the California Cap Company. By 1916 there were at least a dozen buildings on the site. World War II brought thousands of defense industry jobs to Richmond. The California Cap Company was one of the most important local employers, but it did not survive the transition to a peacetime economy, and by 1949 the plant was shuttered and the Oliver family began looking for a buyer.

After World War II, UC Berkeley's Engineering Department needed an off-campus location to do experiments requiring more space than a laboratory. The University purchased the California Cap Company site from the Oliver family for the use by the Engineering Department in 1950 for $750,000.[22] The University named the acquired property the Richmond Field Station.

The RFS has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory was the first department to do research at the site. This laboratory focused primarily on sewage treatment technology; it supported research on pollution control and disposal of solid and liquid waste.[23] At first the University used the buildings left behind by the California Cap Company. The Engineering Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in the old blasting company buildings.[24] By the 1970s, the department had done many experiments at the RFS.

Records Searches and Cultural Resources Sites and Buildings

Archaeological and Landscape Resources

A records search at the Northwest Information Center of the California Historical Resources Information System at Sonoma State University, Rohnert Park was conducted on January 16, 2013 (File No. 12-0713). The records search compiled information regarding the locations of previously recorded cultural resources sites and previous studies within a 0.25-mile radius of the RBC site for the proposed 40-year LRDP undertaking. This defines the area in which eligible properties may be affected by the undertaking, including direct effects (such as destruction of the property) and indirect effects (such as visual, audible, and atmospheric changes that affect the character and setting of the property). This information was used to assess the archaeological sensitivity of the RBC site.

The records search found that 29 cultural resources investigations were completed within a 0.25-mile radius of the RBC site, with four of these on the RBC site. Seven cultural resources, including five prehistoric shell mounds and a historic-period pier and seawall, were recorded within this area. Two of the previously recorded cultural resources are on the RBC site. One of these cultural resources (CA-CCO-157, Loud's No. 299) is in a developed portion of the LRDP development area. The second cultural resource (CA-CCO-753H, Stege Marsh Seawall) is in the development area, but it has been partially dismantled.

In January 2013, a pedestrian survey of a portion of the development area was conducted. The survey found that approximately 70 percent of the 16 acres is developed with buildings, roads,

[21] Oliver, p. 1.

[22] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975–An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[23] University of California, Berkeley, 2008, p. 13.

[24] McGauhey, p. 71.

parking lots, and a large stock pile of soil. The remaining 30 percent consists of a large grassy field, lawns, landscaping, dirt driveways and parking lots, and wetlands. A small southern portion of the project site was inaccessible. The previously recorded historic period resource in the project site, CA-CCO-753H (Stege Marsh Seawall), could not be located during the survey. This area was inaccessible because it is in the fenced area marked as hazardous waste and habitat restoration. The survey identified two previously unrecorded historic period resources that were assigned temporary field numbers by the researchers. These include two stands of eucalyptus trees, GANDA-622-01, and one isolated bottle, GANDA-ISO-622-01(GANDA 2013).

The University of California, Berkeley Museum of Paleontology conducted a record search for paleontological resources in the area and determined that there have been no prior fossil finds in the RBC. Therefore paleontological resources are not further discussed in the analysis (Holroyd 2013).

The following discussion provides information regarding the known cultural resources in the LRDP development area. ***CA-CCO-157/P-07-000099 (Loud's No. 299).*** In 1915, L. L. Loud originally recorded this resource as an approximately 350-foot wide by 250-foot long shell mound on the end of a slough about 800 feet from the San Francisco Bay's historic shoreline. It is currently under a warehouse and paved parking lot at 3200 Regatta Boulevard in Richmond (Banks 1985a). This resource is in the LRDP development. This resource has not been evaluated for NRHP or California Register of Historical Resources (CRHR) eligibility because it is currently inaccessible.

CA-CCO-753H/P-07-002591 (Stege Marsh Seawall). Constructed in the late 19th or early 20th centuries, this segment of the Stege Marsh Seawall consists of an approximately 18-foot long wood beam mounted in place by two sets of round wood poles. Seventeen 1-foot by 3-inch wood planks form the back of the seawall and the other portion of the seawall has been dismantled. Subsurface portions of it may still be present and buried. This resource was evaluated and recommended as not eligible for listing in the NRHP or the CRHR (Hatoff et al. 2003).

GANDA-622-01 (Eucalyptus Stands 1 and 2). This landscape feature consists of two historic period Eucalyptus stands. Eucalyptus Stand 1 is on the east side of the development area, along the east side of S. 46th Street (Egret Way). Eucalyptus Stand 2 is on the northwest side of the development area, east of Avocet Way. According to the technical report for the Richmond Field Station Remediation Project (S-26851), Richard Stege purchased 600 acres of land and established an estate in 1876. Around the same time, chemical and explosive companies began buying land in the area and constructing manufacturing plants. In 1880, the California Cap Company was established at the Stege property, and trees were planted to serve as a buffer between the manufacturing facility and nearby residents (Hatoff et al. 2003). It is possible that the eucalyptus stands contain many of the same trees planted in the 1880s. The University purchased the property in 1950s and reused many of the existing buildings (Hatoff et al. 2003). It also may have retained the original eucalyptus stands. The eucalyptus stands have been evaluated and are recommended as not eligible for listing in the NRHP or CRHR.

GANDA ISO-622-01. This isolated resource is a late 19th to early 20th century complete aqua whiskey bottle identified on the south side of Building 110. As an isolated artifact that lacks association in the larger historic context of the LRDP, this resource is not eligible for listing in the NRHP or CRHR.

Historical Architectural Resources

There are 81 buildings in the RBC site. In January 2013, a historic properties survey was done for a portion of the RBC development area. Twenty-five buildings were inventoried and recorded.

Research was conducted at the Contra Costa Historical Society archives, the DOE Library, the Earth Sciences and Map Library at UC Berkeley, and through the Oakland Public Library's Oakland History Room. A records search at the Northwest Information Center (file No. 12-0776) did not yield any evaluated or eligible buildings or structures. The records search identified one previous historic structure survey by Holman (1989). This study identified the buildings that were over 50 years old and did not include all of the buildings in the current survey population. None of the buildings were considered to be individually significant, but they were not recorded individually or formally evaluated using NRHP or CRHR criteria.

Of the 25 buildings evaluated for listing in the NRHP and CRHR, Tetra Tech determined that two were eligible for listing—Buildings 150 and 175. These buildings were determined eligible under Criterion A/1 for their association with the California Cap Company and its innovation in explosives during the late 1800s through the middle of the 20th century. The other buildings in the surveyed area are not historically significant or do not retain sufficient integrity to be considered eligible for listing on the NRHP or the CRHR individually or as a contributing element to a historic district.

Native American Consultation

As part of the consultation process with Native American organizations and individuals, the Native American Heritage Commission was contacted on January 24, 2013, with a request for information about any sacred lands related to the project site and for a list of interested Native American groups and individuals in Contra Costa County. The Native American Heritage Commission has not responded to date.

4.4.3 Regulatory Considerations

Federal

Section 106 of the NHPA (16 USC 470 [f]), as amended (PL 89-515), and its implementing regulations (36 CFR Part 800.9 [a] and [b]) require federal agencies to consider the effects of their actions on properties listed or eligible for listing on the NRHP. The criteria for inclusion (36 CFR 60.4) are as follows:

A. Association with events that have made a significant contribution to the broad patterns of our history;

B. Association with the lives of persons significant to our past;

C. Resources that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

D. Resources that have yielded or may be likely to yield information important in prehistory or history.

In addition to historic significance, a property must have integrity to be eligible for the NRHP. This is the property's ability to convey its demonstrated historical significance through location, design, setting, materials, workmanship, feeling, and association.

Section 106 describes the procedures for identifying and evaluating eligible properties, assessing the effects of federal actions on eligible properties, and consulting to avoid, reduce, or minimize adverse effects. Eligible properties need not be formally listed on the NRHP, but are afforded the

same protections as listed properties. Federal agencies are required to consult with the SHPO as part of the Section 106 process. Section 106 does not require the preservation of historic properties, but it ensures that the decisions of federal agencies concerning the treatment of these properties include meaningful considerations of cultural and historic values and of the options available to protect the properties.

State

California Environment Quality Act

The CEQA Statute and Guidelines include procedures for identifying, analyzing, and disclosing potential adverse impacts to historical resources, including all resources listed in or formally determined eligible for the NRHP, the CRHR, or local registers. CEQA Guidelines, Section 15064.5(a), defines the term "historical resources" to include:

1) A resource listed in, or determined to be eligible by, the State Historical Resources Commission, for listing in the CRHR (PRC Section 5024.1, Title 14 California Code of Regulations, Division 3, Chapter 11.5 Section 4850 et seq.).

2) A resource included in a local register of historical resources, as defined in PRC Section 5020.1(k), or identified as significant in an historical resource survey meeting the requirements in PRC Section 5024.1(g), shall be presumed to be historically or culturally significant. Public agencies must treat any such resource as significant unless the preponderance of evidence demonstrates that it is not historically or culturally significant.

3) Any object, building, structure, site, area, place, record, or manuscript which a lead agency determines to be historically significant or significant in the architectural, engineering, scientific, economic, agricultural, educational, social, political, military or cultural annals of California may be considered to be an historical resource, provided the lead agency's determination is supported by substantial evidence in light of the whole record.

California Register of Historical Resources

Generally, a resource shall be considered by the lead agency to be "historically significant" if the resource meets the criteria for listing on the CRHR (PRC Section 5024.1, Title 14 CCR Division 3, chapter 11.5, Section 4852). The four eligibility criteria for CRHR listing closely parallel those of the NRHP. Each resource must be determined to be significant at the local, state, or national level under one of these four criteria:

1. Is associated with events that have made a significant contribution to the broad patterns of California history and colonial heritage; or
2. Is associated with the lives of persons significant in our past; or
3. Embodies the distinctive characteristics of a type, period, or method of construction, or represents the work of an important creative individual, or possesses high artistic values; or
4. Has yielded, or may be likely to yield, information important in prehistory or history. [25]

[25] California Public Resources Code, Sections 4850 through 4858; Office of Historic Preservation, Instructions for Nominating Historical Resources to the California Register of Historical Resources, August, 1997.

A resource may still be considered historical if it does not meet these standards. CEQA Statutes Section 21084.1, states that a resource need not be listed on any register to be historical. CEQA Guidelines Section 15064.5(a)(4) states that "until such time as a structure is evaluated for possible inclusion in the inventory pursuant to subdivisions (b) and (c) of PRC Section 5024.5 (historical significance criteria), state agencies shall assure that any structure which might qualify for listing is not inadvertently transferred or unnecessarily altered."

To be eligible for listing, a resource must also have sufficient integrity. The CRHR definition of integrity is slightly different from that used for the NRHP. Integrity is defined as the authenticity of a historical resource's physical identity evidenced by the survival of characteristics that existed during the resource's period of significance. The CRHR states that eligible resources must retain enough of their historic appearance or character to be recognizable as historic resources and to convey the reasons for their significance, and it lists the same seven aspects of integrity used for evaluating properties under the NRHP criteria.

Regulations Concerning Discovery of Human Remains

California Public Resources Code Section 5097.98 (Notification of Native American human remains, descendants; disposition of human remains and associated grave goods) mandates that the lead agency adhere to the following regulations when a project results in the identification or disturbance of Native American human remains:

a) Whenever the Native American Heritage Commission receives notification of a discovery of Native American human remains from a county coroner pursuant to subdivision (c) of Section 7050.5 of the Health and Safety Code, it shall immediately notify those persons it believes to be most likely descended from the deceased Native American. The descendants may, with the permission of the owner of the land or his or her authorized representative, inspect the site of the discovery of the Native American remains and may recommend to the owner or the person responsible for the excavation work means for treating or disposing of, with appropriate dignity, the human remains and any associated grave goods. The descendants shall complete their inspection and make their recommendation within 24 hours of their notification by the commission. The recommendation may include the scientific removal and nondestructive analysis of human remains and items associated with Native American burials.

b) Whenever the Native American Heritage Commission is unable to identify a descendent, or the descendent identified fails to make a recommendation, or the landowner or his or her authorized representative rejects the recommendation of the descendent, and the mediation provided for in subdivision (k) of Section 5097.94 fails to provide measures acceptable to the landowner, the landowner or his or her authorized representative shall reinter the human remains and items associated with Native American burials with appropriate dignity on the property, in a location not subject to further subsurface disturbance.

c) Notwithstanding the provisions of Section 5097.94, the provisions of this section, including those actions taken by the landowner or his or her authorized representative to implement this section, and any action taken to implement an agreement developed pursuant to subdivision (l) of Section 5097.94, shall be exempt from the requirements of the California Environmental Quality Act [Division 13 (commencing with Section 21000)].

d) Notwithstanding the provisions of Section 30244, the provisions of this section, including those actions taken by the landowner or his or her authorized representative to implement this section, and any action taken to implement an agreement developed pursuant to

subdivision (1) of Section 5097.94, shall be exempt from the requirements of the California Coastal Act of 1976 [Division 20 (commencing with Section 30000)].

Local

City of Richmond Historic Structures Code

Historic preservation is implemented in the City of Richmond through the enforcement of its Historic Structures Code (Chapter 6.06 of the Richmond Municipal Code; City of Richmond 2013). The Historic Structures Code includes the following historic resource designation criteria:

On the recommendation of the Committee and approval of the Council a structure, site, or other improvement, not already designated as such, may be designated a historic resource in the City or may be designated an historic district if it meets any of the following criteria:

(1) It exemplifies or reflects valued elements of the City's cultural, social, economic, political, aesthetic, engineering, archaeological, or architectural history; or

(2) It is identified with persons or events important in local, state, or national history; or

(3) It reflects significant geographical patterns, including those associated with different eras of settlement and growth, particular transportation modes, or distinctive examples of park or community planning; or

(4) It embodies distinguishing characteristics of an architectural style, type, period, or method of construction, or is a valuable example of the use of indigenous materials or craftsmanship; or

(5) It is representative of the notable work of a builder, designer, or architect whose style influenced the City's architectural development.

A structure, site, or other improvement which meets any of the above criteria at the highest level and whose loss would be a major loss to the City may be designated an outstanding historical resource.

City of Richmond General Plan

Historic Resources, Richmond General Plan 2030, is the Historic Resources Element that provides regulatory guidance for preserving and restoring the city's historic assets. The element is designed to protect cultural assets and to ensure that policies that relate to historic resources will ensure their protection. Three goals, Historic Resource Preservation, Expanded Economic Opportunities Based on Historic Resources, and Increased Public Awareness of Richmond's History, are included in the Historic Resources Element of the General Plan. Policies and implementing procedures associated with these goals are described in the plan.

The 2030 General Plan EIR determined that the effects on cultural resources from future development pursuant to the General Plan would be significant and unavoidable. Development could cause a substantial adverse change in the significance of historical resources because existing and proposed City policies do not explicitly prohibit demolition or inappropriate alteration of historic-period buildings or structures. Mitigation measures would be implemented to reduce potential impacts, but the impact would remain significant and unavoidable. Development could adversely impact archaeological or paleontological resources, but these impacts would be mitigated to less than significant. Cumulative impacts would be cumulatively considerable for historic structures and archaeological resources but less than significant for paleontological resources.

4.4.4 Impacts and Mitigation Measures

CEQA Guidelines Section 15064.5(b) states that "a project with an effect that may cause a substantial adverse change in the significance of an historical resource is a project that may have a significant effect on the environment."

Standards of Significance

Cultural resources impacts from the 2014 LRDP implementation would be considered significant if they would exceed the following Standards of Significance, in accordance with Appendix G of the State CEQA Guidelines and the UC CEQA Handbook:

- Cause a substantial adverse change in the significance of a historical resource as defined in 15064.5
- Cause a substantial adverse change in the significance of an archaeological resource pursuant to 15064.5
- Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature
- Disturb any human remains, including those interred outside of formal cemeteries

Public Resources Code (PRC) Section 5020.1 and CEQA Guidelines Section 15064.5(b)(1) define a significant effect as one that would materially impair the significance of an historical resource. According to CEQA Guidelines Section 15064.5(b)(2), material impairment of a resource's historic significance could result if the project would:

- Demolish or materially alter in an adverse manner those physical characteristics of a historical resource that convey its historical significance and that justify its inclusion in, or eligibility for inclusion in, the CRHR as determined by the lead agency
- Demolish or materially alter in an adverse manner those physical characteristics that account for its inclusion in a local register of historical resources pursuant to local ordinance or resolution (PRC Section 5020.1[k]), or its identification in an historical resources survey meeting the requirements of PRC Section 5024.1(g) unless a preponderance of evidence establishes that the resource is not historically or culturally significant
- Demolish or materially alter in an adverse manner those physical characteristics of a resource that convey its historical significance and that justify its eligibility for its inclusion on the CRHR

Although not a standard of significance, CEQA Guidelines Section 15064.5(b)(3) holds that, in general, a project impact on historic resources will be considered mitigated to a less than significant level if mitigation follows the Secretary of the Interior's guidelines.

Analytical Methods

Impacts must be considered when a proposed undertaking has the potential to affect cultural resources, such as those resources described above. CEQA associates a "substantial adverse change" in the significance of an historical resource with a significant impact on the environment. *PRC Section 5020.1* and *CEQA Guidelines Section 15064.5(b)(1)* define the term "substantial adverse change" as demolition, destruction, relocation, or alteration of a historical resource or its immediate surroundings such that a resource's value would be materially impaired. The analysis must determine whether there are historical resources that may be affected by the proposed project and whether the project would result in a substantial adverse change to the extent that the resource's historical value is materially impaired or lost.

The general method for determining whether a significant impact on historical resources could result requires determining a project's region of influence, identifying the presence or absence of cultural resources in that region, evaluating resource significance and/or whether it meets historical resource eligibility criteria, and determining the project's likelihood of causing a substantial adverse change.

In this analysis, there are near-term, reasonably foreseeable actions and longer-term planning actions associated with LRDP implementation. Impacts are determined by reviewing the proposed LRDP development program actions against the region's known or anticipated historical resources. The types, risks, context, and intensity of anticipated impacts are assessed qualitatively using the cultural resource professionals' best judgment.

Known historical resources under CEQA are present in the LRDP development areas. Other "unknown" historical resources may be present, but any such resources are currently unidentified, unevaluated, buried, and/or not yet of historic age. Implementation of the 2014 LRDP have the potential to result in a "substantial adverse change" and a "significant impact" on known and unknown historical resources.

Excavations, trenching, and grading for campus development could disturb or destroy significant archaeological resources in the developable areas identified in the LRDP. Much of the RBC site's ground surface is not visible and has not been examined for archaeological resources. The location of one recorded site is beneath an existing structure. Based on the environmental setting and recognized archaeological sites that were recorded and partially investigated nearly 100 years ago, the RBC site is considered highly sensitive for prehistoric archaeological resources. Likewise the historic industrial use of the LRDP developable area for over 100 years indicates that the RBC site is highly sensitive for historic-era archaeological deposits.

Two of the surveyed buildings have been determined to be eligible for the NRHP and are considered historical resources under CEQA. There are 81 RBC site buildings, only 25 have been formally evaluated. Of the 59 unevaluated buildings, some may currently be of historic age or will be during the life of the plan and may be historic resources under CEQA. Actions that could directly affect historic structures include demolition, seismic retrofitting, and accidents or vibration caused by nearby construction activities.

Given the prehistoric use of the LRDP development area, on-site resources may exist that are of interest to contemporary Native American populations. Ongoing efforts seek to determine whether there are such Native American resources present at the LRDP development sites.

RBC 2014 LRDP Policies

The RBC 2014 LRDP policies related to cultural resources include the following:

- LU2 – Land Use Policy on Character: Provide a setting capable of attracting new research programs and retaining world class researchers
    - Support excellence in building design that is harmonious with the waterfront location and creates visual variety in form and massing. Include iconic structures or buildings on the campus.

LRDP Impacts and Mitigation Measures

LRDP Impact CR-1: **Development under the 2014 LRDP could result in significant impacts on previously undiscovered, unevaluated, or unrecorded archaeological resources or human remains during construction and clearing. (*Potentially Significant; Less than Significant with Mitigation*)**

Although most, if not the entire RBC site, has been disturbed in conjunction with previous site uses, previously unknown archaeological resources or human remains may be encountered during ground-disturbing construction activities. Much of the ground surface is obscured by past development. Based on old maps, the location of site CA-CCO-157/P-07-000099 (Loud's No. 299) is believed to be collocated with an existing building and parking lot. Geo-archaeological and environmental setting analysis indicate a very high sensitivity for buried, surface, or near surface prehistoric resources throughout the RBC site. Subsurface historic period archaeological resources may also be present (GANDA 2013). The 2014 LRDP campus development may adversely affect previously unknown or unevaluated subsurface archaeological resources and possibly human remains by causing destruction, damage, loss of context, or complete or partial removal of site components. This would be a potentially significant impact. Implementing LRDP MM CR-1 would include site surveys and other measures to avoid impacting archaeological resources, reducing this impact to less than significant.

LRDP MM CR-1: Prior to any project-related excavation or construction, the University shall adequately survey all relevant disturbance areas for archaeological resources and assess the potential for buried resources based on past land use, site records, and proximity to known resources and landforms. Depending on the resulting level of suspected archaeological sensitivity, archaeological testing shall be done and/or qualified archaeological monitors will be present during ground disturbing activities.

Prior to any ground disturbing activities that could disturb potentially existing archaeological resources, the University would prepare a Construction Monitoring and Unanticipated Cultural Resources Discovery Plan to be implemented if an unanticipated discovery is made. At a minimum the plan would detail the following elements:

- Worker and supervisor training in the identification of cultural remains that could be found in the proposed project area
- Worker and supervisor response procedures to be followed if there is an unanticipated discovery, including appropriate points of contact for professionals qualified to make decisions about the potential significance of any find
- Identities of persons authorized to stop or redirect work that could affect the discovery, and their on-call contact information
- Procedures for monitoring construction activities in archaeologically sensitive areas

- A minimum radius (typically a minimum of 50 feet) around any discovery in which work would be halted until the significance of the resource has been evaluated and mitigation implemented as appropriate
- Procedures for identifying and evaluating the historical significance of a discovery
- Procedures for consulting Native Americans when identifying and evaluating the significance of discoveries involving Native American cultural materials
- Procedures to be followed for treatment of discovered human remains per current state law, including appropriate notification and consultation with Native American groups or individuals

If any suspected human bone is found during construction, all work should stop and the Contra Costa County coroner would be notified immediately per State law and the Discovery Plan. If the remains are determined to be Native American, the Native American Heritage Commission shall be notified for determination of the most likely descendent and tribal affiliation for disposition. No additional work shall take place near the find until the identified actions have been implemented.

LRDP Impact CR-2: **Development under the 2014 LRDP would result in significant impacts on historic Buildings 150 and 175 through demolition or visual intrusion from new building construction. (*Potentially Significant; Significant and Unavoidable*)**

Two buildings (Buildings 150 and 175) were determined eligible for listing on the NRHP and CRHR under Criterion A/1 for their association with the California Cap Company and its innovation in explosives during the late 1800s through the middle of the 20th century. Significant unavoidable impacts would result directly from demolition of these structures under the 2014 LRDP. Implementing LRDP MM CR-2 would reduce the impact; however because historic resources will be demolished, the proposed project will impact historic resources. Therefore, even with implementation of LRDP MM CR-2, the impact to historic resources is determined to be significant and unavoidable.

LRDP MM CR-2: Because demolition of Buildings 150 and 175 cannot be avoided, historic documentation would be completed by professionals meeting the Secretary of the Interior's Professional Qualification Standards for architectural history. Recording each structure to the standard established for the National Park Service's Historic American Building Survey or Historic American Engineering Record would include high resolution digital photographs taken of historic buildings in their current condition. Up to 20 archival black and white prints would be prepared as part of the recordation package. Construction or as-built drawings (if available) would be reproduced on archival paper.

LRDP Impact CR-3: Development under the 2014 LRDP could result in significant impacts on historic structures that have not been identified or that would become of historic age over the life of the plan. (*Potentially Significant; Significant and Unavoidable*)

The 2014 LRDP addresses a 40-year planning horizon. The RBC site is developed with approximately 81 one- and two-story buildings, roadways, parking lots, and landscaped areas. Twenty-five of the existing buildings in the development area have been evaluated for their historic significance. Some of the other buildings may be historic structures, and others that are not of historic age could become of age during the LRDP planning period. Significant unavoidable impacts could result directly from demolition or alteration of these structures under the LRDP or indirectly through the visual intrusion from the future construction anticipated under the plan. Implementing LRDP MM CR-3a would reduce the impact; however if avoidance of direct or indirect impacts is not possible, the proposed project may still impact historic resources. Therefore, even with implementation of LRDP MM CR-3a, conservatively, the impacts to historic resources are determined to be significant and unavoidable.

LRDP MM CR-3a: Prior to any project construction or demolition activities, the University shall ensure that all buildings and structures in the construction footprint have been adequately inventoried. If any of the inventoried structures are found to be historically significant and are to be retained, the University shall develop reuse or maintenance plans to identify the historic features of the building and prepare design guidelines based on the Secretary of Interior's Standards and Guidelines for the Treatment of Historic Properties and to ensure that the buildings retain their historic, character–defining features.

LRDP MM CR-3b: If avoidance of direct or indirect impacts on (as yet unidentified) historic buildings is not possible, the University shall determine site specific mitigation measures. Historic documentation would be completed by professionals meeting the Secretary of the Interior's Professional Qualification Standards for architectural history. Structures would be recorded to the standard established for the National Park Service's Historic American Building Survey or Historic American Engineering Record. This would include high resolution digital photography of historic buildings in their current condition. Up to 20 archival black and white prints would be prepared as part of the recordation package. Construction or as-built drawings (if available) would be reproduced on archival paper.

Cumulative Impacts and Mitigation Measures

LRDP Cumulative Impact CR-1: Development under the 2014 LRDP together with regional cumulative development would result in a cumulatively minor cultural resources impact. (*Less than Significant*)

This section evaluates whether implementation of the 2014 LRDP, in combination with other past, present, and reasonably foreseeable future LBNL, UC Berkeley, and non-UC projects, would result in significant cumulative cultural resources impacts in the project's region of influence. The region of influence, or cumulative setting, includes the Southern Shoreline Planning Area of the City of Richmond.

Past developments in the region have resulted in the loss or destruction of the spatial integrity of prehistoric and historic archaeological resources through ground-disturbing activities. Historic buildings and structures have been lost or impacted due to demolition, substantial alteration, neglect, or incompatible construction. Current and future projects and plans have the potential to cause substantial adverse changes to historical resources by altering, disturbing, or destroying archaeological resources during construction or by demolishing or altering buildings or structures or their setting. Construction of the Bio-Rad Laboratories Upgrade Project includes land where there are recorded archaeological sites. The extent to which historical resources are present in the region and would be impacted by cumulative projects and plans is unknown. The City of Richmond 2030 General Plan includes provisions for taking into account cultural resources and addressing adverse effects on historical resources, and future development in the region would be completed in the context of federal, state, and local laws and planning processes.

None of the known resources in the LRDP development area would be affected by other cumulative projects. Future actions in the LRDP development area would be subject to site-specific CEQA review, during which impacts on historical resources would be identified and mitigated. Therefore, cumulative impacts on cultural resources from the proposed LRDP and other projects and plans in the region of influence would be less than significant.

Mitigation Measure: No mitigation measure is required.

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4.5 GEOLOGY AND SOILS

4.5.1 Introduction

This section discusses existing RBC site geology and soils resources and analyzes the potential for development under the proposed 2014 LRDP to affect those resources. The section also describes RBC's regional geologic and seismic setting and analyzes potential geologic and seismic hazards that may affect the proposed project based on the site conditions and location. The analysis focuses on increased exposure of people and structures to hazards such as groundshaking, liquefaction, and erosion. Section information and analysis is based on existing project site documentation.

One NOP public comment related to geology and soils was received. This comment noted the liquefaction potential from a large earthquake along the Hayward or San Andreas Faults due to the presence of loose sandy fill at the RBC site.

4.5.2 Environmental Setting

Regional Geology

The San Francisco Bay Area geology is dominated by the San Andreas fault system that includes the San Andreas fault, the San Gregorio fault, the Hayward fault, the Calaveras fault, and other faults that have been active during approximately the last 30 million years. Bay Area geology is quite complex, owing to the relative movement of the North American continental and Pacific Ocean crustal plates. The terrain was created by tectonic forces that compressed ancient sedimentary deposits into a sub-parallel series of anticlines (concave downward) and synclines (concave upward). These folds were subsequently right-laterally faulted, uplifted, and eroded into their present configuration. The bedrock underlying the sediments in the San Francisco Bay basin, and exposed in some of the hills surrounding the Bay, consists of a complex of partially metamorphosed sedimentary and volcanic rocks belonging to the Franciscan Formation. The region was apparently well above sea level until about 1 million years ago when a combination of subsidence of the basin and rising sea levels from melting of continental ice caps led to deposition of sediments on the Franciscan bedrock surface.

Richmond is underlain by the Franciscan Formation. The Franciscan Formation consists of sedimentary and volcanic rocks that accumulated to a thickness of more than 50,000 feet, probably in a deep part of the oceanic basin beyond the continental slope, during Late Jurassic to Late Cretaceous time. Most of the Franciscan rock types are dense, hard, resistant, and form ground that will be generally stable during earthquake shaking. Where intensively sheared or weathered, these rocks disintegrate into much less stable ground, and the slopes underlain by these sheared materials are much less stable than areas of outcropping hard rock.

Above the Franciscan Formation lie tertiary marine and non-marine sedimentary and volcanic rocks. Outcrops of marine sedimentary rocks that formed when the sea invaded the area south of Santa Rosa in Miocene and Eocene time (24 million to 5 million years ago), are very limited in Richmond. Miocene and Eocene rocks comprise a sequence of hardened sandstone and shale. On the surface in shallow areas and under the bay waters is a combination of alluvium and bay mud.

Site Specific Geology

The Franciscan bedrock (primarily greywacke, black shale and slate, greenstone, and chert) underlies the site at depths between 80 to 160 feet or more. Depth to bedrock generally increases to the southwest. The groundwater table is about 10 feet below existing grade; tidal fluctuation will affect the groundwater elevation.

Historically, artificial fill was placed on the RBC site to reclaim the original low-lying lands and marshlands. In addition, pyrite cinders from the adjacent Stauffer Chemical facility were placed on the site. Much of the original pyrite has been removed and replaced with other imported fill soil, but some is still present. The native near surface geology consists of Holocene alluvial fan and alluvial fan levee deposits. The alluvial fan deposits consist of stiff to dense silty clay with interbedded sand and gravel lenses.

Faults and Seismic Hazards

The Hayward fault, approximately 2 miles northeast of the RBC site, is the closest active fault to the site (Figure 4-9). Based on the soil type, the relatively young age of the soil, and the shallow depth to groundwater, the sandy areas on the site could be susceptible to liquefaction during an earthquake. The areas dominated by clay would be less susceptible to liquefaction. Liquefaction hazard maps produced by ABAG indicate that the eastern portion of the project site is susceptible to liquefaction (ABAG 2011).

Repeated tectonic events in the San Francisco Bay Area resulted in a complex geologic structure with numerous folds, faults, and cross faults. Today, the most significant manifestations of these forces with respect to the project site are the San Andreas fault system and Hayward fault zone.

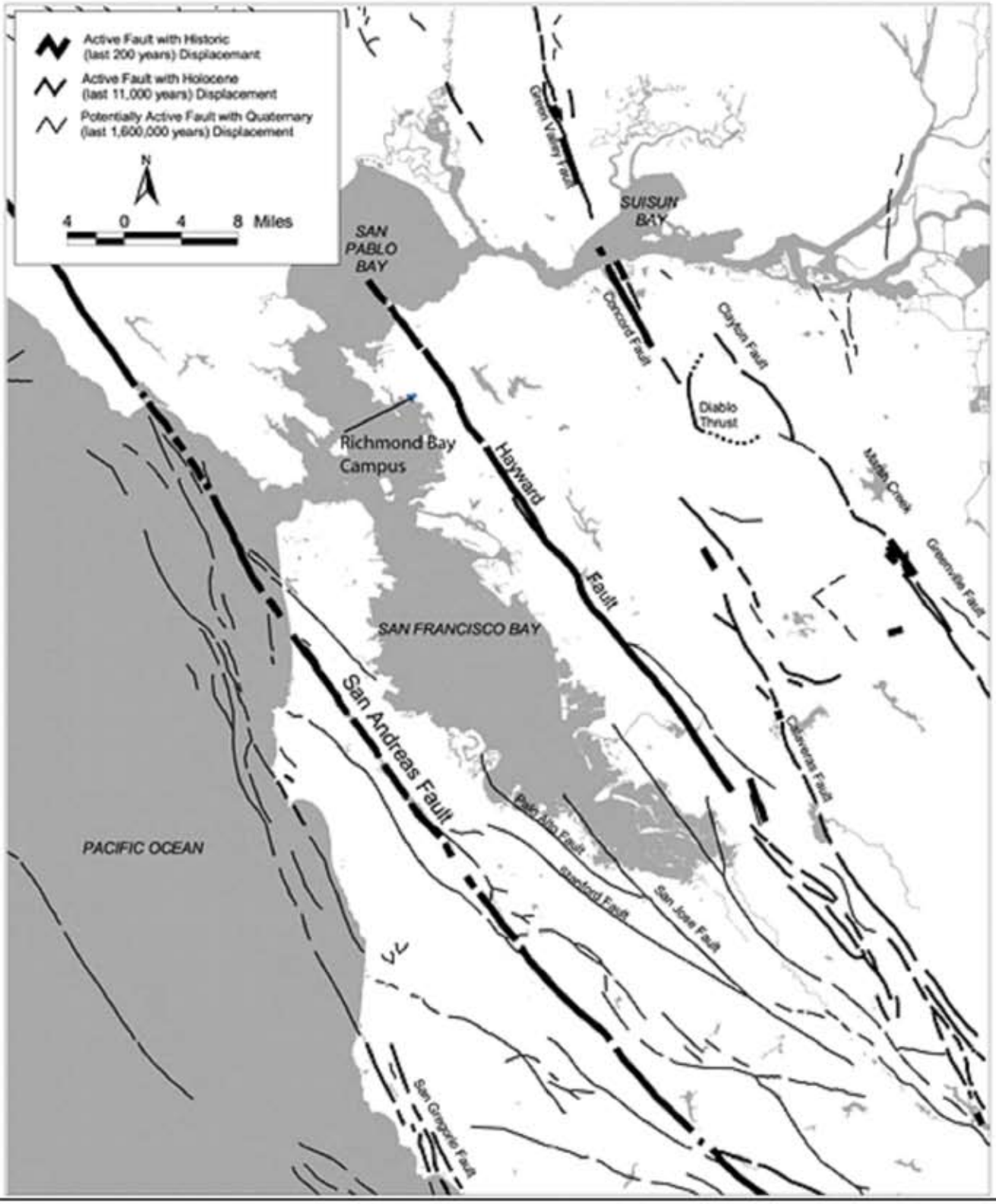
The Hayward fault is designated by the Alquist-Priolo Earthquake Fault Zoning Act as an active fault. A characteristic feature of the fault is its well-expressed and relatively consistent fault creep. Although large earthquakes on the Hayward fault have been rare since 1868, slow fault creep has continued to occur and has caused measurable offset. Fault creep on the East Bay fault segment is estimated at 0.35 inches per year. There have been two recorded incidents of major earthquakes along the Hayward fault. A magnitude 6.5 earthquake occurred on June 10, 1836, and a magnitude 6.9 occurred on October 21, 1868.

The San Andreas fault, 15 miles to the west, could produce significant groundshaking at the RBC site. The greatest Bay Area region earthquake in historic times occurred along the San Andreas fault on April 18, 1906, with a magnitude of 7.8.

The magnitude 6.9 Loma Prieta earthquake occurred in October 1989 with its epicenter about 70 miles south of Richmond. The damage in Richmond was relatively slight compared to that in San Francisco and Oakland. Older buildings were damaged, cracking appeared in residences and commercial buildings, and there was damage in the industrial areas near the Port. City staff relocated from City Hall, which was declared unsafe. There were no bridge or building collapses and no significant fire damage. The energy released during the Loma Prieta earthquake was just 3 percent of the amount of energy released during the 1906 earthquake.

Three moderate earthquakes occurred along the Calaveras fault, 20 miles to the southeast, in 1980. The Morgan Hill Earthquake of April 24, 1984, occurred on this fault. The effects of these earthquakes on Richmond were insignificant. The maximum credible earthquake on this fault is approximately magnitude 6.3.

During the recent historical period, six significant earthquakes have occurred in the San Francisco Bay Area, commencing with the 1868 earthquake. Other earthquakes between 1868 and 1906 were estimated as being in the range of magnitude 6.0 to 6.5.



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Fault Zones

Richmond, California

TETRA TECH

Figure 4-9

After the 1989 Loma Prieta earthquake, the US Geological Survey and other scientists estimated that there is a 62 percent probability of at least one magnitude 6.7 or greater earthquake, capable of causing widespread damage, striking somewhere in the San Francisco Bay region before 2032 (USGS 2003). The region is defined as extending north-to-south from Healdsburg to Salinas. The probability of such earthquakes occurring on the Hayward and Rogers Creek faults is estimated at 27 percent. They projected that there was at least an 80 percent chance of one or more magnitude 6 to 6.6 earthquakes occurring in the Bay region before 2032.

Ground Shaking

Ground movement during an earthquake can vary depending on the overall magnitude, distance to the fault, focus of earthquake energy, and type of affected geologic material. The composition of underlying soils, even those relatively distant from faults, can intensify ground shaking. For this reason, earthquake intensities are also measured in terms of their observed effects at a given locality. The Modified Mercalli intensity scale (Table 4.5-1) is commonly used to measure earthquake damage from ground shaking. The intensity values in that scale range from I (earthquake not felt) to XII (damage nearly total), and intensities ranging from IV to X could cause moderate to significant structural damage. The intensities of an earthquake will vary over the region of a fault and generally decrease with distance from the epicenter of the earthquake.

Table 4.5-1
Modified Mercalli Scale of Earthquake Intensities

Earthquake Intensity	Effects Observed	Average Peak Acceleration
I	Earthquake shaking not felt. But people may observe marginal effects of large distance earthquakes without identifying these effects as earthquake-caused. Among them: trees, structures, liquids, bodies of water sway slowly, or doors swing slowly.	< 0.0015 g
II	*Effect on people:* Shaking felt by those at rest, especially if they are indoors, and by those on upper floors.	< 0.0015 g
III	*Effect on people:* Felt by most people indoors. Some people can estimate duration of shaking. But many may not recognize shaking of building as caused by an earthquake: the shaking is like that caused by the passing of light trucks.	< 0.0015 g
IV	*Other effects:* Hanging objectives swing. *Structural effects:* Windows or doors rattle. Wooden walls and frames creak.	0.015 g-0.02 g [a]
V	*Effect on people:* Felt by everyone indoors. Many estimate duration of shaking. But they still may not recognize it as caused by an earthquake. The shaking is like that caused by the passing of heavy trucks, though sometimes, instead, people may feel the sensation of a jolt, as if a heavy ball had struck the walls. *Other effects:* Hanging objects swing. Standing autos rock. Crockery clashes, dishes rattle or glasses clink. *Structural effects:* Doors close, open, or swing. Windows rattle.	0.03 g-0.04 g
VI	*Effect on people:* Felt by everyone indoors and by most people outdoors. Many now estimate not only the duration of shaking but also its direction and have no doubt as to its cause. Sleepers wakened. *Other effects:* Hanging objectives swing. Shutters or pictures move. Pendulum clocks stop, start or change rate. Standing autos rock. Crockery clashes, dishes rattle or glasses clink. Liquids disturbed, some spilled. Small unstable objectives displaced or upset. *Structural effects:* Weak plaster and Masonry D* crack. Windows break. Doors close, open, or swing.	0.06 g-0.07 g

Table 4.5-1
Modified Mercalli Scale of Earthquake Intensities

Earthquake Intensity	Effects Observed	Average Peak Acceleration
VII	*Effect on people:* Felt by everyone. Many are frightened and run outdoors. People walk unsteadily. *Other effects:* Small church or school bells ring. Pictures thrown off walls, knickknacks and books off shelves. Dishes or glasses broken. Furniture moved or overturned. Trees, bushes shaken visibly, or heard to rustle. *Structural effects:* Masonry D* damaged; some cracks in Masonry C*. Weak chimneys break at roof line. Plaster, loose bricks, stones, tiles, cornices, unbraced pampers and architectural ornaments fall. Concrete irrigation ditches damaged.	0.10 g-0.15 g
VIII	*Effect on people:* Difficult to stand. Shaking noticed by auto drivers. *Other effects:* Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Furniture broken. Hanging objects quiver. *Structural effects:* Masonry D* heavily damaged; Masonry C* damaged, partially collapses in some cases; some damage to Masonry B*; none to Masonry A*. Stucco and some masonry walls fall. Chimneys, factory stacks, monuments, towers, elevated tanks twist or fall. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off.	0.25 g-0.30 g
IX	*Effect on people:* General fright. People thrown to ground. *Other effects:* Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes. Steering of autos affected. Branches broken from trees. *Structural effects:* Masonry D* destroyed; Masonry C* heavily damaged, sometimes with complete collapse; Masonry B* is seriously damaged. General damage to foundations. Frame structures, if not bolted, shifted off foundations. Frames racked. Reservoirs seriously damaged. Underground pipes broken.	0.50 g-0.55 g
X	Effect on people: General Panic. *Other effects:* Conspicuous cracks in ground. In areas of soft ground, sand is ejected through holes and piles up into small craters, and, in muddy areas, water fountains are formed. *Structural effects:* Most masonry and frame structures destroyed along with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes and embankments. Railroads bent slightly.	> 0.60 g
XI	*Effect on people:* General panic. *Other effects:* Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. *Structural effects:* General destruction of buildings. Underground pipelines completely out of service. Railroads bent greatly.	> 0.60 g
XII	*Effect on people:* General panic. *Other effects:* Large rock masses displaced. Lines of sight and level distorted. Objects thrown into air. *Structural effects:* Damage nearly total, the ultimate catastrophe.	> 0.60 g

Notes:
a. g is gravity = 32 feet per second squared.
* Masonry A: Good workmanship and mortar, reinforced, designed to resist lateral forces;
* Masonry B: Good workmanship and mortar, reinforced;
* Masonry C: Good workmanship and mortar, unreinforced;
* Masonry D: Poor workmanship and mortar, weak materials like adobe.

Predicted ground shaking for a large event on the Hayward fault would be severe to violent along the length of the fault. Hayward fault rupture would generate structurally damaging ground motions in Richmond ranging from Modified Mercalli intensity VII to X.

Liquefaction

Liquefaction may occur when loose, unconsolidated, saturated fine- to medium-grained sandy soils are subjected to ground vibrations during a seismic event. This usually occurs in areas where the groundwater table is within 50 feet of the ground surface, and it is generally associated with uncompacted, saturated, or nearly saturated, non-cohesive sandy and silty soils. During liquefaction, loose soil sediments are shaken. This creates a sudden increase in pore water pressure and loss of shear strength and causes the soils to behave like a liquid. If the liquefying layer is near the ground surface, the effects may resemble those of quicksand. If the layer is deep below the ground surface, it may provide a sliding surface for the material above it or cause differential settlement of the ground surface that may damage building foundations by altering weight-bearing characteristics. Liquefaction can affect soils to 50 feet deep during prolonged periods of ground shaking.

The State has not designated any liquefaction hazard areas in the City of Richmond under the Seismic Hazard Zones Mapping Program, although as noted above, liquefaction hazard maps have been produced by ABAG indicating that the eastern portion of the RBC site is susceptible to liquefaction.

Tsunami and Seiche

Tsunamis (seismic sea waves) are long period waves typically caused by underwater disturbances (landslides), volcanic eruptions, or seismic events. Areas highly susceptible to tsunami inundation tend to be in low-lying coastal areas such as tidal flats, marshlands, and former bay margins that have been artificially filled but are still at or near sea level. There have been 19 recorded tsunamis in the Bay Area from 1868 to 1968. The maximum wave height associated with these tsunamis was just less than 15 feet at the Golden Gate Tide Gage in 1868. After natural attenuation across the Bay, estimates are that the wave height was approximately half that on the Richmond shoreline and negligible by the Carquinez Strait.

The West Coast and Alaska Tsunami Warning Center in Alaska and the Pacific Tsunami warning Center in Hawaii monitor potential tsunamis. The Centers currently issue “warnings” to particular locales when a 7.5 magnitude earthquake or greater occurs within 3 hours tsunami travel time to those locations, and issue “watches” when tsunami travel time is within 3 to 6 hours of particular locations. Information is transmitted to the Governor’s Office of Emergency Services Warning Control Center and local emergency managers.

There are no State or other officially designated tsunami evacuation zones in the City of Richmond.

A seiche is an earthquake-generated wave in enclosed or restricted bodies of water such as lakes and reservoirs caused when an earthquake ground wave matches the natural period of oscillation of the body of water. Seiche risk in the shoreline areas would be minimal because there are no large confined bodies of water with sufficient depth to resonate with earthquake generated shaking. Catastrophic earthquake damage also can result from dam failure or from large masses of earth breaking loose and sliding into a reservoir or the Bay.

Landslides

Landsliding is a form of ground failure where there is a relatively rapid downslope movement of a mass of soil, rock, and rock debris. The term is used here to include mudslides and earthflows. Landsliding is affected by the degree of water saturation, strength of rocks, slope angle, mass and

thickness of deposit, and type and extent of vegetative cover. Landslides occur from shearing between layers of soil below the ground surface. In clay, the ground slumps or drops in a mass, whereas in Bay Mud, the ground spreads laterally. Soil flows occur when the cohesion of the soil fails, generally after heavy rainfall. Rainfall saturates the soil, adding weight and decreasing friction. Most landslides occur on slopes greater than 15 percent. Slopes at the RBC site range from 0 to 5 percent. Soils at the RBC site consist of artificial fill, alluvial fan deposits, a mix of stiff to dense silty clay with interbedded sand and gravel lenses, bay sediments, and Yerba Buena Mud (Older Bay Mud). Bay sediments may exist in the site's upper 18 feet. The bay sediments consist of fine- to very fine-grained sediments, while the Yerba Buena mud is a fine-grained unit that behaves as a regionally extensive aquitard.

4.5.3 Regulatory Considerations

Federal

In October 1977, the US Congress passed the Earthquake Hazards Reduction Act to reduce earthquake risks to life and property in the United States. To accomplish this, the Act established the National Earthquake Hazards Reduction Program. This program was significantly amended in November 1990 by the National Earthquake Hazards Reduction Program Act by refining the description of agency responsibilities, program goals, and objectives. The mission of the program includes improved understanding, characterization, and prediction of hazards and vulnerabilities; improved building codes and land use practices; risk reduction through post-earthquake investigations and education; development and improvement of design and construction techniques; improved mitigation capacity; and accelerated application of research results. The Act designates the Federal Emergency Management Agency as the program lead agency and assigns several planning, coordinating, and reporting responsibilities. Other program agencies include the National Institute of Standards and Technology, National Science Foundation, and US Geological Survey.

State

The Alquist-Priolo Earthquake Fault Zoning Act (Public Resources Code Sections 2621-2630) was passed in 1972 to mitigate surface faulting hazards to structures designed for human occupancy. The Act's main purpose is to prevent the construction of buildings for human occupancy on the surface trace of active faults. The law addresses only the hazard of surface fault rupture and not of other earthquake hazards. The Act requires the State Geologist to establish regulatory zones known as "Earthquake Fault Zones" around the surface traces of active faults and to issue appropriate maps. The maps are distributed to all affected cities, counties, and state agencies for their planning efforts. Before a project can be permitted in a designated Alquist-Priolo Earthquake Fault Zone, cities and counties must require a geologic investigation to demonstrate that proposed buildings would not be constructed across active faults.

The Seismic Hazards Mapping Act of 1990 (Public Resources Code Sections 2690–2699.6), addresses earthquake hazards from nonsurface fault rupture, including liquefaction and seismically induced landslides. The Act established a mapping program for areas that have the potential for liquefaction, landslide, strong ground shaking, or other earthquake and geologic hazards. The Act specifies that project lead agencies may withhold development permits until site specific geologic or soils investigations are conducted and mitigation measures are incorporated into plans to reduce hazards associated with seismicity and unstable soils.

The State of California provides building design standards through the California Building Code (CBC, California Code of Regulations, Title 24). Where no other building codes apply, Chapter 29 regulates excavation, foundations, and retaining walls. The CBC applies to building design and construction in the state and is based on the federal Uniform Building Code (UBC) used

widely throughout the country (generally adopted state-by-state or district-by-district). The CBC has been modified for California conditions with numerous more detailed or more stringent regulations. The state earthquake protection law (California Health and Safety Code Section 19100 et seq.) requires that structures be designed to resist stresses produced by lateral forces from wind and earthquakes. Specific minimum seismic safety and structural design requirements are in Chapter 16 of the CBC. The CBC identifies seismic factors that must be considered in structural design. CBC Chapter 18 regulates the excavation of foundations and retaining walls; Appendix Chapter A33 regulates grading activities, including drainage and erosion control, and construction on unstable soils, such as expansive soils and areas subject to liquefaction.

Local

The RBC would be a University of California property where work within the University's mission is performed. As a state entity, the University is exempt under the state constitution from compliance with local land use regulations, including general plans and zoning. The University seeks to cooperate with local jurisdictions to reduce to the extent feasible any physical consequences of potential land use conflicts. The RBC is in the City of Richmond. The following section summarizes the UC Seismic Safety Policy as it relates to geology and soils.

University of California Seismic Safety Policy

The University of California Seismic Safety Policy (UC 2011) requires "The design and construction of buildings on University premises shall comply, at a minimum, with the current seismic provisions of CBC for new or existing buildings as appropriate."

City of Richmond General Plan

The 2030 General Plan EIR determined that future General Plan development effects on geology, soils, and minerals would be less than significant. Future development would not expose people or structures to seismic hazards, soil spreading, land subsidence, soil erosion, or landslide hazards beyond an acceptable level of risk. Development would adhere to the California Building Code to minimize risk. No mitigation measures would be required. Cumulative impacts would be less than significant.

4.5.4 Impacts and Mitigation Measures

Standards of Significance

The 2014 LRDP implementation impacts on geology and soils would be considered significant if they would exceed the following Standards of Significance listed below, in accordance with Appendix G of the *State CEQA Guidelines* and the UC CEQA Handbook:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
    - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault;
    - Strong seismic groundshaking;
    - Seismic related ground failure, including liquefaction; and
    - Landslides.
- Result in substantial soil erosion or the loss of topsoil.
- Be on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse.

- Be on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994 or most current edition), creating substantial risks to life or property.
- Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.

CEQA Checklist Items Adequately Addressed in the Initial Study

The Initial Study analysis circulated with the NOP concluded that further analysis of the following issues was not required in the EIR.

- Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault.
- Landslides.
- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater.

A portion of the Hayward fault zone occurs in the City of Richmond, about 2 miles northeast of the site. No fault is present on the RBC site and there is no potential for fault rupture.

The RBC site is relatively flat, at the distal end of an alluvial plain, so there is no potential for landslide risk.

The Richmond properties are served by the City of Richmond wastewater treatment system, and RBC would not be served by septic systems or alternate wastewater disposal systems.

Analytical Methods

This section describes the potential geology and soils impacts resulting from development under the proposed 2014 LRDP and assesses them based on the Standards of Significance. Potential impacts were analyzed based on existing site data and the generalized scope of facility development analyzed in this EIR.

A project site's geotechnical characteristics determine its potential for structural and safety hazards that could occur during proposed project construction or operation. The conditions presented in the Richmond General Plan Update Final Environmental Impact Report, supplemented as necessary with widely available industry sources, were used to document regional and local geology in this EIR. Site assessment studies characterizing geotechnical conditions at each future proposed building site would be required prior to specific project approvals.

RBC 2014 LRDP Policies

The RBC 2014 LRDP policies related to geology and soils include the following:

- S3 – Sustainability Policy on Site Development: Embody environmental stewardship and respect the unique character of the RBC in site development.
    - Draw on the neighborhood context and prominently feature the natural assets including climate, wetlands, and proximity to the San Francisco Bay and the Bay Trail.
    - Actively promote sustainability as a core value at the campus and provide practical opportunities for innovation and education in sustainable design.

- Manage soil contamination as a component of each construction project.
- Control construction dust by implementing the best management practices (BMPs) defined in the BAAQMD CEQA Guidelines.

LRDP Impacts and Mitigation Measures

LRDP Impact GEO-1: Development under the 2014 LRDP would not expose people and structures to substantial adverse effects from seismic hazards such as ground shaking and earthquake-induced ground failure at the RBC site. (*Less than Significant*)

The RBC site is in an area potentially subject to strong seismic ground shaking from earthquakes along several active Bay Area faults. Due to its proximity to Hayward fault, the RBC site is subject to levels of ground shaking ranging up to very strong to violent (Modified Mercalli Intensity IX). Ground shaking intensities from a major Hayward Fault seismic event could approach or exceed a peak ground acceleration of 0.60 g. The RBC site area has not been officially assessed by the State of California for its liquefaction potential, but based on the soil type, the relatively young soil age, and the shallow groundwater depth, the sandy areas on the RBC site could be susceptible to liquefaction during an earthquake.

Seismic ground shaking could damage the proposed buildings, roadways, retaining walls, and other ancillary facilities and the development of the proposed campus would expose future campus population to risk from seismic ground shaking.

UC Seismic Safety Policy implementation would ensure that people or structures would not be exposed to a significant risk from ground shaking. The 1995 University policy on seismic safety, revised in 2011, requires that all new construction at the RBC site comply with the current seismic provisions of the California Code of Regulations, Title 24, California Buildings Standards or local seismic requirements, whichever is the most stringent. Adherence would include:

- Use of CBC seismic standards as the minimum seismic-resistant design for all proposed facilities;
- Seismic-resistant earthwork and construction design criteria based on the site-specific recommendations of a California-licensed professional civil engineer in cooperation with the project's California-licensed professional geotechnical and structural engineers (section 1802 ff and 1802A ff);
- An engineering analyses that demonstrates satisfactory performance of alluvium or fill where either forms part or all of the support, especially where the possible occurrence of liquefiable soils exists; and
- An analysis of soil expansion potential and appropriate remediation (compaction, removal/replacement) prior to using any expansive soils for foundation support.

With adherence to the University Seismic Safety Policy, all campus development would be designed and constructed to current seismic standards. Although conformance to the highest seismic standards does not guarantee avoidance of structural damage in the event of a maximum credible earthquake, it is reasonable to expect that structures built in compliance with the seismic requirements would not collapse or cause loss of life in a major earthquake. There are seismic shaking hazards beyond that associated with building collapse, including falling debris, fire, gas leaks, and others that are difficult to quantify given the potential magnitude and unpredictable nature of seismic events. The UC Seismic Safety Policy dictates stringent standards intended to

limit the impacts of such hazards. For all of these reasons, the impact related to seismic ground shaking would be less than significant.

Mitigation Measure: No mitigation measure is required.

LRDP Impact GEO-2: Development under the 2014 LRDP would result in construction on soils that could be subject to erosion and instability. (*Potentially Significant; Less than Significant with Mitigation*)

RBC site soils consist of artificial fill; alluvial fan deposits, a mix of stiff to dense silty clay with interbedded sand and gravel lenses; bay sediments; and Yerba Buena Mud (Older Bay Mud). Bay sediments may exist in the upper 18 feet. The bay sediments consist of fine- to very fine-grained sediments, while the Yerba Buena Mud is a fine-grained unit that behaves as a regionally extensive aquitard. Because of this soil lithology, there is potential for expansive soils and settlement at the RBC site. Expansion occurs in clay soils and results in soil swelling and shrinking with change in moisture conditions. Such shrinking and swelling can cause problems with building foundations, slab on-grade, and pavement unless adequately addressed during design and construction. Settlement is the gradual downward movement of an engineered structure (e.g., a building) from the compaction of the unconsolidated material below the foundation. Structures built on Bay Mud are prone to settlement that can damage the building's foundation and structural integrity unless identified and addressed during design and construction. Erosion potential at the RBC site is relatively low because the area is flat with slopes between 0 and 5 percent and clay-bearing soils encountered are likely to be cohesive.

LRDP MM GEO-2

GEO-2a: A site-specific, design-level geotechnical investigation shall be completed during the design phase of each new building project and prior to construction approval on the RBC site. This investigation shall be conducted by a licensed geotechnical engineer and shall include an evaluation of potential soils hazards and appropriate measures to minimize these hazards. Geotechnical recommendations shall subsequently be incorporated into building design.

GEO-2b: Construction under the LRDP shall comply with ABAG's Manual of Standards for Erosion and Sediment Control Measures, and the California Stormwater Quality Association's Stormwater Best Management Practice Handbook for Construction (CASQA 2003) (or subsequent editions thereof). Construction under the LRDP shall use construction BMPs and standards to control and reduce erosion. These measures could include, but are not limited to, restricting grading to the dry season, protecting all finished graded slopes from erosion using such techniques as erosion control matting and hydroseeding, or other suitable measures.

GEO-2c: All LRDP construction projects shall include, as appropriate, revegetation of disturbed areas (including slope stabilization projects) using native shrubs, trees, or grasses.

Cumulative Impacts and Mitigation Measures

LRDP Cumulative Impact GEO-1: Development under the 2014 LRDP together with cumulative development in the region would not result in significant cumulative impacts related to geology and soils. (*Less than Significant*)

Development under the proposed 2014 LRDP would attract an increased number of people to an area exposed to potential seismic effects such as ground shaking or liquefaction. Development under the 2014 LRDP would allow an increase in the size and number of structures subject to the effects of expansive soils or other soil constraints that could affect structural integrity, roadways, or underground utilities. Site preparation and development would create temporary or permanent ground surface changes that could alter erosion rates. Other reasonably foreseeable future development in Richmond would also be exposed to similar seismic hazards or be affected by expansive soils and erosion. Potentially adverse environmental effects associated with seismic hazards, expansive soils, topographic alteration, and erosion are site-specific and generally do not aggregate. Implementation of the UC Seismic Safety Policy, the National Pollutant Discharge Elimination System permit requirements, and the UC safety policies would help ensure that potential site-specific geotechnical and soil conditions would be adequately addressed and that potential impacts to future City development would be maintained at less-than-significant levels. Therefore, the proposed 2014 LRDP would result in less than significant cumulative geologic, seismic, and soil impacts.

4.5.5 References

A3GEO. 2012. Preliminary Foundation Consultation. September 10, 2012.

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4.6 GREENHOUSE GAS EMISSIONS

4.6.1 Introduction

This section discusses existing global, national, and statewide GHG and climate change conditions, and it evaluates the potential global climate impacts from development under the proposed 2014 LRDP. The section identifies the applicable federal, state, regional, and local agencies that regulate, monitor, and control GHG emissions. The proposed project GHG emissions calculations, estimates, and supporting technical data are in Appendix B.

Public and agency NOP comments related to greenhouse gas emissions are summarized below:

- The RBC development should reduce its vehicle miles traveled per capita as much as possible. Bicycling should be emphasized as an important transit option. A plan and strategies to reduce greenhouse gas emissions from transportation to and from the new campus should be prepared.
- The host city's climate action plan (CAP) should be analyzed and respected in the RBC design.
- The RBC development should minimize total vehicle miles traveled (VMT) generated by inter-campus travel, especially by private automobile.
- The RBC development should minimize total VMT generated by workers commuting by private vehicles, especially from solo driving along freeway corridors.
- The RBC development should provide significant access to both regional and local transit and contribute to general improvements in local and regional transit infrastructure to offset any increase in project-related VMT.
- The RBC development should recommend affirmative ideas and effective programs to encourage dense worker housing near new RBC jobs; the proposed project should also ensure that the host city or cities have an adequately supportive certified Housing Element in their general plans.
- The RBC development should support meaningful "traffic demand management" programs such as car share and vanpooling.
- The RBC development should reduce the predominance of free employee parking by under-sizing parking facilities compared with traditional office-park standards.
- The RBC development should avoid the collateral construction of "attractor" shopping malls or similar developments that encourage more regional VMT.
- The University should comply with the CAPs that all of the potential host cities have separately been implementing. The proposed project should also incorporate the California state goals and policies intended to reduce greenhouse gases and encourage "complete communities," consistent with Senate Bill (SB) 275 and Assembly Bill (AB) 32.
- The RBC development should mesh its bicycle/pedestrian network seamlessly with the Bay Trail and other surrounding access points.
- The RBC development should provide secure, indoor bicycle storage for employees who commute by bicycle and bike-sharing facilities at convenient locations so that visitors and employees may borrow RBC bicycles for running errands, visiting nearby retail stores and restaurants, or recreating during work breaks.

4.6.2 Environmental Setting

Background

Global climate change refers to any significant change in climate measurements, such as temperature, precipitation, or wind, lasting for an extended period (i.e., decades or longer) (EPA 2008a). Climate change may result from:

- Natural factors, such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun;
- Natural processes in the climate system (e.g., changes in ocean circulation, reduction in sunlight from the addition of atmospheric gases and particles from volcanic eruptions, forest fires, etc.); and
- Human activities that change the atmosphere's composition (e.g., through burning fossil fuels) and the land surface (e.g., deforestation, reforestation, urbanization, and desertification).

The primary effect of global climate change has been a rise in the average global tropospheric[26] temperature of 0.2 degree Celsius (°C) per decade, determined from meteorological measurements worldwide between 1990 and 2005. Climate change modeling using 2000 emission rates shows that further warming is likely to occur, which would induce further changes in the global climate system during the current century (IPCC 2007). Changes to the global climate system and ecosystems, and specifically the changes in California, could include:

- Declining sea ice and mountain snowpack levels, thereby increasing sea levels and sea surface evaporation rates with a corresponding increase in tropospheric water vapor due to the atmosphere's ability to hold more water vapor at higher temperatures (IPCC 2007);
- Rising average global sea levels primarily due to thermal expansion and the melting of glaciers, ice caps, and the Greenland and Antarctic ice sheets (model-based projections of global average sea level rise at the end of the 21st century (2090–2099) range from 0.18 meter to 0.59 meter or 0.59 foot to 1.94 feet) (IPCC 2007);
- Changing weather patterns, including changes to precipitation, ocean salinity, and wind patterns, and more energetic aspects of extreme weather including droughts, heavy precipitation, heat waves, extreme cold, and the intensity of tropical cyclones (IPCC 2007);
- Declining Sierra snowpack levels, which account for approximately half of the surface water storage in California, by 70 percent to as much as 90 percent over the next 100 years (Cal/EPA 2006);
- Increasing the number of days conducive to tropospheric ozone formation by 25 to 85 percent (depending on the future temperature scenario) in high ozone areas in southern California and the San Joaquin Valley by the end of the 21st century (Cal/EPA 2006);
- Increasing the potential for California's coastline erosion and sea water intrusion into the Sacramento and San Joaquin Delta and associated levee systems from the rise in sea level (Cal/EPA 2006);

[26] The troposphere is the bottom layer of the atmosphere, which varies in height from the Earth's surface from 6 to 7 miles).

- Increasing pest infestation, making California more susceptible to forest fires (Cal/EPA 2006);
- Increasing electricity demand by 1 to 3 percent by 2020 due to rising temperatures; this would result in hundreds of millions of dollars in extra expenditures (Cal/EPA 2006); and
- Summer warming projections in the first 30 years of the 21st century ranging from about 0.5 to 2 °C (0.9 to 3.6 °F) and by the last 30 years of the 21st century, from about 1.5 to 5.8 °C (2.7 to 10.5 °F) (Cal/EPA 2006).

The natural process through which heat is retained in the troposphere is called the "greenhouse effect." The greenhouse effect traps heat in the troposphere through a threefold process: (1) short-wave radiation in the form of visible light emitted by the sun is absorbed by the earth as heat; (2) long-wave radiation is re-emitted by the earth; and (3) greenhouse gases in the upper atmosphere absorb or trap the long-wave radiation and re-emit it back toward the earth and into space. This third process is the focus of current climate change actions.

Gases that absorb or trap long-wave radiation are called "greenhouse gases" because of their role in producing the greenhouse effect. While water vapor and carbon dioxide (CO_2) are the most abundant GHGs, other trace GHGs have a greater ability to absorb and re-radiate long-wave radiation. To gauge the potency of GHGs in intercepting long-wave radiation, scientists have established a Global Warming Potential (GWP) for each GHG based on its ability to absorb and re-emit long-wave radiation over a specific time period. The GWP of a gas is determined using carbon dioxide as the reference gas, with a GWP of 1 over 100 years (IPCC 1996).[27] For example, a gas with a GWP of 10 is 10 times more potent than carbon dioxide over 100 years. The use of GWP allows GHG emissions to be reported using carbon dioxide as a baseline. The sum of each GHG multiplied by its associated GWP is referred to as "carbon dioxide equivalent" (CO_2e). This essentially means that 1 metric ton of a GHG with a GWP of 10 has the same climate change impacts as 10 metric tons of carbon dioxide.

Greenhouse Gases

State law defines GHGs to include:

- Carbon Dioxide (CO_2). Anthropogenic, or human-caused carbon dioxide primarily is generated by fossil fuel combustion from stationary and mobile sources. Due to the emergence of industrial facilities and mobile sources over the past 250 years, the concentration of carbon dioxide in the atmosphere has increased 35 percent (US EPA 2008b). Carbon dioxide is the most widely emitted GHG and is the reference gas (GWP of 1) for determining the GWP of other GHGs. In 2004, 82.8 percent of California's GHG emissions were carbon dioxide (CEC 2007).
- Methane (CH_4). Methane is emitted from biogenic sources (i.e., resulting from the activity of living organisms), incomplete combustion in forest fires, landfills, manure management, and leaks in natural gas pipelines. In the United States, the top three sources of methane are landfills, natural gas systems, and enteric fermentation (EPA n.d.[a]). Methane is the primary component of natural gas used for space and water heating, steam production, and power generation. The GWP of methane is 21.
- Nitrous Oxide (N_2O). Nitrous oxide is produced by natural and human-related sources. Primary human-related sources include agricultural soil management, animal manure

[27] All Global Warming Potentials are given as 100-year values.

management, sewage treatment, mobile and stationary combustion of fossil fuel, adipic acid production, and nitric acid production. The GWP of nitrous oxide is 310.

- Hydrofluorocarbons (HFCs). HFCs typically are used as refrigerants in both stationary refrigeration and mobile air conditioning. HFC use for cooling and foam blowing is growing, particularly as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) use is phasing out. The GWP of HFCs ranges from 140 for HFC-152a to 6,300 for HFC-236fa.
- Perfluorocarbons (PFCs). Perfluorocarbons are compounds consisting of carbon and fluorine. They are primarily an aluminum production and semiconductor manufacturing byproduct. PFCs are potent GHGs with a GWP several thousand times that of carbon dioxide, depending on the specific PFC. Another area of concern regarding PFCs is their long atmospheric lifetime (up to 50,000 years) (Energy Information Administration 2007). The GWPs of PFCs range from 5,700 to 11,900.
- Sulfur Hexafluoride (SF_6). Sulfur hexafluoride is a colorless, odorless, nontoxic, nonflammable gas. It is most commonly used as an electrical insulator in high voltage equipment that transmits and distributes electricity. Sulfur hexafluoride is the most potent GHG that has been evaluated by the United Nations Intergovernmental Panel on Climate Change (IPCC) with a GWP of 23,900. However, its global warming contribution is not as high as the GWP would indicate due to its low mixing ratio, as compared to carbon dioxide (4 parts per trillion in 1990 versus 365 ppm of CO_2) (EPA n.d.[b]).

Contributions to Greenhouse Gas Emissions

Global

Worldwide anthropogenic (man-made) GHG emissions are tracked for industrialized nations (referred to as Annex I) and developing nations (referred to as Non-Annex I). Man-made GHG emissions for Annex I nations are available through 2007. Man-made GHG emissions for Non-Annex I nations are available through 2005. The sum of these emissions totaled approximately 42,133 million metric tons of CO_2e ($MMTCO_2e$).[28] Global emissions inventory data are not all from the same year and may vary depending on the source of the emissions inventory data.[29] The top five countries and the European Union accounted for approximately 55 percent of the total global GHG emissions according to the most recently available data.

United States

The United States was the number two producer of global GHG emissions as of 2007, the most current year of IPCC Assessment reporting. The primary GHG emitted by human activities in the United States was CO_2, representing approximately 84 percent of total GHG emissions (EPA 2008a). Carbon dioxide from fossil fuel combustion, the largest source of GHG emissions, accounted for approximately 80 percent of US GHG emissions (EPA 2008a).

[28] The CO_2 equivalent emissions commonly are expressed as "million metric tons of carbon dioxide equivalent ($MMTCO_2e$)." The carbon dioxide equivalent for a gas is derived by multiplying the tons of the gas by the associated GWP, such that $MMTCO_2e$ = [million metric tons of a GHG] x [GWP of the GHG]. For example, the GWP for methane is 21. This means that the emission of one million metric tons of methane is equivalent to the emission of 21 million metric tons of CO_2.

[29] The global emissions are the sum of Annex I and non-Annex I countries, without counting land use, land-use change and forestry (LULUCF). For countries without 2005 data, the UNFCCC data for the most recent year were used. United Nations Framework Convention on Climate Change, "Annex I Parties – GHG total without LULUCF," http://unfccc.int/ghg_emissions_data/ghg_data_from_unfccc/time_series_annex_i/ items/3841.php and "Flexible GHG Data Queries" with selections for total GHG emissions excluding LULUCF/LUCF, all years, and non-Annex I countries, http://unfccc.int/di/FlexibleQueries/Event.do?event= showProjection. n.d.

State of California

ARB compiles GHG inventories for the State of California. Based on the 2008 GHG inventory data (i.e., the latest year for which data are available), California emitted 474 $MMTCO_2e$ including emissions from imported electrical power in 2008 (ARB 2010). Based on the ARB inventory data and GHG inventories compiled by the World Resources Institute, California's total statewide GHG emissions rank second in the United States (Texas is number one) with emissions of 417 $MMTCO_2e$ excluding emissions related to imported power (ARB 2010). The primary contributors to GHG emissions in California are transportation, electric power production from both in-state and out-of-state sources, industry, agriculture and forestry, and other sources, including commercial and residential activities.

Between 1990 and 2008, the population of California grew by approximately 7.3 million (from 29.8 to 37.9 million) (US Census 2009). This represents an increase of approximately 27.2 percent from 1990 population levels. In addition, the California economy, measured as gross state product, grew from $788 billion in 1990 to $1.8 trillion in 2008 representing an increase of approximately 128 percent (more than twice the 1990 gross state product) (California Department of Finance 2009). Despite the population and economic growth, California's net GHG emissions grew only by approximately 11 percent. The California Energy Commission (CEC) attributes the slow rate of growth to the success of California's renewable energy programs and its commitment to clean air and clean energy (CEC 2006a).

4.6.3 Regulatory Considerations

Federal

In *Massachusetts vs. EPA*, the Supreme Court held that the EPA has the statutory authority under Section 202 of the CAA to regulate GHGs from new motor vehicles. The court did not hold that the EPA was required to regulate GHG emissions; however, it indicated that the agency must decide whether GHGs from motor vehicles cause or contribute to air pollution that is reasonably anticipated to endanger public health or welfare. Upon the final decision, the President signed Executive Order 13432 on May 14, 2007, directing the EPA, along with the Departments of Transportation, Energy, and Agriculture, to initiate a regulatory process that responds to the Supreme Court's decision.

In December 2007, the President signed the Energy Independence and Security Act of 2007, which sets a mandatory Renewable Fuel Standard requiring fuel producers to use at least 36 billion gallons of biofuel in 2022. The Act also sets a national fuel economy standard of 35 miles per gallon by 2020. The Act contains provisions for energy efficiency in lighting and appliances and for green building technology implementation in federal buildings. On July 11, 2008, the EPA issued an Advanced Notice of Proposed Rulemaking on regulating GHGs under the CAA. The Advanced Notice of Proposed Rulemaking reviews the various CAA provisions that may be applicable to the regulation of GHGs and presents potential regulatory approaches and technologies for reducing GHG emissions. On April 10, 2009, the EPA published the Proposed Mandatory Greenhouse Gas Reporting Rule in the *Federal Register* (EPA 2009). The rule was adopted on September 22, 2009 and covers the approximately 10,000 facilities nationwide that account for 85 percent of US GHG emissions.

On September 15, 2009, the EPA and the Department of Transportation's (DOT) National Highway Traffic Safety Administration jointly established a national program that set new standards to reduce GHG emissions and improve fuel economy; these standards apply to model year 2012 through 2016 light-duty vehicles. The proposed standards would be phased in and would require passenger cars and light-duty trucks to comply with a declining emissions standard. In 2012, passenger cars and light-duty trucks had to meet an average standard of 295 grams of

CO_2 per mile and 30.1 miles per gallon. By 2016, the vehicles would have to meet an average standard of 250 grams of CO_2 per mile and 35.5 miles per gallon.[30] These standards were formally adopted by the EPA and DOT on April 1, 2010.

On October 5, 2009, the President signed Executive Order 13514 that provides a strategy for sustainability and greenhouse gas reductions for federal agencies. The Executive Order has a number of requirements for agencies to achieve, including:

- Setting a GHG emissions reduction target to be achieved by 2020,
- 50 percent recycling and waste diversion by 2015,
- Drafting a sustainability plan,
- Reporting GHG emissions, and
- 30 percent reduction in petroleum consumption in agency fleets by 2020.

On December 7, 2009, the EPA Administrator signed two distinct findings regarding GHGs under section 202(a) of the CAA:

- **Endangerment Finding:** The Administrator finds that the current and projected concentrations of the six key well-mixed GHGs (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride) in the atmosphere threaten the public health and welfare of current and future generations.
- **Cause or Contribute Finding:** The Administrator finds that the combined emissions of these well-mixed greenhouse gases from new motor vehicles and new motor vehicle engines contribute to the greenhouse gas pollution which threatens public health and welfare.

While these findings do not impose additional requirements on industry or other entities, this action was a prerequisite to finalizing the EPA and DOT jointly proposed GHG emissions standards for light-duty vehicles. On April 1, 2010, the EPA and National Highway Traffic Safety Administration issued final rules requiring that by the 2016 model-year, manufacturers must achieve a combined average vehicle emission level of 250 grams of CO_2 per mile, which is equivalent to 35.5 miles per gallon as measured by EPA standards. These agencies are currently in the process of developing similar regulations for the 2017-2025 model years.

State

Title 24 Building Standards Code

The California Energy Commission first adopted Energy Efficiency Standards for Residential and Nonresidential Buildings (California Code of Regulations, Title 24, Part 6) in 1978 in response to a legislative mandate to reduce statewide energy consumption. Although not originally intended to reduce GHG emissions, increased energy efficiency and reduced electricity, natural gas, and other fuels consumption would result in fewer GHG emissions from buildings subject to the standards. The standards are updated periodically to allow for the consideration and inclusion of new energy efficiency technologies and methods. The latest revisions were adopted in 2008 and became effective on January 1, 2010.

[30] The CO_2 emission standards and fuel economy standards stated are based on EPA formulas.

Part 11 of the Title 24 Building Standards Code is referred to as the California Green Building Standards Code (CALGreen Code). The purpose of the CALGreen Code is to "improve public health, safety and general welfare by enhancing the design and construction of buildings through the use of building concepts having a positive environmental impact and encouraging sustainable construction practices in these categories: (1) planning and design, (2) energy efficiency, (3) water efficiency and conservation, (4) material conservation and resource efficiency, and (5) environmental air quality (California Building Standards Commission 2009). The CALGreen Code is not intended to substitute for or be identified as meeting the certification requirements of any green building program that is not established and adopted by the California Building Standards Commission (CBSC). The CBSC released a *2010 Draft California Green Building Standards Code* on its website (California Building Standards Commission 2010). The update to Part 11 of the Title 24 Building Standards Code became effective on January 1, 2011. Unless otherwise noted in the regulation, all newly constructed buildings in California are subject to the requirements of the CALGreen Code.

Assembly Bill 1493

In response to the transportation sector's contribution of more than half of California's CO_2 emissions, AB 1493 was enacted on July 22, 2002. AB 1493 requires ARB to set GHG emission standards for passenger vehicles, light-duty trucks, and other vehicles whose primary use is noncommercial personal transportation. ARB adopted the standards in September 2004. The new standards will be phased in during the 2009–2016 model years. When fully phased in, the near term (2009–2012) standards will result in a reduction of about 22 percent in GHG emissions compared to the emissions from the 2002 fleet, while the midterm (2013–2016) standards will result in a reduction of about 30 percent.

Before these regulations may go into effect, the EPA must grant California a waiver under the federal CAA that ordinarily preempts state regulation of motor vehicle emission standards. On June 30, 2009, the EPA formally approved California's waiver request. In light of the September 15, 2009 announcement by the EPA and National Highway Traffic Safety Administration regarding the national program to reduce vehicle GHG emissions, California—and states adopting California emissions standards—have agreed to defer to the proposed national standard through model year 2016 if granted a waiver by the EPA. The 2016 endpoint of the two standards is similar, although the national standard ramps up slightly more slowly than required under the California standards. The Pavley standards require additional reductions in CO_2 emissions beyond 2016 (referred to as Phase II standards). While the Phase II standards have yet to be fully developed, ARB has made it clear that the state intends to pursue additional reductions from motor vehicles in the 2017 through 2020 timeframe under the California Global Warming Solutions Act of 2006 or AB 32, discussed in detail below.

Executive Order S-3-05 and the Climate Action Team

In June 2005, Governor Schwarzenegger established California's GHG emissions reduction targets in Executive Order S-3-05. The Executive Order established these targets: GHG emissions should be reduced to 2000 levels by 2010, 1990 levels by 2020, and 80 percent below 1990 levels by 2050. The Secretary of the California Environmental Protection Agency (Cal/EPA) is required to coordinate efforts of various agencies to collectively and efficiently reduce GHGs. Some of the agency representatives involved in the GHG reduction plan include the Secretary of the Business, Transportation and Housing Agency; the Secretary of the Department of Food and Agriculture; the Secretary of the Resources Agency; the Chairperson of ARB; the Chairperson of the CEC; and the President of the Public Utilities Commission.

Representatives from each of the aforementioned agencies comprise the Climate Action Team. The Cal/EPA secretary is required to submit a biannual progress report from the Climate Action

Team to the governor and state legislature disclosing the progress made toward GHG emission reduction targets. Another biannual report must be submitted illustrating the impacts of global warming on California's water supply, public health, agriculture, coastline, and forests, and reporting possible mitigation and adaptation plans to combat these impacts. Some strategies currently being implemented by state agencies include ARB's vehicle climate change standards and diesel anti-idling measures, the CEC's building and appliance efficiency standards, and Cal/EPA's green building initiative. The Climate Action Team also recommends future emission reduction strategies, such as using only low-GWP refrigerants in new vehicles, developing ethanol as an alternative fuel, reforestation, solar power initiatives for homes and businesses, and investor-owned utility energy efficiency programs. According to the report, implementation of current and future emission reduction strategies has the potential to achieve the goals in Executive Order S-3-05.

Assembly Bill 32

In furtherance of the goals established in Executive Order S-3-05, the legislature enacted AB 32, the California Global Warming Solutions Act of 2006 that Governor Schwarzenegger signed on September 27, 2006. AB 32 represents the first enforceable statewide program to limit GHG emissions from all major industries with penalties for noncompliance. AB 32 requires the state to undertake several actions; the major requirements are discussed below.

ARB Early Action Measures. ARB is responsible for carrying out and developing the programs and requirements necessary to achieve the goal of AB 32—the reduction of California's GHG emissions to 1990 levels by 2020. The first action under AB 32 resulted in ARB's adoption of a report listing three specific early-action greenhouse gas emission reduction measures on June 21, 2007. On October 25, 2007, ARB approved six additional early-action GHG reduction measures under AB 32. ARB has adopted regulations for all early action measures. The early-action measures are divided into three categories:

- Group 1 – GHG rules for immediate adoption and implementation
- Group 2 – Several additional GHG measures under development
- Group 3 – Air pollution controls with potential climate co-benefits

The original three adopted early-action regulations meeting the narrow legal definition of "discrete early-action GHG reduction measures" include:

- A low-carbon fuel standard to reduce the "carbon intensity" of California fuels;
- Reduction of refrigerant losses from motor vehicle air conditioning system maintenance to restrict the sale of "do-it-yourself" automotive refrigerants; and
- Increased methane capture from landfills to require broader use of state-of-the-art methane capture technologies.

The six additional early-action regulations adopted on October 25, 2007, also meeting the narrow legal definition of "discrete early-action GHG reduction measures," are:

- Reduction of aerodynamic drag, and thereby fuel consumption, from existing trucks and trailers through retrofit technology;
- Reduction of auxiliary engine emissions of docked ships by requiring port electrification;
- Reduction of perfluorocarbons from the semiconductor industry;

- Reduction of propellants in consumer products (e.g., aerosols, tire inflators, and dust removal products);
- The requirement that all tune-up, smog check, and oil change mechanics ensure proper tire inflation as part of overall service to maintain fuel efficiency; and
- Restriction on the use of sulfur hexafluoride from non-electricity sectors if viable alternatives are available.

State of California Greenhouse Gas Inventory and 2020 Limit. As required under AB 32, on December 6, 2007, ARB approved the 1990 greenhouse gas emissions inventory, thereby establishing the emissions limit for 2020. The 2020 emissions limit was set at 427 $MMTCO_2e$. ARB also projected the state's 2020 GHG emissions under "business as usual" conditions—that is, emissions that would occur without any plans, policies, or regulations to reduce GHG emissions. ARB used an average of the state's GHG emissions from 2002 through 2004 and projected the 2020 levels based on population and economic forecasts. The projected net emissions totaled approximately 596 $MMTCO_2e$. Therefore, the state must reduce its 2020 "business as usual" emissions by approximately 29 percent to meet the 1990 target.

The inventory revealed that in 1990, transportation, with 35 percent of the state's total emissions, was the largest single sector, followed by industrial emissions, 24 percent; imported electricity, 14 percent; in-state electricity generation, 11 percent; residential uses, 7 percent; agriculture, 5 percent; and commercial uses, 3 percent. AB 32 does not require individual sectors to meet their individual 1990 GHG emissions levels; the total statewide emissions are required to meet the 1990 threshold by 2020.

AB 32 Climate Change Scoping Plan. AB 32 requires ARB to adopt a scoping plan indicating how reductions in significant GHG sources will be achieved through regulations, market mechanisms, and other actions. After receiving public input on their draft scoping plan, the ARB Governing Board approved the Climate Change Scoping Plan on December 11, 2008. Key elements of the Scoping Plan include these recommendations:

- Expanding and strengthening existing energy efficiency programs and building and appliance standards;
- Achieving a statewide renewable energy mix of 33 percent;
- Developing a California cap-and-trade program that links with other Western Climate Initiative partner programs to create a regional market system;
- Establishing targets for transportation-related GHG emissions for regions throughout California and pursuing policies and incentives to achieve those targets;
- Adopting and implementing measures pursuant to existing state laws and policies, including California's clean car standards, goods movement measures, and the Low Carbon Fuel Standard; and
- Creating targeted fees, including a public goods charge on water use, fees on high global warming potential gases, and a fee to fund the administrative costs of the state's long-term commitment to AB 32 implementation.

Under the Scoping Plan, approximately 85 percent of the state's emissions are subject to a cap-and-trade program where covered sectors are placed under a declining emissions cap. The emissions cap incorporates a margin of safety whereas the 2020 emissions limit will still be achieved even if uncapped sectors do not fully meet their anticipated emission reductions.

Emissions reductions will be achieved through regulatory requirements and the option to reduce emissions further or purchase allowances to cover compliance obligations. It is expected that emission reduction from this cap-and-trade program will account for a large portion of the reductions required by AB 32.

Senate Bill 97 (CEQA Guidelines)

In August 2007, the legislature enacted SB 97 (Dutton) that directed the Governor's Office of Planning and Research (OPR) to develop guidelines under CEQA for the mitigation of greenhouse gas emissions. A number of actions have taken place under SB 97; they are discussed below.

OPR Climate Change Technical Advisory. On June 19, 2008, OPR issued a technical advisory as interim guidance regarding the analysis of GHG emissions in CEQA documents (OPR 2008). The advisory indicated that a project's GHG emissions, including those associated with vehicular traffic and construction activities, should be identified and estimated, and recommended that the lead agency determine significance of the impacts and impose all mitigation measures that are necessary to reduce GHG emissions to a less than significant level. The advisory did not recommend a specific significance threshold. Instead, OPR requested that ARB recommend a method for setting thresholds that lead agencies may adopt (OPR 2009).

CEQA Guideline Amendments. In its work to formulate CEQA Guideline Amendments for GHG emissions, OPR submitted the Proposed Draft CEQA Guideline Amendments for Greenhouse Gas Emissions to the Secretary for Natural Resources on April 13, 2009. The Natural Resources Agency conducted formal rulemaking procedures in 2009 and adopted the CEQA Guideline Amendments on December 30, 2009. They became effective in March 2010.

Local

Bay Area Air Quality Management District

On June 2, 2010, BAAQMD adopted updated CEQA Air Quality Guidelines. These guidelines contain GHG operational emissions significance thresholds and recommended methodologies and models for use in assessing the impacts of a project's GHG emissions on global climate change (BAAQMD 2010a). The updated CEQA Air Quality Guidelines recommend that significance thresholds for GHG emissions should be related to AB 32's GHG reduction goals or the state's strategy to achieve the 2020 GHG emissions limit, and also provide recommended mitigation measures for reducing GHG emissions from land use development projects and stationary sources.

The CBIA filed a lawsuit alleging that the District had violated CEQA by failing to review the potential environmental impacts of the revised thresholds before adopting them. On March 5, 2012, the Alameda County Superior Court issued a judgment finding that BAAQMD had failed to comply with CEQA when it adopted the June 2010 thresholds of significance. However on July 13, 2013, the court of appeal ruled that adoption of the thresholds was not subject to CEQA. Although this decision may be appealed by the CBIA, the University has determined that in this circumstance it will use the methodological approach and emissions thresholds in the BAAQMD guidelines to evaluate the impacts of the proposed project. The thresholds for the evaluation of GHG impacts from the BAAQMD CEQA Air Quality Guidelines are presented below in Section 4.6.4.

Local Plans and Policies

The proposed RBC site is a University property that conducts work within the University's mission on land that is owned or controlled by The Regents. As a state entity created by Article IX, Section

9 of the California State Constitution, the University is exempt under the state constitution from compliance with local land use regulations, including local plans and policies. However, the University seeks to cooperate with local jurisdictions. The RBC site is in the City of Richmond. The City of Richmond has adopted a resolution committing to the emissions targets in AB 32, and has adopted an Energy and Climate Change element as part of its General Plan 2030.

The applicable local plan or policy would be a greenhouse gas reduction plan or a CAP adopted or proposed by the University for the RBC. While the University plans to adopt a CAP, it has not been developed for the RBC. BAAQMD's Clean Air Plan is a multi-pollutant plan that includes GHGs but specifically states that it is not to be considered a GHG reduction plan. Therefore, consistent with BAAQMD's CEQA guidance on GHG emissions, which is designed to meet AB 32 requirements in the region, AB 32 is the applicable plan. AB 32 establishes GHG reduction goals for the state through 2020. Because the time horizon for campus development under the proposed 2014 LRDP is 2050, in addition to AB 32, other state requirements also provide the planning framework. This is discussed further in the sections below.

4.6.4 Impacts and Mitigation Measures

Standards of Significance

The impacts related to 2014 LRDP implementation GHG emissions would be considered significant if they would exceed the following significance criteria, in accordance with Appendix G of the *2013 State CEQA Guidelines*:

- Generate GHG emissions, either directly or indirectly, that may have a significant impact on the environment; or
- Conflict with an applicable plan, policy, or regulation adopted for the purpose of reducing the emissions of GHGs.

Section 15064.4 of the amended *2013 State CEQA Guidelines* states that, when making a GHG emissions significance determination, a lead agency shall have discretion to determine whether to: (1) Use a model or methodology to quantify greenhouse gas emissions resulting from a project, and which model or methodology to use; or (2) Rely on a qualitative analysis or performance based standards.

Section 15064.4 also states that a lead agency should consider these factors when assessing the significance of GHG emissions on the environment: (1) the extent to which the project may increase or reduce greenhouse gas emissions as compared to the existing environmental setting; (2) whether the project emissions exceed a significance threshold that the lead agency determines applies to the project; and (3) the extent to which the project complies with regulations or requirements adopted to implement a statewide, regional, or local plan for the reduction or mitigation of GHG emissions.

The first Appendix G criterion may be evaluated by directly calculating the proposed project GHG emissions and comparing the emissions with the available significance thresholds. BAAQMD has operational GHG emissions significance thresholds in its CEQA Air Quality Guidelines. There are no significance thresholds for construction emissions of GHGs, although BAAQMD recommends that emissions be quantified, reported, and evaluated. BAAQMD's significance thresholds for operational-related GHG emissions are:

- Compliance with a Qualified GHG Reduction Strategy,
- Annual emissions less than 1,100 $MTCO_2e$, or

- Annual emissions of 4.6 $MTCO_2e$/service person/year (where service persons are residents plus employees).

BAAQMD has a stationary sources emissions threshold of 10,000 $MMTCO_2e$ per year. Stationary source emissions are to be assessed separately from area and mobile sources associated with a project's operation.

The BAAQMD emissions thresholds are specifically designed to bring the region into compliance with AB 32 requirements.

The 2014 LRDP has a projected full implementation date of 2050, which is beyond the final AB 32 target date. Therefore, the BAAQMD threshold of 4.6 $MTCO_2e$/service person could not be used to evaluate the emissions from full LRDP development. AB 32 mandates reduction of GHG emissions to 1990 levels by 2020, with no targets beyond that date. Executive Order S-3-05 includes the same 2020 target, and includes a 2050 target of an 80 percent reduction from 1990 levels. BAAQMD was consulted to develop a significance threshold with which the University could evaluate the GHG emissions effect of full RBC development. The BAAQMD recommended that the LRDP should show progress toward the Executive Order S-3-05 target, and that interpolation between the 2020 and 2050 targets would be an acceptable manner to develop a significance threshold to evaluate the emissions associated with the full 2014 LRDP implementation.

Using California Department of Finance projections of state population in 2050 and by reducing 1990 emissions of GHG by 80 percent, the 2050 target was estimated to be 0.81 $MTCO_2e$/service person/year. This threshold is used in this EIR to evaluate the operational GHG emissions from the full 2014 LRDP implementation. The stationary emissions threshold for 2050 would remain at 10,000 $MTCO_2e$/year per BAAQMD guidance.

The second Appendix G criterion may be evaluated by demonstrating compliance with plans, policies, or regulations adopted by local governments to control GHG emissions. According to the Natural Resources Agency:

> Provided that such plans contain specific requirements with respect to resources that are within the agency‘s jurisdiction to avoid or substantially lessen the agency‘s contributions to GHG emissions, both from its own projects and from private projects it has approved or will approve, such plans may be appropriately relied on in a cumulative impacts analysis (Natural Resources Agency 2009).

Under CEQA, "the determination of whether a project may have a significant effect on the environment calls for careful judgment on the part of the public agency involved, based to the extent possible on scientific and factual data" (CEQA Section 15064). CEQA grants agencies the general authority to adopt criteria for determining whether a given impact is "significant" (California Public Resources Code Section 21082). When there is no CEQA guidance, the agency may look to and assess general compliance with comparable regulatory schemes. The BAAQMD's Clean Air Plan represents a comparable regulatory scheme, but specifically states that it is not to be considered a GHG reduction plan. As AB 32 is the basis for the BAAQMD's regulations to control GHG emissions, it is a relevant policy for this analysis. Because the LRDP full development is projected to occur well past the final target date for AB 32, Executive Order S-3-05 becomes relevant.

Based on the above, the proposed project's GHG emissions significance and its global climate impacts are assessed based on the BAAQMD's GHG significance thresholds and the interpolated

thresholds based on Executive Order S-3-05 targets. Full 2014 LRDP implementation is assessed relative to Executive Order S-3-05 and with the interpolated thresholds.

Analytical Methods

OPR in its technical advisory has recommended that GHG emissions from project-related traffic, energy consumption, water usage, and construction activities be identified and estimated, to the extent that data are available to calculate them. ARB staff has considered extensively the value of indirect emissions in a mandatory reporting program. ARB believes that indirect energy usage provides a more complete picture of a facility's emissions footprint. According to ARB, "As facilities consider changes that would affect their emissions – addition of a cogeneration unit to boost overall efficiency even as it increases direct emissions, for example – the relative impact on total (direct plus indirect) emissions by the facility should be monitored. Annually reported indirect energy usage also aids the conservation awareness of the facility …" For these reasons, ARB has proposed requiring the calculation of direct and indirect GHG emissions as part of the AB 32 reporting requirements, and the analysis in this EIR address both types of emissions (ARB 2007).

The California Air Pollution Control Officers Association (CAPCOA) stated that the information needed to characterize GHG emissions from manufacture, transport, and end-of-life of construction materials (often referred to as lifecycle emissions) would be speculative at the CEQA analysis level (CAPCOA 2008). Since accurate and reliable data do not exist for estimating project lifecycle emissions, the analysis does not assess them.

The data sources and tools used to evaluate the proposed project's operational GHG impacts include the CalEEMod and calculation algorithms supported by the sources listed above. The CalEEMod model uses the EMFAC2007 emissions factor model for on-road motor vehicle sources and the OFFROAD2007 emissions factor model for off-road equipment. Site-specific or project-specific data were used in the CalEEMod model where available. Where information was not available for the project, model default values were selected. CalEEMod calculates GHG emissions from a project based on Bay Area-specific data and assumptions, and includes corrections for future applicable regulatory requirements, such as the Low Carbon Fuel Standard, the Renewable Fuels Portfolio standards, and others.

Additional sources consulted for this analysis include data and guidance from the EPA, the US Energy Information Administration, ARB, the CEC, the California Climate Action Registry's General Reporting Protocol, and other GHG and global climate change data as referenced. Emission calculations for the proposed project are in Appendix B.

RBC 2014 LRDP Policies

The RBC 2014 LRDP policies related to GHG emissions include the following:

- S1 – Sustainability Policy on Decision Making: Sustainability choices will be given equal weight with other planning, programming, cost, and design factors for facilitating scientific research and facility operations.
  - Include deliberate steps during early planning, design, and construction to encourage communication and integrated design across all disciplines to identify coordinated, low-cost means to fully satisfy occupant needs with minimized resource use.
- S2 – Sustainability Policy on Living Laboratory: The RBC will be cultivated as a living laboratory, in which planning, operating practices and infrastructure, facilities performance monitoring data, and sustainability goals are leveraged to engage, apply, and strengthen research.

  - Install energy, water and other performance monitoring systems to facilitate efficient use of those resources.
  - Develop infrastructure and resources for the campus based on state-of-the-practice research in sustainability fields. Make and prioritize decisions based on scientific research and outcomes and lifecycle costing whenever possible.
- S3 – Sustainability Policy on Site Development: Embody environmental stewardship and respect the unique character of the RBC in site development.
  - Draw on the neighborhood context and prominently feature the natural assets including climate, wetlands, and proximity to the San Francisco Bay and the Bay Trail.
  - Actively promote sustainability as a core value at the campus and provide practical opportunities for innovation and education in sustainable design.
  - Manage soil contamination as a component of each construction project.
  - Control construction dust by implementing the BMPs defined in the BAQMD CEQA Guidelines.
- S4 – Sustainability Policy on Energy and Climate: Pursue energy efficiency targets and renewable energy use consistent with leading-edge best practices in mitigating climate change.
  - Develop, track, and pursue energy efficiency goals that include annual consumption and peak demand targets for all buildings and infrastructure.
  - Use building orientation and passive design strategies to minimize energy use.
  - Maximize on-site generation of renewable energy.
  - Purchase grid power from 100 percent renewable sources where available at reasonable cost.
  - Directly address the challenge of high energy use in laboratory research facilities by exploring innovative design and making use of the mild climate at the RBC site to minimize energy use.
  - Develop projections for infrastructure and resources to serve the campus that are measured relative to benchmarks from best practice scenarios.
  - Prepare a CAP to guide RBC development and operations and publically report greenhouse gas emissions using standard protocols.
- S5 – Sustainability Policy on Transparency: Operate transparently in sustainability efforts by setting targets, measuring performance, and regularly reporting results.
  - Establish a multi-stakeholder committee that periodically evaluates sustainability goals and progress made towards those goals in a transparent process.
  - Make the cost for future flexibility, redundancy, and spare capacity explicit and subject to budgeting processes.
- S6 – Sustainability Policy on Green Building: New construction projects exceeding $5 million will target certification through the US Green Building Council of LEED Gold® at a minimum.
  - In addition to the LEED Gold requirement, laboratory and data center spaces and buildings will be designed to an equivalent "Gold" level using the LBNL Environmental Performance Criteria (EPC) or equivalent rating system for each building type.

  - Buildings will be designed to comply with the UC Sustainable Practices Policy, the UC Berkeley Campus Sustainability Plan, the LBNL Policy on Sustainability Standards for New Construction, and any future sustainability policies, as applicable.
- S7 – Sustainability Policy on Reduced Total Costs: Plan and manage use of all resources to minimize lifecycle costs.
  - Implement integrated design approaches that manage first costs and minimize life cycle costs for all facility and infrastructure investments.
- S8 – Sustainability Policy on Waste Minimization: Waste minimization and diversion planning for the RBC will target 100 percent diversion of municipal solid waste to composting and recycling by 2020, while simultaneously minimizing all waste streams.
  - Take advantage of opportunities to minimize the overall amount of material handled either as compost, recycle, or landfill waste identified through ongoing evaluation of activities.
  - Apply acquisition policies to minimize waste and environmental impacts.
- S9 – Sustainability Policy on Health and Wellness: RBC development will promote health and wellness of the community, including employees, visitors, and ecosystems associated with the site.
  - The on-campus transportation system will encourage walking and bicycling between buildings on the campus, minimizing the levels of greenhouse gases produced for local travel.
  - Provide an outdoor recreation area suitable for physical exercise.
  - Provide walkways with signs interpreting the ecological value of the grassland and marsh areas.
  - Provide health-conscious food choices at on-site eating amenities.
- S10 – Sustainability Policy on Local Connections: The RBC procurement policies will embody the University's commitment to sustainability and improving the quality of life of citizens in the local communities.
  - Food and other goods and services will be sourced from local growers and vendors to the degree practicable.
  - Recognize that potable water is a shared resource that must be conserved though building design, utility and landscape approaches.

LRDP Impacts and Mitigation Measures

LRDP Impact GHG-1: Development under the 2014 LRDP would generate GHG emissions that would result in a significant impact on the environment. (*Potentially Significant; Significant and Unavoidable*)

Construction GHG Emissions

During construction, the proposed project would generate GHGs from the exhaust of construction equipment and construction workers' vehicles. The manufacture of construction materials used by the project would indirectly generate GHG emissions (upstream emission source). Upstream emissions are generated during the manufacture of construction materials (e.g., cement, steel, and materials transport). This project's upstream GHG emissions, which may include perfluorocarbons and sulfur hexafluoride, are not estimated in this impact analysis because they

are not under the University's control and the lack of data precludes their quantification without speculation.

The BAAQMD does not provide any guidance on project-level analysis of construction GHG emissions impacts. It recommends that construction GHG emissions be estimated, reported, and evaluated. While the exact construction schedule is not currently known, it is possible to estimate the maximum amount of construction that would occur during any one year and estimate emissions based on that maximum activity level. This was done using CalEEMod to estimate GHG emissions during a theoretical 12-month maximum construction activity period. Carbon dioxide emissions associated with these maximum construction activities are approximately 450 metric tons. Emissions in other LRDP development years would be less than or equal to this maximum annual total. This annual amount is too small to have a measureable effect on global climate and is well below the threshold of 1,100 $MTCO_2e$ developed by the BAAQMD for evaluating the significance of the impact from a project's operational GHG emissions. The impact from LRDP-level construction emissions would be less than significant.

Operational GHG Emissions

Campus development under the proposed LRDP would generate direct operational GHG emissions. Most of these emissions—primarily carbon dioxide, methane, and nitrous oxide—would be from fuel combustion from building heating systems and motor vehicles. Building and motor vehicle air conditioning systems may use HFCs (and HCFCs and CFCs to the extent that they have not been completely phased out at later dates); these emissions are not quantified because they would only occur through accidental leaks. It is not possible to estimate the frequency of accidental leaks without speculation. ARB drafted a proposed Regulation for Management of High Global Warming Potential Refrigerants that would reduce stationary refrigeration and air conditioning systems emissions by requiring persons subject to the rule to reclaim, recover, or recycle refrigerant and to properly repair or replace faulty refrigeration and air conditioning equipment (ARB 2009).

Non-Stationary Source Emissions. Non-stationary sources include mobile sources and area sources. Mobile sources include motor vehicles, as well as gas-powered yard tools, construction equipment, and trains. Mobile source emissions were calculated using CalEEMod, which uses emission and Bay Area-specific consumption factors to calculate GHG emissions from projects within BAAQMD's jurisdiction. For estimating GHG emissions, the proposed project was assumed to fall under the CalEEMod land use category of Research and Development. Mobile emissions were calculated using trip rates from the transportation study (Fehr & Peers 2013).

Area sources include emissions from activities such as landscaping, natural gas and electricity consumption for heating and lighting, water use and wastewater generation, and solid waste disposal. Rates of electricity and natural gas consumption, water and wastewater generation, and solid waste production were based on information provided by the University. Emissions were calculated using emission factors from CalEEMod, with the exception of electricity that was calculated using emission factors reported by PG&E,[31] the local utility.

Stationary Source Emissions. Stationary sources associated with the proposed project include boilers and emergency generators. Boilers emissions were calculated using estimated fuel consumption rates provided by the University in combination with emission factors found in the

[31] It is possible that the University would obtain electricity from other energy providers that may include a higher proportion of renewable energy in their power mix than PG&E. Therefore the use of PG&E emission factors provides a conservative estimate of emissions.

Code of Federal Regulations (40 CFR Part 98 Subparts A and C). Emergency generators emissions were calculated using fuel consumption rates found in AP-42 (the EPA's compilation of air pollution emission factors), an assumed carbon content for diesel fuel of 87 percent, and the assumption that 100 percent of the carbon content becomes carbon dioxide during combustion.

Summary of Emissions. Table 4.6-1 summarizes total net estimated GHG emissions per year at full 2014 LRDP implementation and compares the resulting emission rate to the significance threshold based on Executive Order S-3-05. The service person figure for this analysis was assumed to be 10,000 persons.

Table 4.6-1
Estimated Operational GHG Emissions – LRDP

GHG Emissions Source	Emissions (metric tons CO_2e/year)
Total Non-Stationary Source Emissions	**44,723**
Total Operational GHG Emissions per Service Person	**4.5**
Threshold based on EO S-3-05	**0.8**
Exceeds Threshold?	Yes
Total Stationary Source Emissions	**31,880**
BAAQMD Threshold	**10,000**
Exceeds Threshold?	Yes

Source: Golder Associates 2013. Emissions calculations are provided in Appendix B.

As shown in Table 4.6-1, the proposed project's operational emissions would exceed the stationary and non-stationary source thresholds. The impact of GHG emissions from stationary and non-stationary sources would be significant. For stationary sources, the primary source of emissions is the boilers that are used for heating. For non-stationary sources, the emissions are relatively evenly split between electricity use and vehicle travel.

UC Berkeley has adopted the 2009 CAP plan to reduce GHG emissions and the 2009 Sustainability Plan to reduce overall resource use on the UC Berkeley campus. LBNL has also developed a Sustainability Plan to minimize its impact on the environment. CAPs provide a framework for reducing site-wide facility or campus emissions. That is, while each individual project on a campus may not meet AB 32 or Executive Order S-3-05 targets, the CAP's facility-wide programs help the facility meet its aggregate emissions targets. The 2014 LRDP includes policies to develop a CAP for the RBC, minimize energy and water use, and minimize waste. The CAP has not been developed yet, and its effectiveness to reduce the impact of the proposed LRDP cannot be evaluated.

Implementing LRDP MM GHG-1 would reduce this impact. However, it is uncertain if the Executive Order S-3-05 targets would be achieved. Therefore conservatively, the impact is determined to be significant and avoidable.

LRDP MM GHG-1: One or more CAPs would be developed and implemented for the RBC. The CAP would include target emission rates per service person that are consistent with AB 32 and Executive Order S-3-05 emissions targets. The CAP would also implement specific control measures and programs to achieve these targets. These control

measures and programs would be developed specifically for each project based on its siting and design needs, but they would at minimum address these general topics:

- Energy Efficiency: minimize energy consumption to the extent possible through measures such as design guidelines for new buildings that require specific levels of energy efficiency, incentive programs for employees or departments to reduce energy use, programs to track energy use and discover opportunities to reduce waste, and landscaping or other features that provide shade or otherwise help reduce energy use.
- Renewable Energy Generation: investigate and develop opportunities for renewable energy generation on campus, whether solar, wind, or other sources.
- Vehicle Trip Minimization: encourage the use of carpools, shuttles, bicycles, or public transportation that provide resources for employees to access and use alternative transportation, and provide infrastructure that allows employees to interact or conduct meetings and business without traveling.
- Renewable Fuel Vehicles: encourage or require the use of renewable fuel vehicles such as by providing electric vehicle charging and compressed natural gas fueling stations, purchasing renewable fuel vehicles for the campus fleet, and providing preferential parking or other incentives for drivers using renewable fuel or hybrid vehicles.
- Waste Reduction: implement waste reduction, aggressive recycling goals with incentives, composting systems for general buildings and dining areas, guidelines for low waste construction and purchasing, and educational programs.

LRDP Impact GHG-2: Development under the 2014 LRDP would conflict with an applicable plan, policy, or regulation adopted for the purpose of reducing GHG emissions. (*Potentially Significant; Significant and Unavoidable*)

AB 32 and Executive Order S-3-05 are the basis for GHG emissions reductions in California. Local agencies such as BAAQMD base their planning and regulations on the AB 32 requirements, including a reduction of GHG emissions to 1990 rates by 2020. BAAQMD adopted its GHG significance thresholds specifically to meet AB 32 requirements in its jurisdiction, and so projects meeting those thresholds can be assumed to meet the requirements of AB 32. Projects that exceed the timeline in AB 32 that ends in 2020 will be expected to comply with Executive Order S-3-05, which requires an 80 percent reduction from 1990 emission rates by 2050. Because the estimated rate of emissions associated with the proposed project exceeds the threshold based on Executive Order S-3-05, the proposed project would conflict with the applicable regulation and the impact is considered significant.

If emissions were reduced to levels meeting the Executive Order S-3-05 goal, an 80 percent reduction from 1990 levels by 2050, the proposed project would be in compliance with the

relevant regulation. Because there is uncertainty whether GHG reduction achieved pursuant to LRDP MM GHG-2 would be sufficient to meet the Executive Order S-3-05 goal, this impact is considered significant and unavoidable.

LRDP MM GHG-2: Implement LRDP MM GHG-1.

4.6.5 References

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4.7 HAZARDS AND HAZARDOUS MATERIALS

4.7.1 Introduction

This section discusses existing hazards and hazardous materials at the project site. It analyzes the potential for development under the proposed 2014 LRDP development to increase the use, generation, and disposal of, or exposure to hazards and hazardous materials, focusing on existing site conditions and anticipated future demolition, construction, and laboratory activities.

Public and agency NOP comments related to hazards and hazardous materials are summarized below:

- The EIR should include a comprehensive, independent, and transparent safety and risk analysis of the proposed actions, including for any novel aspects of new science.
- The EIR should identify and propose remedies related to known contamination.
- The EIR should discuss prevention of, and planned response to, any possible release of pollutants and biohazards into the environment if there is an accident, including earthquake, fire, and flood.

4.7.2 Environmental Setting

Historical chemical manufacturing operations at the California Cap Company and industrial operations at neighboring properties released or deposited chemicals onto the uplands, marsh, and transition areas of the RFS and the property adjacent to Regatta Boulevard. More recently, research studies at the RFS have been primarily in the field of engineering; thus, hazardous materials[32] use at the RFS has been relatively minor. As described in historical records, chemicals used at the RFS include bench-scale laboratory chemicals and radioisotopes, mercury manometers, radioisotopes for tracer studies, wood treatment chemicals, gasoline, diesel fuel, hydraulic oil, herbicides for grounds maintenance, PCBs in electrical equipment, building paint and caulking, and other miscellaneous products for housekeeping and other facilities maintenance activities (UC Berkeley 2008).

Because the RFS is an academic teaching and research facility, generally only small laboratory-scale (1 gallon or less) amounts of chemicals are used and stored at the site. Available records indicate that larger quantities were used in a few exceptional instances, but currently the only laboratory research chemicals in reportable quantities are gases, hydraulic oil, and petroleum products (UC Berkeley 2008).

Current site operations include the use of solvents, adhesives, cements, paints, cleaning agents, degreasers, and vehicle fuels. The 2013 Hazardous Materials Business Plan for the RFS lists the following chemicals in reportable quantities: acetylene, argon, asphalt, asphalt cold patch, carbon dioxide, cleaners, orange oil degreaser, gasoline, helium, hydraulic oil, hydrogen, nitrogen, oil, oxygen, paint, propane, roof sheeting, safety kleen, transmission fluid, and waste oil. The 2013 Hazardous Materials Business Plan for the RBC site property west of Regatta Boulevard lists diesel fuel being present in a 400-gallon container at this property. The May 2013 Chemical Inventory for the RFS reports less than 1,000 gallons of liquids and less than 500 pounds of solids of laboratory chemicals on hand. Wet chemistry laboratories remain in operation at Buildings

[32] Section 22501(o) of the California Health and Safety Code defines "hazardous material" as any material that, because of quantity, concentration, or physical or chemical characteristics, poses a significant present or potential hazard to human health and safety or to the environment. Hazardous materials are commonly used in research laboratories and commercial, agricultural, and industrial applications, and in residential areas to a limited extent.

112, 478, and 484, and a number of small mechanical engineering shops with some shop chemicals are present in other buildings. Hazardous wastes are packaged, labeled, and categorized for transport to appropriately licensed off-site treatment and disposal facilities.

Existing Structures

As with the UC Berkeley main campus, many current and historical RFS research facilities used or stored hazardous chemicals. These include the earthquake engineering facilities at Buildings 420 and 421 and Buildings 102, 110, 111, 112, 113, 114, 117, 118, 121, 125, 138, 151, 158, 177, 197, 278, 280A, 280B, 450, 460, 470, 474, 478, 480, and 482 (UC Berkeley 2008). Although there are no indications that spills have occurred, few, if any, samples have been collected in these areas. While few soil samples have been collected adjacent to these buildings, a site-wide groundwater monitoring well network has been installed that did not detect any evidence of widespread contamination of the RFS.

Building 120 was used as a solvent storage shed at the time of the 1989 inspection, and approximately 20 55-gallon drums of thinner, kerosene, and various petroleum hydrocarbon products were observed in the building (UC Berkeley 2008). Spills were observed on the floor and in drip pans and these were cleaned up at the time. Empty and full unlabeled drums were observed. This building is currently used to store chemical wastes prior to off-site disposal. Approximately 20 unlabeled 55-gallon drums were stacked three-high against a wall outside the building, and most of the drums appeared to be empty (UC Berkeley 2008). Another six 55-gallon drums were found just outside Building 120 near a small area of stained soil. Several of the six drums were empty, while others contained a mixture of water and unknown product (UC Berkeley 2008).

There are potentially asbestos-containing materials in existing facilities in the form of transite walls and wall partitions, floor tiles and mastic; and in pipe and heating, ventilation, and air conditioning insulation materials. A number of surveys for asbestos-containing material have been done at the RFS. The campus maintains an active Asbestos Operations & Maintenance Program to assess suspect asbestos-containing materials that might be impacted by upcoming construction and maintenance projects, including hiring licensed third party industrial hygiene firms to conduct comprehensive surveys for planned building renovation and demolition. When some of the existing facilities were built, lead-based paint was in common use.

Aboveground Storage Tanks

Currently there are eight aboveground storage tanks (ASTs) at the RFS storing fuels for facility operations and one AST at the RBC site property, west of Regatta Boulevard storing fuel for an emergency generator.

At the RFS, three ASTs hold fluids for teaching and research laboratories. Tank A-18-1, installed in 1996 on the west side of Building 280A, is an empty 1,500-gallon double-walled SuperVault™ tank that used to contain diesel fuel. Tank A-18-3, installed in 1969 at Building 421, is a 2,000-gallon single-walled steel tank that contains hydraulic fluid for equipment in the Earthquake Engineering Research Center. Tank A-18-4, installed in 1965 at Building 484, consists of two linked tanks containing a maximum of 1,000 gallons of hydraulic fluid for equipment in the Structural Test Laboratory.

Five ASTs are used to store fuels for RFS facilities' operations. Tank A-18-2, installed in 1997 in the Corporation Yard, is a 1,500-gallon double-walled SuperVault™ tank that stores gasoline for fueling RFS maintenance vehicles. The four remaining tanks contain diesel fuel for emergency generators and a fire suppression water pump. Tank A-18-5, installed in 1982, is a 120-gallon single-walled steel tank at Building 400 that supplies fuel to the fire suppression system pressure

booster engine. Tank A-18-6, installed in 2004 in Building 400, is a 110-gallon double-walled steel belly tank attached to a diesel-powered emergency electrical generator. Tank A-18-7, installed in 2005, is a 110-gallon double-walled steel belly tank attached to a diesel-powered emergency electrical generator for Building 194. Tank A-18-8 is a 365-gallon double walled generator belly tank installed in 2012 and attached to a diesel-powered emergency electrical generator for Buildings 112 and 113.

The ASTs are all in good condition and there have been no reports of releases except for a valve seep onto soil from the hydraulic fluid piping between Buildings 421 and 484 (planned for excavation in summer 2013). During a site walk with DTSC staff on May 12, 2011, it was confirmed that there is no staining or evidence of a spill at the other AST locations.

Fifty-five-gallon drums and two potable fuel tanks (70 and 100 gallons) store petroleum products (for research and vehicle fueling and maintenance) and waste petroleum products, such as waste oil. Drums are kept in Buildings 120, 197, 280A, and 421.

The AST at the RBC site property west of Regatta Boulevard is a 400-gallon double-walled steel belly tank attached to a diesel-powered emergency electrical generator that provides emergency power to the cooling system of the Film Archive.

Underground Storage Tanks

Currently, no known underground storage tanks (USTs) are at the RFS. Five USTs were removed between 1986 and 1997. No known leaks or releases were associated with these tanks (UC Berkeley 2008).

Polychlorinated Biphenyls Transformers

Current RFS electrical power distribution equipment contains only non-PCB dielectric fluids. Historically, most transformers were originally mounted to utility poles and they were later replaced with ground-level transformers on pads. Records showed that all PCB-containing electrical distribution system transformers were either removed for off-site disposal or retrofilled on-site with non-PCB oils in the late 1980s and early 1990s (UC Berkeley 2008). During this period, approximately 40 pieces of electrical equipment (mostly capacitors and some transformers) were temporarily placed on a concrete pad in the northern portion of Building 280B, as part of a campus-wide cleanout of PCB items. There are no records indicating that spills of PCB oils ever occurred, and former employees did not recall any leaks or spills associated with the transformers at the RBC (UC Berkeley 2008). PCBs have been detected in the soil at a number of locations that require cleanup, as discussed in Section 3.10 (Tetra Tech 2013).

Radiological Materials

Radiological materials have been used in certain types of research at the RFS since the 1950s. Meter readings were taken and building interior surfaces were wipe-surveyed as part of the routine radiation safety inspections conducted for decades, with no evidence of radiological contamination identified (UC Berkeley 2008).

Records also show two locations where radionuclides were used in tracer experiments in the outdoor environment. In one study, short-lived radionuclides were used in areas secured with four-foot-high “antipersonnel” fences to research nutrient uptake in isopods. In another location, UC Berkeley developed a research project in the early 1950s for deep-well injection and contaminant transport as part of a State of California-funded program. Following completion of studies in 1953, some or all of these wells were used in studies in the 1950s and 1960s to evaluate groundwater transport. These studies used primarily short-lived radionuclide tracers, such as cesium (Cs-134), iodine (I-131), and strontium (Sr-89); however, small amounts of

several long-lived radionuclides (strontium (Sr-90), cesium (Cs-137), tritium (H3), and carbon (C-14)) were also used.

No radiological spills outside of buildings have been reported. Records indicate that well purge water with residual radioactive tracer compounds from the Research Well Field was discharged to San Francisco Bay through the storm drain system of ditches and pipes. Also, a former UC employee reported in 2005 that he witnessed drums of rocks he was told were radioactive buried in trenches in the bulb portion of the transition area (in the Natural Open Space). Meter surveys and soil sample analyses have not detected radiological content above background, but in 2006, a magnetometer survey by DTSC found an anomaly in one area indicating ferrous metal beneath the surface.

Currently, there are two Radiation Use Authorizations for UC Berkeley activities-- one for radiation-producing machines and one for radioactive sources; the number of Radiation Use Authorizations can change regularly depending on current research needs.

Soil and Groundwater Contamination

Soil and Groundwater Investigations

Investigations between 1981 and 2008 involved collection of soil and groundwater samples in a variety of locations in the RFS. Soil samples were generally analyzed for metals, PCBs, polycyclic aromatic hydrocarbon (PAH), semivolatile organic compounds, or pesticides. The investigations prior to 2010 focused on potential source areas and identified areas requiring further investigation. The data collected during these investigations is summarized in the Current Conditions Report (Tetra Tech 2008) and Site Characterization Report (Tetra Tech 2013).

Significant soil and groundwater sampling has been done through the oversight of DTSC through the Field Sampling Workplan (FSW) that was prepared by UC Berkeley and approved by DTSC in 2008. This section summarizes FSW Phases I, II, and III investigation activities and sampling results from 2010 through 2012.

The FSW addresses data gaps identified in the Current Conditions Report that warranted additional characterization or evaluation at the RFS. The purpose of the FSW investigation was to close previously identified data gaps and to identify any immediate or potential risks to public health and the environment. The results are briefly summarized below and are described in detail in the Site Characterization Report (Tetra Tech 2013), which was recently submitted to and approved by the DTSC in connection with a proposed RAW for developable portions of the RBC within the RFS.

Chemicals of Concern

The results of the historical and FSW investigations indicate that there are elevated concentrations of certain metals, PAHs, and PCBs. Other potential contaminants more limited in soils include dioxins, total petroleum hydrocarbon (TPH), and VOCs. For this discussion, "elevated" concentrations in soil refers to soil concentrations above the screening criteria used in the Site Characterization Report. Two VOCs in groundwater (TCE and carbon tetrachloride) have been detected above the calculated human health vapor intrusion criteria for future commercial workers.

Metals. Arsenic concentrations above background levels in soil are the result of historical placement of pyrite cinders as fill material. Arsenic is commonly associated with iron sulfides, such as those used in production of sulfuric acid at the former Stauffer production areas. In addition, it is found in related sulfide minerals, including arsenopyrite and chalcopyrite.

Potential sources of lead include (1) emissions from automobiles and fuels such as those associated with the adjacent I-580 freeway, (2) as a component of metals used in manufacturing ammunition shells and blasting caps, (3) pyrite cinder used as fill, and (4) lead-based paint from former or existing buildings. Some elevated concentrations of lead are found in isolated areas of RFS soils, perhaps attributable to the "nugget effect" that can occur when lead-based paint chips enter the soil.

Mercury is present at elevated concentrations in RFS soils primarily due to historical activities associated with manufacturing explosives. The former California Cap Company historically used elemental or liquid mercury in the Mercury Fulminate Area (MFA). This form of mercury can volatilize into the atmosphere from soil, sediment, or water. Drawings of the mercury fulminate production plant show an open structure (presumably for ventilation) and air stack that could have contributed to aerial deposition of mercury in the areas surrounding the mercury fulminate plant in the central meadow. Drawings also identify storage tank rinsate areas in the MFA. Additionally, movement of the blasting caps around the facility via the tram system could have tracked mercury away from the mercury fulminate plant.

PAHs. PAHs at the RFS are likely a result of burning carbon-containing compounds (including at the former waste incinerator near Building 120 and the former Field Laboratory), aerial emissions from surrounding industrial facilities, and gasoline and diesel exhaust from regional roadways and railyards. An assessment of the soil data, mostly in the Corporation Yard, indicates that concentrations of PAHs decrease with depth; where PAHs are present, concentrations of PAHs are elevated above screening criteria in surface soils (0 to 0.5 foot below ground surface (bgs)), but are typically less than screening criteria at deeper depths (2 to 2.5 feet bgs), and are not detectable below 2 to 2.5 feet bgs.

PCBs. Aroclors-1248, -1254, and -1260 are commonly found at the RFS and are likely associated with hydraulic fluids and di-electrical fluids in capacitors and transformers, or with one of the many uses of PCBs allowed until 1977, including heat transfer fluids for gas turbines, hydraulic fluids for vacuum pumps, fire retardants, and plasticizers in adhesives, textiles, surface coatings, sealants, printing, and carbonless copy paper (Lloyd and others 1975). Typically, a release of PCBs to surface soils from a spill would have migrated little from its original release point, as PCBs adsorb strongly to soil. This model is supported by the sampling data obtained during the FSW Phase II investigation, which sampled near former PCB-containing transformers. Where PCB contamination was detected, elevated concentrations of PCBs were limited to a small area, both horizontally and vertically, confirmed through step-out sampling.

PCBs have also been detected at low concentrations (below screening criteria) in surficial soils in the RFS, most of which may not be attributed to a spill but possibly to aerial deposition from surrounding industrial facilities, including the PG&E facility northwest of the property.

Dioxins. Dioxins in the environment are the result of burning chlorine-based chemical compounds with hydrocarbons, such as stack emissions from the incineration of municipal refuse and certain chemical wastes or exhaust from automobiles powered by leaded gasoline. The former waste incinerator at Building 120 may be a potential historical source of dioxins; soil samples collected for dioxin analysis near the former incinerator location indicate that dioxin concentrations in that area exceed commercial screening values in surficial soil, but concentrations decrease as sample depth increases.

VOCs. Although RFS soils have not been found to contain concentrations of VOCs exceeding screening criteria, groundwater results indicate that TCE, TCE-related chlorinated hydrocarbons, and carbon tetrachloride exceed groundwater screening criteria.

Groundwater impacted with elevated levels of TCE and TCE-related chlorinated hydrocarbons exceeding California and federal maximum contaminant levels has migrated onto the RFS from the adjacent former Zeneca site. UC concluded that the source of TCE and related chlorinated hydrocarbons in groundwater at the RFS is legacy industrial activities at the former Zeneca site, based on (1) the measured groundwater gradient from the former Zeneca site to the RFS, (2) known historical TCE sources and groundwater contamination at the upgradient former Zeneca site, and (3) lack of measured or identified TCE sources within the RFS property. The remedy for contaminants in groundwater originating from the former Zeneca Site, including TCE and its breakdown components, is subject to the former Zeneca Site Investigation and Remediation Order (IS/E-RAO 06/07-005) issued by DTSC.

Carbon tetrachloride was detected at one location in the coastal-terrace prairie at concentrations exceeding the commercial vapor intrusion screening criteria and California maximum contaminant levels during the FSW Phase I investigation. Carbon tetrachloride has also been detected at some locations downgradient of this location at concentrations exceeding the California maximum contaminant level. No source of carbon tetrachloride has been identified in the immediate area or upgradient of the locations where it was detected.

TPH. Low concentrations of TPH compounds in soil may originate from small diesel spills from equipment, from ASTs or former USTs, from incomplete combustion of petroleum from nearby automobiles and industrial uses, or as a carrier in herbicides. No evidence of spills was observed at any of the ASTs still in place, and all USTs have been removed and administratively closed. Soil sample results indicate that the Earthquake Engineering hydraulic lines at Building 484 have leaked, and soil excavation in this area is proposed to be completed as a maintenance activity. TPH contamination may be present near and around the Earthquake Engineering hydraulic lines.

Explosives. Between the late 1800s and 1948, the California Cap Company and other smaller companies manufactured blasting caps, ammunition shells, and explosives on the RFS property. The chief constituent of the explosive used by the California Cap Company was a nitrocellulose (guncotton) base called "tonite," the manufacturing of which included the production of mercury fulminate. Documentation indicates that nitrocellulose and mercury fulminate were the primary explosives used in these manufacturing operations; however, other explosives such as octogen (HMX), cyclotrimethylenetrinitramine (RDX), or 2,4,6-trinitrotoluene (TNT) may have been employed. Historical documents indicate that explosives were tested and stored in the north-central portion of the RFS property. Soil data indicates that HMX may have been used, as it was detected at a low level in one soil sample collected near the former explosives storage area at a concentration of 0.37 milligrams per kilogram, five orders of magnitude below the commercial screening criteria.

4.7.3 Regulatory Considerations

The RBC site is subject to environmental, health, and safety regulations applicable to proposed site activities, including the transportation, use, management, and disposal of hazardous materials and wastes. This section provides an overview of the regulatory setting.

State and Federal

Among primary federal agencies with regulatory responsibility for environment, health, and safety management are EPA, US Department of Labor, Occupational Safety and Health Administration (OSHA), DOT, and DOE. Federal laws, regulations, and responsible agencies relevant to the proposed RBC are discussed in detail in this section. In many cases, California state law mirrors or is more restrictive than federal law, and enforcement of these laws has been delegated to the state or a local agency. All demolition activities involving possible radiological contamination would be coordinated with the California Department of Public Health in order to

assure proper management of any possible radiological contamination. In January 1996, the California Environmental Protection Agency adopted regulations implementing a Unified Hazardous Waste and Hazardous Materials Management Regulatory Program (Unified Program). The program has six elements: hazardous waste generators and hazardous waste on-site treatment, underground storage tanks, aboveground storage tanks, hazardous materials release response plans and inventories, risk management and prevention programs, and Unified Fire Code hazardous materials management plans and inventories. The local agency responsible for implementing the Unified Program is called the Certified Unified Program Agency. Because the RBC site is in the city limits of the City of Richmond, the City of Richmond is the designated Certified Unified Program Agency.

Hazardous Materials Management

Federal and state laws require detailed planning to ensure that hazardous materials are properly handled, used, stored, and disposed of, and if they are accidentally released, to prevent or to mitigate injury to public health or the environment. These laws require hazardous materials users to prepare written plans detailing the types and quantities of hazardous materials used on site and addressing emergency response and training procedures. The City of Richmond, through its Certified Unified Program Agency program, requires any business that handles hazardous materials above certain thresholds to prepare a Hazardous Materials Business Plan. At the proposed RBC site, UC Berkeley voluntarily complies with these state requirements as implemented by the City of Richmond. LBNL also maintains a Hazardous Materials Business Plan for LBNL facilities and operations.

Hazardous Waste Handling

Under the federal Resource Conservation and Recovery Act of 1976 (RCRA), the EPA regulates the generation, treatment, and disposal of hazardous waste, and the investigation and remediation of hazardous waste sites. Individual states may apply to the EPA to be authorized to implement their own hazardous waste programs in lieu of RCRA, if the state program is at least as stringent as federal RCRA requirements. The EPA authorized California to implement its own hazardous waste program, with certain exceptions. In California, DTSC regulates the generation, transportation, treatment, storage, and disposal of hazardous waste and the investigation and remediation of hazardous waste sites. The DTSC program incorporates the provisions of federal and state hazardous waste laws (LBNL 2007). In California, oversight of waste management practices at hazardous waste generator sites is generally provided by Certified Unified Program Agencies.

Hazardous Materials Transportation

The DOT regulates the transportation of hazardous materials between states. The State of California has adopted DOT regulations for the intrastate movement of hazardous materials and regulates the transportation of hazardous waste originating in the state and passing out of the state. The two state agencies that have primary responsibility for enforcing federal and state regulations and responding to hazardous materials transportation emergencies are the California Highway Patrol and the California Department of Transportation (Caltrans). The California Highway Patrol enforces hazardous material and hazardous waste labeling and packing regulations to prevent leakage and spills in transit and to provide detailed information to cleanup crews if there is an accident. The California Highway Patrol regularly inspects licensed transporters to assure regulatory compliance. Caltrans has emergency chemical spill identification teams at as many as 72 locations throughout the state that can respond quickly if there is a spill (LBNL 2007).

At the proposed RBC site, DOE Order 460.1B (“Packaging and Transportation Safety”) would also apply to LBNL activities, as this Order establishes the safety requirements for the proper

packaging and transportation of DOE offsite shipments and onsite transfers of hazardous materials.

Department of Toxic Substances Control

Pursuant to Section 102 of CERCLA, 42 U.S.C, Section 9602, and California Health and Safety Code (HSC) Section 25316, DTSC provides the oversight of "hazardous substances" as listed in 40 CFR Section 302.4. DTSC has issued a Site Investigation and Remedial Action Order (Order) as a result of hazardous substances identified at the RFS property.

The HSC provides jurisdiction to DTSC regarding the oversight and enforcement of the DTSC Order for the RFS. The Order is issued pursuant to its authority under HSC Sections 25358.3(a), 25355.5(a)(1)(B), 58009, and 58010.

- HSC Section 25358.3(a) authorizes DTSC to take various actions, including issuance of the Order, upon DTSC's making certain determination of a release or a threatened release of a hazardous substance.
- HSC Section 25355.5(a)(1)(B) authorizes DTSC to issue an order establishing a schedule for removing or remedying a release of a hazardous substance at a site, or for correcting the conditions that threaten the release of a hazardous substance. The order may include but is not limited to requiring specific dates by which the nature and extent of a release shall be determined and the site adequately characterized, a remedial or removal action plan prepared and submitted to DTSC for approval, and a removal or remedial action completed.
- HSC Section 58009 authorizes DTSC to commence and maintain all proper and necessary actions and proceedings to enforce its rules and regulations; to enjoin and abate nuisances related to matters within its jurisdiction that are dangerous to health; to compel the performance of any act specifically enjoined upon any person, officer, or board, by any law of California relating to the matters within its jurisdiction; or on matters within its jurisdiction, to protect and preserve the public health.
- HSC Section 58010 authorizes DTSC to abate public nuisances related to matters within its jurisdiction.

All response actions taken pursuant to the Order must be consistent with the requirements of HSC Chapter 6.8 and any other applicable state or federal statutes and regulations, including Title 29 CFR 1910.120 and Title 8 CCR Section 5192 health and safety regulations.

Occupational Safety

Occupational safety standards are in federal and state laws to minimize worker safety risks from physical and chemical hazards in the workplace. The federal OSHA is generally responsible for assuring worker safety in the workplace. In California, the Department of Industrial Safety (Cal/OSHA) operates an occupational worker safety and health program under an agreement with OSHA. Under that agreement, Cal/OSHA has jurisdiction in California over most public and private sector workplaces, with certain exceptions. At the proposed RBC, while Cal/OSHA would have jurisdiction over UC Berkeley non-radiological occupational safety and health, future LBNL operations would be subject to LBNL policy and DOE's jurisdiction and worker safety regulation, which includes requirements to comply with various OSHA standards.[33] LBNL also

[33] DOE's "Worker Safety and Health Program" (10 CFR 851) establishes DOE's nonradiological occupational safety and health regulation for DOE workplaces, just as OSHA and Cal/OSHA regulations do for non-DOE workplaces. This program ensures

adheres to Cal/OSHA Construction Safety Orders for subcontracted work when a Cal/OSHA standard is more stringent than federal standards. OSHA and Cal/OSHA regulations contain requirements, concerning the use of hazardous materials in the workplace and during construction, that mandate employee safety training, safety equipment, accident and illness prevention programs, hazardous substance exposure warnings, emergency action and fire prevention plan preparation, and a hazard communication program. The hazard communication program regulations contain training and information requirements and require preparation of emergency action plans (escape and evacuation procedures, rescue and medical duties, alarm systems, and training in emergency evacuation).

Biosafety Standards

Federal and state laws and funding agencies establish standards for working with biohazardous materials and biological materials in research. Materials are defined as being biohazardous based on the applicable biosafety standard. Biohazardous materials are generally materials, agents, or organisms that potentially present a risk to humans, animals, plants, or the environment (e.g., infectious agents, and research recombinant organisms) The U.S. Public Health Service, including the National Institutes of Health and the Centers for Disease Control and Prevention, establish standards for working with biohazardous materials. These federal guidelines address biological safety in research, including containment levels (e.g., biosafety level 1 to 4) and controls for different types of recombinant experiments and research operations such as laboratories, animals, or greenhouses. Operations at RBC will operate at the lower and more common biosafety levels (e.g., biosafety level 1 or 2). OSHA also establishes worker safety requirements for research with materials such as human blood or tissue. In addition, U.S. Department of Agriculture and California agencies set requirements to control acquisition of and prevent release of materials (e.g., soil), agents (e.g., pathogens), or organisms (e.g., transgenic plants) that may harm plants or animals such as crops or livestock. UC Berkeley and LBNL research involving biohazardous materials is conducted in compliance with these federal and state laws and guidelines and in compliance with California Department of Public Health medical waste regulations.

Radiation Safety—Ionizing Radiation and Non-Ionizing Radiation

Ionizing Radiation. Ionizing radiation is high energy particle and non-particle radiation (such as x-rays and gamma rays) emitted from radioactive sources and radiation-producing machines which is capable of imparting ionizing energy in a biological medium such as the human body. Sources of ionizing radiation are present at UC Berkeley and LBNL in research applications. UC Berkeley laboratories using radioactive materials must comply with regulations of several federal agencies, including the Nuclear Regulatory Commission. Radionuclides released to the atmosphere from LBNL research activities must adhere to EPA National Emission Standards for Hazardous Air Pollutants regulations and DOE Order 458.1, "Radiation Protection of the Public and the Environment." EPA administers the National Emission Standards for Hazardous Air Pollutants regulations (under 40 CFR Part 61), which limit the dose to the public from airborne radionuclide emissions to 10 millirem per year. DOE has established a set of limits for radiation workers in 10 CFR Part 835. To minimize radiological impacts to the environment and the public, UC and LBNL manages its programs so that radioactive emissions and exposures are as low as reasonably achievable.

that DOE contractor workers have safe and healthful workplaces where hazards are abated, controlled, or otherwise mitigated in a manner that provides reasonable assurance that workers are protected from the hazards associated with their jobs. It establishes management responsibilities, workers' rights, required safety and health standards, and worker training on the hazards of their jobs, and hazard controls.

Non-ionizing Radiation. Non-ionizing radiation is energy that is not created by radioactive materials and does not impart ionizing energy in a biological medium such as the body. Many sources of non-ionizing radiation are present at UC Berkeley and LBNL in research applications or in ancillary equipment. These sources include lasers, large magnets, microwave generators, and radio-frequency radiation. In general, non-ionizing radiation tends to be less hazardous to humans than ionizing radiation. However, depending on the wavelength/frequency and the irradiance (or power density) value, non-ionizing radiation sources may present a human health hazard. Most typically, the hazard, if any, is to those in the lab and not members of the public.

OSHA standards apply to non-ionizing radiation by requiring a safe and healthful workplace free of recognized serious hazards. Additionally, DOE's "Worker Safety and Health Program" (10 CFR 851) ensures that DOE contractor workers have safe and healthful workplaces where hazards are abated, controlled, or otherwise mitigated in a manner that provides reasonable assurance that workers are protected from the hazards associated with their jobs. Both UC Berkeley and LBNL have laser safety programs that include control measures, medical surveillance, and safety training. These laser safety programs are based on ANSI Z136.1 Standard for the Safe Use of Lasers.

Local

The proposed RBC would include portions of the RFS and other properties in Richmond owned or controlled and operated by the University of California. As a state entity, the University is exempted by the state constitution from compliance with local land use regulations, including general plans and zoning. However, the University seeks to cooperate with local jurisdictions to reduce any physical consequences of potential land use conflicts to the extent feasible.

The City of Richmond General Plan 2030 includes the following policies pertaining to hazardous materials:

- Continue to work with the appropriate local, state, and federal agencies to promote the clean-up and reuse of contaminated sites to protect human and environmental health. Work with property owners and regional agencies to prevent, reduce or eliminate soil and water contamination from industrial operations, the Port and other activities that use, produce or dispose of hazardous or toxic substances. Implement appropriate mitigation measures and clean-up of sites that are known to contain toxic materials as a condition of reuse. Support the remediation and reuse of large, disturbed sites, such as the Winehaven complex at Point Molate and the Terminal 4 site at Point San Pablo, into mixed-use centers that provide the maximum benefit to the community without compromising the integrity of the surrounding natural areas.
- Implement standards dealing with the safe management of hazardous substances in close coordination with the City Fire Department and the DTSC. The standards should require soil testing at development sites where contamination is suspected, address safe household hazardous and universal waste disposal and ensure compliance with hazardous substance regulations and safe transport of hazardous materials. Use of the latest technologies available should be considered when conducting remediation to expedite the cleansing process and do the least harm to the environment (City of Richmond 2012).

The 2030 General Plan EIR determined that the effects on hazards and hazardous materials from future development pursuant to the General Plan would be less than significant. Future development would not create a significant hazard from the routine use, storage, transportation, and disposal of hazardous materials or from the demolition or renovation of existing structures that could contain hazardous materials. Existing regulations would minimize the potential for

people to be exposed to hazardous materials at contaminated sites. No mitigation measures would be required. Cumulative impacts would also be less than significant.

Emergency response plans are maintained at the federal, state and local level for all types of disasters, including human-made and natural. UC Berkeley EH&S maintains a Dedicated Spill Response Team that consists of health and safety professionals, hazardous materials technicians, and appropriately licensed hazardous materials drivers. The team is trained to respond to most incidents and arranges for appropriate outside assistance when necessary. LBNL developed a Master Emergency Program Plan (MEPP) that establishes policies, procedures, and an organizational structure for responding to and recovering from a major disaster. The MEPP uses the Standardized Emergency Management System for managing response to multi-agency and multi-jurisdiction emergencies in California and the National Incident Management System, which is a nationwide standardized approach to incident management prescribed by Homeland Security Presidential Directive 5. The plan includes four phases of emergency management: mitigation, preparedness, response, and recovery. UC Berkeley and LBNL would coordinate with state and local authorities to develop a site-specific emergency response plan for the new facilities proposed for the RBC.

4.7.4 Impacts and Mitigation Measures

Standards of Significance

The impacts related to hazards and hazardous materials from development under the 2014 LRDP would be considered significant if they would exceed the following Standards of Significance, in accordance with Appendix G of the State CEQA Guidelines and the UC CEQA Handbook:

- Would the project create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?
- Would the project create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?
- Would the project result in development that would emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?
- Would the project be on a site that is on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?
- Would the project impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?

CEQA Checklist Items Adequately Addressed in the Initial Study

The analysis in the Initial Study prepared for the project and circulated with the NOP concluded that further analysis of the following issues was not required in the EIR:

- For a project within an airport land use plan or, where such a plan has not been adopted, within 2 miles of a public airport or public use airport, would the project result in a safety hazard for people residing or working in the project area?
- For a project near a private airstrip, would the project result in a safety hazard for people residing or working in the project area.

- Would the project expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands

The proposed RBC is not in an airport land use plan or within 2 miles of a public airport, so further analysis is not required. The proposed RBC is not near a currently operating or planned private airstrip, so further analysis is not required. The proposed RBC is not near wildlands and the risk of wildland fires is low. There are numerous open space and wetland areas, but these are not considered moderate or high-risk for wildland fires due to their limited and non-contiguous setting away from large open or natural areas that are susceptible to wildland fires. Further analysis is not required.

Analytical Methods

By convention, most hazardous materials are thought to be hazardous chemicals, but certain radioactive materials and biohazardous materials, as defined here, are also hazardous. This EIR considers hazardous materials to include hazardous chemicals, radioactive materials, and biohazardous materials that would be used at the RBC.

This analysis was prepared using information gathered from available documentation and information in the 2014 LRDP. Data regarding hazardous materials, materials of concern, and wastes that would be used and generated at the RBC were gathered by compiling available documentation such as program descriptions, monitoring reports, and the LRDP project description. Potential 2014 LRDP impacts concerning hazardous materials and materials of concern were then evaluated in light of existing programs and proposed LRDP policies intended to protect the environment from unintended consequences.

RBC 2014 LRDP Policies

The RBC 2014 LRDP policies related to hazards and hazardous materials include the following:

- SP1 – Safety and Preparedness Policy on Model Programs: Develop model health and safety programs for the RBC.
    - Develop comprehensive and effective physical safety, life safety, and emergency service plans to protect the environment, the public, employees, and guests at all times.
    - Ensure clear and responsible management of environment, health, and safety programs and services.
    - Implement land use controls to prohibit unsafe exposure of workers, visitors, and the surrounding community to environmental contaminants.
    - Use transparent environment, health, and safety reporting practices.
- SP2 – Safety and Preparedness Policy on Inclusion: Ensure that the RBC contributes to and serves as a resource for the Richmond community.
    - Encourage inclusion through an open, un-gated campus to advance the ideals of institutional transparency and mutual trust, with security at the building level rather than the campus level.
    - Enable community access to RBC amenities such as outdoor spaces and meeting facilities to promote a better understanding of the University's mission.

- Expand partnerships with local agencies, including fire and police departments, and local neighborhoods to promote understanding and address safety and security concerns of neighbors and the campus population (University of California 2013).

LRDP Impacts and Mitigation Measures

This section describes the potential hazardous materials impacts from development under the 2014 LRDP based on the Standards of Significance, whether they are significant or less than significant, and whether any significant impacts can be mitigated to less than significant levels.

LRDP Impact HAZ-1: **Development under the 2014 LRDP would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials. (*Less than Significant)***

Development under the 2014 LRDP would increase the amount of space at the site from 1,050,000 gsf to approximately 5,400,000 gsf. Construction would typically begin with demolition of existing facilities, followed by site clearing, soil contamination investigation and management, and excavation work. As described in Section 4.7.2, asbestos and lead-based paint are likely present in facilities that would be demolished. Before demolition, areas with contamination would have to be abated or cleaned as described below.

During demolition, any hazardous materials would be managed in accordance with UC and LBNL procedures. The University would remove, and contain, any asbestos- and lead-containing materials, a process to be overseen by asbestos-certified staff.

In general, asbestos-containing materials would be removed before the start of demolition by a licensed asbestos abatement professional (40 CFR Part 61, Subpart M).[34] BAAQMD regulates the demolition and renovation of buildings and structures that may contain asbestos, and the BAAQMD must be notified at least 10 working days before any demolition. Regulated asbestos-containing materials removed before demolition or encountered in the demolition debris would have to be segregated and packaged in sealed, leak-tight containers and properly labeled for transport and disposal in a disposal facility authorized to accept asbestos. Asbestos-containing materials can be disposed of at a solid waste management facility, such as a demolition landfill. Standard asbestos abatement and removal safety protocols include:

- Seal the area undergoing removal to prevent release of asbestos fibers to noncontaminated areas; use polyethylene film, duct tape, and negative air pressure machines with high-efficiency particulate air (HEPA) filters;
- Wear proper safety equipment, including approved respirators and disposable protective clothing;
- Use a decontamination unit before leaving the sealed area;
- Keep all asbestos-containing materials wet from removal until disposal;
- Leave large pieces of asbestos-containing material intact to avoid the creation of dust;

34 Per 40 CFR Part 61, Subpart M, Section 61.145, asbestos-containing materials do not have to be removed from the building if: (1) it is Category I nonfriable material that is not in poor condition, is on a facility component that is encased in concrete or other similarly hard material, and is adequately wet when exposed during demolition; or (2) it is Category II nonfriable material, and the probability is low that it will become crumbled, pulverized, or reduced to powder during demolition.

- Put all friable asbestos in airtight, leak-proof containers with warning labels for transport to approved asbestos disposal facilities;
- Use only a HEPA-filtered vacuum cleaner designed for asbestos containment when cleaning during and after asbestos removal.

Demolition waste would be likely to include paint residue (chips and scrapings); demolition debris (masonry, metal, and boards painted with lead-based or other heavy metal-based paint); scrap metal (metal objects that contain lead or other heavy metals) that could be classified as hazardous waste, which would have to be managed, transported, and disposed of at an appropriately permitted and licensed off-site facility. All hazardous wastes would be disposed of in accordance with applicable UC Berkeley and LBNL procedures at properly licensed and permitted facilities.

As discussed in Section 4.7.2, the RFS portion of the proposed RBC site includes some areas of contaminated soil and groundwater. The University has done substantial work in characterizing site contamination. Arsenic, copper, lead, mercury and PCBs have been detected in the soil at levels exceeding commercial use standards. Any remediation would be done in accordance with a DTSC Order (see Section 3.9) or other DTSC authority. More specifically, soil would be excavated or evaluated for contamination prior to on-site reuse or off-site disposal, pursuant to a RAW, including Soil Management Plan requirements, if approved by DTSC under Chapter 6.8 of the California Health and Safety Code, which includes requirements to ensure protection of public health and safety and the environment, or under currently specified requirements of the existing DTSC Order under Health and Safety Code Section 6.8. Hazardous soil would be categorized for transport to appropriately permitted and licensed off-site facilities. Contaminated groundwater would be treated to remove contamination as required under DTSC Order or authority. The impacts of such activities would not be expected to create a significant hazard to workers or the public.

During demolition activities, the intrusion of subsurface vapors into buildings is one of the exposure pathways to be considered in assessing the risk posed by releases of hazardous chemicals into the environment. DTSC has provided guidance regarding an approach for evaluating vapor intrusion into buildings and its subsequent impact on indoor air quality (DTSC 2011). Demolition activities would be conducted in accordance with the DTSC guidance, which would include compliance with an 11-step process to identify, evaluate, and potentially mitigate human exposure from vapor intrusion. Compliance with the DTSC guidance should minimize the potential for any significant impacts.

Once operational, there would be an increase in the use of hazardous materials and chemicals, radioactive materials, and production of wastes at the site. The chemicals used in new laboratories and support space developed under the 2014 LRDP would be similar to those currently used at other UC sites such as UC Berkeley and LBNL. The level and the nature of the hazards posed by these chemicals and wastes vary widely and are unique to the individual materials, although they often can be grouped by chemical types. Substances can possess one or more common hazard characteristics such as corrosivity (acids and bases), flammability (solvents such as acetone), toxicity (cyanides, mercuric chloride) and reactivity. Some nonradioactive chemicals have the potential for causing cancer or acute and chronic illnesses, while some substances may present little hazard.

Because most handling of hazardous materials would take place indoors, potential pathways for exposure to non-radioactive hazardous materials under routine conditions include direct contact or injection during research or through accidental spills, or inhalation. To address this potential impact, laboratories and other facilities constructed under the 2014 LRDP would continue to comply with all applicable hazardous materials standards. For UC Berkeley activities, fume

hoods and other engineering controls would be required to meet Cal/OSHA requirements, and fume hood ventilation rates would continue to be checked annually. For LBNL activities, fume hoods and other engineering controls would be required to meet DOE and LBNL requirements, and fume hood ventilation rates would continue to be checked at their established frequencies. Proper use of the fume hoods and other engineering controls would keep indoor laboratory air toxics concentrations below the Cal/OSHA Permissible Exposure Limits for UC Berkeley activities and below the American Conference of Governmental Industrial Hygienists Threshold Limit Values and the OSHA Permissible Exposure Limits for LBNL activities. Continued implementation of UC Berkeley and LBNL policies and procedures, and continued compliance with existing laws and regulations would minimize the risk to workers and students from exposure to non-radioactive hazardous chemicals and the impact would be less than significant.

During operations, the intrusion of subsurface vapors into buildings is one of the exposure pathways to be considered in assessing the risk posed by releases of hazardous chemicals into the environment. As with demolition, operations would be conducted in accordance with the DTSC guidance, which should minimize the potential for any significant impacts from vapor intrusion.

Hazardous materials use and storage areas would be periodically inspected by local regulatory agencies. The following inspections currently occur:

- The Contra Costa County Hazardous Materials Program Division inspects the site approximately annually for hazardous waste storage.
- The Richmond Fire Department inspects the site approximately annually for hazardous materials storage and fire safety.
- The Richmond Public Works Industrial Pretreatment Program inspects the site approximately every two years for hazardous waste storage, hazardous waste manifest recordkeeping, and spill prevention control and countermeasure requirements.
- The City of Richmond collects wastewater samples a number of times per year for compliance with the Industrial Discharge Permit issued to the site.

The above inspections occur in addition to inspections by campus EH&S and the fire marshal.

The potential for exposure to the public, including nearby homes and schools, from hazardous materials used at the RBC under routine conditions would be limited, because most hazardous materials use and storage on the campus would take place indoors. The most probable potential pathway for public exposure would be air emissions from accidental releases either on campus or during transportation and routine operations. Exposure to routine air emissions are analyzed in Section 4.2 (Air Quality) and were determined to be less than significant. The potential for public exposure under upset or accident conditions, both from handling of hazardous materials on campus and during transportation, is discussed under LRDP Impact HAZ-2, below.

Development under the 2014 LRDP could introduce the use of biohazardous materials at the RBC, such as microorganisms, plants, and animals that have been genetically engineered or modified using recombinant DNA techniques. All research involving biohazardous materials at the RBC would be required to comply with UC Berkeley policies and procedures (for UC Berkeley facilities) and with LBNL policies and procedures (for LBNL facilities). The potential for exposure of RBC workers or the public to biohazardous materials would be minimized by compliance with Centers for Disease Control and National Institutes of Health guidelines for research involving biohazardous materials. These guidelines specify containment practices for plants, microorganisms, and animals, depending on the potential hazard posed by the organism.

Hazardous waste, mixed waste, combined waste, and radioactive waste would be packaged, labeled, and categorized for transport to appropriate permitted and licensed off-site treatment, storage, and disposal facilities. Biohazardous waste and universal waste would also be generated and managed at the RBC. On-site waste collection areas equipped with all required safety features would be designated to accommodate hazardous waste and radioactive waste (including mixed waste and combined waste) collection and management (e.g., consolidation). Hazardous waste storage areas would be physically separate from the radioactive waste storage area. The RBC would have designated storage areas for management of biohazardous waste (including medical waste) and universal waste.

Compliance with hazardous waste storage and transportation regulations, and continuation of current UC Berkeley and LBNL programs and controls to reduce and manage hazardous wastes and to prevent inadvertent releases of hazardous materials to the sanitary sewer would minimize the hazards to workers, the public, and the environment. Treatment, storage, and disposal facilities are currently available with adequate capacity to accept and safely manage any wastes produced. The increase in hazardous waste generation would be insignificant in relation to the vendor's disposal capacity.

Development under the 2014 LRDP could result in an increase in radioactive material use. Safety controls, plans, and procedures would be implemented to limit exposure to radiation from radioisotopes, radiation-producing machines, and radioactive wastes. The potential for the proposed project to expose workers, non-involved site workers or visitors, or the public to significant health or safety risks is low. With respect to radioactive waste, no radioactive waste would be disposed of at RBC, LBNL, or any offsite LBNL facilities. Implementation of the 2014 LRDP would continue the practice of using out-of-state disposal facilities. The quantities of radioactive wastes would be insignificant relative to the available disposal capacity.

UC Berkeley holds a Broad Scope Radioactive Materials License issued by the State of California Department of Public Health, Radiological Health Branch. Approval and oversight for campus use of radioactive materials and radiation producing machines is provided by the Radiation Safety Committee and the EH&S Radiation Safety Officer (RSO). Any use of radioactive materials and radiation producing machines at UC Berkeley must be preauthorized in writing. The written authorization is referred to as an Radiation Use Authorization and is fundamental to the UC Berkeley campus radiation safety program. The RSO conducts an evaluation of the radiation safety aspects of the proposed use and at the RSO's discretion, complex uses may need review by the Radiation Safety Committee. All aspects of radioactive material or radiation producing machine use on the campus is governed by the Radiation Safety Team that provides oversight and services to support the safe use of these materials and machines.

All work with ionizing radiation at LBNL is subject to a DOE-approved Radiation Protection Program (RPP). This RPP contains plans for implementing measures to ensure worker and public safety from hazards arising from LBNL work with ionizing radiation. All work is conducted according to the As Low As Reasonably Achievable principle.

Implementation of safety plans, programs, practices, and procedures, as defined in this section, would ensure that impacts to the public or the environment through the routine transport, use, or disposal of hazardous and radioactive materials and wastes would be less than significant.
With respect to potential impacts from non-ionizing radiation, compliance with applicable federal and state regulations, UC Berkeley and LBNL requirements, and DOE Orders, would provide reasonable assurance that workers are protected from non-ionizing hazards.

LRDP ENVIRONMENTAL PROTECTION PRACTICE HAZ-1:

In implementing the 2014 LRDP, UC Berkeley and LBNL shall continue the same (or equivalent) health and safety plans, programs, practices and procedures related to the use, storage, disposal, and transportation of hazardous materials and wastes (including chemical, radioactive, and bio-hazardous materials and waste) as are currently practiced at the UC Berkeley main campus and at the LBNL hill site. These include, but are not limited to, UC Berkeley and LBNL requirements for safe transportation of hazardous materials; EH&S training programs; the requirement that laboratories have chemical hygiene plans; a chemical inventory; a toxic use reduction program; a spill prevention, control, and countermeasure plan; monitoring of USTs; a waste minimization program; a biosafety program; a waste management program (including medical and biohazardous waste); a radiation safety and/or protection program; compliance with radioactive air emission regulations (40 CFR 61) and compliance with DOE Orders for LBNL activities; compliance with the National Institutes of Health Guidelines for Research Involving Recombinant DNA Molecules; and compliance with US Department of Agriculture requirements for open-field-based research involving transgenic plants.

Mitigation Measure: No mitigation measure is required.

LRDP Impact HAZ-2: **Development under the 2014 LRDP would not create a significant public or environmental hazard through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. (*Less than Significant)***

Federal, state, and local emergency response plans would be implemented to respond to most RBC emergency incidents. UC Berkeley EH&S maintains a Dedicated Spill Response Team that consists of health and safety professionals, hazardous materials technicians, and appropriately licensed hazardous materials drivers. The team is trained to respond to most incidents and arranges for appropriate outside assistance when necessary. LBNL developed a MEPP that establishes policies, procedures, and an organizational structure for responding to and recovering from a major disaster. The MEPP uses the Standardized Emergency Management System for managing response to multi-agency and multi-jurisdiction emergencies in California and the National Incident Management System, which is a nationwide standardized approach to incident management prescribed by Homeland Security Presidential Directive 5. The plan includes four phases of emergency management: mitigation, preparedness, response, and recovery. UC Berkeley and LBNL would coordinate with state and local authorities to develop a site-specific emergency response plan for the new facilities proposed for the RBC.

One state law governing the storage of hazardous materials is the California Accidental Release Program (CalARP). This law addresses facilities that contain specified hazardous materials or "regulated substances" that, if released, could result in adverse off-site consequences. Chemical inventories that would be maintained by UC in the Materials Business Plan and Chemical Inventory would be reviewed at least annually to determine whether the use or storage of regulated substances at any RBC facility would be large enough to trigger CalARP requirements. A risk management plan under CalARP would be required for any chemicals with maximum storage quantities greater than levels that would potentially cause an off-site consequence. RBC best practices would inventory campus hazardous materials in future locations and quantities would be kept to a minimum. Given past experience at other UC facilities, quantities above CalARP thresholds are not anticipated. Should that occur, UC would comply with all applicable CalARP reporting requirements. LBNL activities would also comply with all applicable DOE orders. Compliance with all applicable federal, state, and local laws and regulations related to the

transportation, storage, and use of hazardous and radioactive materials would minimize the potential for a release and provide for prompt and effective cleanup if an accidental release occurred. Therefore, the impacts related to accidental release due to the increased transportation, storage, or use of hazardous and radioactive materials under the 2014 LRDP would be less than significant. Safety plans, programs, practices, and procedures implementation, as defined in the LRDP Impact HAZ-1 discussion, would ensure these impacts remain less than significant.

Mitigation Measure: No mitigation measure is required.

LRDP Impact HAZ-3: **Development under the 2014 LRDP would not emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school. (*Less than Significant)***

The RBC site is not within one-quarter mile of an existing or proposed school per CEQA Guideline 15186. While the RBC would handle certain hazardous materials, these materials and their handling protocols are subject to extensive regulations, procedures, and oversight, as discussed in LRDP Impact HAZ-1. The potential impacts associated with site contamination are also addressed under LRDP Impact HAZ-1. As described in that section, operations would not result in hazardous emissions or hazardous materials handling that could expose off-site receptors to a significant human health or safety risk. The impact would be less than significant.

Mitigation Measure: No mitigation measure is required.

LRDP Impact HAZ-4: **The RBC would be on a site included on a list of hazardous materials sites compiled pursuant to the California Government Code Section 65962.5, but this would not create a significant hazard to the public or the environment. (*Less than Significant)***

The RFS portion of the proposed RBC site is listed on the current California EPA Hazardous Waste and Substances Sites List, also known as the "Cortese list" (California Government Code Section 65962.5). This listing is due to prior site activities that resulted in soil contamination at specific site locations. The DTSC has been directing efforts to address the effects of this past contamination on the RFS portion of the RBC site (see Section 3.9). The potential impacts associated with site contamination are also addressed under LRDP Impact HAZ-1. Because on-site contamination would be addressed in accordance with a RAW if approved by DTSC under California Health and Safety Code Section 6.8, which requires DTSC to ensure protection of public health and safety and the environment from the harmful effects of releases or threatened releases of hazardous substances, or under the current provisions in the existing DTSC order for the RFS under Health and Safety Code Chapter 6.8, the impacts would be less than significant.

Mitigation Measure: No mitigation measure is required.

LRDP Impact HAZ-5: **Development under the 2014 LRDP would not impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan. (*Less than Significant)***

As discussed in Section 4.7.3, emergency response plans are maintained at the Federal, State, and local level for all types of disasters, including human-made and natural. UC Berkeley and LBNL would coordinate with state and local authorities to develop a site-specific emergency response plan for the proposed new RBC facilities. The UC Berkeley EH&S Emergency Response Team and LBNL responders would be capable of responding to most RBC incidents and, if necessary, may arrange for appropriate assistance from the City of Richmond Fire Department, the LBNL Fire Department, and outside emergency response contractors. New 2014 LRDP development would be in areas adjacent to other developed sites. Because on-site activities that could trigger emergency response would generally be similar in nature to current types of LBNL and UC Berkeley activities, and because existing emergency control and avoidance programs would continue, implementation of the 2014 LRDP would not exceed emergency response capabilities and impacts would be less than significant.

Mitigation Measure: No mitigation measure is required.

Cumulative Impacts and Mitigation Measures

LRDP Cumulative Impact HAZ-1: Development under the 2014 LRDP in conjunction with other reasonably foreseeable future development in the project vicinity would not create a significant public or environmental hazard through the routine transport, use, or disposal of hazardous materials. (*Less than Significant*)

The potential for public exposure, including at nearby homes and schools, to RBC hazardous materials under routine conditions would be limited, because most RBC hazardous materials use and storage would take place indoors and under controlled conditions. The most probable potential pathway for public exposure would be air emissions from on-site accidental releases or during transportation and routine operations. Air would be sampled for dust and particulates during removal of soil contaminated with mercury fulminate and during construction. Cumulative exposure to routine air emissions is analyzed in Section 4.2 (Air Quality) and determined to be less than significant. Compliance with all applicable Federal and State laws related to the transportation of hazardous materials would reduce the likelihood and severity of accidents during transit, thereby ensuring that a less than significant cumulative impact would occur in this regard.

LRDP Cumulative Impact HAZ-2: Development under the 2014 LRDP in conjunction with other reasonably foreseeable future development in the project vicinity would not create a significant public or environmental hazard through reasonably foreseeable upset and accidental conditions involving the release of hazardous materials into the environment. (*Less than Significant*)

Cumulative development in the project area would include some industrial and commercial entities that could use various hazardous products in greater quantities than under current conditions. The use, storage, disposal, and transport of hazardous materials could result in an increased risk for

spills and accidents. Although the specific risks of such spills and accidents are not quantifiable, all construction and demolition activities, and all new development, would be subject to compliance with hazardous materials regulations. Future developments would be required to evaluate their respective hazards and hazardous materials impacts on a project-by-project basis. Compliance with all applicable federal, State, and local regulations during the construction and operation of new developments would ensure that there are no significant cumulative hazards to the public or the environment associated with the routine transportation, use, disposal, or release of hazardous materials.

4.7.5 References

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4.8 HYDROLOGY AND WATER QUALITY

4.8.1 Introduction

This section presents existing RBC site hydrologic and water quality conditions and analyzes the potential for development under the proposed 2014 LRDP to affect those resources. This analysis is based on information summarized in the Current Conditions Report (Tetra Tech 2008), more recent Tetra Tech reports including the 2012 Groundwater Results Technical Memorandum, and various publicly available technical studies.

The hydrology and water quality discussion includes a description of the regulatory environment; stormwater drainage features; flooding potential; groundwater hydrology, including groundwater depth and flow; surface water and groundwater interaction; and current water quality. Existing RBC site conditions are described in terms of historical and current site uses.

Public and agency NOP comments related to hydrology and water quality concerned restoration of the Meeker Ditch to a natural state, existing site contamination, completion of site remediation, increasing runoff to Western Stege Marsh, and assessing and planning for sea-level rise and storm surges.

4.8.2 Environmental Setting

The RBC site is approximately 134 acres and consists of upland areas developed with buildings that are used for academic teaching and research activities and spaces leased by private entities, areas of coastal grasslands, a tidal salt marsh (known as the Western Stege Marsh), and a transition zone between the upland areas and the marsh. Grasslands occur in a number of meadows on the RBC site. The parcel west of Regatta Boulevard is fully developed.

Surface Water

Runoff on the RFS portion of the RBC site currently flows from north to south by way of sheet flow, open swales, culverts, and storm drains. The existing storm drain system consists of two main 24-inch storm drain lines -- the Eastern Storm Drain and the Western Storm Drain – spanning the respective eastern and western edges of existing improvements. It is believed that the Western Storm Drain was originally a sewer line draining to the San Francisco Bay mudflats that was placed along Syndicate Avenue prior to the establishment of the Richmond Publically Owned Treatment Works and construction of the existing City of Richmond sewer mains traversing the north and south portion of the RFS (Hyde et al. 1941). After construction of the Richmond Publically Owned Treatment Works, the Western Storm Drain remained connected as an overflow port to the City of Richmond sanitary sewer main traversing the northern portion of the RFS before the overflow was closed by UC Berkeley in 2004 with permission from the City of Richmond. The Western Storm Drain now conveys only runoff from the central and northeastern portions of the RFS, the NRLF (Building 400), eastern portions of the coastal-terrace prairie, and the asphalt pads to the east of Building 128.

The Western Storm Drain discharges to Meeker Slough downstream of the confluence of Meeker Tidal Creek and Meeker Ditch. The Eastern Storm Drain collects runoff from the southeast portion of the RFS (Building 180 and south) and discharges in the northeastern corner of Western Stege Marsh, which drains to the west into Meeker Slough upstream of the Bay Trail bridge. The most western portion of the RFS, including most of the coastal-terrace prairie and Building 280, drains through an open swale west of the EPA Laboratory, then overland into Meeker Slough downstream of the Meeker Ditch/Meeker Tidal Creek confluence.

The Regatta portion of the RBC drains to City storm drains that discharge to Meeker Tidal Creek and Meeker Ditch.

A tidally influenced trapezoidal concrete-lined storm drain channel, Meeker Ditch, runs north-south along the eastern edge of Regatta Boulevard and South 32nd Street. Meeker Ditch is the continuation of a mostly culverted former creek channel draining a watershed extending to McBryde Avenue near Alvardo Park that is almost completely urbanized and consists of housing, light industry, commercial and institutional facilities, and some small parks. Meeker Ditch discharges at the southwest corner of the RBC upland area into Meeker Slough at the confluence with Meeker Tidal Creek. The creek is a tidally influenced storm drain channel at the northern boundary of the Marina Bay housing complex that collects runoff from the watershed between Richmond Inner Harbor and I-580, which is also almost completely urbanized and consists of housing, institutional buildings, warehouses, and rail yards.

The former Zeneca site is east of 46th Street. In the past, runoff from a portion of the former Zeneca Site drained into the RFS Eastern Storm Drain via an interconnecting storm drain originating on South 46th Street near RFS Building 185. Following 2002 and 2003 Zeneca site remediation activities, only a small amount of Zeneca site surface runoff now flows into the interconnecting and Eastern Storm Drain (Tetra Tech 2008).

Flooding

A flood hazard zone exists along the RFS southern margin as offshore winds can combine with high tides to increase shoreline water elevations. The project site's southern portion is within the 100-year flood hazard zone and is potentially subject to water inundation due to projected storm surge, a tsunami, or a seiche.

Sea levels are expected to rise in coming years due to global climate change. Estimates forecast by experts differ and are expressed in ranges; by year 2100, for example, the International Panel on Climate Change estimates a sea level rise range of 19 to 58 cm (7 to 23 inches) (IPCC 2007) while others cited in this EIR forecast a 50 to 140 cm (19 to 55 inches) range (Rahmstorf 2007). San Francisco Bay is the base level elevation for Meeker Ditch stormwater discharge west of the project site. At high tidal stands, a higher base level has the potential to reduce the Meeker Ditch stormwater discharge rate to the Bay and to increase the water table elevation, including in the project area. As a result, flooding frequency within the lower Meeker Tidal Creek reaches could increase when high tides, westerly wind-driven waves, and high storm discharges occur. However, these effects would not result from alteration of drainage patterns.

As discussed in the 2014 LRDP, the areas that are now Western Stege Marsh and the transition area just north of the marsh were historically intertidal mudflats. Offshore breakwaters constructed in the 1930s and the rerouting of Meeker Creek from further west to its current location resulted in soil deposition and transition of the mudflats to the tidal marshland which exists today. The 1959 construction of the embankment which now supports the Bay Trail includes a bridge over Meeker Slough where tidal and storm drain waters connect the marsh and the bay. Assuming natural adaptation with sea level rise, the marsh will likely transgress up the slopes that border the marsh which include areas reserved under the RBC LRDP as Natural Open Space, with or without the project. Within its existing boundary, the marsh will need to aggrade upward to continue supporting vegetation in adaptation to sea level rise. Adequate wave sheltering and sediment deposition are necessary to promote upward aggradation of the marsh.If the existing offshore structures (e.g. breakwaters and Bay Trail embankment) degrade and are not replaced by a beach dune or other shoreform, the Bay waves may limit sediment deposition. If the sea level rises at a faster rate than natural soil deposition, marsh vegetation continuity may depend on soil augmentation by the University. Aggradation at a pace slower than sea level rise would result in a lower elevation relative to the sea level which may cause the marsh to revert back to an intertidal mudflat.

Groundwater Occurrence

RBC site contamination investigations have revealed three water-bearing zones within 100 feet below the ground surface (Tetra Tech 2008). These are:

- Shallow zone, 10 to 20 feet below the surface;
- Intermediate zone, 30 to 74 feet below the surface; and
- Deeper zone, 90 to 100 feet below the surface.

The shallow water-bearing zone spans the depth in which artificial fill, Quaternary alluvium, and young Bay sediments are found. Although the sediments are generally coarser in the upper 20 feet, clay content and sufficiently discontinuous permeable lenses slow groundwater flow such that the yield from shallow wells is low (Tetra Tech 2012). Intermediate zone groundwater appears to flow through a relatively continuous, five-foot-thick sand stratum at a depth of about 30 to 35 feet. Groundwater may be under semi-confined conditions within this zone. The older Bay Mud acts as a confining layer or aquitard. The deeper groundwater zone is below or within the older Bay Mud.

The ground surface elevation slopes from about 30 in the north and 25 feet National Geodetic Vertical Datum in the RBC site northeast corner and slopes down to the south and west. To the south, it slopes to about 15 to 20 feet in the site's central portion, down to about 2 feet along the edge of Meeker Slough. To the west, it slopes to about 10 feet at the far western boundary of the Regatta property.

Groundwater gradients vary somewhat seasonally and locally across the RBC site, probably due to differences in the amount of recharge and local differences in vertical permeability. The general direction of flow is toward the southwest, in the direction of Meeker Slough. In the late fall, groundwater elevations in the shallow zone are about 10 to 11 feet National Geodetic Vertical Datum (15 feet bgs) in the RBC site northeast corner, falling to about 6 feet National Geodetic Vertical Datum (10 feet bgs) in the RBC site central area, and dropping to about just below the ground surface along Meeker Slough. During groundwater monitoring rounds between November 2010 and April 2011, groundwater elevations in the site's northeast corner increased about one foot in April relative to November, probably as a result of greater springtime recharge.

During the 2010/2011 monitoring period, a groundwater mound observed near Building 150 was reportedly caused by a leaking underground water line. The break was identified and repaired in fall 2010 but by April 2011, the mound had not diminished significantly. This suggests that vertical permeability is very low in the shallow zone and that the mounded groundwater may have been perched on low permeability sediments.

Groundwater elevation measurements in grouped wells spanning different aquifer zones reveal slight vertical gradients, probably due to the low permeability within the shallow sediments and poor hydraulic connection across zones. However, the vertical gradient direction appears to be influenced by seasonal recharge and local conditions. For example, during the spring, regional recharge would be expected to increase hydrostatic pressure in deeper aquifer units, creating an upward gradient. However, the effect might be reversed in unpaved areas that receive more local recharge and where the shallower, perched zone is replenished.

Groundwater Quality

Total dissolved solids at the RFS average 1,420 milligrams per liter with a maximum of 27,500 milligrams per liter at the northwestern edge of the Western Stege Marsh adjacent to the Meeker Slough. The high total dissolved solids levels are due to the proximity to the Bay (Tetra Tech

2013). Groundwater at the RBC site has not been significantly impacted by contaminated soils. However, as described in the 2013 Site Conditions Report, Proposed Richmond Bay Campus (Tetra Tech 2013), results of four semi-annual rounds of groundwater sampling from piezometers installed site-wide in 2010 show that volatile organic compounds (tetrachloroethylene (PCE), TCE, and others) are present along the eastern property boundary of the RFS and adjacent areas of the former Zeneca site where historic industrial activities resulted in groundwater contamination. In addition, an area of carbon tetrachloride groundwater contamination is present in the northwest portion of the RFS from an unknown source that may be on-site or off-site.

Of the 25 monitoring wells analyzed in April 2011 (Tetra Tech 2012), only three produced metal concentrations exceeding drinking water standards. Above-standards arsenic was found in a well at the edge of Western Stege Marsh; nickel was detected in a well near Building 163 at the site's southeast corner and in a well east of Building 472 at the eastern site boundary.

A passive groundwater treatment system known as a "biologically active permeable barrier" is installed across the shallow aquifer zone just south of the RBC site uplands area to treat dissolved metals from upgradient sources. The biologically active permeable barrier traps dissolved metals as the groundwater passes through the barrier toward Western Stege Marsh. In addition, a subsurface slurry wall has been installed along the RBC southeastern boundary (south from Building 178). This slurry wall prevents shallow groundwater from migrating across the RBC boundary and it channels upgradient groundwater into the biologically active permeable barrier. The primary purpose of this system is to protect water quality in Western Stege Marsh.

A Final Site Characterization Report (SCR) (Tetra Tech 2013) has been prepared to help determine remedies and prescriptive requirements for certain 2014 LRDP-defined developable areas of the RFS site. The SCR found that carbon tetrachloride concentrations (primarily) in the RFS northeast area exceeded commercial vapor intrusion risk-based concentration and maximum contaminant levels. The carbon tetrachloride source is unknown but is suspected to be historical activities near Building 280B. TCE exceeded the commercial vapor intrusion risk-based concentration and maximum contaminant levels primarily along the eastern boundary of the RFS.

Additional information on groundwater contamination is presented in Section 4.7.2.

4.8.3 Regulatory Considerations

Federal

Clean Water Act

The Clean Water Act (CWA) (33 U.S.C. 1251 et seq.) of 1972 is the principal federal law protecting the quality and integrity of the nation's surface waters. The CWA offers a range of mechanisms to reduce pollutant input to waterways, manage polluted runoff, and finance municipal wastewater treatment facilities. Permit review serves as the CWA's principal regulatory tool; CWA regulation operates on the premise that discharges to jurisdictional waters are unlawful unless authorized by a permit. The following CWA sections are particularly relevant to the proposed project:

- Section 303 – water quality standards and implementation plans
- Section 401 – State Water Quality Certification or waiver
- Section 402 – National Pollutant Discharge Elimination System (NPDES)
- Section 404 – Discharge of dredged or fill materials into waters of the US

Section 303 of the CWA requires states to identify waters that do not meet applicable water quality standards, establish priority rankings for listed waters, and develop action plans, called Total Maximum Daily Loads, to improve water quality.

Section 401 of the Clean Water Act, in order to ensure water quality standards compliance, requires State Water Quality Certification for all federal permit or license applications for any activity that may result in a discharge to a water body. Most Certifications are issued in connection with Section 404 permits for dredge and fill discharges.

Section 402 of the Clean Water Act established a permit system, the NPDES, to regulate point sources of discharges in navigable waters of the United States. The EPA implements the NPDES, although the Act also allows states with sufficient authority to implement the NPDES program in lieu of the EPA. UC Berkeley operates under its own NPDES permit. The RBC may operate under this permit or its own individual permit.

Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into waters of the US, which include wetlands and vernal pools. Discharge activities regulated under this program include fill for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports), and mining projects (www.epa.gov/owow/wetlands/pdf/reg_authority_pr.pdf).

The Water Quality Control Plan for the San Francisco Bay Basin is the San Francisco Bay RWQCB's planning document.

The State Water Resources Control Board and the nine RWQCBs share authority for implementation of the federal Clean Water Act and the state Porter-Cologne Act.

Energy Independence and Security Act

Section 438 of the Energy Independence and Security Act (42 USC 17094) requires federal agencies, or projects using federal funds, to reduce stormwater runoff from federal development and redevelopment projects to protect water resources. Stormwater management strategies should be implemented to plan, design, construct, and conduct operations in a manner to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow or retain all stormwater on site. The State Water Resources Control Board's LID goal parallels the EISA strategies. LID practices include bioretention, rain gardens, rooftop gardens, sidewalk storage, vegetated swales, buffers and strips, tree preservation, roof leader disconnection, rain barrels and cisterns, permeable pavers, soil amendments, impervious surface reduction and disconnection, pollution prevention, and good housekeeping (SWRCB 2010).

State

The State Water Resources Control Board and the San Francisco Bay RWQCB implement the Non-Point Source regulations under the Clean Water Act. The State has developed a General Permit for Discharges of Storm Water Associated with Construction Activity (Construction General Permit Order 2009-0009-DWQ) for developments that would disturb an acre or more of land. The General Permit requires developers to prepare a Storm Water Pollution Prevention Plan (SWPPP) that identifies BMPs to be implemented. These plans must be prepared by a Qualified Construction Storm Water Developer and must be implemented under supervision of a Qualified Construction Storm Water Practitioner with appropriate levels of training.

Local

Because the RBC would be operated by the University on UC land for UC purposes, it is exempt from many local regulations. However, LBNL and UC Berkeley seek to coordinate with local jurisdictions to reduce any potential conflicts with the local regulations.

Contra Costa County Watershed Program

The Contra Costa County Watershed Program is responsible for ensuring that the County complies with its municipal stormwater NPDES permits. The City of Richmond and 15 other cities and towns, Contra Costa County, and the Contra Costa County Clean Water Program are co-permittees under this program. The watershed program's current NPDES permits are the Municipal Regional Permit for discharges to the San Francisco Bay (Region 2) and the East Contra Costa County Permit for discharges to the Delta (Region 5). The Municipal Regional Permit was adopted on October 14, 2009; it applies to 76 Bay Area municipalities in order to standardize requirements, pool resources, and achieve results on a large scale.

Under Phase 1 Non-Point Source requirements, municipalities are responsible for ensuring that stormwater discharges from municipal storm sewers meet the receiving water standards. Municipalities must develop local ordinances or programs to ensure compliance. The Contra Costa County Watershed Program defines standards for new developments. LID is one of the requirements of the Clean Water Program.

City of Richmond General Plan

The RBC site is a University property where work within the University's mission is performed. As a state entity, the University is exempt under the state constitution from compliance with local land use regulations, including general plans and zoning. However, the University seeks to cooperate with local jurisdictions to reduce any physical consequences of potential land use conflicts to the extent feasible. The RBC site is located within the City of Richmond and is within the Southern Shoreline Planning Area of the City of Richmond General Plan. The following sections summarize goals and policies from the City of Richmond General Plan and local ordinances as they relate to hydrology and water quality.

The Conservation, Natural Resources and Open Space Element (Element 7) of the City of Richmond General Plan addresses hydrology and water quality issues both directly and indirectly. For example, Element 7 calls for habitat conservation and restoration, open space conservation, establishment of creek corridor performance standards, and urban creek restoration actions. Although these are not specifically intended to address hydrology and water quality, they are likely to result – indirectly – in water quality improvements and may improve drainage and hydrology. Conversely, General Plan policies that would directly address hydrology and water quality include:

Policy CN1.3 Urban Creek Restoration. Encourage the restoration of urban creeks and coordinate efforts with property owners and local interest groups. Creek "daylighting" of culverts or hardened channels shall be pursued where feasible in new and redevelopment projects. Actions identified in the General Plan to implement this policy include establishing Creek Corridor Performance Standards and restoring Urban Creeks. Among the specific Creek Corridor Performance Standards identified in the General Plan are:

- Offer sufficient width in or adjacent to preserves to allow for existing and created wildlife habitat, species sensitive to human disturbance, vegetative filtration for water quality, corridors for wildlife habitat linkage, protection from runoff, and other impacts of adjacent urban uses;

- Allow for sufficient width adjacent to natural resource preserves to allow for trails and greenbelts; and
- Discourage the use of herbicides and provide sufficient width for a mowed firebreak (where necessary), adjacent passive recreation uses, and access for channel maintenance and flood control.
- In areas of creek restoration, implement design specifications and modeled flow conditions to ensure that creek channel configuration and vegetation would withstand storm flows, that conveyance capacity is not impeded, and that the system is stabilized following construction. Design shall be conducted by a certified professional in stream restoration and fluvial geomorphology processes.
- Implement construction BMPs to reduce erosion potential including, but not limited to, construction scheduled for dry season work; high flow bypass until the system is stabilized; temporary and permanent erosion and sediment controls; prevention of run-off during construction.
- Implement monitoring, inspection, and maintenance programs and plans to ensure long-term continued function.

To restore urban creeks the General Plan calls for:

- Restoring creeks currently diverted in culverts or hardened channels to their natural state, where feasible;
- Adopting regional guidelines for channel creation or modification to ensure that channels meander, have a naturalized side slope and a varied channel bottom elevation; and
- Including improvement standards for soft bottom channels.

Policy CN3.1 Stormwater Management. Develop strategies to promote stormwater management techniques that minimize surface water runoff in public and private developments. Use low-impact development techniques to best manage stormwater through conservation, on-site filtration and water recycling.

In order to continue to comply with the City of Richmond's NPDES Permit, the General Plan calls for following actions to be implemented:

- Require development to comply with the Contra Costa Clean Water Program Stormwater Guidebook;
- Work with developers to ensure compliance with the City’s minimum standards and NPDES requirements;
- Encourage all projects to use pervious pavements, cluster structures, disconnect downspouts, minimize land disturbance and use micro- detention such as LID;
- Require adequate source control measures to limit pollution generation in businesses including draining non-stormwater discharges such as swimming pools, trash and food compactor racks, vehicle outdoor storage, fire sprinkler test water and equipment washing; and
- Require businesses that may be susceptible to polluting stormwater to implement BMPs including covering drains and storage precautions for outdoor material storage, loading docks, repair and maintenance bays and fueling areas.

Policy CN3.2 Water Quality. Work with public and private property owners to reduce stormwater runoff in urban areas to protect water quality in creeks, marshlands and water bodies and the bays. Promote the use of sustainable and green infrastructure design, construction and maintenance techniques on public and private lands to protect natural resources. Incorporate integrated watershed management techniques and to improve surface water and groundwater quality, protect habitat and improve public health by coordinating infrastructure and neighborhood planning and establishing best practices for reducing non-point runoff. To this end, the General Plan calls for:

- Support efforts by the regional water provider to increase water recycling by residents, businesses and developers;
- Installing water recycling and rainwater catchments in new developments as appropriate to recycle water; and
- Evaluation of the use of recycled water in new and existing buildings and landscapes.

Policy CN3.3 Flood Management. Minimize the flood hazard risks to people, property and the environment. Address potential damage from a 100-year flood, tsunami, sea level rise and seiche, and implement and maintain flood management measures in all creeks and in all watersheds. The General Plan requires new developments to:

- Install and maintain flood control measures on all creeks and watersheds in coordination with the Contra Costa County Flood Control and Water Conservation District;
- Include flood prevention mitigation measures within the 100-year floodplain;
- Install flood control measures to address sea level rise as appropriate; and
- Improve groundwater recharge and minimize stormwater runoff to better accommodate floodwaters.

Policy CN3.4 Water Conservation. Promote water conservation. Encourage residents, public facilities, businesses and industry to conserve water especially during drought years. Work with East Bay Municipal Utility District to advance water recycling programs including using treated wastewater to irrigate parks, golf courses and roadway landscaping and by encouraging rainwater catchment and graywater usage techniques in buildings. The General Plan calls for:

- Low-flow appliances and fixtures to be required in all new development in accordance with EBMUD Water Service Regulations (Section 31);
- Working with water providers and water conservation agencies to create an incentives program that encourages retrofitting existing development with low-flow water fixtures;
- New developments and landscaped public areas to use state-of-the-art irrigation systems that reduce water consumption including graywater systems and rainwater catchment;
- Encouraging use of drought-tolerant and native vegetation;
- New plantings to be grouped by hydrozones of water needs listed in the Water Use Classification of Landscape Species III developed by the Department of Water Resources and the UC Cooperative Extension (or successor document); and
- Development project approvals to include a finding that all feasible and cost-effective options for conservation and water reuse are incorporated into project design including graywater systems.

The 2030 General Plan EIR determined that the effects from future development pursuant to the General Plan on hydrology and water quality would be less than significant. Future development would not violate stormwater management requirements. It would not substantially alter groundwater, drainage patterns, runoff, or flooding potential, including flooding potential associated with dam failure or sea level rise. No mitigation measures would be required. Cumulative impacts would be less than significant.

City of Richmond Landscape Design and Development Guidelines

The Department of Public Works implements the City of Richmond's Landscape Design and Development Guidelines. The Department encourages new developments to design and manage landscaping that is appropriate to local environmental conditions and effective in water conservation, during both drought and normal conditions. The Guidelines apply to all new residential developments of 4 or more dwelling units or with a minimum of 10,000 square feet of landscaping and all new or rehabilitated commercial, industrial, and institutional developments. The City reviews all development plans submitted via the Site Development Review process administered by the Planning Department.

4.8.4 Impacts and Mitigation Measures

Standards of Significance

Potential impacts of the 2014 LRDP on hydrology and water quality would be considered significant if they would exceed the following Standards of Significance, in accordance with Appendix G of the *State CEQA Guidelines* and the UC CEQA Handbook:

- Violate any water quality standards or waste discharge requirements;
- Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)
- Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site
- Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site
- Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff
- Otherwise substantially degrade water quality
- Place within a 100-year flood hazard area structures which would impede or redirect flood flows
- Expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam
- Expose people or structures to a significant risk of loss, injury, or death involving inundation by seiche, tsunami, or mudflow.

CEQA Checklist Items Adequately Addressed in the Initial Study

The NOP Initial Study concluded that further analysis of the following issue was not required in the EIR:

- Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map.

As stated in the Initial Study, while the RBC could include temporary lodging, it would not include temporary or permanent housing within the 100-year flood hazard area; therefore, this topic is not discussed further in the EIR.

Analytical Methods

CEQA and University of California guidelines identify standard information sources and methods for evaluating potential hydrology and water quality impacts. The following methods have been used in this analysis:

- Information on drainage patterns, water volumes and quality, floodplains, and locations of groundwater recharge areas were obtained from available sources, including: the US Geological Survey, California Geological Survey, California Department of Water Resources, the State Water Resources Control Board, the San Francisco Bay RWQCB, the Federal Emergency Management Agency (which prepares flood insurance rate maps); and recent environmental reports for the project vicinity.
- Project-related changes (increases) in stormwater runoff were estimated in preliminary drainage studies prepared to determine whether mitigation is needed.
- The effects of stormwater runoff on the quality of the receiving water were qualitatively evaluated based on data from previous investigations at the site.
- Applicable regulatory standards were identified, including federal NPDES permits administered by the State Water Resources Control Board and the San Francisco Bay RWQCB, construction nonpoint source discharge requirements, and Phase 1 program requirements.
- Potential cumulative impacts were evaluated, with particular focus on downstream effects of increased stormwater runoff and reduction in floodplain storage area.

RBC 2014 LRDP Policies

The RBC 2014 LRDP policies related to hydrology and water quality include the following:

- UI2 – Utilities and Infrastructure Policy on Sustainability: Design infrastructure improvements to embody sustainable practices.
    - Maintain or restore, to the maximum extent technically and practically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of stormwater flow.
    - Incorporate low impact development strategies in site planning to manage stormwater.
    - Protect the campus development from 55” of sea level rise through the year 2100 using natural shore forms where practicable; and coordinate closely with the East Bay Regional Park District on maintaining the Bay Trail embankment.

LRDP Impacts and Mitigation Measures

LRDP Impact HYD-1: Stormwater runoff and dewatering associated with 2014 LRDP-related construction activities could result in a violation of water quality standards. *(Less than Significant)*

During construction, there is potential for rainwater to come into contact with disturbed soils containing elevated metals concentrations, remnant cinders, or other contaminants. During construction, some construction areas may need to be dewatered due to a high groundwater table or the accumulation of rainwater. Discharge of these fluids could violate water quality requirements if the fluids contain sediment or chemical contaminants.

For construction projects subject to the statewide stormwater general permit, the University would obtain coverage under the Storm Water General Permit and would prepare a SWPPP.

If dewatering is needed, discharge of the accumulated groundwater or rainwater to either the storm system or sanitary sewer system would require a permit from the appropriate regulatory agency. The University would apply for and obtain such a permit, which would contain requirements for discharges, including testing, treatment, monitoring, and reporting to ensure that impacts to surface and groundwater quality would be minimal.

With implementation of standard construction BMPs and the measures described above, the proposed project would not result in contaminants reaching adjacent receiving waters; any potential effect would be less than significant.

LRDP Impact HYD-2: Development under the 2014 LRDP would not substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level. (*Less than Significant*)

As described in Chapter 3, Project Description, campus development in accordance with the 2014 LRDP would tend to be concentrated in already developed parts of the RBC site. As a result, RBC site impervious surfaces would increase by only about 3 acres. Impermeable surface increases typically decrease infiltration in those areas. The introduction of LID measures, such as installing pervious pavements and directing surface runoff to pervious areas, would further offset the effects of increased impervious surface. Since potable water is supplied by EBMUD and not from groundwater wells, and because the elevation of the water table is controlled by regional hydrologic conditions, and given the above stormwater management planning, no overall decline in groundwater levels is expected. The impact on groundwater would be less than significant.

Mitigation Measure: No mitigation measure is required.

LRDP Impact HYD-3: Development under the 2014 LRDP would not substantially alter the existing drainage pattern of the RBC site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site. (*Less than Significant*)

There are no streams present on the project site. Meeker Ditch, Meeker Tidal Creek, and Meeker Slough are located along the western boundary of the RBC site; Meeker Ditch is within the 2014 LRDP Natural Open Space designated area. RBC development would not alter the course of

Meeker Tidal Creek or place new structures in the creek's vicinity. Furthermore, the existing RBC site drainage patterns would be maintained. The proposed project would not result in increased erosion from runoff on or off the site. 2014 LRDP development impacts would be less than significant. While scoping comments raised Meeker Ditch changes as an issue, the proposed project does not include Meeker Ditch alterations or plans to return it to a natural state.

Mitigation Measure: No mitigation measure is required.

LRDP Impact HYD-4: Development under the 2014 LRDP would not substantially alter drainage patterns in a manner which would result in flooding on- or off-site. (*Less than Significant*)

As discussed above, the existing RBC site drainage patterns would be maintained and impervious surfaces would increase by no more than approximately 3 acres under 2014 LRDP development. In addition, LID measures, such as installing pervious pavements and directing surface runoff to pervious areas, would further offset the effects impervious surface creation. Therefore campus development would not increase the risk of on or off-site flooding. The impact would be less than significant.

Sea levels are expected to rise in coming years due to global climate change. The San Francisco Bay is the base elevation for Meeker Ditch stormwater discharge. At high tidal stands, a higher base level would likely reduce the rate of Meeker Ditch stormwater discharge to the Bay while increasing the water table elevation. As a result, flooding frequency would potentially increase within the lower reaches of the creek when high tides, westerly wind-driven waves, and high storm discharges occur. However, these effects are expected to occur with or without the project and would not result or be intensified from project-related alteration of site drainage patterns.

Mitigation Measure: No mitigation measure is required.

LRDP Impact HYD-5: Development under the 2014 LRDP would not create or contribute runoff water that would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff. (*Less than Significant*)

The RBC site is about 54 acres or 41 percent impervious area. With full 2014 LRDP development, the RBC is anticipated to comprise approximately 43 percent impervious surface area, (an increase of about 3 acres of impervious surfaces). At full 2014 LRDP development, RBC building space would be approximately 5.4 million gsf, or about 100,000 gsf per acre of impervious surfaces. This would exceed a 3-fold increase in land use efficiency compared to the current ratio, with little reduction in pervious land area. RBC stormwater runoff would be moderated by LID design techniques that are consistent with NPDES requirements, the UC Sustainable Practices Policy, and LRDP sustainability goals. As a result, runoff rates from the RBC site are not expected to increase over existing conditions, but would likely decrease.

For construction projects subject to the Stormwater General Permit for Construction, the University would obtain coverage under the Storm Water General Permit and would prepare a SWPPP. The new construction would incorporate State Water Resources Control Board standards for stormwater runoff. Stormwater quality discharge permit requirements are anticipated to include, where practical: infiltration; evapotranspiration through landscape-based stormwater facilities; and capture, treatment, and re-use systems (tanks and ponds supported by treatment and irrigation systems or recycled water systems). Wherever possible, RBC drainage would be designed to use

low-impact surface conveyance solutions to minimize need for underground drainage line construction. The RBC would also incorporate new open swales, runoff treatment features, and BMPs commensurate with San Francisco Bay RWQCB requirements to treat stormwater before it is discharged into Western Stege Marsh. Buildings that are constructed using federal funds would also be required to comply with EISA Section 438 requirements.

Mitigation Measure: No mitigation measure is required.

LRDP Impact HYD-6: Development under the 2014 LRDP would not place structures within a 100-year flood hazard area which would impede or redirect flood flows or expose people or structures to a significant risk of loss, injury, or death involving flooding. (*Less than Significant*)

Only the southernmost portion of the RBC site lies within the current 100-year flood hazard zone (southern portion of Illustrative Development Scenario Neighborhood 1). A flood hazard zone exists along the RBC site shoreline due to the potential for offshore winds in combination with high tides to increase shoreline water elevations. There would be no impact related to flood hazard or redirection of flood flows within a 100-year flood hazard area associated with development of other parts of the RBC site.

Future facilities to be constructed in the southern portion of this neighborhood would need to be protected from water inundation related to sea level rise combined with storm or seiche/tsunami events. As reflected in LRDP Policy UI2, campus facilities would be protected from the amount of sea level rise anticipated through 2100. Potential protective steps include increasing the base elevation of this area from an average of approximately 13 feet NGVD to a minimum of 15 feet NGVD. This would address potential flood hazards associated with predicted future sea level rise and reduce or avoid potential flood risks to site, people, and structures. That impact would be less than significant.

Future development at what would be the former Regatta property under the RBC LRDP would also potentially be subject to water inundation by year 2100 due to a 100-year flood, taking future sea level rise into account. As noted, LRDP Policy UI2 requires protection of development under the LRDP from sea level rise. Specific protections for development at the former Regatta property in accordance with that policy would be defined, using updated projections, at the time of a proposal to construct one or more facilities at that portion of the RBC.

Mitigation Measure: No mitigation measure is required.

LRDP Impact HYD-7: Development under the 2014 LRDP would not expose people or structures to inundation by seiches, tsunamis, or mudflows. *(Less than Significant)*

The project site is located along the eastern shore of San Francisco Bay. Tsunami waves generated by seismic events outside the Bay tend to be greatly attenuated by passage through the Golden Gate's narrow channel and by the Bay's generally shallow bathymetry. Only 5 of 51 historic tsunamis are believed to have produced runups of more than 0.5 meters (1.6 feet) within San Francisco Bay (Borrero et al. 2006). The maximum probable runup in the Richmond Inner Harbor from any tsunami event is estimated to be about 1.6 meters (4.5 feet); however, the probability of such an event is very low (Borrero et al. 2006). The recurrence time for a 10 foot high tsunami wave outside the Golden Gate is estimated at about 100 years; such waves are

expected to be reduced about 50 percent upon passing through the Central Bay (Ritter and Dupre, 1972).

Potential protective steps that may be taken to implement LRDP Policy UI2, discussed under LRDP Impact HYD-6 above, would keep the entire RBC development area above the maximum predicted tsunami level.

Seiches are similar to tsunamis but are generated by local seismic or other abrupt displacement events in a closed water bodies. The probable seiche height in San Francisco Bay is predicted to be approximately one foot above the water level at the time of occurrence (Ritter and Dupre 1972). The greatest impacts from a seiche would logically be when the water level was at a peak high level; however, the probability of a seiche occurring during a tidal extreme is negligible. The maximum wave height at Richmond Inner Harbor from a large, local earthquake is estimated to be 0.44 meters (1.4 feet) (Borrero et al. 2006).

Potential protection measures discussed under LRDP Impact HYD-6 above would keep the entire RBC development area above the maximum predicted seiche level.

Mitigation Measure: No mitigation measure is required.

Cumulative Impacts and Mitigation Measures

Development under the 2014 LRDP would include impacts on hydrology and water quality that would be localized and less than significant or less than significant with mitigation. Proposed project elements with a potential for off-site cumulative impacts include stormwater discharge runoff and floodplain alterations. There are no current development plans in the vicinity sufficiently defined to indicate that they would raise the level of local topography therefore there would be no cumulative effect.

LRDP Cumulative Impact HYD-1: **Development under the 2014 LRDP, in conjunction with other foreseeable development, would increase the amount of impermeable surfaces in the area which could increase stormwater discharge to Meeker Slough and Western Stege Marsh. (*Less than Significant*)**

Foreseeable development, including the proposed project, in the greater watershed area would contribute to cumulative increases in impermeable surfaces that could affect stormwater runoff. However, new development would occur within a largely built-out urban area where stormwater drainage systems generally already exist; stormwater drainage would be addressed on a site-by-site basis prior to new development approvals. The expected incremental increase in impermeable surfaces would not exceed stormwater drainage system capacity. Stormwater management associated with the proposed project would be expected to reduce the amount of stormwater discharged from the RBC site as retention and infiltration techniques are implemented in compliance with NPDES requirements and as well as EISA Section 438 requirements. The cumulative impact would be less than significant.

4.8.5 References

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4.9 LAND USE AND PLANNING

4.9.1 Introduction

This section evaluates the potential land use and planning impacts of development under the 2014 LRDP. The planned 2014 LRDP land uses are described and assessed for potential conflicts with existing RBC site and surrounding land uses and land use plans.

Public and agency NOP comments related to land use and planning are summarized below:

- The EIR should consider proposed new building heights and massing in terms of compatibility with surrounding uses.
- The EIR should consider 2014 LRDP compatibility with the Eastshore State Park General Plan goals and policies.
- The 2014 LRDP should conform to local zoning and approved local land use policies to the maximum extent feasible.

These comments are considered in the analysis below.

4.9.2 Environmental Setting

Project Site

The approximately 134-acre RBC site is in the City of Richmond, approximately 5 miles northwest of the UC Berkeley campus and the LBNL site in Berkeley (see Figure 3-1). The City of Richmond is in Contra Costa County. The RBC site is bounded on the west by a PG&E service station, on the northwest by Regatta Boulevard, on the northeast by Meade Street, on the east by South 46th Street, and on the south by the San Francisco Bay. I-580 runs parallel to Meade Street along the northeastern boundary of the RBC site.

Existing On-Site Land Uses

The RBC site has been the location of a variety of industrial enterprises dating back to the mid-19th century. At the time of acquisition by the University in 1950, a portion of the RBC site (109.8 acres) was developed with a number of buildings associated with previous uses. After UC acquisition, certain University programs were moved into existing and new buildings at this property, known as the RFS. The RFS continues to operate as a field station for mostly UC Berkeley research programs and is currently developed with roadways, parking lots, landscaped areas, and approximately 80 one- and two-story buildings. Figure 3-2 shows current land uses at the overall RBC site, which is currently developed with 1,050,000 gross square feet of facilities, including more than 500,000 assignable square feet of research space.

Programs at the RFS include the NRLF, an archive for 7.7 million volumes of lesser-used books for the four northern UC campuses. The NRLF is at the northern boundary of the RBC site on Regatta Boulevard. Other research space includes one of the world's largest earthquake shaking tables and test facilities for advanced transportation research. The southwestern corner of the RBC developed area is occupied by the EPA regional laboratory. The Regatta parcel, which comprises the western portion of the RBC site, is developed with a warehouse building and surface parking. The warehouse building currently houses University archives and other uses. The existing facilities are concentrated in the RBC site's eastern and western portions; and a large portion of the central area is open space.

Existing Surrounding Land Uses

Land uses surrounding the RBC site include industrial and office uses and a major interstate freeway. Regatta Boulevard, along the RBC site northwestern boundary, is adjacent to a railroad spur and a business complex developed with one- to two-story buildings. Bio-Rad Laboratories, a private research equipment manufacturing company, is immediately west of the RBC site. The adjacent property to the east is the location of former chemical production operations and is currently vacant.

Across Meeker Slough adjacent to the southwestern boundary of the RBC site is a mix of single- and multi-family residences known as the Marina Bay neighborhood; to the north and across I-580 are low- and medium-density residential neighborhoods adjacent to the northeastern boundary of the RBC site.

The Eastshore State Park is located along the shoreline adjacent to the RBC site. The park extends approximately 8.5 miles along the San Francisco Bay eastern shoreline from the Oakland Bay Bridge northward to the Marina Bay neighborhood. The park includes approximately 2,262 acres of waterfront uplands and tidelands along the cities of Oakland, Emeryville, Berkeley, Albany, and Richmond. The portion of the state park nearest the project is called the South Richmond Shoreline, a southwest-facing stretch of gravel beaches in its southern reaches and tidal marsh to the north behind the seawall. The arc of upland area extending from Point Isabel to Marina Bay is the dike the railroad used to run on (California Department of Parks and Recreation 2002). A segment of the Bay Trail is built on this dike. The East Bay Regional Park District manages the state park.

Planned Land Use Changes in the Project Vicinity

The City of Richmond General Plan 2030 outlines a long-term vision for land uses and development in the area surrounding the RBC site. It designates the RBC site and its immediate surroundings southwest of I-580 as Business/Light Industrial and Open Space. The Marina Bay neighborhood is designated for low- and medium-density residential uses, which is the current use. The project vicinity is already mostly developed, and the General Plan proposes no substantive land use changes; however, the City of Richmond has identified its southern shoreline area for revitalization and redevelopment.

4.9.3 Regulatory Considerations

Local

City of Richmond General Plan 2030

The RBC site is a University property where work within the University's mission is performed on land owned by The Regents. As a state entity created by Article IX, Section 9 of the California State Constitution, the University is exempt under the state constitution from compliance with local land use regulations, including general plans and zoning. The University has a tradition of working cooperatively with local communities, and it is University practice to seek consistency with local plans and policies where feasible. The local municipal jurisdiction for the RBC site is the City of Richmond. The City of Richmond General Plan 2030, Economic Development Element and Land Use and Urban Design Element contain the following goals, policies, and actions related to land use and planning.

Goal ED8: A Thriving Mixed-Use Neighborhood along the Southern Shoreline. Transform the Southern Shoreline into a model mixed-use neighborhood characterized by green development, a fully developed university research and development campus, new employment centers, attractive residential communities, a connection to regional ferry services, an

accessible shoreline and a modern port. Incorporate a range of commercial uses including industrial activities, high-technology and professional firms and a local-serving retail, and medium to higher-density housing outside of the Harbour Way-Marina Way South Industrial Buffer Zone and other designated buffers. Expand public improvements along the Southern Shoreline to offer access to the Richmond waterfront for recreational activities which take advantage of impressive Bay views.

The following policies are outlined in relation to Goal ED8:

- **Policy ED8.1 - A Balanced Mix of Land Uses:** Promote a balanced mix of office, retail, and light industrial uses in the Southern Gateway Change Area. Partner with the UC Berkeley Field Station to attract and expand new technology firms in the area.
- **Policy ED8.2 - Land Use Compatibility:** Minimize conflicts between land uses to protect human and environmental health and safety, preserve community character and retain job generating activities that have long-term viability. Types, intensities and ranges of use and development should be compatible with existing uses and should minimize or eliminate conflicts that adversely impact public safety, human or environmental health or generate nuisances.

  Encourage existing larger industries that have surplus land to develop modern industrial parks that could attract new and existing industries and facilitate a reduction of existing and future land use conflicts.

  New development should complement the character and scale of existing neighborhoods, cultural resources, historic structures and landscapes.
- **Action ED8.A - Southern Shoreline Specific Plan:** Develop a specific plan to guide improvements in the Southern Shoreline area. Work with the University of California and other stakeholders to articulate a vision. Maintain and improve public access to the shoreline including a mix of uses along the shoreline to activate the area throughout the day.

Goal LU4: Enhanced Environmental Quality. Protect and preserve natural resources to nurture environmental and human health. Work with local and regional regulating bodies to protect water quality in creeks and bays, and to reduce or mitigate air, water and soil pollution and contamination. Encourage the sensitive integration of built and natural environments to develop a high-quality urban experience.

- **Policy LU4.1 - Richmond Shoreline:** Conserve, protect and enhance natural and cultural resources along the Richmond shoreline. Promote a balance of uses along the shoreline that supports multiple community needs.

  Protect and restore wetlands, native habitats and open space; develop shoreline parks and trails; and enhance and showcase historic and cultural resources. Prepare, adopt, and implement plans that will to protect natural and built environments from adverse potential impacts of sea level rise due to climate change.
- **Policy LU4.2 - Open Space and Conservation Areas:** Preserve open space areas along the shoreline, creeks, and in the hills to protect natural habitat. Maintain the integrity of hillsides, creeks and wetlands. Protect existing open space, agricultural lands and parks.
- **Policy LU4.3 - Habitat and Biological Resources Protection and Restoration:** Protect natural habitat and work with the CDFW, the San Francisco Bay RWQCB, the East Bay Regional Park District and other regional agencies to identify areas for special protection and establish appropriate protection measures for these areas.

Protect wetlands from direct and indirect impacts of new and existing development and infrastructure.

Protect marshlands and baylands to ensure they are not polluted or damaged from bay filling and dredging.

Protect and restore creek corridors and riparian areas to ensure they function as healthy wildlife habitat and biological areas.

Identify mitigations of impacts to sensitive species in coordination with the USFWS, the CDFW, and other regulatory agencies.

- **Policy LU4.4 - Toxic and Contaminated Sites:** Continue to work with the appropriate local, state, and federal agencies to promote the clean-up and reuse of contaminated sites to protect human and environmental health. Work with property owners and regional agencies to prevent, reduce or eliminate soil and water contamination from industrial operations, the Port and other activities that use, produce or dispose of hazardous or toxic substances. Implement appropriate mitigation measures and clean-up of sites that are known to contain toxic materials as a condition of reuse. Support the remediation and reuse of large, disturbed sites, such as the Winehaven complex at Point Molate and the Terminal 4 site at Point San Pablo, into mixed-use centers that provide the maximum benefit to the community without compromising the integrity of the surrounding natural areas (City of Richmond 2012).

The General Plan 2030 EIR evaluates General Plan consistency with existing land use plans and policies as well as land use compatibility. Future development would not physically divide an established community; conflict with existing land use plans, policies, or regulations; or result in substantial land use incompatibilities. The potential physical environmental effects resulting from future development and land use changes are analyzed in the appropriate General Plan 2030 EIR sections.

Eastshore State Park General Plan

The Eastshore State Park General Plan guides efforts to balance recreation and conservation, protect and enhance the natural resource base, and expand opportunities for public enjoyment of the park's shoreline setting.

Policies that apply to the South Richmond shoreline portion of the state park are:

PI/SR-7	Removal of invasive exotic plant species and re-vegetation with native plant species in Hoffman Marsh and along South Richmond shoreline.
PI/SR-8	Coordinate with the owners of the adjacent tidal marsh, mudflat, subtidal, and upland habitat areas to ensure adequate protection of this valuable natural area.
PI/SR-9	Explore the possibility of adding one or two new vista points seating areas along the Bay Trail north of Point Isabel.
PI/SR-10	Incorporate interpretive panels into the vista points and other key points along the Bay Trail that explore the natural, cultural and social history of this portion of the park project.
PI/SR-11	Provide fencing along the Bay Trail where necessary to protect tidal marshes, tidal mudflats, and water birds from disturbance.

4.9.4 Impacts and Mitigation Measures

Standard of Significance

The impacts from development under the proposed 2014 LRDP related to land use and planning would be considered significant if they would exceed these Standards of Significance, in accordance with Appendix G of the *State CEQA Guidelines* and the UC CEQA Handbook:

- Physically divide an established community;
- Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the general plan, specific plan, local coastal plan, or zoning ordinance) adopted for avoiding or mitigating an environmental effect; or
- Conflict with any applicable habitat conservation program or natural community conservation plan.

CEQA Checklist Items Adequately Addressed in the Initial Study

The analysis in the NOP Initial Study concluded that no further analysis of the following issue is required in the EIR:

- Conflict with any applicable habitat conservation program or natural community conservation plan.

The RBC site is not in an area for which a federal, state, or local habitat conservation plan or natural community conservation plan has been adopted or proposed.

Analytical Methods

This section focuses on compatibility of the proposed 2014 LRDP development with other relevant land use plans and zoning provisions for the area surrounding and including the RBC site. Compatibility is evaluated by comparing the proposed RBC land uses and campus development patterns with the City of Richmond land use designations for the area surrounding and including the RBC site.

RBC 2014 LRDP Policies

The RBC 2014 LRDP policies related to land use and planning include the following:

- LU1 – Land Use Policy on Development Capacity: Provide for development of up to 5,400,000 square feet of facilities.
  - Maximize density to reduce overall building footprints, conserve open space, and share attractive views.
  - Vary building heights for visual interest on site and views into the campus, with lower buildings at the waterfront edge and taller buildings in the northern and western areas of the site.
  - Convey the values of the campus in each phase of development.
- LU2 – Land Use Policy on Character: Provide a setting capable of attracting new research programs and retaining world class researchers.
  - Support excellence in building design that is harmonious with the waterfront location and creates visual variety in form and massing. Include iconic structures or buildings on the campus.

- Locate and design buildings, rooftops, open space, and circulation routes to allow for a variety of view corridors within and beyond the campus.
- Create a distinct identity and sense of place by preserving and enhancing the site's assets including the grasslands, marsh, and bayfront areas.

- LU3 – Land Use Policy on Inspiration: Facilitate the casual interactions and new awareness of synergistic research which leads to inspiration and innovation through the layout of the campus, provision of amenities, and design of buildings and spaces.
  - Plan the initial development to create a critical mass of core facilities and research programs selected to attract future synergistic enterprise.
  - Design buildings to include uses such as informal meeting zones, open stairways, light-filled lobbies, and transparent walls which promote the exchange of new ideas.
  - Provide amenities such as cafes, sculpture gardens, public art, recreation fields, and outdoor gathering places at multiple scales with weather protection where feasible for casual interaction, contemplation, and community-building activities.
  - Develop the campus to become the centerpiece of a vibrant and revitalized South Shoreline Area, serving as a catalyst for additional development on nearby properties.
- LU4 – Land Use Policy on Growth: Ensure that the RBC grows in a logical and cost-effective manner.
  - Retain existing uses on campus for as long as possible and evaluate opportunities to retain or relocate uses on site for the long term.
  - Concentrate development to preserve future capacity while maintaining natural areas.
  - Create complete collections of buildings and open spaces as development progresses.
  - Phase growth to create the critical mass of activities and population needed to support amenities.
  - Plan and develop infrastructure to allow logical and cost effective extensions to support future development.
  - Implement LRDP provisions for development undertaken by the private sector for synergistic uses by public or private entities.
- LU5 – Land Use Policy on Community: The RBC will be an asset to residents of local East Bay communities.
  - Provide programs and facilities on site that can be used for education and outreach to the local community including an arts program that helps to establish the campus as a visitor destination.
  - Support integration of the campus into the Richmond South Shoreline Area; remove peripheral fencing as adequate population is achieved; and consider adjacent uses in decisions on building siting and design.
  - Allow convenient multi-mode access to the campus and promote public transit, bicycle, and pedestrian transportation modes.
  - Identify Lark Drive and Regatta Boulevard as where the public realm will be designed to integrate with the neighboring community fabric.

LRDP Impacts and Mitigation Measures

LRDP Impact LU-1: Development under the 2014 LRDP would not physically divide an established community. *(No Impact)*

The RBC would be on University-owned land parcels; both parcels are currently developed with institutional and light industrial uses. The RBC site is separated from the Richmond community by I-580 and the railroad lines north and east of the site and by Meeker Slough southwest of the site. The University would work with the City of Richmond to acquire the road right-of-way parcel for Regatta Boulevard and realign the right-of-way on the western boundary of the proposed campus. The realignment would not divide the nearby neighborhood. 2014 LRDP implementation would not expand the campus site into the surrounding community and would not physically divide any established communities. No impact would occur.

Mitigation Measure: No mitigation measure is required.

LRDP Impact LU-2: Development under the 2014 LRDP would not result in development that would conflict with land use plans applicable to the project site or with land use plans for properties adjacent to the project site. (*Less than Significant*)

Since its acquisition in 1950, the RFS has been used as a field station by UC Berkeley to house certain research programs. The Regatta parcel, at the western edge of the RBC site and acquired in 2007, has been used to house archives for UC Berkeley and other private leased uses. No applicable land use plan has been adopted for these portions of the proposed RBC site. The proposed 2014 LRDP is a land use plan that, once adopted, would be the RBC site's governing plan. As there is no existing applicable land use plan, campus development under the proposed 2014 LRDP would not conflict with an applicable land use plan.

City of Richmond General Plan

The land use plan for areas surrounding the RBC site is the City of Richmond General Plan 2030. All of the lands immediately west and south of the Regatta parcel, north of the Regatta and RFS parcels, and east of the RFS parcel are designated Light Industrial/Business uses in the General Plan; that is also the General Plan land use designation for the RBC site. Light industrial uses are developed on some adjacent parcels and some other parcels are vacant. There are no proposals to develop or redevelop land near the RBC site. If any of these properties were to be developed in the future, the uses would be industrial or business.

The proposed 2014 LRDP would not conflict with the City's General Plan vision for the RBC site and the Richmond's shoreline area. The proposed RBC facilities would include research laboratories, which would not conflict with the business/light industrial use designation. The 2014 LRDP identifies two land use designations to inform the pattern of RBC development: (1) Research, Education, and Support, and (2) Natural Open Space; the LRDP Land Use Plan is shown as Figure 3-3. Using the land use plan and the LRDP development goals and objectives, a conceptual portrayal of potential RBC development has been devised, as shown on Figure 3-4 (that conceptual layout is part of an Illustrative Development Scenario, which is discussed in detail in Section 3.7). As shown in both the LRDP Land Use Plan and the LRDP Conceptual Layout, the RBC site central and southern portions would remain undeveloped and protected as open space; most of the remainder of the site would be developed. This manner of development would place developed campus uses in areas that adjoin industrial and business uses and would provide a buffer between RBC facilities and nearby sensitive land uses such as residential and natural areas. The Marina Bay residential neighborhood to the southwest would continue to be

separated from development on the RBC site by an approximately 250-foot open space buffer. The residential neighborhood to the northeast would be more than 500 feet from any RBC development and further shielded from the RBC by the intervening I-580. These neighborhoods are designated in the 2030 General Plan for low- and medium-density residential uses.

RBC building heights are expected to vary, with lower buildings at the Bay front edge and taller buildings farther inland. Four- and five-story buildings are expected to be a common building module, with heights of 100 feet for five-story buildings featuring floor-to-floor heights typical of laboratory buildings. These tall stories allow for extra capacity and access to utility systems that often need to be altered as laboratory uses and needs change over time. Neighborhoods within the campus may also feature iconic buildings that help establish a sense of place. An example would be Sather Tower (the Campanile) at UC Berkeley, which measures 303 feet to the top. As shown on Figure 3-4, the building heights proposed in the RBC site eastern and northeastern portions would not conflict with the industrial land uses or I-580 to the east and northeast. The proposed buildings and expansion of the Northern Regional Library Facility in the RBC site northern portion would be consistent with the existing industrial land uses north of Regatta Boulevard. The building heights in the RBC site Regatta area would not conflict with the light industrial and business land uses to the north, west, and southeast of the property. There would be an open space buffer between the Marina Bay neighborhood and the existing EPA building and proposed buildings in the RBC site's southwestern portion. This buffer and the plan to construct only lower buildings along the Bay front edge would minimize building height impacts on nearby residents and park recreational users.

As noted in the 2014 LRDP planning principles, the RBC would respect and promote its connection to the City of Richmond through its site planning and programs. Opportunities to do so include coordinating planning with the City of Richmond for the South Shoreline Area, developing an open campus, creating science education outreach programs, providing skills training for RBC-affiliated jobs, instituting a campus community arts program, and promoting new retail outlets to serve the RBC and local communities. The 2014 LRDP would develop a research and development campus and provide a new employment center consistent with General Plan Goal ED8. The campus would conform to General Plan Policy ED8.1 by partnering with the City of Richmond to promote advanced technology, research, and development. New RBC building types, uses, and scale would complement nearby industrial and commercial operations in accordance with General Plan Policy ED8.2. An appropriate buffer zone is proposed between proposed new RBC development and existing residential uses and the natural areas such as the Western Stege Marsh and Meeker Slough. The natural areas would remain undisturbed by development in accordance with General Plan Policies LU4.1, LU4.2, and LU4.3. The existing contamination on the RBC site would be addressed consistent with General Plan Policy LU4.4. Although the proposed 2014 LRDP is designed to avoid land use conflict with nearby existing and future land uses, the University will evaluate and as appropriate prepare CEQA documentation for new RBC facilities. Early in the design process, the University will evaluate the proposed campus developments for consistency with the 2014 LRDP and will consider the off-campus implications as described in LRDP Impact AES-1.

Given the proposed 2014 LRDP land use designations, planning principles, and the pre-project design review process described above, the proposed 2014 LRDP would not conflict with the City of Richmond General Plan 2030 goals and policies. This impact is considered less than significant.

Eastshore State Park General Plan

A portion of the Eastshore State Park, the South Richmond Shoreline, is adjacent to the RBC site. The Eastshore State Park General Plan indicates that the RFS, which is a portion of the proposed RBC, is expanding and transitioning toward cleaner and higher technology uses. The 2014 LRDP

would indeed further develop the RBC site to accommodate research and development in technologically advanced and environmentally proactive ways. The 2014 LRDP would protect the site's natural resources, including those near the South Richmond Shoreline. This resource protection would conform to Eastshore State Park General Plan policies. The University would work with the East Bay Regional Park District to identify possible natural resource enhancements and thus further promote the Park's General Plan policies. The 2014 LRDP would not conflict with the General Plan for the Eastshore State Park. This impact is considered less than significant.

Mitigation Measure: No mitigation measure is required.

Cumulative Impacts and Mitigation Measures

LRDP Cumulative Impact LU-1: **Development under the 2014 LRDP, together with other reasonably foreseeable regional growth, would not result in development that would conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project. (*Less than Significant*)**

The South Shoreline Specific Plan is currently under preparation. The Planning Area comprises the City of Richmond southeastern portion that is west and south of I-580. It includes areas designated for light industrial, commercial, and residential uses, and it includes the entire RBC site and adjacent sites. This plan tiers off the recently adopted City of Richmond General Plan 2030. Therefore, the Specific Plan is anticipated to include policies promoting higher residential densities and continued industrial, research, and development uses. The 2014 LRDP would be complemented by Specific Plan policies that anticipate RBC site development through the year 2050.

There is one foreseeable project near the RBC site. Bio-Rad Laboratories, on a 4-acre site at 3110 Regatta Boulevard and immediately west of the Regatta parcel, proposes to replace six existing structures with a new 16,888 gsf building to accommodate laboratory office, research, and development uses. As the new structure would be in the same location and used for the same activities as the current on-site buildings, a land use change in conflict with an applicable plan would not occur.

It is anticipated that development of future off-campus projects near the RBC site would be reviewed for consistency with the City of Richmond General Plan 2030 land use plans and policies; the University would evaluate projects for 2014 LRDP consistency and would analyze consistency with nearby land uses. Future development is therefore assumed to be consistent with applicable plans or polices would result in a less than significant cumulative land use impact.

Mitigation Measure: No mitigation measure is required.

4.9.5 References

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4.10 NOISE

4.10.1 Introduction

This section discusses existing project area noise and analyzes the potential for implementation of the proposed 2014 LRDP to affect the ambient noise environment. Information and analysis in this section is based on existing project site documentation; the municipal code, general plans, and general plan CEQA documentation for the city of Richmond; a traffic study prepared by Fehr and Peers; noise and vibration guidance manuals; RBC site noise monitoring data; the CEQA statute and guidelines; and the *UC CEQA Handbook*.

The existing noise environment is described by identifying existing land uses especially sensitive to noise and vibration and existing noise sources. Noise environment changes would result from development under the 2014 LRDP implementation. Construction and demolition would result in short-term noise impacts from construction equipment and vehicle operation. Long-term noise impacts would result from on-site increases in traffic volumes, building mechanical system equipment, and site population. Mitigation measures are included to reduce construction and operational noise impacts.

Public and agency NOP comments related to noise are summarized below:

- Project construction and operational noise, including that from operational equipment such as ventilation fans and fume hood fans, should be reduced as much as possible and should be shielded from natural areas.
- RBC site noise increases could disturb marshland wildlife near the Bay Trail.

The first issue is addressed in the analysis that follows. Noise effects on wildlife are discussed in Section 4.3, Biological Resources.

4.10.2 Environmental Setting

Noise is defined as unwanted sound. Noise can disturb or annoy people, interfere with activities such as sleep or learning, or cause physical effects such as headaches and hearing loss. Noise may also disturb or drive away wildlife.

Sound is typically measured in decibels (dB). Because the human ear is not equally sensitive to all frequencies of sound, the A-weighted decibel (dBA) scale was developed to better approximate the human response to different sound levels. Typically, the human ear cannot perceive a difference in sound levels of less than 3 dB, an increase of 5 dB is the lowest readily apparent change in noise levels, and a 10 dB increase is perceived as twice as loud.

Several measurements are commonly used to describe sound levels over a period of time, including:

- Equivalent sound level (L_{eq}) is the average sound level over a given time period, typically 1 hour.
- Day-night average sound level is the average dBA over a 24-hour period, with 10 dBA added to sound levels between 10:00 p.m. and 7:00 a.m. This weighted result accounts for the typically greater receptor sensitivity for nighttime noises.
- Community noise equivalent level (CNEL) is similar to day-night average sound level with an additional 5 dBA added to sound levels between 7:00 and 10:00 p.m.
- L_n refers to sound level that is exceeded "n" percent of the time over a measurement period (e.g., L_{90} = sound level exceeded 90 percent of the time). The sound level

exceeded for a small percent of the time, L_{10}, closely corresponds to short-term, higher-level noise such as that of a passing vehicle. The sound level exceeded for a large percent of the time, L_{90}, closely corresponds to the background noise level. L_{50} is the level exceeded 50 percent of the time and is typically referred to the median sound level over a given period.

Noise levels attenuate, or decrease, as distance from a noise source increases. Noise from point sources, such as construction equipment, decreases approximately 6 dBA for every doubling of distance[35] and noise from line sources such as roadways decrease approximately 3 dBA for every doubling of distance. These attenuation factors are based on the inverse square law and assume no other factors are influencing the sound attenuation rate. Different frequency sounds attenuate at different rates. Under real world conditions, noise attenuation rates are influenced by factors such as intervening objects between the source and the receptor, vegetation, and atmospheric conditions such as wind, temperature, and humidity. This analysis uses the inverse square law sound attenuation factors that provide a conservative analysis of the rate of sound attenuation. Sound may attenuate at slightly different rates than those represented here due to influencing factors such as frequency, line of sight, and atmospheric conditions.

Buildings also reduce sound transmission from exterior sources to interior occupants. Typical buildings without specific sound-reducing construction provide approximately 25 dBA of noise attenuation (difference between outside noise levels and indoor noise levels) when the windows and doors are closed (American Industrial Hygiene Association 2003).

Because noise levels decrease relatively rapidly as distance increases, the region of influence for noise is relatively small. This area of effect for noise point sources is less than 0.5 mile and for line sources is less than 1,000 feet from the roadway centerline.

The ambient, non-construction noise environment at the RBC site is generated by vehicular traffic on roadways and building heating, ventilating, and air conditioning (HVAC) equipment. The area surrounding the RBC site includes I-580 to the north, undeveloped land and farther office and industrial areas to the east, open space and the San Francisco Bay Trail to the south, residential areas to the southwest, office and industrial areas to the west, and a railroad spur to the northwest.

Some land uses are more sensitive to ambient noise levels than others due to the types of activities involved. Residences, motels and hotels, schools, libraries, churches, hospitals, nursing homes, auditoriums, and parks and other outdoor recreation areas generally are more sensitive to noise than commercial and industrial land uses. These land uses are referred to as sensitive receptors. The nearest sensitive receptor to the RBC site is the Marina Bay residential neighborhood to the southwest. The distance to the nearest sensitive receptor is 150 feet from the boundary of the RBC development.

Other areas near the RBC site that may be sensitive to elevated noise levels are the EPA laboratory adjacent to the west, the NRLF and labs, and the San Francisco Bay Trail adjacent to the south and southwest.

Sound level measurements were taken at 10 locations on and around the RBC site in January 2013 (Tetra Tech 2013). The monitoring locations are shown in Figure 4-10. The duration of the monitoring period and the time of day (daytime or nighttime) are also shown on Figure 4-10. The monitoring results are presented in Table 4.10-1.

[35] This attenuation factor is based on the inverse square law.

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Noise Monitoring Locations

Richmond, California

- 24-Hour Measurement
- 30-Minute Daytime & Night Measurement
- 30-Minute Daytime Measurement Only
- RBC Site Boundary

TETRA TECH

Figure 4-10

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community. Noise Monitoring Locations - Tetra Tech 2013

Table 4.10-1
Ambient Noise Levels at the RBC Site and its Vicinity

Map ID	Land Use	Location Description	Time Period	L_{eq}	L_{10}	L_{50}	L_{90}	CNEL*
MP-1	Residential	Residential Neighborhood at Point Isabel Shoreline	Day	53	54	51	50	58
			Night	51	53	47	46	
MP-2	Residential	Eastern Residences at Bayside Court	Day	53	53	52	51	58
			Night	51	52	49	48	
MP-3	Residential	Residences at Bayside Court	Day	53	55	51	50	56
			Night	48	50	46	45	
MP-4	Residential	Trade Winds Sailing School	Day	57	61	53	50	59
			Night	50	53	48	44	
MP-5	Civic/Public	Rosie the Riveter World War II Home Front	Day	50	52	48	46	NA
MP-6	Residential	The Anchorage at Marina Bay	Day	54	58	52	49	61
			Night	54	58	47	44	
MP-7	Residential	Neighborhood at 30th Street. and Hoffman Boulevard	Day	62	64	62	60	NA
MP-8	Residential	Neighborhood at 43rd Street and Carlson Boulevard	Day	70	71	60	56	NA
MP-9	Civic/Public	Booker T. Anderson, Jr. Park	Day	66	67	65	63	NA
LT-1	Commercial	Richmond Bay Campus	Day	54	54	50	48	57
			Night	51	51	47	45	

Source: Tetra Tech 2013

*CNEL calculated for only those measurement locations with both day and nighttime monitoring results.
L_{eq} = Equivalent noise level, or average sound level during the measurement period.
L_n = Noise level exceeded "n" percent of the time during the measurement period, either 10, 50, or 90 percent.
NA = not applicable

As shown in Table 4.10-1, a wide range of baseline noise levels is found in and around the RBC site. This variation is due in part to the surrounding land uses, population density, and proximity to transportation corridors. Higher baseline noise levels were generally found closer to major roadways and railway lines. I-580 is generally audible throughout the area at all hours (Tetra Tech 2013).

The Richmond General Plan Update Final EIR includes noise data for the city's busiest and likely noisiest roadways. As part of the General Plan EIR analysis, a model was used to calculate the existing 70 dBA, 65 dBA, and 60 dBA CNEL noise contours for the selected streets. None of the selected streets are at or adjacent to the RBC site. I-580 is one of the modeled roadways. The 60 dBA CNEL noise contour for I-580 is approximately 850 feet north of the RBC site (City of Richmond 2011).

Groundborne vibrations are produced by construction equipment and large vehicles traveling over roads. Groundborne vibrations can be a source of annoyance to people or, if amplitudes are high enough, can damage structures or disrupt sensitive scientific equipment. Like noise, vibrations attenuate with distance from the source. Groundborne vibrations attenuate at different rates in different soil types. Vibration magnitude is often measured using peak particle velocity (PPV) that is measured in inches per second (in/sec), with a larger value representing a vibration with more potential to cause damage.

Sources of vibration at the RBC site are the adjacent railroad tracks, I-580, and the seismic laboratory.

4.10.3 Regulatory Considerations

Federal

In the early 1970s, the EPA established the Office of Noise Abatement and Control under the authority of the Clean Air Act Title IV – Noise Pollution. In the early 1980s the EPA concluded that noise issues were best handled at the state and local level and the Office of Noise Abatement and Control was closed. Although noise regulation has since been primarily a state and local responsibility, the EPA retains certain authorities related to noise investigation and regulation (EPA 2013a, 2013b). The EPA's Noise Abatement Program regulations are found in 40 CFR, Chapter I, Subchapter G and contain federal noise regulations, including noise emission standards for construction equipment in Part 204.

The Noise Control Act of 1972 (42 USC § 7641) requires the all Federal agencies implement programs that promote an environment free from noise that jeopardizes health and welfare. The Quiet Communities Act of 1978 (42 USC § 4913) authorized the EPA to provide grants to state and local governments for noise abatement. The Federal Occupational Health and Safety Administration regulations for workplace noise exposure are found in 29 CFR § 1910.95, Occupational Noise Exposure. Other standards for occupational noise exposure are the American Conference of Governmental Industrial Hygienists' Threshold Limit Values and the National Institute for Occupational Safety and Health's recommended standards.

State

The California Noise Control Act of 1973 (California Health and Safety Code §§ 46000-46080) addresses unwanted and hazardous noise as a public health and welfare issue. The Act establishes criteria and guidelines for local governmental use in setting noise exposure standards.

California Government Code Section 65302[f] requires local jurisdictions to prepare general plans that address noise and identify goals, policies, and implementation measures that can be used to guide future land use development with regard to noise.

Cal/OSHA generally regulates workplace noise exposure in California. California Code of Regulations, Title 8, Article 105 established a time-weighted worker noise exposure limit of 90 dBA averaged over 8 hours.

Local

The RBC site is a University-owned property where work within the University's mission is performed on land owned or controlled by The Regents. As a state entity created by Article IX, Section 9 of the California State Constitution, the University is exempt under the state constitution from compliance with local land use regulations, including general plans and zoning. The University seeks to cooperate with local jurisdictions to reduce any physical consequences of potential land use conflicts to the extent feasible. The RBC site is in the City of Richmond. The following sections summarize local noise ordinances and noise-related City of Richmond General Plan objectives and policies.

City of Richmond 2030 General Plan

The City of Richmond 2030 General Plan Public Safety and Noise Element (City of Richmond 2012) contains the following noise-related goal:

Goal SN4 – Acceptable Noise Levels. Achieve noise levels consistent with acceptable standards and reduce or eliminate objectionable noise sources. Prevent where possible, or mitigate noise impacts from industries, roadways, railroads and businesses in residential areas and sensitive uses in the community. In addition, apply new technology, buffers and other solutions to reduce excessive noise.

The following policies are related to this goal:

- **Policy SN4.1 – Noise Levels.** Work with regulatory agencies to monitor and enforce noise standards in the community. Reduce or mitigate objectionable noise sources and require new noise sources to comply with noise standards. Regulate both indoor and outdoor noise levels to protect health and safety. Use a combination of noise standards and existing noise levels to determine impacts and mitigation measures.
- **Policy SN4.2 – Land Use Compatibility (excerpt).** All new development must avoid or mitigate to the greatest extent feasible potential negative impacts such as noise, odors, and pollution.
- **Policy SN4.3 – Transportation-Related Noise.** Monitor changes in technology that will prevent and mitigate transportation related noise impacts on residential and sensitive uses in the community. Support traffic and freeway improvements that will reduce noise impacts of vehicles. Alternatives to sound walls should be considered where possible.

The following actions are intended to implement the stated goal and policies:

- **Action SN4.A – Noise Study Report Requirement.** Require proposed commercial and industrial uses with potential noise and vibration-producing activities or new noise-sensitive uses that locate in an area with day-night average sound level of 55 or greater to provide noise study reports. The report should identify noise mitigation measures that limit noise to an acceptable level compared to existing conditions.
- **Action SN4.B – Noise Study Guidelines.** Regularly review and update guidelines for the analysis of noise impacts and conflicts in the community. Ensure that the effect of brief loud noises such as locomotive horns are analyzed and that noise limitations include a maximum acceptable noise level for noises of short duration for interior sleeping areas of residential and other uses. Use the noise analysis to review development proposals to assure consistency with noise standards. Consider the following measures for mitigating noise impacts on adjacent properties:
    - Screen and control noise sources such as parking, outdoor activities and mechanical equipment.
    - Use technology to reduce noise impacts in instances where setbacks cannot be increased.
    - Use state of the art noise-abating materials technology and construction standards and double or triple glazed windows to meet noise standards.
    - Control hours of operation, including deliveries and trash pickup to minimize noise impacts.
    - Use the Future Noise Contours data and Municipal Codes on noise to determine if additional noise studies are needed.
- **Action SN4.C – Noise Ordinance.** Regularly review and update the noise ordinance to regulate noise-generating activities and proposed developments near noise generating activities based upon changes in state law. Where feasible, limit the impact of noise

sources on noise-sensitive uses and consider noise and vibration impacts in land use planning decisions. Require mitigation of potential noise impacts on adjacent properties. Enforce the Land Use Compatibility Standards presented in the State of California's General Plan Guidelines when siting new uses in existing noise environments. Require new residential development and other noise sensitive uses near railroad crossings or other sources of brief loud noise to be analyzed for noise compatibility using standards based on both 24-hour averages and maximum instantaneous interior noise levels to determine the noise effects on sleep disturbance and other essential human functions. Encourage projects to use site planning and building orientation principles and state-of-the-art noise-abating materials, technology and construction standards to minimize noise.

Reduce noise levels generated by roadways, railroads and other facilities by: encouraging Caltrans to institute noise reduction measures on existing and future freeways to lessen noise impacts on areas immediately adjacent to the freeway; encouraging public agencies to ensure that their programs are consistent with those of the City as they relate to noise control; and urging strict enforcement of current federal railroad noise emission standards by the DOT.

- **Action SN4.D – Quiet Zone Expansion.** Establish the entire City of Richmond as a railroad quiet zone and complete a study to determine the improvement costs for all of Richmond's at-grade railroad crossings.
- **Action SN4.E – Construction Traffic Plan Guidelines.** Maintain guidelines for preparing traffic plans to mitigate noise, traffic and dust during major construction activity. Continue to require construction traffic plans for all developments of 10 or more homes or commercial projects larger than 5 acres to regulate vehicle speeds, dust and noise mitigation, hours of operation, phased fencing plans and safety standards. The plan should ensure the safety of the public and employees during construction of major projects.

The General Plan defines acceptable noise levels for various types of land uses as shown in Table 4.10-2. These definitions are based on the California Governor's Office of Planning and Research General Plan Guidelines (State of California 2003).

The 2030 General Plan EIR determined that the noise effects from future development pursuant to the General Plan would be significant and unavoidable. Construction noise would cause temporary noise and vibration increases that would remain significant and unavoidable after implementing mitigation measures. Train and traffic noise would, in some cases, continue to remain significant and unavoidable even after mitigation. Operational activities associated with future development under the General Plan would result in less than significant impacts on noise and vibration. Cumulative impacts would be significant and unavoidable.

City of Richmond Municipal Code

City of Richmond Municipal Code Chapter 9.52 is known as the Community Noise Ordinance and provides City noise regulations. The ordinance is enforced by the Richmond Police Department. Key provisions of this ordinance are:

- Loading, unloading, and other handling of building materials, refuse, or similar items is prohibited between 9 p.m. and 6 a.m. if the noise creates a disturbance or violates the noise provisions of the City Planning Code (Section 9.52.050(g)).
- Operation of construction equipment is prohibited between 9 p.m. and 7 a.m. on weekdays and on weekends if the noise creates a disturbance or violates the noise provisions of the City Planning Code (Section 9.52.050(h)).

Table 4.10-2
Acceptable Noise Levels in the City of Richmond

Land Use Category	Normally Acceptable (dBA)	Conditionally Acceptable (dBA)	Normally Unacceptable (dBA)	Clearly Unacceptable (dBA)
Residential low density single family, duplexes, and mobile homes	Up to 60	55 to 70	70 to 75	75 or more
Residential multifamily	Up to 65	60 to 70	70 to 75	75 or more
Transient lodging (motels, hotels)	Up to 65	60 to 70	70 to 80	80 or more
Schools, libraries, churches, hospitals, and nursing homes	Up to 70	60 to 70	70 to 80	80 or more
Auditoriums, concert halls, and amphitheaters	Not specified	Up to 70	65 or more	Not specified
Sports arenas and outdoor spectator parks	Not specified	Up to 75	70 or more	Not specified
Playgrounds and neighborhood parks	Up to 70	67 to 75	72 or more	Not specified
Golf courses, riding stables, water sports, and cemeteries	Up to 75	Not specified	70 to 80	80 or more
Office buildings and business commercial and professional buildings	Up to 70	67 to 77	75 or more	Not specified
Industrial, manufacturing, utilities, and agriculture	Up to 75	70 to 80	75 or more	Not specified

Source: State of California 2003; City of Richmond 2012
dBA A-weighted decibel

- Temporary noise barriers must be constructed at construction sites adjacent to noise sensitive uses when the construction activity is projected to last for a year or more (Section 9.52.050(i)(1)).
- Noise from construction and demolition activities, ventilation and air conditioning systems, and similar equipment must comply with the noise regulations of the City Planning Code (Section 9.52.050(j)).
- Construction equipment must comply with the following (Section 9.52.060):
  - All construction equipment powered by internal combustion engines shall be properly muffled and maintained.
  - Unnecessary idling of internal combustion engines is prohibited.
  - All stationery noise-generating construction equipment such as tree grinders and air compressors are to be as far as is practical from existing residences.
  - Quiet construction equipment, particularly air compressors, are to be selected whenever possible.
  - Use of pile drivers, sources of impulsive sound and jack hammers shall be prohibited on Sundays and holidays, except for emergencies or as approved in advance by the Building Official.

The Community Noise Ordinance contains maximum noise levels of operational noise (Section 9.52.100) as shown in Table 4.10-3.

The Community Noise Ordinance contains maximum noise levels for construction equipment (Section 9.52.110) as shown in Table 4.10-4. The code states that "where technically and economically feasible," sound levels at the receiving properties should not exceed these noise limits.

Table 4.10-3
Maximum Noise Limits in Richmond Noise Ordinance

Zoning	Level not to be exceeded more than 30 minutes in any hour (dBA)		Level not to be exceeded more than 5 minutes in any hour (dBA)
	Measured at property line or district boundary	Measured at any boundary of a residential zone	From 10 p.m. to 7 a.m. measured at any boundary of a residential zone
Single Family Residential	60	60	50 or ambient noise level
Multifamily Residential	65	65	50 or ambient noise level
Commercial	70	60	50 or ambient noise level
Light industrial and office flex	70	60	50 or ambient noise level
Heavy and marine industrial	75	65	50 or ambient noise level
Public facilities and community use	65	60	50 or ambient noise level
Open space and recreational districts	65	60	50 or ambient noise level

Source: Richmond Municipal Code, Section 9.52.100
dBA A-weighted decibel

Table 4.10-4
Construction Noise Limits in Richmond Noise Ordinance

	Single Family Residential Zoning (dBA)	Multifamily Residential Zoning (dBA)	Commercial and Industrial Zoning (dBA)
Mobile Construction Equipment			
Weekdays, 7 a.m. to 7 p.m.	75	80	85
Weekends and holidays, 9 a.m. to 8 p.m.	60	65	70
Stationary Construction Equipment			
Weekdays, 7 a.m. to 7 p.m.	60	65	70
Weekends and holidays, 9 a.m. to 8 p.m.	55	60	65

Source: Richmond Municipal Code, Section 9.52.110

Note: The Community Noise Ordinance Section 9.52.110 states: "Where technically and economically feasible temporary construction activity shall be conducted in such a manner that the maximum sound levels at affected properties shall not exceed the following dBA levels." These levels are presented in Table 4.10-4. Mobile construction equipment is equipment that is used intermittently for less than 15 days. Stationary construction equipment is equipment that is used for 15 days or more.
dBA A-weighted decibel

4.10.4 Impacts and Mitigation Measures

Standards of Significance

The 2014 LRDP noise impacts would be considered significant if they would exceed the following Standards of Significance, in accordance with Appendix G of the *State CEQA Guidelines* and the UC CEQA Handbook:

- Exposure of persons to or generation of noise levels in excess of standards established in any applicable plan or noise ordinance, or applicable standards of other agencies
- Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels

- A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project
- A substantial temporary or periodic increase in ambient noise levels in the project vicinity above existing levels existing without the project
- For a project located within an airport land use plan or, where such a plan has not been adopted, within 2 miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?
- For a project near a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?

For construction and operational noise, this EIR analysis uses Richmond Community Noise Ordinance and Richmond Municipal Code Sections 9.52.100 and 9.52.110 to establish significance thresholds.

For vibration, the thresholds for structural damage and annoyance in the Transportation- and Construction-Induced Vibration Guidance Manual are the applicable significance thresholds (Caltrans 2004).

For traffic noise, no impact would occur if traffic volumes were to increase by less than 200 percent because the resulting change in noise level, less than 3 dBA, would not be readily perceptible. A significant noise impact would occur if traffic volumes were to increase more than 1,000 percent. This would result in an increase in traffic noise levels of approximately 10 dBA. Between these two thresholds, a less than significant impact would occur.

CEQA Checklist Items Adequately Addressed in the Initial Study

The Initial Study for the RBC circulated with the NOP concluded that further analysis of the following issues was not required in the EIR.

- For a project within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?
- For a project near a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?

The RBC site is not in a current or proposed airport land use plan or Airport Influence Area, as defined by Assembly Bill 2776. The RBC site is not within 2 miles of a public airport or near a current or planned private airstrip. Therefore, no further analysis is required.

Analytical Methods

Construction and demolition noise was evaluated assuming that typical construction equipment would be used. Noise level ranges were calculated using the distance from the property boundary to the nearest sensitive receptor. Construction would not likely occur at the edge of the RBC site, but construction footprints have not yet been fully defined. Consequently, this EIR noise analysis conservatively calculates noise sources from the boundary edges of the RBC development area (not including Natural Open Space). The nearest sensitive receptor is 150 feet from the RBC development boundary. Calculated noise level ranges were compared to the Richmond Municipal Code Section 9.52.110 construction noise limits to evaluate impact significance. Noise level ranges were also calculated for other surrounding receptors which, although not defined as sensitive and therefore not factoring into significance determination, might be close enough to experience construction noise.

Vibration impacts were analyzed by comparing Caltrans vibration thresholds (Caltrans 2004) to typical construction equipment vibration ratings and then calculating nearby building distances. Potential vibration impacts on project laboratories and scientific instruments would be self-managed and are not analyzed in this EIR.

Traffic noise impacts were evaluated using EIR traffic study data (Fehr and Peers 2013). Existing and future traffic volumes were compared and the difference was used to determine the approximate noise level increases and evaluate significance.

Operational noise was analyzed by (1) determining approximate equipment noise levels such as from generators and cooling towers, (2) determining approximate equipment noise levels at the nearest sensitive receptor, and then (3) comparing noise levels at the nearest sensitive receptor to the Richmond Municipal Code Section 9.52.100 exterior noise limits to evaluate significance. Modern HVAC equipment that would not exceed the noise limits in the Richmond Noise Ordinance when installed and operated in accordance with the manufacturer's instructions would be used. Therefore, HVAC noise was evaluated qualitatively.

RBC 2014 LRDP Policies

The RBC 2014 LRDP does not contain any policies related to noise.

LRDP Impacts and Mitigation Measures

LRDP Impact NOISE-1: Construction activities associated with development under the 2014 LRDP could generate and expose people to noise levels exceeding Richmond Community Noise Ordinance standards. (*Potentially Significant; Less than Significant with Mitigation*)

Construction and demolition would occur intermittently throughout development under the 2014 LRDP. Construction would take place on most portions of the RBC during this period, except for on designated Natural Open Space areas. Although temporary, construction at an individual site could last several years.

Construction and demolition would result in short-term noise impacts from construction equipment and vehicle use. In some instances, construction activities that occur near the project boundary and near sensitive receptors (in the southwest portion of the project site) could expose people to noise levels in excess of Richmond's Noise Ordinance standards, resulting in a potentially significant impact.

Table 4.10-5 contains maximum measured noise level of typical construction phases at distance of 50 feet from the noise source.

Table 4.10-5
Maximum dBA at 50 feet for Typical Construction Phases

Construction Phase	Maximum dBA at 50 feet
Excavation	87
Foundations	85
Building Erection	88
Exterior Finishing	90

Source: Illingworth & Rodkin 2010
dBA = A-weighted decibel

Using the construction noise levels in Table 4.10-5 and the noise attenuation factor of 6 dBA for every doubling of distance, Table 4.10-6 has the noise level ranges that would be experienced at various distances from the noise sources.

Table 4.10-6
Maximum dBA at Various Distances for Typical Construction Phases

Construction Phase	Noise Level at Distance from Noise Source (dBA)			
	100 feet	150 feet	300 feet	600 feet
Excavation	81	78	72	66
Foundations	79	76	70	64
Building Erection	82	79	73	67
Exterior Finishing	84	81	75	69

dBA = A-weighted decibel

The distance from each construction site to sensitive receptors would vary. The nearest sensitive receptor to the RBC site is a residential area to the southwest. The residential area boundary is 150 feet from the RBC development boundary (that excludes RBC Natural Open Space areas). The next nearest sensitive receptor is a residential area 460 feet northeast across I-580. I-580 traffic noise is expected to eclipse any RBC site construction noise. Consequently, no project noise impacts would likely be experienced in this residential area, so it is not further considered in this analysis.

As a result of construction and demolition activities, noise levels at the nearest sensitive receptor and in other surrounding areas could exceed the Richmond Noise Ordinance noise limits for stationary construction equipment (i.e., equipment that is operated for more than 15 days). As shown in Table 4.10-4, the Richmond Community Noise Ordinance limits for construction noise are 60 dBA in areas zoned single-family residential, 65 dBA in areas zoned multifamily residential, and 70 dBA in areas with commercial and industrial zoning.

The following mitigation measures would reduce construction and demolition noise in accordance with the Richmond Community Noise Ordinance. By implementing these mitigation measures, construction noise impacts would be reduced to less than significant.

LRDP MM NOISE-1:

NOISE-1a: Where technically and economically feasible, construction activities shall be conducted in such a manner that the maximum sound levels at the surrounding properties shall not exceed the dBA levels set forth in the Richmond Municipal Code Section 9.52.110.

NOISE-1b: The following measures shall be implemented for all construction equipment in accordance with Richmond Municipal Code Section 9.52.060. Quiet construction equipment, particularly air compressors, shall be used whenever possible. Construction equipment powered by internal combustion engines shall be properly muffled and maintained. Stationery noise-generating construction equipment such as tree grinders and air compressors are to be as far as is practical from existing residences. Unnecessary idling of internal combustion engines shall be prohibited. Sources of impulsive sound and jack hammers shall not be used on Sundays and holidays, except for emergencies.

NOISE-1c: If after implementing NOISE-1a and -1b, construction noise creates a disturbance or results in noise complaints from adjacent property, additional noise reduction strategies shall be evaluated and the necessary practicable technically and economically feasible noise mitigating measures would be implemented, sufficiently to ensure meeting City Noise Ordinance requirements.

LRDP Impact NOISE-2: Development under the 2014 LRDP would not generate or expose people to excessive groundborne vibration. (*Less than Significant*)

Construction equipment would cause vibrations that would spread through the ground and could cause damage to nearby structures, annoy people, or disrupt scientific equipment. Table 4.10-7 has guidelines to assess the damage potential from ground vibration induced by construction equipment. Table 4.10-8 has guidelines for the likely annoyance caused by vibration-producing activities.[36]

Table 4.10-7
Guideline Vibration Damage Thresholds

Structure	PPV (in/sec)*
Extremely fragile historic buildings, ruins, ancient monuments	0.08
Fragile buildings	0.1
Historic and some old buildings	0.25
Older residential structures	0.3
Newer residential structures	0.5
Modern industrial and commercial buildings	0.5

* Threshold for frequent, intermittent, or continuous sources such as pile drivers and compactors.
Source: Caltrans 2004
in/sec = inches per second
PPV = peak particle velocity

Table 4.10-8
Vibration Annoyance Thresholds

Human Response	Continuous Vibration PPV (in/sec)*	Intermittent Vibration PPV (in/sec)*
Very disturbing/severe	3.6 (at 2 Hz)–0.4 (at 20 Hz)	2.0
Strongly perceptible	0.10	0.9
Distinctly perceptible	0.035	0.24
Slightly perceptible	0.012	0.035

Source: Caltrans 2004
in/sec = inches per second
PPV = peak particle velocity

[36] These guideline vibration damage thresholds were developed for Caltrans by synthesizing the results of multiple vibration studies.

Table 4.10-9 shows the vibration associated with several types of common construction equipment.

Table 4.10-9
Vibration Levels produced by Typical Construction Equipment

Equipment	PPV (in/sec) at a distance of 25 feet
Pile driver (impact, typical)	0.644
Pile driver (sonic, typical)	0.170
Vibratory roller	0.210
Large bulldozer	0.089
Loaded truck	0.076
Jackhammer	0.035
Small bulldozer	0.003

Source: Federal Highway Administration and Federal Transit Administration 2006; Caltrans 2004.
in/sec inches per second
PPV peak particle velocity

The distance from each construction site to structures that could be affected by vibration would vary but is not likely to be less than 25 feet. Only pile driving would exceed the vibration damage threshold for newer residential and modern commercial buildings and pile driving is not anticipated as part of the project. The nearest residential area is 150 feet southwest of the RBC development boundary and the residential buildings are of relatively newer construction. Project construction equipment would neither exceed the vibration damage threshold nor be perceptible at these neighborhoods. Since the vibration damage thresholds would not be exceeded and vibrations would not be an annoyance at the nearest sensitive receptor, vibration impacts would be less than significant.

If vibration-sensitive equipment is located at the RBC, appropriate vibration-dampening design would be included in laboratory construction.

Under the 2014 LRDP, campus operations would not induce substantial groundborne vibration so there would be no impact.

Mitigation Measure: No mitigation measure is required.

LRDP Impact NOISE-3: Development under the 2014 LRDP could generate and expose people to noise levels exceeding Richmond Community Noise Ordinance standards or result in a substantial permanent increase in ambient project vicinity noise levels. (*Less than Significant*)

Long-term noise impacts would occur from increasing the onsite population and traffic volumes on the RBC site and nearby roads and from installing new building cooling towers, emergency generators, and HVAC equipment. Noise would not increase sitewide, but rather near the noise source, with the increase in noise decreasing with distance from the source.

Traffic Volume and Average Daily Population Increases

Development under the 2014 LRDP would ultimately raise the RBC site adp to 10,000 by 2050 and therefore increase the amount of and noise from vehicle traffic.

Vehicle noise depends on a number of factors including the mode split, type of vehicle (for example, passenger car, bus, or truck) and the vehicle's speed. Vehicle noise also fluctuates depending on traffic volume. A doubling of traffic volume results in a 3 dBA increase in noise levels. A 3 dBA noise difference is too small to be perceived by the average person. Traffic volume would need to be tripled to result in a readily perceivable (5 dBA) increase in noise. When traffic volume increases 1,000 percent, it results in a 10 dBA increase in the sound level, which is perceived by the average person as twice as loud (Federal Highway Administration 2011).

Development under the 2014 LRDP would increase traffic volumes and therefore increase traffic noise levels. At most of the 14 intersections studied, traffic volumes would not double (Fehr and Peers 2013); therefore, the increase in traffic noise would be less than 3 dBA and would not be readily perceivable by the average person. Traffic volumes would more than triple at two intersections: Meade Street and Regatta Boulevard and Meade Street and Seaver Avenue. There would be a readily perceptible increase in traffic noise levels near these roadways. However, traffic volumes at these intersections would not increase by 1,000 percent, so the impact on traffic noise levels would be less than significant.

New Mechanical Equipment

Operation of the project would introduce new noise sources, including cooling towers, air compressors, emergency backup generators, electrical transformers, and HVAC systems.

The HVAC systems would include both indoor and outdoor noise-producing components such as fans, pumps, and compressors. Air compressors would be located indoors. HVAC systems would be installed and operated according to the manufacturer's instructions to minimize noise both indoors and outdoors. Although the HVAC systems would add an incremental amount of noise to the area, the resulting difference in ambient noise levels would likely not be perceptible (i.e., would be less than 3 dBA). Since sound levels decrease by 6 dBA with each doubling of distance, the HVAC systems would need to emit a very high noise level (e.g., akin to an operating jackhammer) to exceed the lowest Richmond Community Noise Ordinance threshold of 50 dBA at the nearest sensitive receptor (the residential area 150 feet from the nearest proposed building). The HVAC systems would operate well below this level of noise output. Thus, the HVAC systems would not violate the Richmond Community Noise Ordinance and the impact of HVAC operation would be less than significant.

The approximate noise output of operational equipment is presented in Table 4.10-10.

Table 4.10-10
Typical Noise Levels for Operational Equipment

Equipment	50 feet	Noise level at 150 feet, Distance from RBC boundary to nearest sensitive receptor
Air compressor	66	57
Electrical transformer	51	42
Generator (diesel engine)	71	62
Cooling tower	44	35

Source: EPA 1971; LBNL 2010

The backup generators would generally be outdoors next to each building at ground level and toward the perimeter of the site. The generators would operate a minimum of 100 hours per year to maintain them properly. They would be tested during the day and would typically operate for about 30 minutes; therefore, they would have a minimal effect on ambient noise levels. Any additional operation would be as needed to provide emergency backup power, so with only occasional exceptions, the generators would not be operating and would not produce any noise.

The cooling towers would generally be on building rooftops toward the site perimeter. Each cooling tower would rise approximately 20 feet above the roof. Cooling towers may also be placed adjacent to buildings.

The air compressors would be inside buildings. Being inside a building would provide approximately 25 dBA of sound attenuation, based on the sound dampening properties of buildings of average construction, so the air compressors would not exceed the Richmond Community Noise Ordinance threshold (American Industrial Hygiene Association 2003).

In addition to the air compressors, some of the other equipment could be housed inside the building or an enclosure, so it would not exceed the Richmond Community Noise Ordinance threshold.

As shown in Table 4.10-3, the Richmond Community Noise Ordinance limits equipment noise received at the nearest sensitive receptor. The Ordinance stipulates that such noise cannot exceed 60 dBA in the daytime and cannot exceed 50 dBA or the ambient noise level in the nighttime. The electrical transformers and cooling towers would not exceed these limits. The air compressors would not exceed these limits since they would be inside. The generators could exceed these limits; however, the generators would rarely be used. Therefore, operational noise impacts would be less than significant.

Mitigation Measure: No mitigation measure is required.

Cumulative Impacts and Mitigation Measures

The cumulative noise analysis evaluates whether the 2014 LRDP impacts, together with the cumulative development impacts in the region, would result in a significant impact based on the criteria presented at the beginning of this section. If so, this analysis determines whether the 2014 LRDP contributions would be considerable. Both conditions must apply in order for the project's cumulative impacts to be significant.

The cumulative noise impact region of influence is limited by the distance over which noise propagates. Off-site noise sources would not overlap substantially with proposed project noise at distances of more than 0.5 mile from the RBC site or 1,000 feet from the roadway centerline of affected roads.

LRDP Cumulative Impact NOISE-1: Development under the 2014 LRDP and regional cumulative development would not result in a cumulatively considerable temporary increase in ambient noise levels and groundborne vibration in the project vicinity. (*Less than Significant with Mitigation*)

Development under the 2014 LRDP and cumulative development in the region would intermittently generate short-term noise and vibration from construction and demolition activities. As described under LRDP Impacts NOISE-1 and NOISE-2, construction and demolition activities associated with the 2014 LRDP would not expose people to noise levels in excess of standards established in Richmond's Noise Ordinance or result in significant temporary or periodic increases in noise or vibration with the incorporation of mitigation measures LRDP MM NOISE-1a through 1c.

RBC project construction noise and vibration would cumulatively overlap with construction noise from only one cumulative project in the area: the proposed redevelopment at Bio-Rad Laboratories west of the RBC site. The Bio-Rad Laboratories project is required to comply with the Richmond Noise Ordinance for construction noise limits. The City of Richmond prepared CEQA documentation for the proposed Bio-Rad project that includes imposition of noise mitigation measures. These measures limit noisy Bio-Rad project construction activities, including on-road truck trips near the project, to 7:00 a.m. to 7:00 p.m. on weekdays and 8:30 a.m. to 6:00 p.m. on Saturdays and legal holidays. No construction is permitted on Sundays. There is no indication that the proposed construction would include any unusual vibration-generating activities or equipment that would exceed vibration damage thresholds (City of Richmond 2010). Therefore, temporary noise and vibration impacts from the proposed Bio-Rad Laboratories project in combination with LRDP implementation would be less than significant. Accordingly, with implementation of LRDP MM NOISE-1, there would not be a cumulatively considerable temporary increase in ambient noise levels and groundborne vibration in the project vicinity.

LRDP Cumulative Impact NOISE-2: Development under the 2014 LRDP and regional cumulative development would not result in a cumulatively considerable permanent increase in ambient noise levels in the project vicinity. (*Less than Significant*)

The proposed 2014 LRDP and regional cumulative development would permanently increase noise levels in the area by adding population and vehicle traffic and installing new mechanical equipment such as cooling towers and generators. As described under LRDP Impact NOISE-3, long-term noise impacts associated with the 2014 LRDP would not expose people to noise levels exceeding Richmond's Community Noise Ordinance standards under normal operating conditions.

Project operational noise could overlap with operational noise from only one cumulative project in the area: the proposed redevelopment at Bio-Rad Laboratories west of the RBC site. The Bio-Rad Laboratories project is required to comply with the Richmond Noise Ordinance for exterior noise limits. The City of Richmond prepared CEQA documentation for the proposed Bio-Rad project that requires installation of improved machinery sound insulation in the replacement building. There is no indication that the equipment would be considerable a source of vibration (City of Richmond 2010). Therefore long-term noise and vibration impacts from the proposed

Bio-Rad Laboratories project in combination with development under the proposed 2014 LRDP would be less than significant.

Under cumulative conditions, traffic volumes and therefore traffic noise levels would increase. At 13 of the 14 intersections studied, the project's contribution to traffic volume increases would not cause traffic volumes to double (Fehr and Peers 2013); therefore, the increase in traffic noise would be less than 3 dBA and would not be readily perceivable by the average person. Traffic volumes would more than triple at the intersection of Meade Street and Seaver Avenue, increasing by 315 percent during the a.m. peak hour and by 337 percent during the p.m. peak hour. There would be a readily perceptible increase in traffic noise levels near this location; however, because the traffic volumes at this intersection would not increase 1,000 percent, the impact on traffic noise levels would be less than significant. Accordingly, there would not be a cumulatively considerable permanent increase in ambient noise levels and groundborne vibration in the project vicinity.

4.10.5 References

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4.11 POPULATION AND HOUSING

4.11.1 Introduction

This section presents existing and projected population and housing at the project site and its vicinity and analyzes the potential for development under the proposed 2014 LRDP to affect those resources. The analysis is based on information in the City of Richmond General Plan 2030, the 2010 US Census, American Community Surveys, and ABAG projections data.

Public and agency NOP comments related to population and housing are summarized below:

- The EIR should analyze the fiscal impacts of RBC site construction, operation, and maintenance (including insurance) on residents of Richmond, Alameda County, and the State of California including financial costs of the project and funding mechanisms that will be used.
- Analyze and plan to minimize local housing impacts from the expected concentration of employment.

All scoping comments were taken into consideration in the EIR analysis. Because the analysis of fiscal impacts is outside the scope of CEQA analysis, those impacts are not discussed in the EIR.

4.11.2 Environmental Setting

This section discusses existing conditions and projections for employment, population, and housing and their relationship to existing and projected conditions for the city and region. The RBC site is in the city of Richmond in Contra Costa County, California. Contra Costa County is part of the larger 9-county Bay Region Economy. The 9-county Bay Region is made up of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma Counties.

Employment and Income

The civilian labor force for the Bay Area was 3,676,415 in 2010 (see Table 4.11-1). Approximately 14 percent of the civilian labor force resides in Contra Costa County. The civilian labor force of the Bay Area decreased by nearly 2 percent between 2000 and 2010 and the unemployment rate increased from 3.4 percent in 2000 to 10.5 percent in 2010 (BLS 2013).

Table 4.11-1
Bay Area Civilian Labor Force

	2000	2010
Alameda	769,061	761,264
Contra Costa	500,940	523,315
Marin	141,809	133,128
Napa	66,625	75,734
San Francisco	472,759	456,589
San Mateo	398,171	374,909
Santa Clara	940,731	880,803
Solano	194,209	214,620
Sonoma	253,260	256,053
Bay Area	**3,737,565**	**3,676,415**

Source: BLS 2013

Richmond is in western Contra Costa County. In 2010, Contra Costa had 470,495 jobs, a decline of 4.5 percent from 2005. Health care and social assistance, retail trade, and government and government enterprises were Contra Costa's largest employers (BEA 2013a). Health care remains an important Contra Costa County employment source; health care accounted for 11.3 percent of employment and increased 16 percent between 2005 and 2010. The retail sector accounted for more than 10 percent of all jobs in 2010, a decrease of nearly 10 percent from 2005. Government accounted for 10.5 percent of employment in 2010, a slight decrease from 2005. The professional, scientific, and technical services industries are also a key economic sector for Contra Costa County. These account for more than 9 percent of all jobs in 2010, an increase of nearly 2 percent from 2005. The utilities industry had the largest growth in jobs from 2005 with a 59 percent job increase. The construction industry experienced the largest decline from 2005 with a decrease of 33 percent.

In 2010, the Bay Area had 4,312,112 jobs, an increase of 1.8 percent from 2005 (BEA 2013a). The Bay Area is expected to slowly recover the jobs lost during the recent recession and then experience moderate job growth to 2040. The Bay Area is projected to add more than 1.2 million jobs between 2010 and 2040 and is projected to grow slightly faster than California and the U.S. (Levy 2012).

The RBC site currently employs 300 workers. This represents a very small percentage of the total employment in the Bay Area, It is 0.03 percent of employment in Contra Costa County, and 0.3 percent of employment in Richmond.

The Bay Area unemployment rate increased from 3.4 percent in 2000 to 10.5 percent in 2010 (Table 4.11-2). In 2010, unemployment rates in the Bay Area ranged from a low of 8 percent in Marin County to a high of 12 percent in Solano (BLS 2013a). Contra Costa County had an unemployment rate of 11.1 percent and the City of Richmond a rate of 16.7 percent (BLS 2013).

Table 4.11-2
Bay Area Unemployment Rate

Area	2000	2010
Contra Costa	3.6	11.1
Richmond	6.0	16.7
Bay Area	3.4	10.5

Source: BLS 2013

The Bay Area economy has kept up with the state of California in generating income growth. As shown in Table 4.11-3, the Bay Area as a whole has a higher per-capita income than the state of California and the United States. Since 2005, all nine counties in the Bay Area increased in income growth. Marin County had the highest per-capita income in the Bay Area at $82,498 in 2010. Contra Costa County had a per-capita income of $54,817. The average salary per job in the Bay Area was $62,516 and $59,308 in Contra Costa County in 2010.

Population

According to the City of Richmond General Plan 2030, the City of Richmond grew from 87,425 in 1990 to 99,216 in 2000, The increase of 11,791 residents is an 11.9 percent growth. During this same time, the Bay Area population increased 11.2 percent. The 2005 population of the City of Richmond accounted for 10.1 percent of Contra Costa County's population (City of Richmond 2013).

Table 4.11-3
Bay Area Per Capita Income

County/Area	2005 Per Capita Income	2010 Per Capita Income
Alameda	$44,228	$47,603
Contra Costa	$51,585	$54,817
Marin	$81,567	$82,498
Napa	$45,494	$48,765
San Francisco	$64,330	$69,351
San Mateo	$63,115	$66,629
Santa Clara	$52,457	$57,433
Solano	$34,557	$36,929
Sonoma	$41,931	$43,274
Bay Region	$52,115	$55,812
California	$38,731	$41,893

Source: BEA 2013b

Note: All Per Capita Income dollar amounts presented are in nominal dollars (i.e., current dollars, not adjusted Inflation), as reported by BEA.

In 2010 the City of Richmond had a population of 103,701, an increase of 4.5 percent from 2000. The 2010 population for the Bay Area was 7,152,749, a 5 percent increase from 6,785,760 in 2000. Contra Costa and Napa Counties experienced the largest population growth in the Bay Area between 2000 and 2010 with an increase of 10.6 percent in Contra Costa County and 9.8 percent in Napa County. San Mateo County experienced the lowest growth with an increase of 1.6 percent in the same time (ABAG 2013).

Santa Clara County has the largest population in the Bay Area with a 2010 population of 1,781,642. Napa County is the smallest county with a population of 136,484 in 2010. Population forecasts by the California Department of Finance indicate continuous population growth for most of the Bay Area. As shown in Table 4.11-4, Contra Costa County is projected to have continuous strong growth through 2040 with a growth rate between 9 and 11 percent.

Table 4.11-4
Bay Area Historic and Projected Population

County/Area	2000	2010	2020	2030	2040	2050
Alameda	1,443,741	1,510,271	1,608,204	1,657,567	1,678,565	1,684,761
Contra Costa	948,816	1,049,025	1,147,399	1,254,205	1,392,509	1,489,068
Marin	247,289	252,409	251,361	253,026	259,549	264,810
Napa	124,279	136,484	145,660	158,649	172,927	185,238
San Francisco	776,733	805,235	852,788	877,847	891,607	907,443
San Mateo	707,161	718,451	747,563	803,288	850,112	895,603
Santa Clara	1,682,585	1,781,642	1,889,898	1,986,545	2,083,710	2,152,199
Solano	394,542	413,344	447,217	493,422	551,491	592,850
Sonoma	458,614	483,878	507,250	534,439	572,664	598,795
Bay Area	**6,785,760**	**7,150,739**	**7,599,360**	**8,021,018**	**8,455,174**	**8,772,817**

Source: ABAG 2013; DOF 2013

The population at the RBC site consists of UC Berkeley researchers and employees and guests who use the RBC facilities occasionally or work there on a temporary basis collaborating with other scientists and engineers. Guests are not LBNL employees; most are employed by other institutions, businesses, or government agencies. As of late 2012, the RBC site has a daily population of approximately 300.

Based on the places of residences presented in the 2004 UC Berkeley LRDP and the 2006 LBNL LRDP, it is assumed that RBC site employees reside throughout the Bay Area with a majority (90 percent) living in Alameda and Contra Costa counties. Applying that assumption to 2010 county population data, RBC site employees residing in Alameda and Contra Costa counties would constitute approximately 0.01 percent of the counties' populations. RBC site employees and their dependents (assuming an average household size of 2.77) would represent approximately 0.04 percent of the total population of Alameda and Contra Costa counties.

Housing

According to the City of Richmond General Plan 2030, the housing supply in the Bay Area region continues to grow. Between 1990 and 2000, Contra Costa County and the Bay Area had increases of 12.7 percent and 8.9 percent, respectively. Housing growth continued through 2005. Housing growth at a regional level slowed considerably, but Contra Costa County continues to build more homes (City of Richmond 2013).

In 2000, the City of Richmond had approximately 34,625 housing units, representing a 5.4 percent increase from the 32,749 units in 1990. Between 2000 and 2005, the City of Richmond's housing supply grew by 2.4 percent to 35,475 housing units (City of Richmond 2013).

The Bay Area housing characteristics are summarized in Table 4.11-5, which identifies owner-occupied and renter-occupied homes, along with median home values for each Bay Area county The housing units in Table 4.11-5 include all structure types (e.g., single-family homes, apartments, and mobile homes). Santa Clara accounts for 22.7 percent of the housing units in the Bay Area and Contra Costa County accounts for 14.4 percent. The City of Richmond accounts for 1.4 percent of the Bay Area housing units and 9.8 percent of the housing units in Contra Costa County. The median home value ranges from $32,100 in Solano County to $839,100 in Marin County. Contra Costa County had a median home value of $467,200 and the City of Richmond had a median home value of $339,200 (Census 2013b).

Table 4.11-5
Bay Area 2010 Housing Characteristics

County/Area	Total Housing Units	Occupied Housing Units	Owner Occupied Units	Renter Occupied Units	Vacant Units	Median Home Value
City of Richmond	39,328	36,093	18,659	17,434	3,235	$339,200
Alameda	582,549	545,138	291,242	253,896	37,411	$543,100
Contra Costa	400,263	375,364	251,904	123,460	24,899	$467,200
Marin	111,214	103,210	64,637	38,573	8,004	$839,100
Napa	54,759	48,876	30,597	18,279	5,883	$495,900
San Francisco	376,942	345,811	123,646	222,165	31,131	$773,600
San Mateo	271,031	257,837	153,110	104,727	13,194	$756,400
Santa Clara	631,920	604,204	348,298	255,906	27,716	$674,100
Solano	152,698	141,758	89,648	52,110	10,940	$32,100
Sonoma	204,572	185,825	112,280	73,545	18,747	$458,600
Bay Area	**2,785,948**	**2,608,023**	**1,465,362**	**1,142,661**	**177,925**	**$543,100**

Source: Census 2013a; Census 2013b

4.11.3 Regulatory Considerations

Federal

There are no federal laws or regulations regarding population and housing relevant to the proposed 2014 LRDP.

State

There are no state laws or regulations regarding population and housing relevant to the proposed 2014 LRDP.

Local

The RBC site is University-owned property where work within the University's mission is performed on land owned or controlled by The Regents. As a state entity, the University is exempt under the state constitution from compliance with local land use regulations, including general plans and zoning. The University seeks to cooperate with local jurisdictions to reduce the physical consequences of potential land use conflicts to the extent feasible. The RBC site is in the City of Richmond. The following sections summarize objectives and policies from the City of Richmond General Plan 2030 as they relate to population and housing.

City of Richmond General Plan

The City of Richmond 2030 General Plan – Economic Development, Land Use and Urban Design, Community Health and Wellness (City of Richmond 2012) has these goals, policies, and actions related to population and housing:

GOAL ED1: An Appealing Place to Live and Work. Foster neighborhoods, commercial and industrial areas and public spaces that are safe and welcoming environments to live, work and visit. Effective public safety services, neighborhood revitalization effort, opportunities for cultural and recreational activities, affordable housing, socially and environmentally responsible businesses and a diverse and expanded tax base will contribute to this environment.

The following policy is outlined in relation to Goal ED1:

- **Policy ED1.5 A Range of Housing Types**. Continue to require developers to provide a range of housing types and residential densities to meet the needs of all age groups, income levels, and household sizes.

GOAL ED2: Quality Jobs and Revenue. Create an attractive business environment that will support business recruitment, expansion and retention. Attract a variety of small and large firms, national and local establishments, and up-and-coming industries and employers across a variety of economic sectors. Offer a broad range of quality employment opportunities for current and future residents with varying degrees of experience, education and training.

The following policy is outlined in relation to Goal ED2:

- **Policy ED2.4 – Existing Employers:** Encourage established employers to remain and expand in Richmond in order to retain employers in key industries including green businesses, high-technology firms, food-related companies, port-related industries, medical services, manufacturing and distribution and retail/entertainment.

GOAL LU3: Expand Economic Opportunities. Expand economic opportunities in existing commercial and industrial areas and develop new opportunities to diversify the local economy. Create an attractive and socially-responsible business environment that will support business

recruitment, expansion and retention. Encourage innovative, high-growth and green business, and further support business and industries in providing a range of job and entrepreneurial opportunities while minimizing environmental and health impacts.

The following policy is outlined in relation to Goal LU3:

- **Policy LU3.2 – Local Employment Base.** Expand and diversify the local employment base to provide quality jobs for Richmond residents.

GOAL HW5: A Range of Quality and Affordable Housing. Promote stable and integrated communities and healthy living conditions for all residents by continuing to support projects that provide high quality, affordable housing. Well-designed, affordable and well-maintained housing contributes to: neighborhood stability; greater socioeconomic integration; reduced overcrowding; and improved living conditions for all.

The following policies are outlined in relation to Goal HW5:

- **Policy HW5.1 – Housing for All Income Levels.** Maintain the availability of an adequate supply of quality housing units to meet the needs of all income levels and continue to encourage development of additional quality and affordable housing units.

- **Policy HW5.2 – A Range of Housing Types.** Support and encourage development of a range of housing types that meet the needs of a broad range of population groups including seniors, large and small families, low and middle-income households and people of all abilities.

GOAL HW6: Expanded Economic Opportunity. Promote equitable access to economic opportunities that provide the material and social means for human development and upward mobility in the community.

The following policy is outlined in relation to Goal HW6:

- **Policy HW6.1 – Local Employment Base.** Expand and diversify the local employment base to provide quality jobs for Richmond residents.

The 2030 General Plan EIR states that population and job opportunities would increase, resulting in a need for more housing units. The General Plan assumes the addition of housing and jobs in Richmond. The increase in population and job opportunities are not considered physical environmental effects themselves, but environmental impacts of both are analyzed in the appropriate technical section of the City of Richmond General Plan EIR (City of Richmond 2011b). The City of Richmond General Plan EIR assumed that the City of Richmond would capture 13 percent of Contra Costa County's projected population growth of 231,900, resulting in an increase of 30,147 people in the City of Richmond by 2030. The EIR assumed an increase of 22,488 jobs in the City of Richmond by 2030 (City of Richmond 2011b). Growth projections in the General Plan EIR are "aggressive in that they far exceed the past growth in the City and also exceed the growth projected in the City by the Association of Bay Area Governments" (City of Richmond 2011b). The General Plan EIR notes that while growth is an intended consequence of the General Plan, it potentially impacts traffic, air quality, habitat and wildlife, utilities and services. The Final EIR states that the City of Richmond will track the number of new housing units and jobs in the city, to determine if either exceeds projected General Plan levels; if so, an update to the General Plan and EIR would be prepared.

4.11.4 Impacts and Mitigation Measures

Standards of Significance

The impacts on population and housing from the implementation of the 2014 LRDP would be considered significant if they would exceed the following Standards of Significance, in accordance with Appendix G of the *State CEQA Guidelines* and the UC CEQA Handbook:

- Induce substantial population growth or concentration of population in an area, either directly (for example, by proposing new housing or businesses), or indirectly (for example, through extension of roads or other infrastructure);
- Displace substantial numbers of existing housing necessitating the construction of replacement housing elsewhere; or
- Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere.

CEQA Checklist Items Adequately Addressed in the Initial Study

The analysis in the Initial Study prepared for the project and circulated with the NOP concluded that further analysis of the following issues was not required in the EIR.

- Displace substantial numbers of existing housing necessitating the construction of replacement housing elsewhere.
- Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere.

The RBC site does not include housing or any related residential uses, and no housing would be displaced, so no impact would occur, and no additional analysis is required.

Analytical Methods

City and regional baseline data on population, housing, and employment were obtained primarily from the 2000 Census, the 2010 Census, and ABAG's *Projections 2009*.

The section assesses the anticipated RBC-related employment increase in relation to the population and housing policies and projections for the City of Richmond and the Bay Area region. Project-related employment growth and housing demand would occur over several decades. A portion of future RBC-related site employees are assumed to be existing LBNL or UC Berkeley employees whose place of work would be moved to the new campus. Another portion of the employees would be new hires, most of whom are expected to be from within the Bay Area.

RBC 2014 LRDP Policies

The RBC 2014 LRDP policies related to population and housing include the following:

- SP1 – Safety and Preparedness Policy on Model Programs: Develop model environment, health, and safety programs for the RBC.
  - Develop comprehensive and effective physical safety, life safety, and emergency service plans to protect the environment, the public, employees, and guests at all times.
- SP2 – Safety and Preparedness Policy on Inclusion: Ensure that the RBC contributes to and serves as a resource for the Richmond Community.

- Expand partnerships with local agencies, including fire and police departments, as well as local neighborhoods to promote understanding and address safety and security concerns of neighbors as well as the campus workforce.

LRDP Impacts and Mitigation Measures

LRDP Impact POP-1: Development under the 2014 LRDP would incrementally increase the RBC site population over the LRDP's approximately 40-year planning period, but would not induce substantial population growth. (*Less than Significant)*

Under the proposed 2014 LRDP, RBC site population would increase as the RBC site is developed over the approximately 40-year planning period. At full implementation of the LRDP, it is estimated that the RBC site population would increase from 300 in 2012 to 10,000 in 2050, an increase of 9,700.

There would be beneficial economic impacts related to the RBC population growth including increased local commercial activity and sales taxes; a larger RBC population also would generate additional indirect income in supporting industries.

Many of the additional 9,700 RBC site employees are expected to be existing UC employees relocating from other sites. A substantial number would likely be hired from the Bay Area's labor force. Assuming future RBC employees would make the same residential location decisions as current RBC site employees, approximately 90 percent or 8,730 RBC employees would live in Contra Costa and Alameda counties by the year 2050. This population would represent less than 1 percent of the total number of people projected to be living in Contra Costa and Alameda counties in 2050. In all other counties of residence, RBC employees and their associated household population would account for less than 0.05 percent of the total projected population in 2050. Therefore the project-related increase in local population would cause a less than significant impact.

Conservatively assuming that all 9,700 employees are new to the Bay Area, the total population growth from full RBC 2014 LRDP development could add up to 26,869 new persons (RBC employees plus dependents, assuming an average household size of 2.77 for Contra Costa County). The addition of 26,869 to the Bay Area would not alter the regional population significantly. The regional population is projected to grow by about 1.6 million from 2010 to 2050. Growth directly resulting from the 2014 LRDP would amount to less than 1 percent of this increment, so the project-related increase in regional population would cause a less than significant impact.

The increase in permanent employees would add residential population to the City of Richmond, other nearby communities, and the region and could increase demand for permanent housing. Between 2010 and 2040, ABAG projects an increase of approximately 635,650 households in the Bay Area. Approximately 38 percent of the regional total is projected for Alameda and Contra Costa counties, where most RBC employees would likely live.

The housing demand associated with 2014 LRDP permanent employment growth likely would be satisfied by the housing that could be added in Contra Costa and Alameda counties and other nearby communities. The most recent draft forecast for 2010-2040 is the Jobs-Housing Connections Strategy (ABAG 2012) that projects the addition of 83,970 households in Contra Costa County between 2010 and 2040, 160,160 households in Alameda County, and 10,990 households in the City of Richmond. As noted above, the City of Richmond General Plan EIR

assumed an increase in households within the city of more than 30,000 people by 2030 (City of Richmond 2011b). Conservatively assuming that all 9,700 employees are new to the Bay Area and 90 percent of those would live in Contra Costa or Alameda counties, the 2014 LRDP would cause a 8,730-households increase in Contra Costa and Alameda counties by 2050. This would represent a small percentage of the total additional households projected for these counties. Similarly, a portion of those households would be established in the City of Richmond in Contra Costa County—this likely would also represent a small portion of total new households anticipated. Therefore, the project-related impact due to increased employee housing demand would be less than significant.

Mitigation Measure: No mitigation measure is required.

Cumulative Impacts and Mitigation Measures

LRDP Cumulative Impact POP-1: **Development under the 2014 LRDP together with cumulative regional development would induce population growth in the City of Richmond and the Bay Area, but the contribution of the 2014 LRDP to this impact would not be cumulatively considerable. (*Less than Significant*)**

The geographic context for cumulative population and housing impacts analysis includes the nine-county Bay Area. While the employment increase would be concentrated at the RBC site, this impact on residential population growth would be dispersed throughout the Bay Area and would be spread out over 40 years.

The 2014 LRDP is expected to add 9,700 employees to the RBC site by 2050. These new employees would induce additional population growth as they would generate new employee households. Conservatively assuming all these new employees would reside in the Bay Area, the 2014 LRDP could add 26,869 new persons (RBC employees plus dependents, assuming an average household size of 2.77 for Contra Costa County). The addition of 26,869 to the Bay Area would not alter regional population significantly. Regional population is projected to grow by about 1.6 million from 2010 to 2050. Growth directly resulting from the 2014 LRDP would amount to less than one percent of this increment.

The expected population growth from 2014 LRDP development would be a component of overall expected Bay Area growth. Altogether, this future population growth would add to existing population and housing totals. This future growth could be accommodated through new development and in occupancy changes in existing housing and other building space. While the projected growth of the Bay Area population through 2040 could have environmental impacts, particularly to the extent it induces new development at the fringes of urbanized areas, the contribution of the 2014 LRDP to these potential impacts would not be cumulatively considerable.

Mitigation Measure: No mitigation measure is required.

4.11.5 References

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4.12 PUBLIC SERVICES AND RECREATION

4.12.1 Introduction

This section discusses existing public services and recreation facilities serving the project site and its vicinity and analyzes the potential for development under the proposed 2014 LRDP to affect those resources. The analysis is based on information provided by the Richmond Fire Department (RFD) and the UCPD, and information in the City of Richmond General Plan 2030.

Public and agency NOP comments related to public services and recreation are summarized below:

- The EIR should evaluate the need for additional City fire apparatus or services required to support the RBC development.
- The EIR should address the need to establish new or modify existing partnerships between the UCPD and the Richmond Police Department (RPD) to promote RBC public safety. This could include a establishing a joint UCPD/RPD substation or work stop on the project site or an RPD police substation near the project site.
- The EIR should evaluate RBC development impacts on shoreline parks, including the Bay Trail between Central Avenue and Garrard Boulevard.

All of these comments were considered in the analysis presented below.

4.12.2 Environmental Setting

Fire Protection

RFD currently provides fire protection services to the project site. There are seven RFD stations in the City. Personnel assigned to the stations respond to approximately 11,000 emergency calls per year. Approximately 77 percent of the emergency calls are for medical service. All personnel are trained as Emergency Medical Technicians to the level of EMT-D and HazMat First Responder Operational. The RFD goal is to respond to 85 percent of emergency calls in 6 minutes or less. The average response time for emergency and non-emergency calls for the RFD is 5 minutes. The average response of 5 minutes is considered acceptable according to the RFD standards (City of Richmond 2011).

RFD has a staff of 96, which includes 89 sworn officers and 7 non-sworn personnel. RFD is organized into three platoons staffing the eight companies. There are seven engine companies and one truck company. All eight companies are supervised by a Battalion Chief responsible for the emergency and administrative activities (City of Richmond 2011).

The closest fire station to the project site is Fire Station No. 64 at 4801 Bayview Avenue, approximately 0.5 mile to the east. Station No. 64 has seven personnel, two captains, two engineers, two firefighters, and the Battalion Chief. The personnel at Station 64 are trained as a Hazardous Materials Response Team (Banks 2013). The equipment at Station No. 64 includes an engine and a ladder truck.

The City of Richmond has mutual aid agreements for fire, rescue, and emergency medical services with the Contra Costa County Fire Protection District, City of Pinole Fire Department, and City of Rodeo-Hercules Fire Department. Under the agreement, these neighboring departments respond to calls outside their jurisdictional boundaries if appropriate primary response is unavailable or located such that it would result in an extended response time (City of Richmond 2011).

Police Services

The UCPD currently provides police services to the project site. The UCPD handles all patrol, investigation, and related law enforcement duties for UC Berkeley, the LBNL site, and other University-owned properties in the area.

The UCPD includes 77 police officers, 45 full-time non-sworn personnel, and 60 student employees. UCPD, at 1 Sproul Hall on the UC Berkeley campus, is organized into four divisions: Administration, Community Outreach and Emergency Services, Investigative and Support Services, and Patrol. The department is empowered as a full-service state law enforcement agency pursuant to Section 830.2(b) of the California Penal Code and fully subscribes to the standards of the California Commission on Peace Officer Standards and Training. Officers receive the same basic training as city and county peace officers throughout the state, plus additional training to meet the unique needs of a campus environment (UC Berkeley 2004).

There is no current service ratio goal for the project site; when services are requested or required, UCPD sends the appropriate resources to the project site to address the situation.

Schools

The West Contra Costa Unified School District (WCCUSD) serves approximately 235,000 residents in the five cities of El Cerrito, Richmond, San Pablo, Pinole, and Hercules and the unincorporated areas of Bayview-Montalvin Manor, East Richmond Heights, El Sobrante, Kensington, North Richmond, and Tara Hills. The district covers an area of approximately 65 square miles and provides K-8, middle, high school, alternative school, and adult education services. District enrollment in 2011-12 was approximately 30,000 students (California Department of Education 2013).

Coronado Elementary, the closest elementary school to the project site, is at 2001 Virginia Avenue, approximately 1 mile away. Coronado Elementary enrollment in 2011-12 was 451 students. Lovonya DeJean Middle School, the closest middle school, is at 3400 Macdonald Avenue, approximately 1 mile away. 2011-12 enrollment at Lovonya DeJean Middle School was 635 students. Kennedy High, the closest high school, is at 4300 Cutting Boulevard, less than 0.5 miles away. Kennedy High's 2011-12 enrollment was 883 students (California Department of Education 2013).

Parks and Recreation

The City of Richmond has 4,312 acres of parklands and open space that accounts for 22 percent of the land area in the City. Of these parklands, 4,029 acres are owned and operated by regional agencies, and 283 acres are City-owned facilities or jointly used by the City and other public or private entities. The City of Richmond is home to the Rosie the Riveter National Historic Park (City of Richmond 2011).

City Parks and Facilities

The City of Richmond owns and operates 74 parks, consisting of compact parks that include pocket parks, overlooks, pathways, neighborhood parks, and community parks. Recreational facilities at these parks include play lots, play fields, eight community centers, two senior centers, the swim center, an indoor recreation complex, and a municipal natatorium (City of Richmond 2011). The parks closest to the RBC site are Booker T. Anderson Jr. Park & Community Center, a 22-acre facility less than 0.25 mile northeast; Crescent Park, a 3.1-acre facility less than 0.25 mile east; and Marina Park and Green, an 11-acre facility less than 0.25 mile southwest.

National, State, and Regional Parks

Within the Richmond city limits, there are approximately 4,029 acres of regional and state parklands managed by the East Bay Regional Park District. These range in character from large-scale hillside natural areas to shoreline parks. These lands feature trail systems and day use areas and are publicly open for hiking, horseback riding, mountain biking, bird watching, fishing, and picnicking. The closest regional parks to the project site are Point Isabel Regional Shoreline and Brooks Island Regional Preserve. Point Isabel Regional Shoreline is a 23-acre facility on a small promontory in southernmost Richmond less than one mile southeast of the project site. It is owned and operated by the East Bay Regional Park District. Brooks Island Regional Preserve is a 373-acre preserve in the San Francisco Bay just off the Richmond Inner Harbor approximately 1.5 miles southwest of the project site. It is owned and operated by the East Bay Regional Park District (City of Richmond 2011).

The City of Richmond is home to the Rosie the Riveter/World War II Home Front National Historical Park that preserves and interprets stories and historic properties from the World War II home front era. The Rosie the Riveter/World War II Home Front National Historical Park consists of the Rosie the Riveter Memorial (in Marina Park and Green), the Ford Assembly Plant (in Sheridan Point Park), and Kaiser Shipyard No. 3/ SS Red Oak Victory Ship along the waterfront.

San Francisco Bay Trail

The San Francisco Bay Trail links many of the City and regional parks in Richmond, including the Point Isabel Regional Shoreline and six City-owned parks in Marina Bay west of the project site. The San Francisco Bay Trail is a planned 500-mile hiking and biking trail encircling the San Francisco and the San Pablo Bays. Twenty-five miles of this trail have been completed in the City; it is ultimately planned to span the entire shoreline wherever feasible. A completed Bay Trail section follows the shoreline directly adjacent to the southern boundary of the project site.

Eastshore State Park

The Eastshore State Park is located along the shoreline adjacent to the RBC site. The park extends approximately 8.5 miles along the eastern San Francisco Bay shoreline from the Oakland Bay Bridge north to the Marina Bay neighborhood in the city of Richmond. The park includes approximately 2,262 acres of uplands and tidelands along the Oakland, Emeryville, Berkeley, Albany, and Richmond waterfronts. The portion of the state park near the project is called the South Richmond Shoreline; it consists of gravel beaches to the south and tidal marsh to the north behind the seawall. An upland strip of land arcing from Point Isabel to Marina Bay is the dike formerly used by the railroad (Eastshore State Park General Plan 2004). A Bay Trail segment is built on this dike. The East Bay Regional Park District manages the state park. The Eastshore State Park General Plan identifies the possibility of adding one or two new vista seating areas along the Bay Trail north of Point Isabel. The vista points could incorporate interpretive panels with information regarding the natural, cultural, and social history of the specific portion of the park.

4.12.3 Regulatory Considerations

Federal

DOE Order 420.1B

DOE Order 420.1B, Facility Safety, establishes facility and programmatic safety requirements for DOE, including the National Nuclear Security Administration, for nuclear and explosives safety design criteria, fire protection, criticality safety, natural phenomena hazards mitigation, and the System Engineer Program.

DOE Standard 1066-2012

DOE Standard 1066-2012, Fire Protection, facilitates implementation of DOE Order 420.1B by providing criteria and guidance for a standard and acceptable approach to meet the DOE requirements for fire protection programs. The standard was developed to address special or unique fire protection issues at DOE facilities that are not comprehensively or adequately addressed in national consensus standards or other design criteria.

State

Senate Bill 50

The Leroy F. Greene School Facilities Act of 1998, or Senate Bill 50 (SB 50) (Government Code Section 65995), restricts local agencies' ability to deny project approvals based on adequacy of public school facilities (classrooms, auditoriums, etc.). School impact fees are collected at the time building permits are issued. These fees are used by the local schools to accommodate the new students added by the project, thereby reducing potential impacts on schools. School impact fees payment is required by SB 50 for all new residential development projects and is considered full and complete mitigation of school impacts under state regulations.

Local

The RBC site is a University property where work within the University's mission is performed on land owned or controlled by The Regents. As a state entity created by Article IX, Section 9 of the California State Constitution, the University is exempt under the state constitution from compliance with local land use regulations, including general plans and zoning. The University seeks to cooperate with local jurisdictions to reduce any physical consequences of potential land use conflicts to the extent feasible. The following sections summarize objectives and policies from the City of Richmond General Plan and local ordinances as they relate to public services and recreation facilities.

City of Richmond General Plan 2030

Police and Fire Protection

Goal SN2 High Levels of Police and Fire Service

Policy SN2.2 Level of Service. Provide a high level of police and fire service in the community. Secure adequate facilities, equipment and personnel for police and fire and collaborate with neighboring jurisdiction and partner agencies to adequately respond to emergencies and incidents in all parts of the City.

Policy SN2.3 Fire Safety. Regularly update policies that will protect the community and its urban and natural areas from fire hazards. Emphasize prevention and awareness of fire safety guidelines to minimize risk and potential damage to life, property and the environment. In areas designated by the Richmond Fire Department as having a high fire hazard, ensure adequate fire equipment, personnel, firebreaks, facilities, water and access for a quick and efficient response in any area.

Community Facilities and Infrastructure

Goal CF 2 Efficient Use and Adequate Maintenance of Facilities and Infrastructure

Policy CF2.1 Joint-Use and Co-Location. Encourage joint use or co-location of public and private facilities to maximize educational, cultural and recreational opportunities.

Policy CF2.3 Continued Public Use of School Sites. Encourage the continued public use of property owned and operated by the WCCUSD, other educational institutions, and private facilities to maximize multiple functions.

Parks and Recreation

Goal PR1 An Integrated System of Parks, Green Streets and Trails

Policy PR1.1 Diverse Range of Park Types and Functions. Continue to provide a diverse range of park types, functions and recreational opportunities to meet the physical and social needs of the community.

Policy PR1.2 Multimodal Connections to Parks, Open Space and Recreational Facilities. Improve connections to parks, open space and recreational facilities through an interconnected network of pedestrian-friendly green streets, multimodal corridors and trails.

Policy PR1.3 Equitable Distribution of Park and Recreation Facilities. Expand park and recreation opportunities in all neighborhoods and ensure that they are offered within comfortable walking distance of homes, schools and businesses in order to encourage more physically and socially active lifestyles.

The 2030 General Plan EIR determined that the public services and recreation effects from future development pursuant to the General Plan would be less than significant. Future development would increase demand for police and fire protection and emergency medical services and could result in a need for new or expanded services; however, it would not decrease the existing level of protection or service so the impact would be less than significant. The need for new or expanded school or libraries would be mitigated by the collection of fees, so this impact would be less than significant. Future development would increase the use of recreational facilities and create demand for new or expanded facilities but would not substantially degrade them so the impact would be less than significant. No mitigation measures would be required. Cumulative impacts would also be less than significant.

4.12.4 Impacts and Mitigation Measures

Standards of Significance

Project impacts on public services and recreation facilities would be considered significant if they would exceed the following Standards of Significance, in accordance with Appendix G of the *State CEQA Guidelines* and the UC CEQA Handbook:

- Result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times, or other performance objectives for fire protection, police protection, schools, parks, or other facilities.
- Increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated.

- Include recreational facilities or require the construction or expansion of recreational facilities that might have an adverse physical effect on the environment.

CEQA Checklist Items Adequately Addressed in the Initial Study

The Initial Study deferred analysis of the project's public services and recreational facilities impacts to the EIR, so all of the CEQA checklist items listed above are addressed in the following analysis.

Analytical Methods

This section focuses on the potential for adverse physical impacts from the provision of new or altered public service facilities (police and fire service) under the 2014 LRDP. This includes new or expanded facilities needed to increase or maintain services, service personnel, or level of service standards. The analysis involves three steps: (1) assessing whether 2014 LRDP related growth would result in unmet public services demand. This is determined by comparing projected population growth with existing service ratios, response times, capacities, or other performance objectives identified for each service; (2) evaluating whether unmet services needs would require additional staff or equipment necessitating construction of new or expanded facilities; (3) if the project spurred construction of new or expanded facilities, determining whether the new or expanded facilities would result in a significant environmental impact.

The cumulative impacts analysis in this section evaluates the potential for development under the 2014 LRDP, in conjunction with regional growth, to generate a cumulative demand for new or expanded public services facilities that could result in significant environmental effects.

RBC 2014 LRDP Policies

The RBC 2014 LRDP policies related to public services and recreation include the following:

- SP1 – Safety and Preparedness Policy on Model Programs: Develop model environment, health, and safety programs for the Richmond Bay Campus.
    - Develop comprehensive and effective physical safety, life safety, and emergency service plans to protect the environment, the public, employees, and guests at all times.
    - Ensure clear and responsible management of environment, health, and safety programs and services.
    - Implement land use controls to prohibit unsafe exposure of workers, visitors, and the surrounding community to environmental contaminants.
    - Utilize transparent environment, health, and safety reporting practices.
- SP2 – Safety and Preparedness Policy on Inclusion: Ensure that the Richmond Bay Campus contributes to and serves as a resource for the Richmond community.
    - Encourage inclusion with an open campus where security boundaries occur at the building level rather than the campus level to advance the ideals of institutional transparency and mutual trust.
    - Enable community access to Richmond Bay Campus amenities such as outdoor spaces and meeting facilities to promote a better understanding of the University's mission.
    - Expand partnerships with local agencies, including fire and police departments, as well as local neighborhoods to promote understanding and address safety and security concerns of neighbors as well as the campus workforce.

LRDP Impacts and Mitigation Measures

LRDP Impact PS-1: Development under the 2014 LRDP would increase the demand for fire services and could result in the construction of new or expanded fire stations. The impacts from the construction of a fire station would be less than significant. (*Less than Significant*)

Campus development under the proposed 2014 LRDP would add to fire service demand due to increased population and facilities at the RBC site and increased population in the broader region. Direct and indirect effects on fire service are analyzed.

Direct Effect of RBC Development

Fire Station No. 64 provides fire service to the RBC site currently and would continue to do so if the proposed project were implemented until required fire safety and emergency assessments and plans indicate the need for additional services. This fire station has one fire engine and a fire truck. There are no General Plan proposed modifications or expansions for Fire Station No. 64 and no additional fire stations are planned in the vicinity. Currently the RFD is operating at an acceptable level of fire protection service by responding to city-wide emergency and non-emergency calls within 5 minutes. In the long run, it may become desirable or necessary for the University to house emergency service equipment and personnel on the campus. The LBNL Protective Services Department retains responsibility for all security, fire protection, and emergency service requirements for all DOE facilities, assets, and personnel.

Development under the 2014 LRDP would result in an additional 4.35 million gsf of building space on the RBC site (for a total of 5.4 million square feet of space) and up to an additional 9,700 people (for a total of 10,000 persons). The new buildings and personnel would require RFD fire protection and emergency services. The pace of 2014 LRDP development cannot be predicted at this time. As the space envisioned under the 2014 LRDP would be developed, the demand for fire service would increase accordingly.

The City monitors response times for fire and emergency medical calls to determine if there is a need for additional facilities, and identifies locations that may not be adequately served by existing facilities. According to the City's General Plan EIR, the RFD can determine whether additional fire services are required by preparing a "standards of coverage" plan (City of Richmond 2011). The standards of coverage plan would identify locations with high call volumes and high density and would indicate if additional fire services are required and where they would need to be located (Banks 2013). The RFD service goals are based on accepted service levels of distance and time as opposed to firefighters or stations per capita. Therefore, although the RBC site workforce would increase and the campus would be more densely developed, the response time would not be significantly affected.

If the City of Richmond's population grows beyond the General Plan's 2030 planning horizon, modifications or replacement of Fire Station No. 64 may be proposed to maintain adequate service levels. Any future fire station construction or modification is expected to comply with contemporaneous state, local, and City General Plan and zoning requirements. The RBC site also includes space for an on-site fire station once on-site demand (e.g., sufficient built space and population) warrants it. The potential environmental effects associated with constructing an on-site fire station as part of LRDP development are evaluated in Sections 4.1 through 4.11 and Sections 4.12 through 4.14 and are found to be less than significant or reduced to less than significant with mitigation. Although there would be significant and unavoidable impacts of LRDP development related to operational criteria pollutant and toxic air contaminant emissions, demolition of historic buildings, operational GHG emissions, and traffic, due to the nature of fire stations, the construction

and operation of the on-site fire station would not cause or contribute to these significant and unavoidable impacts.

Should RBC development in conjunction with other growth require an expansion of Fire Station No. 64 or a new fire station in this portion of the City, potential expansion or new construction of a fire station is not likely to result in significant environmental impacts. This is because fire stations are relatively small facilities in terms of building space, and fire stations are often sited on infill sites within developed urban areas. New fire station sites are generally small, ranging in size from 1/2 to 1 acre. To the extent that a fire station project might result in some potentially significant impacts, it is anticipated that those would be mitigated to a less than significant level. Furthermore, as stated in the City's General Plan EIR, the City will conduct an environmental review of expanding or building a new fire station and anticipates that the impact of development under the General Plan related to provision of fire service would be less than significant (City of Richmond 2011). Therefore, the impact related to fire service demand triggered by the RBC site development would be less than significant.

Indirect Effect of RBC Development

Approximately 10,000 employees would be on the project site at full development under the 2014 LRDP. A portion of them would be existing LBNL employees who would relocate from other facilities to the RBC; others may be existing UC Berkeley employees. Many of the new employees would likely be hired from the Bay Area. Most employees would likely not relocate and would continue to commute from their current residences; not impacting residential fire service demand. New employees who are hired from outside the Bay Area are likely to relocate as a result of RBC employment. As discussed in Section 4.11, Population and Housing, approximately 90 percent or 8,730 RBC employees would live in Contra Costa and Alameda counties by the year 2050. However, the RBC employees and their associated household population would account for a very small percentage of the projected population of Contra Costa and Alameda counties in 2050. The housing demand associated with 2014 LRDP permanent employment growth likely would be satisfied by the housing that could be added in the City of Richmond, Contra Costa and Alameda counties, and other nearby communities.

RBC personnel who do choose to move to the City of Richmond would indirectly contribute to the residentially-based need for new fire services or facilities. However, these employees would move into areas already served by fire stations, or into new residential developments subject to the dedication of land, development, or impact fees. If the new residential development necessitated a new fire station with subsequent environmental impacts, those impacts would be mitigated by the developer of that residential development.

In summary, the direct and indirect impacts of campus development under the 2014 LRDP related to demand for fire service would be less than significant.

Mitigation Measure: No mitigation measure is required.

LRDP Impact PS-2: Development under the 2014 LRDP would increase police services demand that could necessitate construction of new police facilities on the RBC site, but such construction would not result in significant environmental impacts. (*Less than Significant*)

Campus development under the 2014 LRDP would add to police services demand due to increased RBC site population and facilities and increased population in the broader region. The direct and indirect effects of RBC development on police services are analyzed below.

Direct Effect of RBC Development

Campus development under the 2014 LRDP would result in a RBC site workforce of approximately 10,000 people and on-site building space growth to approximately 5.4 million gsf. The UCPD currently maintains a presence on the RBC site at all times. 2014 LRDP implementation would result in the anticipated need for additional on-site police staff and equipment so as to provide adequate police services. The additional police service demand may not require construction of a new police station on- or off-site, but it may require that office space to be used as an on-site police outpost. The results of required emergency and security assessments and plans may indicate the need for additional services. Over time, the UCPD staff on-site would need to be increased, requiring expansion or replacement of the existing police station. The LBNL Protective Services Department retains responsibility for all security, fire protection, and emergency service requirements for all DOE facilities, assets, and personnel. Therefore, the impact related to the provision of police services would be less than significant.

Indirect Effect of RBC Development

As discussed in Section 4.11, Population and Housing, and LRDP Impact PS-1 above, campus development is not expected to result in the influx of a large number of employee households into Richmond. Those employees who do relocate in the City of Richmond as a result of RBC employment and research opportunities would move into areas already served by police stations, or into new residential developments subject to the dedication of land, development, or impact fees. If new residential development necessitated a new police station, that new station would be subject to local planning and any impacts would be mitigated by the residential developer.

In summary, the direct and indirect impacts of campus development under the 2014 LRDP related to police services demand would be less than significant.

Mitigation Measure: No mitigation measure is required.

LRDP Impact PS-3: Development under the 2014 LRDP would not result in the need for new or physically altered public school facilities. (*Less than Significant*)

Direct Effect of RBC Development

The 2014 LRDP proposes no residential uses on or off the RBC site, so no new school-age children would be directly associated with the proposed project. There would be no direct impact on schools.

Indirect Effect of RBC Development

As discussed in Section 4.11, Population and Housing, and LRDP Impact PS-1 above, campus development is not expected to result in the influx of a large number of employee households into Richmond. Children associated with employee households that do move to Richmond would attend WCCUSD, although the number is not expected to be large. The anticipated growth associated with the 2014 LRDP would occur over an approximately 37-year period, so the population and student enrollment increases would occur incrementally during that time. The WCCUSD anticipates enrollment increases in its overall resident student population over the next 10 years (WCCUSD 2013). The increase in student population from RBC development would conform to the anticipated increase in enrollment in the WCCUSD. The incremental student enrollment increase from families relocating due to RBC development would be distributed throughout the WCCUSD. This would spread and minimize enrollment impacts on any particular public school facilities. Therefore, the project would have a less than significant indirect impact on public school facilities.

Mitigation Measure: No mitigation measure is required.

LRDP Impact PS-4: Development under the 2014 LRDP would not trigger construction, substantially increase demand, or substantially degrade parks and recreational facilities. (*Less than Significant*)

Direct Effect of RBC Development

Currently, the RFS includes a gym and workout space, available to employees at the site. The RBC may include recreational facilities or field space, as outlined in the Research, Education, and Support land use description (see Section 3.6.6). The potential environmental effects associated with constructing new on-site recreational facilities are evaluated in Sections 4.1 through 4.11 and Sections 4.12 through 4.14 and are found to be less than significant or reduced to less than significant with mitigation. Although the analysis in LRDP Impact BIO-5 in Section 4.3, Biological Resources, concludes a significant and unavoidable impact, construction of future recreational facilities would not affect the area of the northwest meadow. Although there would be other significant and unavoidable impacts of LRDP development related to operational criteria pollutant emissions, historic buildings, operational GHG emissions, and traffic, due to the nature of recreational facilities, these improvements would not cause or contribute to these significant and unavoidable impacts.

The 2014 LRDP proposes neither on- nor off-site residential uses that would necessitate the development of recreational facilities. The campus population would consist of researchers, faculty, staff, and some students who would tend be on the campus during daytime hours. The RBC would be developed with open space areas available to the campus population for passive recreation, such as walking along the proposed interpretive boardwalks. It is anticipated that active recreational uses would be developed, such as a sports field, gym, and other athletic facilities. The RBC workforce could also use nearby parks, including the South Richmond Shoreline portion of the Eastshore State Park or Shimada Friendship Park located to the west off the San Francisco Bay Trail. The Eastshore State Park trail would include interpretive panels for recreational users. However, the entire RBC workforce would not be expected to use the parks and any park visits would be interspersed throughout the day due to differing RBC staff schedules. It is unlikely that the small portion of the RBC workforce present at night would use nearby parks after dark due to limited visibility and unfavorable nighttime temperatures and weather. For these reasons, it is not expected that RBC use of nearby parks would be great enough to cause substantial physical deterioration.

The San Francisco Bay Trail would be available for campus population commuting and recreation. As described in the Project Description, Bay Trail access is provided via underpasses and overpasses at Central Avenue, Buchanan Street, Gilman Street, University Avenue, and the Berkeley bicycle and pedestrian bridge. Access is also available along the entire southern gateway district. Some RBC staff and visitors could commute by bicycle using the San Francisco Bay Trail. According to the Bay Area Travel Survey 2000 conducted by the Metropolitan Transportation Commission, about 1.8 percent of home-based work trips in the Bay Area are made by bicycle. This rate ranges from 3.4 percent for City and County of San Francisco to a low of 0.3 percent for Contra Costa County (MTC 2004). If RBC were to follow the Bay Area average, approximately 175 of the full 10,000 employees would use the trail for daily commuting. In reality, bicycle commute rates would likely be much lower because of the RBC's distances and limited connectivity to a wide distribution of residential neighborhoods. The resulting small number of daily bicycle trips via the Bay Trail is unlikely to result in substantial trail deterioration. Therefore the proposed project would not substantially increase demand for park and recreational facilities in any direct manner. No substantial physical deterioration of such

amenities would result, so the direct impact on park and recreational facilities would be less than significant.

Indirect Effect of RBC Development

The City of Richmond has a policy that requires 3 acres of community or neighborhood parkland per 1,000 residents. This policy does not take into account regional and state parks. The City currently does not meet the required ratio; it has a ratio of 2.44 acres per 1,000 residents. Accordingly, the City of Richmond General Plan indicates that there is a deficit in local park space in relation to the current population. There are, however, over 4,000 acres of nearby regional and state parks that are used by the Richmond population to meet recreational demand.

For reasons presented in Section 4.11, Population and Housing, and LRDP Impact PS-1 above, only a relatively small portion of the future RBC workforce is likely to relocate to the City of Richmond. The population increase within the City of Richmond from 2014 LRDP campus development would result in a relatively small increase in local park demand. Employees who relocate to the City of Richmond would move into areas already served by parks and recreational facilities, or into new residential developments subject to the dedication of land, development, or impact fees. Therefore, the proposed project would not indirectly increase demand for parks and recreational facilities in a substantial manner. As a result, substantial physical deterioration of park and recreational facilities would not occur. The indirect impact from the RBC site workforce on park and recreational facilities would be less than significant.

Mitigation Measure: No mitigation measure is required.

Cumulative Impacts and Mitigation Measures

LRDP Cumulative Impact PS-1: **Development under the 2014 LRDP, in conjunction with other regional growth, could increase the demand for public service facilities but would not result in significant environmental impacts related to construction or expansion of such facilities. (*Less than Significant*)**

Demand for all public services in the City of Richmond and surrounding Bay Area region could increase with implementation of the 2014 LRDP in combination with other expected cumulative growth. The expected 2014 LRDP population growth is a component of the overall Bay Area regional growth, and a subset of growth anticipated in the City of Richmond General Plan 2030. As growth occurs in the Bay Area region, the City of Richmond and other cities and counties will undertake facilities planning processes to identify the appropriate size, location, and timing for new facilities.

The City of Richmond General Plan 2030 indicates that as growth occurs, police and fire services may need to be expanded and equipment upgraded. The City of Richmond will continue coordinating with other local and regional emergency service agencies to ensure that police and fire services demands are met. When future facilities are planned, the associated environmental impacts would be analyzed. New fire and police facility projects are expected to comply with the appropriate general plan and zoning requirements and CEQA. Campus development under the 2014 LRDP does not anticipate residential land uses on the RBC site and would not have a direct impact on the WCCUSD or other public school districts. To the extent that some RBC-related households relocate to Richmond, they would add some school-age children to the school district. As is current practice, the WCCUSD would coordinate with communities in its service area, including the City of Richmond, and would plan to provide adequate school facilities and services

to meet population-driven demand increases. Construction of new or expanded public school facilities would be subject to CEQA review and consideration by the WCCUSD. The construction of new or expanded school facilities is not expected to result in significant environmental impacts because, due to the nature of these facilities (i.e., infill sites, surrounded by existing development), potential impacts are expected to be less than significant.

Campus development under the 2014 LRDP does not anticipate residential land uses on the RBC site and therefore, would not have a direct impact on parks and recreational facilities. As described above, some of the campus workforce could use the nearby parks, including the South Richmond Shoreline portion of the Eastshore State Park or Shimada Friendship Park; resources would also be available on the new campus itself. Such use would tend to be limited and during daylight hours. In addition, there would be on-site open space and amenities for passive recreation. A small number of RBC staff or visitors may commute by bicycle or walking and contribute to use of the San Francisco Bay Trail. To the extent that some RBC-related households might relocate to Richmond, their migration would be part of the City's planned and analyzed population growth. Any new residential development in Richmond would dedicate land or pay in-lieu fees that would help the City maintain or create new parks and recreational facilities. The additional growth and subsequent demand on parks and recreational facilities in the City of Richmond from buildout of the 2014 LRDP is considered minimal. The General Plan anticipates growth and the need for parks and recreational facilities to serve the increased demand. The 2014 LRDP would not place an additional demand beyond what was anticipated in the General Plan. Therefore, the cumulative impact to parks and recreational facilities from campus development under the 2014 LRDP would be less than significant.

Mitigation Measure: No mitigation measure is required.

4.12.5 References

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4.13 TRANSPORTATION AND TRAFFIC

4.13.1 Introduction

This section evaluates potential impacts from development under the proposed 2014 LRDP on transportation facilities and existing transportation operating conditions at and near the RBC site, including vehicular traffic and circulation, parking, transit and shuttle services, and pedestrian and bicycle facilities. Information and analysis in this section is based on the transportation impact analysis prepared by Fehr and Peers, Inc. The transportation report is in Appendix F.

Public and agency NOP comments related to transportation and traffic are summarized below:

- The project site planning should be consistent with the Richmond 2030 General Plan, and particularly with the Plan's Circulation Element and the Congestion Management Agency's Congestion Management Plan.
- The EIR should identify mitigation measures for any roadway mainline section or intersection to maintain an acceptable LOS with the addition of project-related or cumulative traffic.
- The project's fair share contribution, financing, scheduling, implementation responsibilities, and lead agency monitoring should be fully discussed for all proposed mitigation measures.
- Potential mitigation measures should include Transportation Management Plan and transportation demand management (TDM) policies and programs, including vehicle trip reduction scenarios.
- The EIR should analyze impacts and mitigation measures concerning transit, bicycle, and pedestrian facilities.
- The EIR should assess the feasibility of new shuttle service from the RBC site to the El Cerrito del Norte Station instead of the El Cerrito Plaza station.
- The effect of sea-level rise on critical transportation infrastructure should be addressed.
- The proposed project should conform with the new Richmond Bicycle Master Plan and Pedestrian Plan, the Bay Trail Plan, and the Contra Costa Countywide Bicycle Plan.
- The EIR should assess potential bicycle safety implications of increased vehicle use and address bicycle access to the Bay Trail, BART, AC Transit Bus Service, and future ferry service.
- The EIR should identify Bay Trail connections along with issues concerning access for bicycles to the RBC site, the Bay Trail, and connecting trails.
- Mitigation measures should include a system of low emission, high occupancy buses to transport persons from major metropolitan areas to the RBC site, similar to the systems employed by Google and Genentech.

Comments relevant to reasonably foreseeable potential impacts of the 2014 LRDP are addressed in the analysis below.

4.13.2 Environmental Setting

The RBC site is in the City of Richmond, south and west of I-580, and west of I-80. Figure 4-11 shows the RBC site, the surrounding roadway system, and the intersections analyzed. The regional and local roadways serving the project site and the internal circulation in the site are described in the sections that follow.

Study Locations

Richmond, California

TETRA TECH

Figure 4-11

Regional Roadways

I-580 is a six-lane freeway connecting I-80 to US 101 near the Richmond-San Rafael Bridge in Marin County. Auxiliary lanes (lanes connecting adjacent on-ramps and off-ramps) provide a fourth travel lane in each direction near the project. Access between RBC and I-580 is by interchanges at Bayview Avenue/51st Street, Regatta Boulevard/Juliga Woods Street, and Marina Bay Parkway/South 23rd Street. I-580 has an average annual daily traffic volume of 91,000 vehicles (Caltrans 2011) between the Regatta Boulevard/Juliga Woods Street and Marina Bay Parkway/South 23rd Street interchanges.

I-80 connects the San Francisco Bay Area with the Sacramento region and continues east. One mile east of the RBC site, I-80 is oriented in a north-south direction, and it provides four lanes of travel in each direction. Access between I-80 and the RBC is provided by I-580 to and from the south and by the Carlson Boulevard interchange to and from the north. I-80 has an average annual daily traffic volume of 171,000 vehicles (Caltrans 2011) north of I-580.

Regatta Boulevard is an east-west roadway that connects Marina Way South to Meade Street, forming the primary east-west connection in the South Shoreline area. Regatta Boulevard provides two travel lanes in each direction with a median and turn lanes at intersections between Marina Way South and Marina Bay Parkway. East of Marina Bay Parkway, the roadway narrows to three lanes with one travel lane in each direction and a center two-way left-turn lane; farther east, the roadway narrows further to a two-lane cross section, terminating at Meade Street. The recently completed extension of Regatta Boulevard provides a direct connection to Meade Street, allowing for another access/egress route for the South Shoreline area when trains block the Marina Bay Parkway just north of Regatta Boulevard. The speed limit on Regatta Boulevard is 25 miles per hour (mph).

Marina Bay Parkway/South 23rd Street is a north-south roadway connecting downtown Richmond to the south shoreline area. In the study area, the roadway generally provides two travel lanes in each direction, with turn lanes at intersections. The speed limit is 30 mph.

Cutting Boulevard is an east-west arterial roadway connecting San Pablo Avenue and I-580 to the east with South Garrard Boulevard to the west. In the study area, Cutting Boulevard generally provides two travel lanes in each direction, with turn lanes at intersections. The speed limit is 35 mph.

Carlson Boulevard is a four-lane roadway that runs generally northwest-southeast through the study area, connecting 23rd Street to I-80 with an interchange, and terminating at San Pablo Avenue in El Cerrito. The roadway generally provides two travel lanes in each direction and turn lanes at major intersections. The speed limit is 35 mph.

Meade Street is a two-lane roadway that runs northwest from the I-580/Bayview Avenue interchange to the I-580/Regatta Boulevard interchange and provides access to the RBC site. The speed limit is 30 mph.

Pedestrian and Bicycle Facilities

Pedestrian facilities in the study area include sidewalks, crosswalks, and multi-use trails. Most roadways in the study area provide sidewalks; exceptions include Regatta Boulevard east of Marina Bay Parkway and along Meade Street, where sidewalks are provided only where there are fronting uses, and Marina Bay Parkway south of Meeker Avenue, where sidewalks are provided only on the west side of the street. The Richmond Bay Trail runs along the bay shoreline south of the project site, connecting by Marina Bay Parkway to Regatta Boulevard and continuing west. There is currently no direct connection between the Bay Trail and the RBC site.

Bicycle facilities in the study area can be classified into three types, including:

- ***Bicycle Paths (Class 1)*** – These facilities are off-street and can serve bicyclists and pedestrians.
- ***Bicycle Lanes (Class 2)*** – These facilities provide a dedicated area for bicyclists in the paved street right-of-way through the use of striping and appropriate signs.
- ***Bicycle Routes (Class 3)*** – These facilities are designated on-street bicycle routes where bicyclists and vehicles share a travel lane. Typically, these facilities are along streets that do not provide sufficient width for dedicated bicycle lane (Class 2) facilities. The street is designated as a bicycle route through signs informing drivers to expect bicyclists or with shared-lane pavement markings (i.e., "sharrows").

Figure 4-12 identifies existing and proposed bicycle facilities in the study area. Existing bicycle facilities near the project site include the Class 1 Bay Trail along the bay shoreline and Class 3 routes on Marina Bay Parkway and on Regatta Boulevard west of Marina Bay Parkway.

The Richmond Bicycle Master Plan and City of Richmond Pedestrian Plan propose several bicycle and pedestrian improvements in the study area, including:

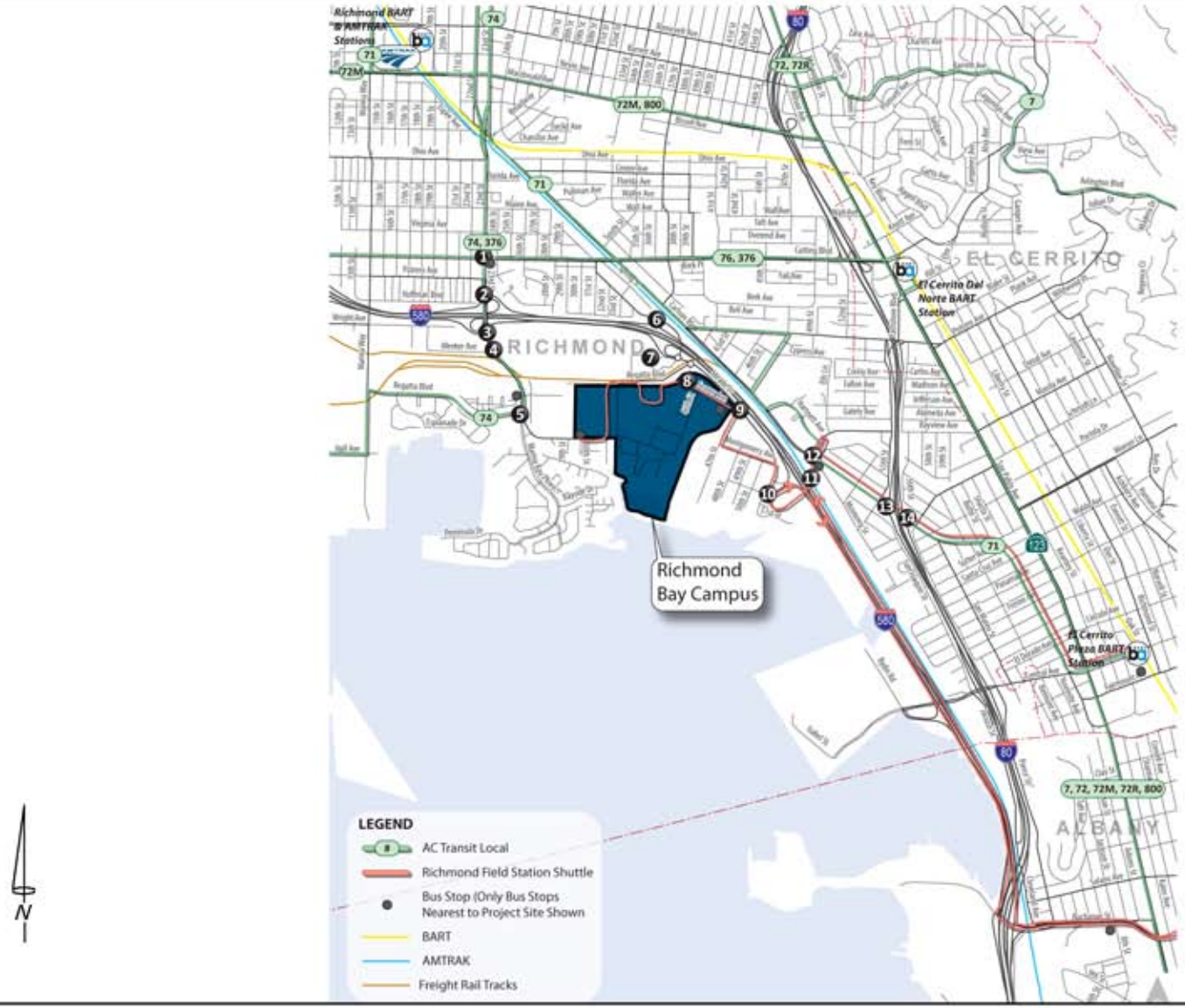
- Class 1 pedestrian path connecting Regatta Boulevard west of Marina Bay Parkway, extending farther east to connect to the I-580 and Bayview Avenue interchange just south of the I-580 interchange.
- Class 1 pedestrian path adjacent to the east-west railroad tracks connecting Meade Street at Seaver Street to Regatta Boulevard.
- Class 1 pedestrian path along south 46th Street connecting the Bay Trail and Meade Street.
- Class 2 bicycle lanes on a segment of Regatta Boulevard between Marina Way and Meade Street.
- Class 2 bicycle lanes on South 23rd Street/Marina Bay Parkway, including potential improvements at the I-580 overpass such as widening sidewalks, and realigning the freeway ramps to square the intersection and shorten pedestrian crossings.
- Class 2 bicycle lanes on Meade Street/South 51st Street between Regatta Boulevard and Seaport Avenue.
- Class 2 bicycle lanes on Bayview Avenue between Seaport Avenue and Carlson Boulevard connecting the two Class 1 paths.
- Class 2 bicycle lanes on Carlson Boulevard between El Cerrito City Limit and Broadway.

These potential improvements are not fully funded, designed, or approved, nor is it known when they would be implemented.

At-Grade Railroad Crossings

There are two at-grade railroad crossings in the study area, on Marina Bay Parkway between Meeker Avenue and Regatta Boulevard, and on Meade Street between Regatta Boulevard and the recently completed Regatta Boulevard extension as shown on Figure 4-12. The public crossings are operated by Richmond Pacific and Union Pacific Railroad Corporations.

On average, daily, about nine trains use the Marina Bay Parkway railroad crossing travelling at speeds from about 1 to 10 mph. Gate controls with bells and pavement markings are on the vehicular approaches. Advanced warning signs are provided. Six years (2007-2012) of collision data was collected from the Federal Railroad Administration for the crossings. One collision related to the Marina Bay Parkway railroad crossing was reported in 2007. It involved



Existing Transit Service

Richmond, California

TETRA TECH

Figure 4-12

an automobile that drove around or through the safety gates and struck rail equipment. No injuries were reported. The Marina Bay Parkway crossing is anticipated to be replaced with a grade-separated crossing; this project is fully funded, and construction is expected to start in 2013.

On average, daily, about four trains use the Meade Street railroad crossing travelling at speeds from about 5 to 10 mph. Gate controls with bells, pavement markings, and advanced warning signs are on the vehicular approaches. There are no recorded collisions related to the Meade Street railroad crossing from 2007 to 2012.

Intersection Operations

Study Intersections

This analysis includes these 14 intersections:

1. Cutting Boulevard/23rd Street
2. I-580 Westbound Ramps/23rd Street
3. I-580 Eastbound Ramps/23rd Street
4. Meeker Avenue/23rd Street/Marin Bay Parkway
5. Regatta Boulevard/Marina Bay Parkway
6. I-580 Westbound Ramps/Juliga Woods Street
7. I-580 Eastbound Ramps/Regatta Boulevard/ Meade Street
8. Meade Street/Regatta Boulevard
9. Meade Street/Seaver Avenue
10. Seaport Avenue/I-580 Eastbound Ramps/South 51st Street/Bayview Avenue
11. I-580 Westbound Ramps/Bayview Avenue
12. Carlson Boulevard/Bayview Avenue
13. Carlson Boulevard/I-80 Eastbound Ramps
14. Carlson Boulevard/I-80 Westbound Ramps

These intersections were selected for analysis because they are most likely to be affected by traffic from 2014 LRDP campus development.

Intersection Counts

The intersection operations analyses are based on the peak hour of traffic occurring during the a.m. and p.m. peak hours (7:00 to 9:00 a.m. and 4:00 to 6:00 p.m.). The peak hours were determined using intersection turning movement, vehicle, pedestrian, and bicycle counts collected December 12 and 13, 2012. These periods were selected because trips from the proposed project, in combination with background traffic, are expected to represent typical worst traffic conditions. During these periods, the peak hour (i.e., the hour with the highest traffic volumes observed in the study area) is from 7:30 a.m. to 8:30 a.m. (a.m. peak hour) and 5:00 p.m. to 6:00 p.m. (p.m. peak hour).

Two comparison counts were taken the week of January 28, 2013. They were compared to the December 2012 counts, in terms of total intersection volumes and certain critical movements, and the intersection volumes at the study intersections were adjusted to reflect typical non-holiday conditions. The adjustments included increasing the northbound through movement at Marina

Bay Parkway/Meeker Street and corresponding upstream movements, and increasing the truck percentages at all the intersections.

Intersection Level of Service Definitions

Intersection operations are described using the performance measure LOS. LOS is a qualitative description of traffic operations from the vehicle driver's perspective, ranging from LOS A. with no congestion and little delay, to LOS F, with excessive congestion and delays. LOS calculations represent the delay experienced by the driver at an intersection or while driving on a freeway or other roadway segment. Different methods are used to evaluate the LOS of signalized and un-signalized intersections, roadway segments, and freeway segments.

Signalized Intersections

Signalized intersection operations are determined using methods in the 2000 Highway Capacity Manual. They use intersection characteristics to estimate average control delay and then assign an LOS. Control delay is defined as the delay associated with deceleration, stopping, moving up in the queue, and acceleration experienced by drivers at an intersection. Table 4.13-1 has descriptions of various LOSs and the corresponding ranges of delays for signalized intersections.

Un-signalized Intersections

Un-signalized intersection (four-way stop-controlled and side-street stop-controlled) LOS is analyzed using the 2000 Highway Capacity Manual. Delay is calculated for movements controlled by a stop sign or that must yield the right-of-way. This method defines operations by average control delay per vehicle (measured in seconds) for each stop-controlled movement. This incorporates delay associated with deceleration, acceleration, stopping, and moving up in the queue. For side-street stop-controlled intersections, the movement or approach with the highest delay is reported.

Table 4.13-1 summarizes the LOS ranges for un-signalized intersections. They are lower than the delay ranges for signalized intersections because drivers will generally tolerate more delay at signals.

Study Intersection Level of Service under Existing Conditions

Table 4.13-2 summarizes existing weekday peak hour intersection LOS analysis results for the study intersections. All currently operate at LOS D or better during the a.m. peak hour; and all but one operates at LOS D or better during the p.m. peak hour. The City of Richmond considers intersections operating at LOS E or LOS F as substandard conditions. The one sub-standard intersection is Meeker Avenue/23rd Street/Marina Bay Parkway that operates at LOS F in the p.m. peak hour.

Table 4.13-1
Intersection Level of Service Definitions

Un-signalized Intersections			Signalized Intersections	
Description	**Average Total Vehicle Delay (Seconds)**	**Level of Service Grade**	**Average Control Vehicle Delay (Seconds)**	**Description**
No delay for stop-controlled approaches.	≤10.0	A	≤10.0	Free flow or Insignificant delays: Operations with very low delay, when signal progression is extremely favorable and most vehicles arrive during the green light phase. Most vehicles do not stop at all.
Operations with minor delay.	>10.0 and ≤15.0	B	>10.0 and ≤20.0	Stable operation or minimal delays: Generally occurs with good signal progression or short cycle lengths. More vehicles stop than with LOS A, causing higher levels of average delay.
Operations with moderate delays.	>15.0 and ≤25.0	C	>20.0 and ≤35.0	Stable operation or acceptable delays: Higher delays from fair signal progression or longer cycle lengths. Drivers begin having to wait through more than one red light. Most drivers feel somewhat restricted.
Operations with increasingly unacceptable delays.	>25.0 and ≤35.0	D	>35.0 and ≤55.0	Approaching unstable or tolerable delays: Influence of congestion becomes more noticeable. Longer delays from unfavorable signal progression, long cycle lengths, or high volume to capacity ratios. Many vehicles stop. Drivers may have to wait through more than one red light. Queues may develop, but dissipate rapidly, without excessive delays.
Operations with high delays, and long queues.	>35.0 and ≤50.0	E	>55.0 and ≤80.0	Unstable operation or significant delays: Considered to be the limit of acceptable delay. High delays indicate poor signal progression, long cycle lengths and high volume to capacity ratios. Individual cycle failures are frequent occurrences. Vehicles may wait through several signal cycles. Long queues form upstream from intersection.
Operations with extreme congestion, and with very high delays and long queues unacceptable to most drivers.	>50.0	F	>80.0	Forced flow or excessive delays: Occurs with oversaturation when flows exceed the intersection capacity. Represents jammed conditions. Many cycle failures. Queues may block upstream intersections.

≤ = Less than or equal to

> = Greater than

Source: Transportation Research Board 2000.

Table 4.13-2
Existing Conditions – Study Intersection LOS Summary

Intersection	Control	AM Peak Hour		PM Peak Hour	
		Delay (Seconds)[1]	LOS [1]	Delay (Seconds) [1]	LOS [1]
1. Cutting Boulevard/23rd Street	Signal	22.9	C	23.0	C
2. I-580 Westbound Ramps/23rd Street	Signal	6.9	A	6.8	A
3. I-580 Eastbound Ramps/23rd Street	Signal	3.6	A	6.3	A
4. Meeker Avenue/23rd Street/Marina Bay Pkwy	Signal	37.1	C	**115.8**	**F**
5. Regatta Boulevard/ Marina Bay Pkwy	Signal	30.0	C	43.6	D
6. I-580 Westbound Ramps/Juliga Woods Street	Side Street Stop	2.5 (10.0)	A (B)	4.4 (10.9)	A (B)
7. I-580 Eastbound Ramps/Regatta Boulevard/ Meade Street	Signal	9.7	A	9.1	A
8. Meade Street/Regatta Boulevard	Side Street Stop	6.4 (10.6)	A (B)	5.6 (10.0)	A (B)
9. Meade Street/Seaver Avenue	Side Street Stop	1.3 (9.7)	A (A)	3.0 (9.0)	A (A)
10. Seaport Avenue/I-580 Eastbound Ramps/ South 51st Street/Bayview Avenue	All-way Stop	27.6	D	20.0	C
11. I-580 Westbound Ramps/Bayview Ave	Signal	5.4	A	6.7	A
12. Carlson Boulevard/ Bayview Ave	Signal	27.0	C	21.6	C
13. Carlson Boulevard/I-80 Westbound Ramps	Signal	19.3	B	20.0	B
14. Carlson Boulevard/I-80 Eastbound Ramps	Signal	10.7	B	9.8	A

Notes: **Bold** indicates an intersection operating at unacceptable LOS E or LOS F.

1. For signalized and all-way stop-controlled intersections, average intersection delay and LOS based on the 2000 HCM method is shown. For side-street stop-controlled intersections, delays for worst movement and average intersection delay are shown: intersection average (worst movement).

LOS Level of Service

v/c Volume-to-capacity ratio

Source: Fehr & Peers 2013.

Freeway Operations

Study Freeway Segments

The seven freeway segments closest to the project site and likely to experience the greatest traffic increases associated with the proposed project were selected for impact analysis in this EIR:

1. I-580 between Harbor Way and Marina Bay Parkway
2. I-580 between Marina Bay Parkway and Regatta Boulevard
3. I-580 between Regatta Boulevard and Bayview Avenue
4. I-580 between Bayview Avenue and Central Avenue
5. I-580 between Central Avenue and I-80
6. I-80 between Carlson Boulevard and Potrero Avenue
7. I-80 at Gilman Street Overpass

Freeway Volumes

Existing highway volumes were primarily derived from two sources of data: (1) October 2012 highway volumes published by Caltrans through their California Freeway Performance Measurement System; and (2) ramp terminal intersection turning movement counts collected on December 12 and 13, 2012, and previously described.

Freeway LOS Definitions

The level of service for a freeway section is based on measures of density (passenger cars per lane per mile). Freeway LOS is a qualitative description of traffic flow based on speed, travel time, delay, and freedom to maneuver. There are six levels, ranging from LOS A (the best operating conditions) to LOS F (the worst operating conditions). LOS E represents "at-capacity" operation. When volumes exceed capacity, stop-and-go conditions result, and operations are designated as LOS F. Table 4.13-3 summarizes the relationship between LOS and density for freeway sections.

Table 4.13-3
Freeway Segment Level of Service Criteria

Level of Service	Freeway Maximum Density (Passenger cars / mile / lane)
A	11
B	18
C	26
D	35
E	45
F	> 45

Study Freeway Segment Level of Service under Existing Conditions

The Leisch Method was used to analyze all freeway segments where an auxiliary lane is present (i.e., weaving segments); the Leisch Method assigns the LOS for the weave section based on volumes, traffic service flow, and capacity using nomographs. All other segments were analyzed as basic segments using the method described in the 2000 Highway Capacity Manual.

Table 4.13-4 summarizes existing weekday peak hour freeway LOS analysis results. All freeway segments operate at LOS D or better during the a.m. and p.m. peak hour.

Parking Conditions

There are currently 760 vehicle parking spaces at the proposed RBC site. These spaces are in surface lots at several locations throughout the site. Parking is currently free and adequately serves employee and visitors.

Transit and Shuttle Services

The RBC site is served indirectly by BART, AC Transit, Amtrak, and the RFS shuttle. Figure 4-13 shows the transit routes near the site. Each transit service is described below.

BART

BART provides regional commuter rail transit in Alameda, Contra Costa, San Francisco, and San Mateo counties. Currently, BART trains operate on weekdays from 4:00 a.m. to midnight, on Saturdays from 6:00 a.m. to midnight, and on Sundays from 8:00 a.m. to midnight. The nearest

Table 4.13-4
Existing Conditions – Freeway Segment LOS Summary

Freeway Segment	Type[2]	Dir	AM Peak Hour		PM Peak Hour	
			Density[1]	LOS	Density[1]	LOS
I-580 between Harbor Way and Marina Bay Pkwy	Weaving	EB	N/A	A	N/A	A
	Weaving	WB	N/A	A	N/A	A
I-580 between Marina Bay Pkwy and Regatta Blvd	Weaving	EB	N/A	A	N/A	A
	Weaving	WB	N/A	A	N/A	A
I-580 between Regatta Blvd and Bayview Ave	Weaving	EB	N/A	A	N/A	A
	Weaving	WB	N/A	A	N/A	A
I-580 between Bayview Ave and Central Ave	Basic	EB	15.4	B	14.0	B
	Basic	WB	14.3	B	16.9	B
I-580 between Central Ave and I-80	Basic	EB	23.5	C	28.7	D
	Basic	WB	25.0	C	22.6	C
I-80 between Carlson Blvd and Potrero Ave	Basic	EB	21.3	C	27.3	D
	Basic	WB	29.5	D	24.0	C
I-80 at Gilman St Overpass	Basic	EB	21.7	C	27.3	D
	Basic	WB	30.9	D	25.6	C

1. Density is expressed in passenger cars per lane per mile (pc/ln/mi).
2. Segments with auxiliary lanes are classified as weaving segments, and were analyzed based on the Leisch Method. Other segments were analyzed as basic segments using methodologies described in the Highway Capacity Manual 2000.

Dir Direction
EB Eastbound
LOS Level of Service
N/A Not applicable
WB Westbound

Source: Fehr & Peers 2013.

BART stations to the RBC site are the Richmond Station (about 2 miles northwest of the RBC site), the El Cerrito del Norte Stations (about 2 miles northeast of the RBC site), and the El Cerrito Plaza Station (about 3 miles east of the RBC site). The average weekday daily riderships for the Richmond, El Cerrito del Norte, and El Cerrito Plaza Stations were about 3,755, 7,620 and 4,468 riders in January 2013, respectively.

AC Transit

Local bus service in Richmond is provided by AC Transit. Figure 4-13 shows the existing AC Transit routes near the RBC. Table 4.13-5 describes the service provided on these routes and the stops nearest to the RBC site.

Amtrak

The Richmond Transit Station, adjacent to the Richmond BART station, provides Amtrak service on three routes—the Capital Corridor (15 trains per day in each direction), the San Joaquin (four trains per day in each direction), and the California Zephyr (one train per day in each direction).

Richmond Field Station Shuttle

UC Berkeley currently operates a shuttle connecting the LBNL and University campuses with El Cerrito Plaza BART Station and the Richmond Field Station. The shuttle runs approximately hourly between 7 a.m. and 6 p.m.

Existing and Future Bicycle Network

Richmond, California

TETRA TECH

Figure 4-13

Table 4.13-5
AC Transit Service Summary

			Weekday		Weekend	
Line	**Route**	**Nearest Stop**	**Hours**	**Frequency**	**Hours**	**Frequency**
Local Routes						
71	Richmond Parkway Transit Center – El Cerrito BART	Carlson/Cutting (approx. 1 mile)	5:00 a.m. – 8:00 p.m.	30 minutes	6:30 a.m. – 9:30 p.m.	60 minutes
74	Castro Ranch – Richmond BART – Harbor Way South/ Ford Point	Marina Bay Parkway/Regatta Boulevard (approx. 1.3 mile)	7:00 a.m. – 10:00 p.m.	30-40 minutes	7:00 a.m. – 8:00 p.m.	30-40 minutes
76	El Cerrito Del Norte BART – Hilltop Mall	Carlson/Cutting (approx. 1 mile)	6:00 a.m. – 7:40 p.m.	30-40 minutes	6:30 a.m. – 8:20 p.m.	30 minutes
376	El Cerrito Del Norte BART – Pinole Vista Center	Carlson/Cutting (approx. 1 mile)	8:00 p.m. – 3:45 a.m.	30 minutes	8:00 p.m. – 3:45 a.m.	30 minutes

Distance shown is measured from S. 46th Street and Seaver Avenue.

Source: AC Transit 2013

4.13.3 Regulatory Considerations

Federal

There are two federally-designated interstate highways near the RBC site, I-80 and I-580. They are managed by Caltrans as part of its California Freeway and Expressway system. The site is not subject to any federal action concerning highways or transportation, nor is the site included in the right-of-way for a future federal highway or federally-funded transportation facility. Even though a portion of the site would be occupied by LBNL, the land would be under the jurisdiction of the Regents and subject to applicable regulations under their management.

State

The State of California established the Congestion Management Program in 1990 with passage of Proposition 111. As a requirement of this program, designated county or equivalent local transportation agencies prepare and maintain Congestion Management Plans that include:

- Traffic level-of-service standards for State highways and principal arterials
- Multi-modal performance measures to evaluate current and future system
- A seven-year capital program of projects to maintain or improve the performance of the system or mitigate the regional impacts of land use projects
- A program to analyze the impacts of land use decisions
- A travel demand element that promotes transportation alternatives to the single-occupant vehicle.

The Congestion Management Plan that applies to the project area is maintained by the Contra Costa Transportation Authority. The 2011 Contra Costa Congestion Management Program identifies I-80, I-580, and Cutting Boulevard as Routes of Regional Significance in the study area. The Congestion Management Plan adopted an LOS standard of E for I-580 in both directions, based on peak hour travel speeds, and an LOS standard of F on I-80 in both

directions near the project. For the study intersections on Cutting Boulevard, the Congestion Management Plan standard is LOS E.

Local

The proposed RBC site is a University property that conducts work within the University's mission on land owned or controlled by The Regents. As a state entity created by Article IX, Section 9 of the California State Constitution, the University is exempt under the state constitution from compliance with local land use regulations, including general plans and zoning. The University seeks to cooperate with local jurisdictions to reduce any physical consequences of potential land use conflicts to the extent feasible. RBC is in the City of Richmond. The following sections summarize objectives and policies from the City of Richmond General Plan and local ordinances as they relate to traffic and transportation.

City of Richmond 2030 General Plan

The Circulation Element (Element 4) of the City of Richmond 2030 General Plan discusses current and projected traffic and transportation patterns and facilities throughout the City, and identifies goals and policies to achieve a balance in transportation modes that support a sustainable circulation framework throughout the City. The transportation goals and policies relevant to the 2014 LRDP are:

Goal CR1 – An Expanded Multimodal Circulation System. Make conditions safer and more attractive for all modes of transportation including travel by foot and bicycle, public transit and automobiles. Evaluate streets and potential enhancements based on surrounding land uses, street function and desired character and by relying on the place-based approach to circulation planning articulated in the General Plan. Take potential improvement measures ranging from physical design treatment of the street environment to social and programmatic responses appropriate to the particular street context.

- **Policy CR1.1 – Balanced Modes of Travel and Equitable Access.** Encourage multiple circulation options in the City and work with transit operators to ensure equitable access for all members of the community. Create streets and corridors that support a variety of travel modes including transit, pedestrians, bicycles and goods movement, and automobiles. Provide affordable circulation options that meet the needs of low-income populations, seniors, youth, and persons with disabilities to ensure equitable access.
- **Policy CR2.1 – Neighborhood Connectivity.** Improve access and connectivity within neighborhoods and to major destinations in the City. Improved connectivity will enhance linkages to local and regional amenities such as neighborhood parks, schools, libraries, community centers, retail, public transit, bicycle paths, historic resources, the shoreline, open space, and medical facilities.
- **Policy CR2.2 – Complete Streets.** Promote mixed-use urban streets that balance public transit, walking and bicycling with other modes of travel. Support pedestrian and bicycle connectivity by restoring and reinforcing Richmond's grid-based network of streets with landscaping and amenities for transit, bicycles, pedestrians, and people with disabilities. Establish a process for modifying streets to support various modes of travel.

- **Policy CR1.6 – Comprehensive Network of Multi-Use Trails.** Develop a comprehensive network of multi-use trails including enhancing bicycle and pedestrian connectivity throughout the City and the region. Completion of the Bay Trail will enhance access to the Richmond shoreline and adjacent open space. The proposed San Francisco Bay Water Trail will provide enhanced access and recreational opportunities to the Bay. Connecting the Richmond Greenway with the Ohlone Greenway and the Bay Trail, and linking Richmond with Marin County with a bicycle trail across the Richmond-San Rafael Bridge will help create a comprehensive network of multi-use trails.

- **Policy CR1.9 – Place-Based Circulation Classification System and Multi-Modal Level of Service Standards.** Classify all streets in the City to conform to the Place-Based Circulation Classification System discussed in the Circulation Element of the General Plan and adopt multi-modal level of service standards that are consistent with each street type's intended function and character.

- **Policy CR1.10 – Vehicular Level of Service Standards for West County Routes of Regional Significance.** Maintain vehicular LOS standards for signalized intersections consistent with the Contra Costa Transportation Authority's West County Action Plan for Routes of Regional Significance. Require a traffic impact study for projects that would generate more than 100 net new peak-hour vehicular trips. Require traffic impact studies to be prepared by professional transportation consultants selected and hired by the City and require the studies to be fully paid for by the project applicant.

  Traffic impact studies shall be prepared according to the Contra Costa Transportation Authority's travel demand model and technical procedures. Approve projects only if they are found to be consistent with the Contra Costa Transportation Authority's West County Action Plan for Routes of Regional Significance. Projects found to be inconsistent with the Contra Costa Transportation Authority's West County Action Plan for Routes of Regional Significance may be approved if findings of special circumstances, including appropriate mitigation measures, are adopted by the City.

- **Action CR1.B – Public Transit and Paratransit Service Improvements.** Continue to collaborate with AC transit, BART, West Contra Costa Transit Agency, Amtrak and major employers in Richmond that provide shuttle service to explore the potential for expanding transit in the evenings and late nights, and for people with special needs. Explore the potential to enhance Richmond's paratransit service. Collaborate with major employers to provide employer-based "open-door" shuttles to BART, the planned ferry terminal and other transit hubs. Collaborate with regional and Contra Costa County transportation agencies to re-establish, maintain and enhance service within the City and region. Explore strategies to address affordability, access and safety. Expand outreach and information programs to promote transit use.

Goal CR2 – Walkable Neighborhoods and Complete Streets. Activate the public right-of-way and improve the experience of moving people between key destinations at the pedestrian level. To make walking and bicycling a more attractive options, enhance connectivity between neighborhoods, schools, the workplace, and daily goods and services so that reaching key destinations is safer and more convenient. Contribute to walkability and livability by promoting mixed-use and complete streets, high-quality pedestrian environments, context-based street design, and efficient public transit.

- **Policy CR2.3 – Integrated Bicycle and Pedestrian System.** Plan, construct and maintain a safe, comprehensive and integrated bicycle and pedestrian system. Walking and bicycling to work, to schools and for recreation can be encouraged by providing amenities and facilities for pedestrians and bicycles, enhancing pedestrian and bicycle connectivity in neighborhoods, promoting multimodal trails and pathways accessible to all, and addressing major barriers in the community such as freeways, railroads, and steep terrain. Pedestrian improvements at parks, community centers, open space areas, schools, transit stops and commercial nodes will further enhance the bicycle and pedestrian system.

Goal CR5 – Sustainable and Green Practices. To create sustainable and clean circulation options, encourage the use of low-impact alternative fuels and new technologies and implement transportation demand management programs. Encourage measures to treat and retain storm water in the design of pedestrian and parking amenities.

- **Policy CR5.1 – Transportation Demand Management.** Promote TDM strategies among residents and businesses to reduce reliance on automobiles. Encouraging major employers to develop and implement TDM for employees will address peak commute traffic, congestion and air quality.
- **Policy CR5.3 – Green Streets.** Promote the development of street design elements that incorporate natural stormwater drainage and landscaping in new and retrofitted streets.

The 2030 General Plan EIR determined that future development associated with the plan would result in traffic congestion that exceeds the Richmond traffic standard of LOS D, as well as local transit agency standards. The EIR further identified that since it was not certain that project-specific mitigation measures would reduce impacts to a less-than-significant level, the impact would be significant and unavoidable. Implementation of enhanced facilities to serve pedestrians and bicyclists as well as reduce conflicts at rail/roadway crossings, thereby increasing connectivity and safety for these modes, would result in no impact. Cumulative impacts to traffic congestion and transit usage would be significant and unavoidable.

4.13.4 Impacts and Mitigation Measures

Standards of Significance

The impacts on transportation and traffic from 2014 LRDP campus development would be considered significant if they would exceed the following Standards of Significance, in accordance with Appendix G of the *State CEQA Guidelines* and the UC CEQA Handbook:

- Conflict with an applicable plan, ordinance or policy establishing measures of effectiveness for the performance of the circulation system, taking into account all modes of transportation including mass transit and relevant components of the circulation system, including, but not limited to intersections, streets, highways and freeways, pedestrian and bicycle paths, and mass transit;
- Exceed, either individually or cumulatively, a level of service standard established by the county congestion management agency for designated roads or highways;
- Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks;
- Conflict with adopted policies, plans, or programs regarding public transit, bicycle or pedestrian facilities, or otherwise decrease the performance or safety of such facilities;

- Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment); or
- Result in inadequate emergency access.

The local jurisdictions and congestion management programs (CMPs) have established specific thresholds of significance for intersections and freeways that are used in this analysis. The local jurisdictions do not have specific thresholds for assessing impacts on other aspects of the transportation network, so the thresholds from the CEQA Guidelines Appendix G Checklist are used to determine significant impacts.

Significance Criteria for City of Richmond Intersections

As the lead agency for this project, the University has the authority to establish its own set of significance criteria. To maintain consistency with the City of Richmond, the City's significance criteria were used to evaluate impacts to intersections in the City's jurisdiction. The project's impact on study intersections in the City of Richmond would be significant if it caused:

- A signalized intersection to deteriorate from LOS D or better to LOS E or LOS F;
- The average control delay to increase by more than 5 seconds or deteriorate to LOS F (for a signalized intersection already at LOS E);
- The overall volume-to-capacity (v/c) ratio to increase by 0.01 or more (for a signalized intersection already at LOS F); or
- The intersection to operate at LOS F and to satisfy the Caltrans peak hour traffic volume signal warrant (for an unsignalized intersection).

Significance Criteria for Congestion Management Program Facilities/Freeways

The 2011 Contra Costa Congestion Management Program is the applicable CMP for the RBC. Based on the CMP requirements, the following significance criteria are used to determine if the project impacts on a freeway segment would be significant:

- I-580: Cause a segment to degrade from LOS E or better to LOS F or increase peak hour volume by five percent or more for a segment already operating at LOS F.
- I-80: Increase peak hour volume by five percent or more for a segment already operating at LOS F.

CEQA Checklist Items Adequately Addressed in the Initial Study

The analysis in the Initial Study and circulated with the NOP concluded that further analysis of the following issue was not required in the EIR:

- Change air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks

Development of the RBC would not alter existing air traffic patterns, so this issue does not require further study in this EIR.

Analytical Methods

Trip Generation

Table 4.13-6 shows the estimated vehicle trip generation for full development of the campus under the 2014 LRDP. The trip generation estimates are derived from trip generation rates developed for the LBNL site in Berkeley. The LBNL rates were developed based on vehicle counts at the LBNL gates and the corresponding population on-site. For the RBC site, these trip

Table 4.13-6
2014 LRDP Trip Generation Summary

	Average Daily Population	Daily	AM Peak Hour			PM Peak Hour		
			In	Out	Total	In	Out	Total
2014 LRDP	**10,000**	20,226	1,770	283	2,053	259	1,678	1,937

Based on trip rates derived from existing LBNL gate counts in April 2011, adjusted as described in the text.

LRDP trip generation based on the following rates: Daily = 2.02 trips per average daily population (adp); AM Peak Hour = 0.20 trip per adp (86 percent in, 14 percent out); PM Peak Hour = 0.19 trip per adp (13 percent in, 87 percent out).

rates were adjusted to reflect the differences between the two sites, most notably, differences in transit availability, pedestrian and bicycle facilities, and proximity to residential and non-residential areas. The Contra Costa Travel Demand Model and Alameda County Travel Demand Models were used to evaluate the effects of these differences, by comparing employment trip generation for the LBNL zone with employment trip generation in the RBC zone. The resulting trip estimates for the RBC site are 30 percent higher than the LBNL site. The trip generation conservatively assumes that the TDM program implemented at RBC would be similar to LBNL, and that parking at RBC would be free, similar to LBNL. The RBC trip generations would be reduced if RBC implements more robust TDM strategies or charges for parking.

Trip Distribution and Assignment

The trip distribution is based on a select-zone assignment using the Contra Costa Countywide Travel Demand Model. Figure 4-14 shows the resulting trip distribution that was used to distribute the traffic from the full development of the RBC.

2035 No Project Conditions

Full development of the RBC under the 2014 LRDP is not anticipated to occur until 2050. The furthest year for which the Countywide Travel Demand Model provides projections is 2035, so the 2035 No Project conditions were estimated for evaluating the traffic impacts of the full development of the RBC.

Traffic forecasts to the year 2035 were developed using the Contra Costa Countywide Travel Demand Model. The model was checked to ensure the land use growth in Richmond was consistent with the recently adopted General Plan 2030. The forecasting process involved running the 2010 and 2035 models and extracting the growth in turning movements at each study intersection, then adding that growth to the existing traffic volumes. The 2035 model run did not include any growth on the project site.

Signal timings were optimized under 2035 conditions with and without the 2014 LRDP growth to reflect typical signal updates due to changing traffic flow over several years. No other roadway modifications are assumed at any of the study intersections under the 2035 No Project scenario. Table 4.13-7 shows the 2035 No Project intersection service levels. All intersections are projected to operate at LOS D or better, with the exception of Meeker Avenue/23rd Street/Marina Bay Parkway that would operate at LOS E in the a.m. peak hour and at LOS F with additional delay in the p.m. peak hour, and Seaport Avenue/I-580 Eastbound Ramps/South 51st Street/Bayview Avenue and Carlson Boulevard/I-80 Westbound Ramps that would operate at LOS E in the p.m. peak hour.

Trip Distribution

Richmond, California

TETRA TECH

Figure 4-14

Table 4.13-7
2035 No Project Conditions – Study Intersection LOS Summary

Intersection	Control	AM Peak Hour		PM Peak Hour	
		Delay (Seconds)[1]	LOS[1]	Delay (Seconds)[1]	LOS[1]
1. Cutting Boulevard/23rd Street	Signal	32.8	C	43.3	D
2. I-580 Westbound Ramps/23rd Street	Signal	8.4	A	9.4	A
3. I-580 Eastbound Ramps/23rd Street	Signal	4.8	A	7.8	A
4. Meeker Avenue/23rd Street/Marina Bay Pkwy	Signal	**61.4**	**E**	**>120 (v/c=0.65)**	**F**
5. Regatta Boulevard/ Marina Bay Parkway	Signal	28.2	C	17.4	B
6. I-580 Westbound Ramps/Juliga Woods Street	Side Street Stop	4.5 (17.0)	A (C)	9.5 (18.0)	A (C)
7. I-580 Eastbound Ramps/Regatta Boulevard/ Meade Street	Signal	17.8	B	13.8	B
8. Meade Street/Regatta Boulevard	Side Street Stop	7.5 (13.5)	A (B)	7.2 (14.3)	A (B)
9. Meade Street/Seaver Avenue	Side Street Stop	1.5 (11.2)	A (B)	2.1 (10.2)	A (A)
10. Seaport Avenue/I-580 Eastbound Ramps/ South 51st Street/Bayview Avenue	All-way Stop	30.9	D	**39.3**	**E**
11. I-580 Westbound Ramps/Bayview Avenue	Signal	6.6	A	10.7	B
12. Carlson Boulevard/ Bayview Avenue	Signal	33.6	C	30.6	C
13. Carlson Boulevard/I-80 Westbound Ramps	Signal	43.6	D	**58.1**	**E**
14. Carlson Boulevard/I-80 Eastbound Ramps	Signal	13.3	B	14.6	B

Notes: **Bold** indicates an intersection operating at unacceptable LOS E or LOS F.

1. For signalized and all-way stop-controlled intersections, average intersection delay and LOS based on the 2000 HCM method is shown. For side-street stop-controlled intersections, delays for worst movement and average intersection delay are shown: intersection average (worst movement).

> Greater than
LOS Level of service
v/c Volume-to-capacity

Source: Fehr & Peers 2013.

Table 4.13-8 shows the 2035 No Project freeway volumes and service levels. All freeway segments are projected to operate at LOS E and better with the exception of I-580 between Central Avenue and I-80 that is expected to degrade to unacceptable LOS F in the a.m. peak hour for the westbound direction and LOS F in the p.m. peak hour for the eastbound direction.

Table 4.13-8
2035 No Project Conditions – Freeway Segment LOS Summary

Freeway Segment	Type[2]	Dir	AM Peak Hour		PM Peak Hour	
			Density[1]	LOS	Density[1]	LOS
I-580 between Harbor Way and Marina Bay Pkwy	Weaving	EB	N/A	A	N/A	C
	Weaving	WB	N/A	C	N/A	A
I-580 between Marina Bay Pkwy and Regatta Blvd	Weaving	EB	N/A	B	N/A	C
	Weaving	WB	N/A	C	N/A	B
I-580 between Regatta Blvd and Bayview Ave	Weaving	EB	N/A	C	N/A	C
	Weaving	WB	N/A	C	N/A	B
I-580 between Bayview Ave and Central Ave	Basic	EB	24.5	C	25.8	C
	Basic	WB	25.9	C	23.5	C
I-580 between Central Ave and I-80	Basic	EB	36.1	E	**>45.0**	**F**
	Basic	WB	40.5	E	26.5	D
I-80 between Carlson Blvd and Potrero Ave	Basic	EB	27.2	D	31.5	D
	Basic	WB	37.6	E	28.8	D
I-80 at Gilman St Overpass	Basic	EB	26.2	D	32.2	D
	Basic	WB	35.1	E	28.3	D

Notes: **Bold** indicates a freeway segment operating at unacceptable levels (LOS F for I-580, and LOS F plus 5 percent added traffic for I-80).

1. Density is in passenger cars per lane per mile.
2. Segments with auxiliary lanes are classified as weaving segments, and were analyzed based on the Leisch Method. Other segments are analyzed as basic segments using methodologies described in the Highway Capacity Manual 2000.

Dir Direction
EB Eastbound
LOS Level of Service
N/A Not available
WB Westbound

Source: Fehr & Peers 2013.

RBC 2014 LRDP Policies

The RBC 2014 LRDP policies related to transportation and traffic include the following:

- ACP1 – Access and Circulation Policy on Connectivity: Ensure that the RBC is readily accessible through a variety of transportation modes, including transit (BART, Amtrak, AC Transit, and ferry), shuttle services, and bicycle and pedestrian routes.
    - Coordinate connectivity plans with City of Richmond transportation plans for the South Shoreline Area and provide convenient connections to City neighborhoods, one or more BART stations, and commercial areas.
    - Work with city, regional, and state authorities to facilitate bicycle and shuttle transportation network improvements between the RBC and the Berkeley campuses.
    - Implement campus shuttle service improvements with the first phase of development and additional improvements as needed for each project implementing the LRDP.
    - Provide robust electronic infrastructure to promote virtual connectivity, telecommuting, and remote teleconferencing.

  - Facilitate the improvement of connections to transit service, ferry service, and bicycle and pedestrian pathways and provide convenient access between the RBC and nearby amenities.

- ACP2 – Access and Circulation Policy on Sustainable Access: The RBC will feature and prioritize access to, from and around the site by sustainable means.
  - Develop a TDM plan to identify strategies for reducing single vehicle trips and encourage travel by other modes. Prioritize convenient access and entries for transit vehicles. Make shuttle use appealing for employees and visitors through frequent scheduling; display real time arrival information at key stops, building lobbies, and over the network; integrate closed-circuit television or emergency phones into shuttle stops; and provide network access in shuttle vehicles.
  - Target less than 50 percent of all trips being made to the campus in single occupant vehicles by supporting alternative modes of transit.
  - Maximize convenient access for employees and visitors, particularly in early stages of campus development. Manage parking to facilitate travel between the campuses.
  - Encourage bicycle use through provision of convenient and secure bicycle parking and maintenance facilities, including showering facilities and changing rooms. Provide bicycle parking for a minimum of 20 percent of anticipated peak period occupants of new buildings.
  - Implement a bicycle sharing program, with bikes to "borrow" at convenient locations in each campus neighborhood, to encourage biking among campus and nearby destinations.
  - Ensure shuttles and other modes serving the campus are equipped with racks to carry bicycles and maximize the capacity of the racks.
  - Capitalize on sustainable transportation research conducted at the RBC and elsewhere, implementing new practices and technologies on the site. Support alternative energy and hybrid vehicle use in shuttles, service, and personal vehicles.
  - Improve the pedestrian and bicycle connection between the RBC and the Bay Trail, construct the proposed staging areas for Bay Trail access, and provide appropriate access to open space areas.
  - Provide infrastructure to improve sustainability of vehicle-related travel, such as electric charging stations.
- ACP3 – Access and Circulation Policy on Pedestrian Priority: Create a pleasant, safe and convenient pedestrian environment that encourages pedestrian circulation on and around the campus.
  - Design site circulation to separate vehicular traffic from walking areas except on shared service roads.
  - Provide safe, attractive, efficient walking connections between shuttle stops, facilities, and parking.
  - Design pedestrian routes to be attractive, interesting, and educational.
- ACP4 – Access and Circulation Policy on Parking: Implement convenient parking in a phased, cost-effective manner.
  - Provide accessible and service vehicle parking adjacent to buildings.

- Locate visitor parking to be convenient and easily accessible from primary campus entrances.
- Provide parking in surface lots in the early years of development in the areas of future development sites.
- Provide parking structures as the campus is developed over time to minimize the amount of land devoted to parking.
- Provide limited-time street parking on the segments of Lark Drive and Regatta Boulevard where retail and other amenities are located.

LRDP Impacts and Mitigation Measures

LRDP Impact TRA-1: **Development under the 2014 LRDP would conflict with an applicable plan, ordinance, or policy establishing effectiveness measures for circulation system performance and would cause an exceedance of a level of service standard established for the study intersections under 2035 conditions. (*Potentially Significant; Significant and Unavoidable*)**

2014 LRDP implementation would result in 5.4 million square feet of space accommodating up to 10,000 employees. The plan would reroute Regatta Boulevard to the west and provide multiple access points on Meade Street, Regatta Boulevard, and South 46th Street. The RBC is estimated to provide about 6,000 parking spaces mostly in parking structures.

Regional access to and from the RBC would continue to be provided through the existing interchanges on I-580. In the near-term, direct access to and from the RBC site would continue to be through the existing entry on Meade Street at Seaver Street. As the RBC is developed, additional entries on Meade Street to the north, Regatta Boulevard to the west, and South 46th Street to the east would be provided. Currently, the LRDP envisions up to seven access points from Regatta Boulevard and Meade Street. These access points would provide direct access to parking facilities for employees and visitors or provide service access for buildings throughout the campus.

Full 2014 LRDP campus development is anticipated to occur by 2050. The furthest year for which the regional travel demand model provides projections is 2035, so traffic impacts of the full RBC development are evaluated relative to 2035 conditions.

Campus development would increase traffic volumes on the local street network. Table 4.13-9 shows the intersection LOSs under 2035 plus 2014 LRDP conditions. Appendix F provides the detailed calculation work sheets. The addition of project traffic would causes five intersections to fall from acceptable (LOS D or better) to unacceptable (LOS E or LOS F) conditions in one or both peak hours. These are:

- Intersection 6 – I-580 WB Ramps/Juliga Woods Street (LOS F, p.m. peak hour)
- Intersection 8 – Meade Street/Regatta Boulevard (LOS F, a.m. and p.m. peak hours)
- Intersection 9 – Meade Avenue/Seaver Street (LOS F, a.m and p.m. peak hours)
- Intersection 10 – Seaport Avenue/I-580 Eastbound Ramps/South 51st Street/Bayview Avenue (LOS F, a.m. and p.m. peak hours)
- Intersection 13 – 80 Westbound Ramps/South 51st Street (LOS F, a.m. and p.m. peak hours)

Table 4.13-9
2035 plus 2014 LRDP Conditions – Study Intersection LOS Summary

Intersection	Traffic Control	Peak Hour	2035 No Project		2035 Plus 2014 LRDP Project		Significant Impact?
			Delay[1] (seconds)	LOS[1]	Delay[1] (seconds)	LOS[1]	
1. Cutting Boulevard/ 23rd Street	Signal	AM	32.8	C	36.6	D	No
		PM	43.3	D	46.1	D	No
2. I-580 Westbound Ramps/ 23rd Street	Signal	AM	8.4	A	8.6	A	No
		PM	9.4	A	9.8	A	No
3. I-580 Eastbound Ramps/ 23rd Street	Signal	AM	4.8	A	7.7	A	No
		PM	7.8	A	8.8	A	No
4. Meeker Avenue/23rd Street/ Marina Bay Pkwy	Signal	AM	**61.4**	**E**	**61.4**	**E**	No
		PM	**>120 (v/c=0.65)**	**F**	**>120 (v/c=0.75)**	**F**	**Yes**
5. Regatta Boulevard/ Marina Bay Parkway	Signal	AM	28.2	C	35.0	C	No
		PM	17.4	B	20.9	C	No
6. I-580 Westbound Ramps/ Juliga Woods Street	Side Street Stop	AM	4.5 (17.0)	A (C)	8.3 (27.1)	A (D)	No
		PM	9.5 (18.0)	A (C)	**>120 (>120)**	**F (F)**	**Yes**
7. I-580 Eastbound Ramps/ Regatta Boulevard/ Meade Street	Signal	AM	17.8	B	54.9	D	No
		PM	13.8	B	41.9	D	No
8. Meade Street/ Regatta Boulevard	Side Street Stop	AM	7.5 (13.5)	A (B)	**46.3 (>120)**	**E (F)**	**Yes**
		PM	7.2 (14.3)	A (B)	47.6 **(>120)**	E **(F)**	**Yes**
9. Meade Street/ Seaver Avenue	Side Street Stop	AM	1.5 (11.2)	A (B)	**>120 (>120)**	**F (F)**	**Yes**
		PM	2.1 (10.2)	A (B)	**>120 (>120)**	**F (F)**	**Yes**
10. Seaport Avenue/I-580 Eastbound Ramps/South 51st Street/Bayview Avenue	All-way Stop	AM	30.9	D	**59.8**	**F**	**Yes**
		PM	**39.3**	**E**	**50.2**	**F**	**Yes**
11. I-580 Westbound Ramps/ Bayview Avenue	Signal	AM	6.6	A	25.7	C	No
		PM	10.7	B	13.6	B	No
12. Carlson Boulevard/ Bayview Avenue	Signal	AM	33.6	C	43.2	D	No
		PM	30.6	C	49.1	D	No
13. Carlson Boulevard/ I-80 Westbound Ramps	Signal	AM	43.6	D	**97.9 (v/c=1.21)**	**F**	**Yes**
		PM	**58.1**	**E**	**79.4**	**E**	**Yes**
14. Carlson Boulevard/ I-80 Eastbound Ramps	Signal	AM	13.3	B	23.7	C	No
		PM	14.6	B	49.0	D	No

Notes: **Bold** indicates an intersection operating at unacceptable LOS E or LOS F.

1. For signalized and all-way stop-controlled intersections, average intersection delay and LOS based on the 2000 HCM method is shown. For side-street stop-controlled intersections, delays for worst movement and average intersection delay are shown: intersection average (worst movement).

> greater than
LOS Level of service
v/c Volume-to-capacity

Source: Fehr & Peers 2013.

A sixth intersection, Meeker Avenue/23rd Street/Marina Bay Parkway (Intersection 4), is projected to operate at LOS F under 2035 No Project conditions. The intersection would continue to operate at LOS F, with a significant increase in delay from the proposed project. More information on the impacts at the six affected intersections is presented below along with improvements that can be implemented to restore intersection operations to acceptable levels.

A. Meeker Avenue/23rd Street/Marina Bay Parkway (Intersection 4; City of Richmond): The project would cause a significant impact at this signalized intersection because it would increase v/c ratio by more than 0.01 during the p.m. peak hour at an intersection operating at LOS F under background conditions. The impact at this intersection can be addressed by:

- Converting the eastbound approach to provide one left-turn lane and one through-right lane
- Converting signal operations for the eastbound and westbound approaches from split phasing to protected left-turn phasing
- Optimizing traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach)

The intersection would improve to LOS C during the a.m. peak hour and LOS D during the p.m. peak hour after implementation of these improvements. These improvements would reduce the impact to less than significant.

B. **I-580 Westbound Ramps/Juliga Woods Street (Intersection 6; City of Richmond and Caltrans):** The project would significantly impact the intersection by reducing the side-street, stop-controlled, p.m. peak hour approach from LOS C to LOS F. The intersection would satisfy the Caltrans peak hour traffic volume signal warrant. The impact at this intersection could be addressed by:

- Installing an actuated signal at the intersection

Even with the proposed project, this intersection would improve to LOS A during both a.m. and p.m. peak hours with the above improvement. The improvement would reduce the impact to less than significant.

C. **Meade Street/Regatta Boulevard (Intersection 8; City of Richmond):** The proposed project would significantly impact the side-street stop-controlled Meade Street/Regatta Boulevard intersection. The side-street stop-controlled approach would deteriorate from LOS B to LOS F during a.m. and p.m. peak hours, and this intersection would satisfy the Caltrans peak hour traffic volume signal warrant. The impact at this intersection could be addressed by:

- Installing an actuated signal at the intersection. The new signal would be coordinated with the existing controls for the at-grade railroad crossing on Meade Street and the I-580 Eastbound Ramps/Regatta Boulevard/Meade Street traffic signal (Intersection 7). This coordination would minimize potential traffic queuing on the railroad tracks.

With this mitigation, this intersection under project conditions would improve to LOS B during both a.m. and p.m. peak hours. The improvement would reduce the impact to less than significant.

D. **Meade Street/Seaver Avenue (Intersection 9; City of Richmond):** The project would cause a significant a.m. and p.m. peak-hour impact at the Meade Street/Seaver Avenue intersection, because the side-street stop-controlled approach would diminish from LOS B to LOS F, and the intersection would satisfy the Caltrans peak hour traffic volume signal warrant. The impact at this intersection can be addressed by:

- Installing an actuated signal at the intersection with protected/permitted phasing for the westbound left-turn movement
- Converting the northbound approach to provide one left-turn lane and one right-turn lane

With the above measures, the intersection would improve to LOS D during the a.m. peak hour and LOS B during the p.m. peak hour. The improvements would reduce the impact to less than significant.

E. **Seaport Avenue/I-580 Eastbound Ramps/Bayview Avenue (Intersection 10; City of Richmond and Caltrans):** The project would significantly impact the all-way stop-controlled Seaport Avenue/I-580 Eastbound Ramps/South 51st Street/Bayview Avenue. Intersection operations would diminish from LOS D during the a.m. peak hour and LOS E during the p.m. peak hour to LOS F during a.m. and p.m. peak hours. The intersection would satisfy the Caltrans peak hour traffic volume signal warrant. The impact at this intersection can be addressed by:

- Installing an actuated signal at the intersection with protected phasing for the northbound and southbound left-turn movements
- Converting the southbound approach to provide two left-turn lanes and one shared right-turn/through lane

After mitigation, the intersection would improve to LOS C during both a.m. and p.m. peak hours. The improvements would reduce the impact to less than significant.

F. **Carlson Boulevard/I-80 Westbound Ramps (Intersection 13; City of Richmond and Caltrans):** The project would cause a significant impact at the signalized Carlson Boulevard/I-80 Westbound Ramps intersection because it would diminish intersection service from LOS D to LOS F during the a.m. peak hour and LOS E to LOS F during the p.m. peak hour. The impact at this intersection can be addressed by:

- Converting the southbound approach to provide one left-turn lane and one right-turn lane

With the above improvement, the intersection would perform at LOS C during both a.m. and p.m. peak hours. The improvement would reduce the impact to less than significant.

Implementing LRDP MM TRA-1 would minimize 2014 LRDP campus development impacts. LRDP MM TRA-1 would reduce new project-related vehicle trips associated with the new RBC facilities and contribute on a proportional share basis to specific improvements at the affected intersections. However, all of the improvements would fall under City of Richmond or Caltrans jurisdiction, neither of which has programmed any improvements to these intersections. The completion of these improvements cannot be assured, as it depends on City and Caltrans discretionary decision making. For these reasons, this impact remains significant and unavoidable. If the City or Caltrans were to make improvements to the affected facilities, University implementation of LRDP MM TRA-1 would reduce the project's impact to a less than significant level at all intersections.

LRDP MM TRA-1: The University shall develop and implement a campus traffic mitigation program, a multi-component program to monitor trip generation, reduce peak-hour trips to the extent feasible, or participate in intersection improvements to mitigate off-site impacts at the intersections affected by the proposed project. Each component of this program is described below.

Travel Demand Management. To reduce on- and off-campus vehicle trips and resulting impacts, the University shall develop and implement a TDM program in consultation with the City of Richmond. The program is proposed to be adopted by the University following The Regents' approval of the RBC LRDP. The TDM program will include measures to increase transit and shuttle use, encourage alternative transportation modes including bicycle transportation, implement parking policies that reduce demand, and other mechanisms that reduce vehicle trips to and from the campus. The University shall monitor the performance of RBC TDM strategies through annual surveys.

Transit Enhancement. To enhance transit systems serving the campus, the University shall work cooperatively with AC Transit and other local agencies to coordinate service routes with existing and proposed shuttle and transit programs.

Sustainability and Monitoring. The University shall review individual projects proposed under the 2014 LRDP for consistency with UC sustainable transportation policy and the RBC TDM program to ensure that bicycle and pedestrian improvements, alternative fuel infrastructure, transit stops, and other project features that promote alternative transportation are incorporated into each project to the extent feasible.

Campus Traffic Impact Monitoring. The University shall conduct traffic counts at key RBC gateway locations every 5 years to determine campus-generated traffic.

Mitigation Payments. The University shall contribute funding on a fair-share basis, to be determined in consultation with the City of Richmond and Caltrans, for periodic (annually or less frequently, as agreed among consulting agencies) signal warrant analyses at the unsignalized intersections significantly impacted by the project. These signal warrant analyses would be used by the City to determine when a signal is needed.

When these signal warrant analyses show that a signal is warranted and the City determines that the required intersection improvements are needed, the University shall reimburse the City on a fair-share basis for the design and construction of the required mitigation, including new traffic signals and related improvements at the intersection impacted by the project. Should the City determine that alternative mitigation strategies may reduce or avoid the significant impact, the University shall work with the City and Caltrans to

identify and implement such alternative feasible measures on a fair-share basis.

LRDP Impact TRA-2: Development under the 2014 LRDP would conflict with an applicable plan, ordinance. or policy establishing effectiveness measures for circulation system performance and would cause an exceedance of a level of service standard established for the study intersections under existing conditions. (*Potentially Significant; Significant and Unavoidable*)

LRDP Impact TRA-1 presents the effects on study intersections from campus traffic at full 2014 LRDP development, which for this EIR is assumed to occur by 2050. Occupancy of the RBC would gradually increase over the life span of the 2014 LRDP. Not all of the additional vehicle trips generated under the 2014 LRDP are expected to be added to the study area transportation network immediately following approval of the proposed LRDP. Thus, an analysis of the project's traffic impacts on study intersections under existing plus 100 percent occupancy of the RBC (i.e., existing plus project conditions) does not represent a realistic condition. An existing plus project analysis is included for information only.

Table 4.13-10 summarizes intersection operations at the study intersections under the existing plus project conditions. Appendix F provides the detailed calculation work sheets. The addition of 2014 LRDP traffic to existing conditions would degrade six intersections from acceptable (LOS D or better) to unacceptable (LOS E or LOS F) during one or both peak hours and would contribute traffic to one intersection that currently operates at LOS F.

The 2014 LRDP traffic would cause the side-street stop-controlled approach at the I-580 Westbound Ramps/Juliga Woods Street (Intersection 6) to degrade from LOS B to LOS E during the p.m. peak hour, and the side-street stop-controlled approach at the Meade Street/Regatta Boulevard (Intersection 8) to degrade from LOS B to LOS F during the a.m. peak hour. These are not considered significant impacts because neither intersection would satisfy the Caltrans peak hour traffic volume signal warrant. The impacts at the seven affected intersections are described below:

A. Meeker Avenue/23rd Street/Marina Bay Parkway (Intersection 4; City of Richmond): The project would significantly impact the signalized Meeker Avenue/23rd Street/Marina Bay Parkway intersection because it would increase v/c ratio by more than 0.01 during the p.m. peak hour at an intersection operating at LOS F regardless of the project. The impact at this intersection can be addressed by:

- Converting the eastbound approach to provide one left-turn lane and one through-right lane
- Converting signal operations for the eastbound and westbound approaches from split phasing to protected left-turn phasing
- Optimizing traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection operations would improve to LOS C during a.m. and p.m. peak hours after implementation of these improvements. These improvements would reduce the impact to less than significant.

Table 4.13-10
Existing Plus 2014 LRDP Conditions – Study Intersection LOS Summary

Intersection	Traffic Control	Peak Hour	Existing		Existing Plus LRDP Project		Significant Impact?
			Delay[1] (seconds)	LOS[1]	Delay[1] (seconds)	LOS[1]	
1. Cutting Boulevard/ 23rd Street	Signal	AM	22.9	C	25.3	C	No
		PM	23.0	C	24.4	C	No
2. I-580 Westbound Ramps/ 23rd Street	Signal	AM	6.9	A	7.1	A	No
		PM	6.8	A	6.8	A	No
3. I-580 Eastbound Ramps/ 23rd Street	Signal	AM	3.6	A	5.6	A	No
		PM	6.3	A	6.7	A	No
4. Meeker Avenue/23rd Street/ Marina Bay Pkwy	Signal	AM	37.1	D	37.1	D	No
		PM	**115.8 (v/c=0.50)**	**F**	**>120 (v/c=0.59)**	**F**	**Yes**
5. Regatta Boulevard/ Marina Bay Pkwy	Signal	AM	30.0	C	**>120 (v/c=0.64)**	**F**	**Yes**
		PM	43.6	D	**69.3**	**E**	**Yes**
6. I-580 Westbound Ramps/ Juliga Woods Street	Side Street Stop	AM	2.5 (10.0)	A (B)	4.7 (13.1)	A (B)	No
		PM	4.4 (10.9)	A (B)	12.3 (**46.2**)	B (**E**)	No
7. I-580 Eastbound Ramps/ Regatta Boulevard/ Meade St	Signal	AM	9.7	A	**>120 (v/c=1.03)**	**F**	**Yes**
		PM	9.1	A	19.5	B	No
8. Meade Street/Regatta Blvd	Side Street Stop	AM	6.4 (10.6)	A (B)	18.2 (82.9)	C (**F**)	No
		PM	5.6 (10.0)	A (B)	4.4 (21.4)	A (C)	No
9. Meade Street/Seaver Avenue	Side Street Stop	AM	1.3 (9.7)	A (A)	**>120 (>120)**	**F (F)**	**Yes**
		PM	3.0 (9.0)	A (A)	**>120 (>120)**	**F (F)**	**Yes**
10. Seaport Avenue/I-580 Eastbound Ramps/South 51st Street/Bayview Ave	All-way Stop	AM	27.6	D	**60.2**	**F**	**Yes**
		PM	20.0	C	**49.4**	**E**	**Yes**
11. I-580 Westbound Ramps/ Bayview Ave	Signal	AM	5.4	A	**>120 (v/c=1.02)**	**F**	**Yes**
		PM	6.7	A	**109.1 (v/c=0.52)**	**F**	**Yes**
12. Carlson Boulevard/ Bayview Ave	Signal	AM	27.0	C	34.7	C	No
		PM	21.6	C	22.5	C	No
13. Carlson Boulevard/ I-80 Westbound Ramps	Signal	AM	19.3	B	**77.7**	**E**	**Yes**
		PM	20.0	B	20.0	B	No
14. Carlson Boulevard/ I-80 Eastbound Ramps	Signal	AM	10.7	B	14.6	B	No
		PM	9.8	A	14.1	B	No

Notes: **Bold** indicates an intersection operating at unacceptable LOS E or LOS F.

1. For signalized and all-way stop-controlled intersections, average intersection delay and LOS based on the 2000 HCM method is shown. For side-street stop-controlled intersections, delays for worst movement and average intersection delay are shown: intersection average (worst movement).

> Greater than
LOS Level of service
v/c Volume-to-capacity

Source: Fehr & Peers 2013.

B. Regatta Boulevard/Marina Bay Parkway (Intersection 5; City of Richmond): The project would cause a significant impact at the signalized Regatta Boulevard/Marina Bay Parkway (Intersection 5) because it would degrade intersection operations from LOS C to LOS F during the a.m. peak hour and from LOS D to LOS E during the p.m. peak hour. The impact at this intersection can be addressed by:

- Optimizing traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach)

The intersection operations would improve to LOS D during the a.m. peak hour after implementation of this improvement. This improvement would reduce the impact to less than significant.

C. I-580 Eastbound Ramps/Regatta Boulevard/Meade Street (Intersection 7; City of Richmond and Caltrans): The project would cause a significant impact at the signalized I-580 Eastbound Ramps/Regatta Boulevard/Meade Street intersection because it would degrade intersection operations from LOS A to LOS F during the a.m. peak hour. The impact at this intersection can be addressed by:

- Optimizing traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach)

The intersection operations would improve to LOS D during the a.m. peak hour after implementation of this improvement. This improvement would reduce the impact to less than significant.

D. Meade Street/Seaver Avenue (Intersection 9; City of Richmond): The project would cause a significant impact at the side-street stop-controlled Meade Street/Seaver Avenue intersection because it would degrade operations for the side-street stop-controlled approach from LOS A to LOS F during both a.m. and p.m. peak hours, and the intersection would satisfy the Caltrans peak hour traffic volume signal warrant. The impact at this intersection can be addressed by:

- Installing an actuated signal at the intersection with protected/permitted phasing for the westbound left-turn movement
- Converting the northbound approach to provide one left-turn lane and one right-turn lane

The intersection operations would improve to LOS C during the a.m. peak hour and LOS B during the p.m. peak hour after implementation of these improvements. These improvements would reduce the impact to less than significant.

E. Seaport Avenue/I-580 Eastbound Ramps/Bayview Avenue (Intersection 10; City of Richmond and Caltrans): The project would cause a significant impact at the all-way stop-controlled Seaport Avenue/I-580 Eastbound Ramps/South 51st Street/Bayview Avenue intersection because it would degrade intersection operations from LOS D to LOS F during the a.m. peak hour and from LOS C to LOS E during the p.m. peak hour. The intersection would satisfy the Caltrans peak hour traffic volume signal warrant. The impact at this intersection can be addressed by:

- Installing an actuated signal at the intersection with protected phasing for the northbound and southbound left-turn movements
- Converting the southbound approach to provide two left-turn lanes and one shared right-turn/through lane

The intersection would improve to LOS C during both a.m. and p.m. peak hours after implementation of these improvements. These measures would reduce the impact to less than significant.

F. I-580 Westbound Ramps/Bayview Avenue (Intersection 11; City of Richmond and Caltrans): The project would cause a significant impact at the signalized I-580 Westbound Ramps/ Bayview Avenue (Intersection 11) because it would degrade intersection operations from LOS A to LOS F during both a.m. and p.m. peak hours. The impact at this intersection can be addressed by:

- Optimizing traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would improve to LOS C during the a.m. peak hour and LOS B during the p.m. peak hour after implementation of this improvement. This measure would reduce the impact to less than significant.

G. Carlson Boulevard/I-80 Westbound Ramps (Intersection 13; City of Richmond and Caltrans): The project would cause a significant impact at the signalized Carlson Boulevard/I-80 Westbound Ramps (Intersection 13) because it would degrade intersection operations from LOS B to LOS E during the a.m. peak hour. The impact at this intersection can be addressed by:

- Optimizing traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach)

The intersection would improve to LOS D during the a.m. peak hour after implementation of this improvement. This measure would reduce the impact to less than significant.

2014 LRDP campus growth would occur over approximately 40 years, and incrementally add traffic to the road network. Thus, these impacts would not occur under existing conditions. Implementing LRDP MM TRA-2 would reduce the proposed LRDP traffic impacts. For the same reasons as presented under LRDP Impact TRA-1, this impact would remain significant and unavoidable.

LRDP MM TRA-2: Implement LRDP MM TRA-1.

LRDP Impact TRA-3: **Development under the 2014 LRDP would conflict with an applicable plan, ordinance, or policy establishing effectiveness measures for circulation system performance and would cause an exceedance of a level of service standard established for CMP facilities (freeways) under 2035 conditions. (*Potentially Significant; Significant and Unavoidable*)**

I-580 and I-80 are the two CMP facilities in the project area. 2014 LRDP campus development would increase traffic volumes on segments of both freeways that serve the RBC site. Table 4.13-11 shows the 2035 plus 2014 LRDP implementation freeway volumes and service levels. With the addition of project traffic, all freeway segments are projected to continue to operate at LOS E and better, with the exception of I-580 between Central Avenue and I-80, which is expected to degrade to unacceptable LOS F in the a.m. for the westbound direction and LOS F in the p.m. for the eastbound direction.

Table 4.13-11
2035 Plus 2014 LRDP Conditions – Freeway Segment LOS Summary

Freeway Segment	Type[2]	Dir	AM Peak Hour		PM Peak Hour	
			Density[1]	LOS	Density[1]	LOS
I-580 between Harbor Way and Marina Bay Pkwy	Weaving	EB	N/A	B	N/A	C
	Weaving	WB	N/A	C	N/A	A
I-580 between Marina Bay Pkwy and Regatta Blvd	Weaving	EB	N/A	B	N/A	C
	Weaving	WB	N/A	C	N/A	C
I-580 between Regatta Blvd and Bayview Ave	Weaving	EB	N/A	C	N/A	C
	Weaving	WB	N/A	C	N/A	B
I-580 between Bayview Ave and Central Ave	Basic	EB	25.1	C	29.9	D
	Basic	WB	30.3	D	24.0	C
I-580 between Central Ave and I-80	Basic	EB	37.9	E	--	**F**
	Basic	WB	--	**F**	27.4	D
I-80 between Carlson Blvd and Potrero Ave	Basic	EB	27.5	D	34.3	D
	Basic	WB	42.2	E	29.2	D
I-80 at Gilman St Overpass	Basic	EB	29.5	D	32.8	D
	Basic	WB	36.0	E	31.8	D

Notes: **Bold** indicates a freeway segment operating at unacceptable levels. Unacceptable levels for I-580 would be LOS F and for I-80 would be LOS F plus 5 percent or more added traffic.

1. Density is in passenger cars per lane per mile (pc/ln/mi).
2. Segments with auxiliary lanes are classified as weaving segments, and were analyzed based on the Leisch Method. Other segments are analyzed as basic segments using methodologies described in the Highway Capacity Manual 2000.

Dir Direction
EB Eastbound
LOS Level of Service
N/A Not available
WB Westbound

Source: Fehr & Peers 2013.

2014 LRDP implementation would cause a significant impact under 2035 conditions on I-580 between Central Avenue and I-80 in the westbound direction during the a.m. peak hour and in the eastbound direction during the p.m. peak hour. This impact would result because the project would degrade the westbound segment from LOS E to LOS F during the a.m. peak hour and would increase the p.m. peak hour volume on the eastbound freeway segment by more than 5 percent on a freeway segment that would operate at LOS F without the addition of the project's traffic.

No freeway capacity projects are currently planned by Caltrans for this section of I-580, and the cost and scale of freeway expansion is not within the University's jurisdiction or mission. As the feasibility of freeway widening is not known, this impact is considered to be significant and unavoidable.

LRDP Impact TRA-4: Development under the 2014 LRDP would not conflict with an applicable plan, ordinance, or policy establishing effectiveness measures circulation system performance and would not cause an exceedance of a level of service standard established for CMP facilities (freeways) under existing conditions. (*Less than Significant*)

LRDP Impact TRA-4 describes effects on freeways of full 2014 LRDP development, which is assumed to occur by 2050. As all the projected 2014 LRDP vehicle trips would not be immediately added to the study area transportation network upon LRDP approval, an existing plus project trips scenario is an unrealistic condition. An analysis was conducted to measure the project's traffic impacts on freeway segments under existing plus project conditions, but as this is an unrealistic scenario, this analysis is informational only and not a basis for determining impacts.

Table 4.13-12 shows the freeway segment LOS results for the existing plus 2014 LRDP conditions. The addition of 2014 LRDP traffic would not cause any study freeway segment to operate at an unacceptable LOS F; therefore, the 2014 LRDP would not cause a significant impact at the study freeway segments under existing conditions.

Mitigation Measures: No mitigation measure is required.

LRDP Impact TRA-5: Development under the 2014 LRDP would not conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities. (*Less than Significant*)

Under the proposed 2014 LRDP, UC Berkeley/LBNL would provide frequent shuttle service to BART, UC Berkeley, and LBNL, consistent with Goal 4 of the City of Richmond Bicycle Master Plan and Goal CR3 of the Circulation Element of the General Plan 2030. The LBNL-UC Berkeley-RBC Shuttle would provide a no-transfer 20-minute ride from LBNL to the RBC with a single stop at the main UC Berkeley campus en route. The BART-RBC Shuttle would run continuously between the El Cerrito Plaza or El Cerrito del Norte BART station and the RBC, providing a nonstop nine-minute ride from BART to the RBC. The El Cerrito Plaza and El Cerrito del Norte BART station would be a connection point to the AC Transit system. Hours of operations and frequency of service would be increased gradually as the RBC expands and the number of employees increases.

Currently, local transit (e.g., AC Transit, WestCAT) does not serve the RBC directly. The University would work with local transit operators, including AC Transit to improve transit access and service to the RBC as the number of employees and transit demand increases. The exact modifications needed to accommodate the demand are not known at this time; however, they may involve modifying routes 71, 74, 76, and 376, or new route(s). Modifications would be coordinated with other on-going transit planning activities performed by the transit operators, such that the modifications would not adversely affect service in other areas. Thus, the project would not cause adverse impacts to transit or require modifications that would reduce transit access elsewhere in the area, and the impacts would be less than significant.

The proposed project would gradually increase the number of vehicle trips on roadway segments with bicycle and pedestrian facilities; however, the increase would not substantially decrease the performance or safety of the existing or planned bicycle or pedestrian facilities. The project would not preclude development of planned bicycle or pedestrian facilities. Therefore, impacts to bicycle and pedestrian facilities would be less than significant.

Table 4.13-12
Existing Plus 2014 LRDP Conditions – Freeway Segment LOS Summary

Freeway Segment	Type[2]	Dir	AM Peak Hour		PM Peak Hour	
			Density[1]	LOS	Density[1]	LOS
I-580 between Harbor Way and Marina Bay Pkwy	Weaving	EB	N/A	A	N/A	A
	Weaving	WB	N/A	A	N/A	A
I-580 between Marina Bay Pkwy and Regatta Blvd	Weaving	EB	N/A	B	N/A	A
	Weaving	WB	N/A	A	N/A	B
I-580 between Regatta Blvd and Bayview Ave	Weaving	EB	N/A	A	N/A	A
	Weaving	WB	N/A	A	N/A	A
I-580 between Bayview Ave and Central Ave	Basic	EB	16.0	B	17.4	B
	Basic	WB	17.9	B	17.4	B
I-580 between Central Ave and I-80	Basic	EB	24.4	C	37.0	E
	Basic	WB	31.7	D	23.4	C
I-80 between Carlson Blvd and Potrero Ave	Basic	EB	21.6	C	29.4	D
	Basic	WB	32.2	D	24.3	C
I-80 at Gilman St Overpass	Basic	EB	24.4	C	27.7	D
	Basic	WB	31.6	D	28.6	D

Notes: **Bold** indicates a freeway segment operating at unacceptable levels (LOS F for I-580 and LOS F plus 5% or more added traffic for I-80).

1. Density is in passenger cars per lane per mile.
2. Segments with auxiliary lanes are classified as weaving segments, and were analyzed based on the Leisch Method. Other segments are analyzed as basic segments using methodologies described in the Highway Capacity Manual 2000.

Dir Direction
EB Eastbound
LOS Level of Service
N/A Not available
WB Westbound

Source: Fehr & Peers 2013.

Mitigation Measures: No mitigation measure is required.

LRDP Impact TRA-6: The 2014 LRDP would not increase hazards due to a design feature or incompatible use, create unsafe conditions for pedestrians or bicycles, or result in inadequate emergency access. (*Less than Significant*)

Traffic Hazards and Emergency Access

2014 LRDP implementation would not create any transportation and traffic-related hazards due to circulation or access design features. The 2014 LRDP would not result in inadequate emergency access, on- or off-site. Emergency responders would have full access to the site and the internal traffic circulation system of the project would incorporate parking and signs for emergency vehicles and personnel.

Bicycle and Pedestrian Circulation

RBC bicycle access would be by existing overpasses at Bayview Avenue, Regatta Boulevard/Juliga Woods Street, Marina Bay Parkway/S. 23rd Street, Marina Way, Harbor Way,

and others farther west. The Richmond Bicycle Master Plan identifies Bayview Avenue, Marina Bay Parkway/S. 23rd Street, Marina Way, and Harbor Way as providing future Class 2 bicycle lanes. Additional RBC bicycle access on the Bay Trail would be by existing underpasses or overpasses at Central Avenue, Buchanan Street, Gilman Street, University Avenue, the Berkeley bicycle and pedestrian bridge, and others farther south. Bicycle lanes and pedestrian paths would be provided on new streets on the RBC site. A bike sharing system may also be implemented for RBC site circulation and for travel to retail and other points nearby during the day. Sidewalks would be provided on all internal streets, and internal pedestrian pathways would connect buildings on the RBC. Sea level rise may eventually impact the Bay Trail; however, other bicycle and pedestrian improvements would likely be in place before such time. See also discussion of sea level rise and the Bay Trail in the Long Range Development Plan.

The facilities and improvements are consistent with the Bicycle Master Plan and the Pedestrian Plan policies and planned facilities. Consistent with Bicycle Master Plan Goals 1 and 4 and the Pedestrian Plan Increased Connectivity goal, the 2014 LRDP would provide on-site bicycle and pedestrian facilities that connect to the Bay Trail and other planned bicycle facilities in the City. The 2014 LRDP would include a TDM program that provides incentives for walking and bicycle use. This is consistent with Policy CR5.1 of the City of Richmond General Plan 2030 Circulation Element.

Although the proposed project would gradually increase the number of vehicle trips on roadway segments with bicyclists and pedestrian facilities, the increase would not create unsafe conditions for bicyclists and pedestrians. Therefore, 2014 LRDP implementation would not result in adverse impacts to bicycle trails near the site or elsewhere in the City of Richmond, including the Bay Trail.

Mitigation Measures: No mitigation measure is required.

LRDP Impact TRA-7: Traffic associated with the 2014 LRDP campus facilities construction would temporarily and intermittently adversely affect the road network near the RBC site. (*Potentially Significant; Less than Significant with Mitigation*)

RBC site construction activity is estimated to continue intermittently until 2050. During facility demolition and construction, there may be temporary and intermittent transportation impacts from truck movements and construction worker vehicles. The construction-related traffic may temporarily reduce area roadway capacities because of the slower movements and larger turning radii of construction trucks compared with passenger vehicles.

Peak-hour (7:00 to 9:00 a.m. and 4:00 to 6:00 p.m. on weekdays) construction worker and truck trips may result in short term adverse effects on local traffic during construction periods.

The temporary closure of streets and paths for construction staging may affect automobile, pedestrian, and bicycle access and circulation; this also may cause a significant temporary impact by increasing traffic hazards or impeding emergency access.

Implementing LRDP MM TRA-7 would reduce any construction-related impact to a less than significant level.

LRDP MM TRA-7: Prepare a construction traffic management plan for each RBC construction project to reduce construction impacts on traffic and parking. RBC shall work with City of Richmond in preparing the plan, which will address:

- Proposed truck routes
- Hours of construction and limits on number of truck trips during peak commute periods (7:00 to 9:00 a.m. and 4:00 to 6:00 p.m.) if traffic conditions demonstrate the need to reduce construction traffic so as to avoid causing significant delays.
- Parking management plan for construction workers;
- Tools to provide safe access for pedestrians, bicyclists, automobiles, and emergency access vehicles.
- Identification of alternative routes for temporary closure of streets or paths during construction.

Cumulative Impacts and Mitigation Measures

The preceding discussion addresses the potential impacts of project-related traffic on nearby roadways and intersections. To address the cumulative 2014 LRDP campus development impacts, this section also analyzes full 2014 LRDP RBC campus development in concert with anticipated development in the area in the analysis year 2035.

LRDP Impacts TRA-1 and TRA-3 evaluate the transportation impacts that would result from regional traffic growth through 2035 combined with the 2014 LRDP RBC growth. That analysis presents the cumulative traffic impacts determined to be significant at certain intersections and one freeway segment. Mitigation measures are included to address the proposed project's contribution to the significant cumulative traffic impacts. Because implementation of the intersection improvements determined necessary to reduce the project's impacts on off-campus intersections is outside the control of the University, LRDP Impact TRA-1 is found to be significant and unavoidable for seven intersections. Because improvements to the freeway segment are not feasible, LRDP Impact TRA-3 is also found to be a significant and unavoidable impact.

4.13.5 References

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4.14 UTILITIES, SERVICE SYSTEMS, AND ENERGY

4.14.1 Introduction

This section describes existing utilities, service systems, and energy resources serving the RBC site and evaluates the potential for development under the 2014 LRDP to affect these systems.

Public and agency NOP comments related to utilities, service systems, and energy are summarized below:

- The EIR should analyze RBC dry and wet weather flows on the City of Richmond's wastewater collection and treatment systems.
- The EIR should analyze RBC development demand impacts on the City of Richmond's water, natural gas, and telecommunications infrastructure.
- The EIR should analyze the impacts of the RBC development on stormwater runoff.
- The EIR should determine if stormwater runoff would be discharged into the City of Richmond's drainage system and whether the RBC site would need to comply with State Water Resources Control Board requirements.
- For potentially significant impacts, the EIR should identify mitigation measures that promote sustainability and conservation of resources.
- The EIR should describe all project waste streams associated and identify how waste would be handled.
- The project sponsor should submit a written request to EBMUD to prepare an RBC development Water Supply Assessment (WSA).
- Off-site water pipeline improvements, including existing water main replacements, may be necessary to provide RBC site water.
- The RBC development should use non-potable water, including recycled water, for non-domestic purposes. The nearest EBMUD recycled water transmission pipeline terminates approximately 3 miles from the project site.
- The RBC development should incorporate WaterSmart technology and design standards in landscape and building design.

All these comments were considered in the analysis.

4.14.2 Environmental Setting

Water

EBMUD provides the RBC site with water service for potable, firefighting, central plant, and irrigation uses. The District's water supply system consists of a network of reservoirs, aqueducts, treatment plants, and distribution facilities. The water supply system originates at the Mokelumne River in the Sierra Nevada mountain range; that water is delivered to treatment plants or to District reservoirs, and ultimately to East Bay residences and businesses. On average, 90 percent of the water delivered by EBMUD comes from the Mokelumne River watershed, with the remaining 10 percent originating as runoff from local service area watersheds. EBMUD is entitled to 325 million gallons per day (mgd) of Mokelumne watershed water, of which 200 mgd is diverted from the Pardee Reservoir and 125 mgd is diverted from the Camanche Reservoir (EBMUD 2012).

EBMUD Water supplied to the City of Richmond is treated at the Sobrante Water Treatment Plant (WTP) or the Orinda WTP. The Sobrante WTP can treat and deliver up to 60 mgd and the Orinda WTP can treat and deliver up to 200 mgd (City of Richmond 2011).

The RBC site is currently served by three 8-inch laterals, each connected to 12-inch EBMUD water mains in South 46th Street, Regatta Boulevard and South 32nd Street, and Regatta Boulevard and South 34th Street. Currently, land uses on the RBC site consume approximately 11 million gallons per year (mgy), with an estimated maximum flow rate of 50 gpm (City of Richmond 2011).

Wastewater

The Richmond Municipal Sewer District (RMSD) provides wastewater services to the RBC site. Wastewater is treated at the RSMD's WWTP on the Point Richmond Peninsula. The RMSD WWTP has a dry-weather secondary treatment capacity of 24 mgd, and wet weather capacity of 24 mgd primary/secondary treatment and 40 mgd of primary treatment. The RMSD WWTP receives approximately 7 mgd dry weather influent flows. Wet weather flows peak at 56 mgd due to infiltration and inflow, approximately 16 mgd more than the RMSD WWTP's primary treatment capacity (US DOI and City of Richmond 2009).

The RBC site currently connects to a City of Richmond sanitary sewer main in several locations in the north portion of the developed area and to a southern City of Richmond sewer main that traverses the southern end of the meadow to the west of the EPA Lab and then exits the site to South 32nd Street. Currently, land uses on the RBC site discharge approximately 9.3 mgy into the City's sewer system for treatment at the RMSD WWTP.

Stormwater

Stormwater currently flows from north to south on the RBC upland area through open swales, culverts, and sheet flow into drainages. Building and other impervious surface runoff is directed into storm drains. There are two main RBC site storm drain lines: the Western and Eastern Storm Drains. Stormwater in the western RBC uplands drains through the Western Storm Drain's open swales and an underground pipe to a trapezoidal storm drain channel called Meeker Ditch. This drain channel runs north-south on the western edge of the uplands; it also carries City of Richmond stormwater collected north of the RBC site. The Eastern Storm Drain also discharges its surface waters into Meeker Ditch. Runoff from the buildings and other impervious surfaces on the Regatta property is directed into storm drains in the adjacent streets.

Solid Waste

The West Contra Costa Integrated Waste Management Authority (WCCIWMA) is the joint powers agency that manages solid waste for the cities of El Cerrito, Hercules, Pinole, Richmond, and San Pablo—an area of approximately 74 square miles. The WCCIWMA is governed by a board of Directors made up of seven city council members. The WCCIWMA was created in response to Assembly Bill 939, which mandated California cities to reduce solid waste by 50 percent by the year 2000. West Contra Costa County met the 50 percent waste diversion goal in 2006 (WCCIWMA 2012).

The project site is in the Richmond Sanitary Service collection district. Refuse is collected and taken to the Golden Bear Transfer Station, from where it is transported to the Potrero Hills Landfill in Solano County (Contra Costa County 2003). The WCCIWMA uses other landfills such as those listed in Table 4.14-1.

Table 4.14-1
Disposal Facilities Used by WCCIWMA in 2008

Facility	Address	Expected Closure Date	Permitted Maximum Disposal (Tons/Day)	Remaining Estimated Capacity (cubic yards)
Acme Landfill	950 Waterbird Way, Martinez CA 94553	6/1/2021	1,500	175,000 (65.1%)
Altamont Landfill and Resources Recovery	10840 Altamont Pass Road Livermore CA 94550	1/1/2029	11,500	45,720,000 (73.7%)
Bakersfield Metropolitan (Bena) SLF	2951 Neumarkel Road Caliente CA 93518	12/31/2038	4,500	34,994,127 (66.0%)
Corinda Los Trancos (Ox Mountain) Landfill	2 miles NE Half Moon Bay off Hwy 92, Half Moon Bay CA 94019	1/1/2018	3,598	44,646,148 (117.8%)*
Forward Landfill, Inc.	9999 S. Austin Road Manteca CA 95336	1/1/2020	8,668	23,700,000 (46.4%)
Guadalupe Sanitary Landfill	15999 Guadalupe Mines Road San Jose CA 95120	1/1/2048	1,300	11,055,000 (38.7%)
John Smith Road Class III Landfill	2650 John Smith Road Hollister CA 94123	1/1/2024	500	3,594,899 (77.7%)
Keller Canyon Landfill	901 Bailey Road Pittsburg CA 94565	12/31/2030	3,500	63,408,410 (84.5%)
Newby Island Sanitary Landfill	1601 Dixon Landing Road Milpitas CA 95035	6/1/2025	4,000	18,274,953 (36%)
Potrero Hills Landfill	3675 Potrero Land Suisun City CA 94585	2/14/2048	4,330	13,872,000 (16.7%)
Recology Hay Road Landfill, Inc.	6426 Hay Road; 1/4 Mi W Hwy 113, Vacaville CA 95687	1/1/2077	2,400	30,433,000 (82.3%)
Recology Ostrom Road Landfill	5900 Ostrom Road Wheatland CA 95692	12/31/2066	3,000	39,223,000 (90.2%)
Redwood Sanitary Landfill	4 miles NE Novato Btwn Santonio and RR Novato, CA 94945	1/1/2039	2,300	12,900,000 (67.5%)
Vasco Road Sanitary Landfill	4001 North Vasco Road Livermore CA 94550	8/31/2019	2,250	9,870,704 (30.0%)
Zanker Material Processing Facility	675 Los Esteros Road San Jose CA 95134	12/31/2018	350	540,100 (100%)

* Calrecycle website shows -6,746,148 cubic yards used, which results in a remaining capacity greater than 100%.
% Percent
SLF Sanitary Landfill

Source: CIWMB, 2009. http://www.calrecycle.ca.gov/SWFacilities/Directory/search.aspx. Accessed January 31, 2013

Potrero Hills Landfill receives the majority of the transfer station solid waste. It is at 3675 Potrero Hills Lane in Suisun City, approximately 28 miles northeast of the RBC site. According to CalRecycle, the landfill currently has a permitted capacity of 83.1 million cubic yards and a permitted daily intake limit of 4,330 tons. The landfill is permitted by the Local Enforcement Agency to continue operating till 2048 (CalRecycle 2012a). To do so, a landfill expansion is required. BCDC issued the required permit for this expansion, but it was overturned by Solano County Superior Court. As a result, it currently is uncertain whether the landfill will realize its full permitted capacity and continue to accept wastes until 2048.

Energy

Electricity
PG&E provides electricity to the RBC site. The company provides electric service to 5.1 million customers in a 70,000-square-mile service area in northern and central California. Electricity is generated from fossil fuels (natural gas and fuel oil), hydroelectric, nuclear, and solar (City of Richmond 2011).

Currently, the RBC site has an estimated peak power demand of about 500 kW and consumes approximately 3.7 million kWh annually. RBC site electricity is provided through multiple overhead 12-kv electrical lines. Aerial and underground power lines comprise the site's electrical service infrastructure.

Natural Gas
PG&E provides natural gas to the site. The company provides natural gas service to 4.2 million customers throughout its service area. The majority of PG&E's gas supply comes from northern California and other sources outside the service area (City of Richmond 2011).

Currently, the RBC site has an estimated peak gas demand of about 2,700 kBtu/h and consumes approximately 73,600 therms annually. RBC site natural gas is supplied through multiple high-pressure gas mains, with underground gas lines serving the larger site facilities.

4.14.3 Regulatory Considerations

Federal

Appropriate LBNL policies and procedures regarding utility use and consumption will be followed.

Energy Independence and Security Act
In 2007, EISA was signed into law. EISA aims to increase building, product, and vehicle efficiency; accelerate clean renewable fuel production; and institute other measures aimed at increasing U.S. energy independence and security.

Federal Facilities Compliance Act (Public Law 102-386)
This act generally waives sovereign immunity for Federal facilities, including the LBNL, from RCRA. It also requires development of plans and agreements with States for the management of mixed waste streams.

State

California Safe Drinking Water Act
This act established a state program and standards for public drinking water contaminant levels, regulates underground injection well use, and prescribes sole source aquifer standards. A public water system is defined as a system that regularly serves at least 25 persons and includes federal facilities that own or operate a public water system.

SB 610 and SB 221 – Water Supply Assessments
In 2001, the California Legislature passed Senate Bill 610 (Water Code Section 10910 et seq.) and Senate Bill 221 (Water Code Section 66473.7) to improve the link between information on water supply availability and certain land use decisions made by cities and counties. SB 610 and SB 221 were companion measures that sought to promote more collaborative planning between

local water suppliers and cities and counties. SB 610 and SB 221 are not applicable to University of California projects.

Assembly Bill 939

In 1989, Assembly Bill (AB 939) established the current organization, structure, and mission of the California Integrated Waste Management Board; directed attention to the increasing waste stream and decreasing landfill capacity; and mandated a reduction in disposed waste. It required jurisdictions to meet diversion goals of 25 percent by 1995 and 50 percent by 2000. Each city and county was required to submit a plan (Source Reduction and Recycling Element) describing how they would meet the waste reduction mandates. The University of California is not subject to this Act. The waste diversion goals were set at 75 percent by June 2012 and 100 percent by 2020.

California Universal Waste Law

This California Universal Waste Law went into effect in February 2006. Universal wastes include a wide variety of hazardous wastes such as batteries, fluorescent tubes, mercury-containing articles, aerosol cans, cathode ray tubes, and electronic devices that can be harmful to human and environmental health. Universal waste may not be discarded in solid waste landfills. Instead, it is recyclable and (to encourage recycling and recovery of valuable metals) can be managed under less stringent requirements than those that apply to other hazardous wastes.

California Government Code Section 54999

California Government Code Section 54999 provides for the University to pay fees to utility companies, under very limited circumstances, to defray the cost of utility capital improvements specifically intended to serve the University. An imposed capital facilities fee must be nondiscriminatory and must not exceed the actual amount necessary to provide utility benefits to the University.

California Building Code

Buildings constructed after June 30, 1977 must comply with the most recent California Code of Regulations Title 24 standards. Current Title 24 regulations are in the 2008 Building Energy Efficiency Standards. New 2013 Building Energy Efficiency Standards will become effective January 1, 2014. Title 24 requires state-of-the-art energy conservation features in building design and construction, use of non-depletable energy resources, or a demonstration that buildings would comply with a designated energy budget. Sustainability is a central 2014 LRDP element and the UC Sustainable Practices Policy requires that building renovations outperform by 20 percent the Title 24, Part 6 Building Energy Efficiency Standards.

Construction General Permit

Construction activity disturbing more than 1 acre of land is currently subject to an NPDES General Permit issued under Water Quality Order No. 2009-0009-DWQ. Permittees enrolled under this permit are required to file a notice of intent with the RWQCB and to develop and implement a SWPPP that includes BMPs. Permittees must perform seasonal monitoring of storm water discharges and submit annual reports until construction is completed. The intent of the General Permit program is to minimize erosion and sediment runoff as well as to prohibit the discharge of any pollutants in storm water runoff through the use of BMPs. Upon completion of construction, the General Permit is cancelled by filing a notice of termination.

California Model Water Efficient Landscape Ordinance

The Department of Water Resources prepared the model landscape ordinance, Title 23 Section 490. The model ordinance was adopted pursuant to AB 1881 Section 65597, the Water Conservation in Landscaping Act of 2006. Specific standards regarding water allowances as

well as methods to achieve water efficiency are detailed in the model ordinance. Local agencies were required to adopt the model ordinance or a local water efficient landscape ordinance by January 1, 2010.

Local

UC Sustainable Practices Policy

The UC Sustainable Practices Policy establishes goals in eight areas of sustainable practices: green building, clean energy, transportation, climate protection, sustainable operations, waste reduction and recycling, environmentally preferable purchasing, and sustainable foodservice. LBNL has its own sustainability policy and also follows the UC policy. The UC Sustainable Practices Policy is updated periodically. The most recent update, located at http://sustainability.universityofcalifornia.edu/policy.html, is from August 2011. The policy goals relevant to utilities and energy are:

Green Building Design

New Buildings

- All new building projects, other than acute care facilities, shall be designed, constructed, and commissioned to outperform the CBC energy-efficiency standards by at least 20 percent. The University will strive to design, construct, and commission buildings that outperform CBC energy efficiency standards by 30 percent or more, whenever possible within the constraints of program needs and standard budget parameters.
- All new buildings (except acute care facilities) will achieve a LEED Silver certification at a minimum. All new buildings (except acute care facilities) will strive to achieve certification at a LEED Gold rating or higher, whenever possible within the constraints of program needs and standard budget parameters.
- The University of California will design, construct, and commission new laboratory buildings to achieve a minimum of LEED Silver certification and meet at least the prerequisites of the Labs21 EPC. Design, construction, and commissioning processes shall strive to optimize the energy efficiency of systems not addressed by the CBC energy efficiency standards.
- All new building projects will achieve at least two points of the available credits in LEED-NC's Water Efficiency category.

Building Renovations

- Renovation of buildings that require 100 percent replacement of mechanical, electrical and plumbing systems and replacement of over 50 percent of all non-shell areas (interior walls, doors, floor coverings and ceiling systems) shall at a minimum comply with III.A.3 or III.A.4. Such projects shall outperform CBC Title 24, Part 6, currently in effect, by 20 percent.
- Renovation projects with a project cost of $5 million or greater (CCCI 5000) that do not fall under item III.A.6 shall at a minimum achieve a LEED-CI Certified rating and register with the utilities' Savings by Design program, if eligible.

Clean Energy

- The University will reduce consumption of non-renewable energy by using a portfolio approach that includes a combination of energy efficiency projects, the incorporation of local renewable power measures for existing and new facilities, green power purchases from the electrical grid, and other energy measures with equivalent demonstrable effect on the environment and reduction in fossil fuel use.

Recycling and Waste Management

- The University prioritizes waste reduction in the following order: reduce, reuse, and recycle.
- The University adopts the following goals for diverting municipal solid waste from landfills:
  - 50 percent by June 30, 2008
  - 75 percent by June 30, 2012
  - Ultimate goal of zero waste by 2020

City of Richmond General Plan 2030

The RBC site is a University property where work within the University's mission is performed. As a state entity created by Article IX, Section 9 of the California State Constitution, the University is exempt under the state constitution from compliance with local land use regulations, including general plans and zoning. The University seeks to cooperate with local jurisdictions to reduce any physical consequences of potential land use conflicts to the extent feasible. The RBC is in the City of Richmond. The following sections summarize objectives and policies from the City of Richmond General Plan and local ordinances as they relate to water supply and distribution, wastewater treatment and conveyance, solid waste disposal, and energy demand and conveyance.

Community Facilities and Infrastructure

Goal CF1 Facilities that Serve a Diverse Range of Community Needs

Policy CF1.1 A Range of High-Quality Community Facilities and Infrastructure. Maintain high-quality facilities and infrastructure to serve diverse community needs.

P**olicy CF1.4** Concurrent Infrastructure Development. Require new development to provide proportionate facilities and infrastructure improvements as it occurs.

The 2030 General Plan EIR determined that the effects of the future development in the City under the General Plan on utilities, service systems, and energy would be significant and unavoidable. Wastewater systems impacts would be significant and unavoidable. Potable water system, solid waste, and energy (including electricity and natural gas) impacts would be less than significant. Cumulative impacts would be the same as project-level impacts.

4.14.4 Impacts and Mitigation Measures

Standards of Significance

Project impacts on water supply and distribution, wastewater treatment and conveyance, solid waste disposal, and energy demand and conveyance would be considered significant if they would exceed the following Standards of Significance, in accordance with Appendix G of the *State CEQA Guidelines* and the UC CEQA Handbook:

Water Supply

- Require or result in the construction of new water treatment facilities or expansion of existing facilities that could cause significant environmental effects
- Result in the need for new or expanded water supply entitlements if there are not sufficient water supplies to serve the project from existing entitlements and resources

Wastewater

- Exceed wastewater treatment requirements of the applicable RWQCB
- Require or result in the construction of new wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects
- Result in a determination by the wastewater treatment provider that serves or may serve the project that it has inadequate capacity to serve the project's projected demand in addition to the provider's existing commitments

Stormwater

- Require or result in the construction of new stormwater drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects

Solid Waste

- Be served by a landfill with insufficient permitted capacity to accommodate the project's solid waste disposal needs
- Fail to comply with applicable federal, State, and local statutes and regulations related to solid waste

Energy

- Require or result in the construction or expansion of electrical and natural gas facilities, that could cause significant environmental impacts
- Encourage the wasteful or inefficient use of energy

CEQA Checklist Items Adequately Addressed in the Initial Study

The Initial Study deferred analysis of the project's water supply and distribution, wastewater treatment and conveyance, solid waste disposal, and energy demand and conveyance impacts to this EIR. Therefore, all of the CEQA checklist items listed above are addressed in the analysis.

Analytical Methods

As a conceptual land use plan, the 2014 LRDP would help guide future physical development siting. The LRDP does not commit the LBNL or UC Berkeley to any specific projects or to grow to the maximum LRDP parameters. This EIR conservatively estimates the maximum LRDP growth and commensurate increases in utility demands. The analytical approach for each utility is addressed below.

Water Supply

Full 2014 LRDP development water demand is based on bioscience programs demand and consumption. The biosciences programs were chosen because they represent a reasonable mid-range consumption of utilities, chemicals, and usage of hazardous materials. The metered data was scaled down for variations in climate, improved building and system design, and consolidation of program functions. The resulting demand is then compared to available water supplies as reported in EBMUD's 2010 Urban Water Management Plan. EBMUD was contacted

to confirm that it would be able to supply the additional amount of water that the RBC would need at full 2014 LRDP development; according to the WSA, EBMUD will be able to serve the RBC under full 2014 LRDP development with its existing and planned water supply (EBMUD 2013).

Wastewater

Future wastewater from new 2014 LRDP development is calculated as 80 percent of total future potable water use. These estimated future flows are then compared to available wastewater treatment capacity. The analysis seeks to measure any future impacts to wastewater treatment capacity and to determine if new or expanded wastewater treatment facilities would be necessary.

Solid Waste

Solid waste quantities and types are determined by extrapolating current waste streams with increased future activities, space, and population. That estimated future waste stream is then compared to projected future landfill capacity. Results are then used to help determine whether the project would be underserved by existing landfills with insufficient permitted capacity; fail to comply with applicable federal, State, and local solid waste statutes and regulations; or hinder University or municipal compliance with applicable solid waste statutes.

Energy

Existing electrical and natural gas facilities and supplies are reviewed for future capacity. Energy demand is calculated by multiplying demand factors with estimated new population, facility space, land use area, and activities. Future energy provision capacity is compared to projected energy demand to help determine new or expanded electrical and natural gas facilities or sources.

The existing and projected RBC site utility demand is in Table 4.14-2.

RBC 2014 LRDP Policies

The RBC 2014 LRDP policies related to utilities, service systems, and energy include the following:

- UI1 – Utilities and Infrastructure Policy on Efficiency: Build a safe, efficient, cost-effective infrastructure.
    - Provide a safe and reliable utility infrastructure capable of supporting the research programs conducted on the campus.
    - Design infrastructure in a manner that can be phased over time and provide redundancy as needed.
    - Consolidate utility distribution into centralized corridors that primarily coincide with campus streets.
- UI2 – Utilities and Infrastructure Policy on Sustainability: Design infrastructure improvements to embody sustainable practices.
    - Design infrastructure to minimize energy use and maximize on-site renewable energy generation.
    - Plan infrastructure in a manner that promotes minimal use of potable water.
    - Explore and implement measures to use recycled gray or black water on-site for non-potable uses such as irrigation and toilet flushing.

- Maintain or restore, to the maximum extent technically and practically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of stormwater flow.
- Incorporate low impact development strategies in site planning to manage stormwater.
- Protect the campus development from 55 inches of sea level rise through the year 2100 using natural shore forms where practicable; and coordinate closely with the East Bay Regional Park District on maintaining the Bay Trail embankment.

LRDP Impacts and Mitigation Measures

Water Supply

LRDP Impact UTL-1: Development under the 2014 LRDP would not result in the need for new or expanded water supply entitlements. (*Less than Significant*)

The RBC site currently consumes approximately 11 mgy, or 30,000 gpd, of water, with an estimated maximum 50 gpm flow rate, as shown in Table 4.14-2. Potable water is used for various potable uses and irrigation. Following full development of the campus under the 2014 LRDP, the estimated annual water consumption would be about 340 mgy and the maximum flow rate would be 2,230 gpm. This represents a water usage increase of 329 mgy, or approximately 0.9 mgd, over existing conditions.

RBC landscape irrigation with recycled water is being explored in discussions with EBMUD. This would reduce the potable water estimated above. Consistent with UC Sustainable Practices Policy, all new building projects would achieve at least two points of the available credits in LEED-NC's Water Efficiency category; that would minimize water use. As required by EBMUD the landscape design would be designed to a water budget as described in the California Model Water Efficient Landscape Ordinance in Title 23 of the California Code of Regulations. The project would comply with EBMUD Water Service Regulation Section 31, Water Efficiency Requirements.

EBMUD is entitled to 325 mgd of water and its service area is projected to have a 230 mgd water demand in 2040, the closest EBMUD planning year to the 2014 LRDP's 2050 planning horizon (EBMUD 2011). Without conservation and recycled water, the EBMUD service area water demand in 2040 would be 312 mgd. RBC full development under the 2014 LRDP would add 0.9 mgd to the service area demand and increase total service area water demand to 231 mgd under the EBMUD conservation and recycled water scenario, and to 313 mgd under the non-conservation and recycling scenario. Both numbers are well below the EBMUD's total water entitlement.

Table 4.14-2
RBC Annual and Peak Utility Demand

Utility	Existing Demand	Projected Demand (2050)	Difference in Demand
Potable Water	11 mgy (peak demand – 50 gpm)	340 mgy (peak demand – 2,230 gpm)	329 mgy (peak demand – 2,180 gpm)
Firefighting Water	(peak demand – 3,000 gpm)	(peak demand – 6,000 gpm)	(peak demand – 3,000 gpm)
Wastewater	9.3 mgy (peak demand – 55 gpm)	273 mgy (peak demand – 2,140 gpm)	263.7 mgy (peak demand – 2,085 gpm)
Electrical energy	3,700 megawatt hours/year (peak demand – 500 kW)	142,400 megawatt hours/year (peak demand – 24.7 MW)	138,700 megawatt hours/year (peak demand – 24.2 MW)
Standby Power	peak demand – 400 kW (installed capacity – 3.9 MW)	peak demand – 16 MW (installed capacity –20 MW)	peak demand – 15.6 MW (installed capacity –16.1 MW)
Natural Gas	73,600 therms/year (peak demand – 2,700 kBtu/h)	6,600,000 therms/year (peak demand – 240,300 kBtu/h)	6,526,400 therms/year (peak demand – 237,600 kBtu/h)

Notes:
1 Wastewater was determined to be 80 percent of the potable water demand.
2 Wastewater flows cannot be netted out because the leased facilities do not all contribute their wastewater to the same wastewater treatment plant.
gpm Gallons per minute
kBtu/h Kilo-British thermal unit hour
kW Kilowatt
Mgy Million gallons per year
MW Megawatt
NA Not Applicable

During normal rainfall years, EBMUD has adequate water supply to meet water demands, including the demand that would be added by RBC development. During drought periods the Mokelumne River would not meet the 325 mgd entitlement. The 2010 Urban Water Management Plan identified additional water sources, in addition to rationing, that could be available during drought years; these include supplemental supplies from the Freeport Regional Water Facility and the Bayside Groundwater Facility. In 2040 there would still be an EBMUD service area deficit of 73 mgd if there were three drought years in a row. Any additional deficit during dry years would be supplemented by short-term supply sources such as the Northern California Water Transfers and the Bayside Groundwater Project Expansion (EBMUD 2011).

EBMUD conducted a WSA of campus development under the proposed 2014 LRDP. According to the WSA, EBMUD will be able to serve the water demand associated with full development of the campus under the 2014 LRDP with its existing and planned water supply (EBMUD 2013). Full 2014 LRDP campus development would increase the daily water demand from EBMUD. However, the increase would be relatively small and would be served by existing water entitlements. It would be further minimized by RBC conservation measures. EBMUD may investigate expanding the existing recycled water infrastructure or constructing a localized

satellite facility to provide recycled water to the RBC site to further reduce potable water use. The impact would be less than significant.

Mitigation Measure: No mitigation measure is required.

LRDP Impact UTL-2: Development under the 2014 LRDP would not require or result in new or expanded water treatment facilities. (*Less than Significant*)

EBMUD water supplied to the RBC is treated at the Sobrante or the Orinda WTPs. Campus development would result in a net water demand increase of approximately 0.9 mgd. EBMUD would be able to serve the campus with its existing supplies for which there are currently adequate water treatment facilities (EBMUD 2013). Therefore, 2014 LRDP development would not require or result in the construction or expansion of water treatment facilities; this impact would be less than significant.

Mitigation Measure: No mitigation measure is required.

LRDP Impact UTL-3: Development under the 2014 LRDP would require the construction of new or expanded water delivery systems. The construction of new or expanded water delivery systems would not result in significant environmental effects. (*Less than Significant*)

The RBC site is currently served by three 8-inch laterals, each connected to 12-inch EBMUD water mains at South 46th Street, Regatta Boulevard and South 32nd Street, and Regatta Boulevard and South 34th Street. Full 2014 LRDP campus development would require that these 8-inch laterals be upgraded to 12-inch laterals, and that they be supplemented and cross-connected by a 12-inch RBC fire water distribution system. This would ensure adequate future delivery of potable and fire water. The underground distribution system would include piping, sectionalizing valves, back-flow preventers, and pressure reducers generally in utility corridors defined in the 2014 LRDP. Each new facility would include an isolation valve and meter at the building's service entry point. The potential environmental effects associated with upgrading and expanding the RBC site water delivery systems are evaluated in Sections 4.1 through 4.13. As indicated by the analysis in these sections, the impacts will be less than significant or will be reduced to less than significant with mitigation. The analysis in LRDP Impact CR-3 in Section 4.4, Cultural Resources, concludes a significant and unavoidable impact. However the future water conveyance systems would not require demolition of a historic building. Although there would be other significant and unavoidable impacts of LRDP development related to operational criteria pollutant and toxic air contaminant emissions, operational GHG emissions, and traffic, due to the nature of infrastructure upgrades and expansion, these improvements would not cause or contribute to these significant and unavoidable impacts.

EBMUD has indicated that improvements to off-site water mains may be necessary to serve the campus development. To the extent that any improvements to off-site water mains are needed, the construction of these improvements is not expected to result in significant environmental impacts. Due to the nature of infrastructure projects (i.e., underground pipelines placed in existing right-of-way underneath city streets), potential impacts are expected to be less than significant or if potentially significant, mitigable to a less than significant level.

Therefore, the environmental impacts from potentially constructing or expanding on- and off-campus water conveyance infrastructure would be less than significant.

Mitigation Measure: No mitigation measure is required.

Wastewater

LRDP Impact UTL-4: Development under the 2014 LRDP would require the construction of new or expanded wastewater treatment facilities. (*Potentially Significant; Less than Significant with Mitigation*)

Currently, the RBC site generates 9.3 mgy, or 25,479 gallons per day (gpd), of wastewater that is discharged into the City's sewer system for treatment at the RMSD WWTP. This wastewater would increase to an estimated 273 mgy or 747,945 gpd at full 2014 LRDP development. This represents an increase of 263.7 mgy or 722,466 gpd (0.7 mgd) of wastewater over existing conditions, as shown in Table 4.14-2.

The current RMSD WWTP dry-weather secondary treatment capacity is 24 mgd and dry weather influent flows are approximately 7 mgd. If projected 2014 LRDP campus wastewater flows of 0.7 mgd were added to the current influent flows of 7 mgd, the total influent would still be substantially below the WWTP's 24 mgd dry-weather treatment capacity. Incremental RBC flows would take up only 3 percent of the WWTP's dry-weather treatment capacity. Therefore, by itself, the proposed project would not require the construction of new or expanded wastewater treatment facilities. For the combined effect of the proposed project in conjunction with other reasonably foreseeable future development on wastewater treatment capacity, see Cumulative Impact UTL-1 below.

The current RMSD WWTP wet weather primary treatment capacity is 40 mgd and wet weather flows peak at 56 mgd due to infiltration and inflow (I&I). Inflow is stormwater that enters into the sanitary sewer systems at system connection points and infiltration is groundwater that enters sanitary sewer systems through pipe and joint cracks or leaks. Peak wet weather flows exceed the primary treatment capacity of 40 mgd by approximately 16 mgd, or 40 percent. I&I accounts for the drastic increase in peak flows to the RMSD WWTP during wet weather events. The proposed project would not increase I&I discharges to the RMSD WWTP as its infrastructure would be new and not subject to I&I problems.

Furthermore, the City of Richmond has commenced efforts to address the wet weather problem at the RMSD WWTP. In 2011, the City of Richmond prepared and adopted the Sewer Collection System Master Plan, which concluded that a 10-year, 24-hour storm could produce a peak flow of 67 mgd (Veolia Water 2011). As stated above, the current wet weather primary treatment capacity is 40 mgd. Therefore, during the specified storm, there would be an excess of 27 mgd of wastewater above treatment capacity. The City of Richmond is currently in the process of constructing storage facilities for the excess wet weather flows. The wet weather storage basin project has not begun construction but is expected to be completed in late 2014. The project would temporarily store the excess flow of up to 27 mgd in storage basins and then return the flow to the WWTP for treatment after the peak flows have subsided. When finished, this project would prevent overflows from overflow structures to Richmond Harbor during storm events but it would not eliminate sewer system overflows from other upper reaches of the sewer system. Based on the project's current schedule, the wet weather storage basin project would be completed before any new wastewater is generated at the RBC site and the impact related to excessive flows beyond wet weather treatment capacity would not occur. However, should that project be delayed and new buildings are constructed and occupied on the campus that generated new wastewater flows, campus development could potentially result in a significant impact related to wastewater. In addition, until such time that all I&I flows are eliminated from the sewer mains between the

RBC site and the RMSD WWTP, new wastewater generated by campus development could potentially contribute to localized system overflows and result in a potentially significant impact.

In summary, 2014 LRDP campus development would not have a significant effect on wastewater treatment capacity during dry weather conditions. During wet weather conditions, RBC development would not contribute to I&I flows but if the completion of wet weather storage facilities is delayed, RBC development could potentially add flows to a WWTP that is operating over capacity during wet weather. In addition, it could add wastewater flows to sewer mains that are at capacity due to I&I and result in localized system overflows. To address this potentially significant impact, Mitigation Measure LRDP CUM UTL-4 is proposed. With mitigation, the impact would be less than significant. In addition, Government Code Section 54999 authorizes public utilities to charge the University a limited capital facilities fee under certain circumstances (i.e., a non-discriminatory charge to defray the actual cost of that portion of a public utilities facility actually serving the University). If there are any costs incurred by the City of Richmond associated with providing wastewater facilities to serve the campus, the University would be expected to comply as authorized under Section 54999.

LRDP MM UTL-4: When a project under the 2014 LRDP is proposed that would increase wastewater flows discharged from the RBC site, the University shall work with the City of Richmond to evaluate the impact of the specific project on both the sewer mains and at the RMSD WWTP, and if necessary based on the results of the evaluation, the University will compensate the City for the cost of implementing improvements such as slip-lining sewer pipelines downstream of the project site to reduce I&I flows volumes equivalent to or greater than the incremental volume of wastewater generated by the project, or if necessary would construct underground vaults on the RBC site to detain wastewater to reduce peak flows to sewer mains during wet weather.

LRDP Impact UTL-5: Development under the 2014 LRDP would require the construction of new or expanded wastewater conveyance systems. The construction of new or expanded wastewater conveyance systems would not result in significant environmental effects. (*Less than Significant*)

Full 2014 LRDP campus development would produce 263.7 mgy or 0.7 mgd of wastewater over current flows, as shown in Table 4.14-2. The current RBC site wastewater conveyance system is not adequate to collect future campus wastewater flows, so additional sewer lines would be needed to connect to the main sewer line at the south end of the developed uplands area. The potential environmental effects of expanding or providing new RBC site wastewater conveyance systems are evaluated in Sections 4.1 through 4.13. As indicated by the analysis in these sections, the impacts will be less than significant or will be reduced to less than significant with mitigation. Although the analysis in LRDP Impact CR-3 in Section 4.4, Cultural Resources, concludes a significant and unavoidable impact related to demolition of historic structures, the future wastewater conveyance systems would not require demolition of a historic building. While there would be other significant and unavoidable impacts of LRDP development related to operational criteria pollutant and toxic air contaminant emissions, operational GHG emissions, and traffic, due to the nature of infrastructure upgrades and expansion, these improvements would not cause or contribute to these significant and unavoidable impacts.

It is not known if and when any improvements to off-site wastewater mains would be needed. RBC wastewater flows would continue to be monitored by LBNL/UC Berkeley and the City of Richmond to determine when off-site improvements are necessary. If improvements to the off-site wastewater mains are needed, their construction is not expected to result in significant environmental impacts. Due to the nature of infrastructure projects (i.e., underground pipelines installed in existing right-of-way under City streets), potential impacts are expected to be less than significant or if potentially significant, mitigable to a less than significant level. If there are any costs incurred by the City of Richmond associated with the provision of wastewater facilities to serve the campus, the University would comply as authorized under Government Code Section 54999.

Therefore the environmental impacts from the construction or expansion of wastewater conveyance facilities on- and off-campus would be less than significant.

Mitigation Measure: No mitigation measure is required.

Stormwater

LRDP Impact UTL-6: Development under the 2014 LRDP would require the construction of new or expanded stormwater drainage facilities. The construction of new or expanded stormwater drainage facilities would not result in significant environmental effects. (*Less than Significant*)

2014 LRDP campus development would result in the construction of 5.4 million gsf of building space and parking structures. Because much of the new construction and development would take place on currently disturbed and developed surfaces, impervious surfaces on the campus would not increase substantially over existing conditions. As discussed in Chapter 2, RBC site surface area is currently about 42 percent impervious and 58 percent pervious. With full 2014 LRDP development, the RBC would likely comprise about 43 percent impervious and 57 percent pervious surfaces. The increase in impervious surfaces would be relatively small (about 3 acres). Reductions in stormwater runoff would be achieved through the incorporation of LID design techniques consistent with NPDES requirements, the UC Sustainable Practices Policy, and LRDP goals that the site model sustainability.

The State Water Resources Control Board would require a project Construction General Permit to minimize erosion and sediment runoff as well as to prohibit the discharge of any pollutants in storm water runoff through the use of BMPs. The Construction General Permit applies to construction projects disturbing 1 or more acres; it requires all such dischargers to develop and implement a SWPPP. The SWPPP specifies BMPs to prevent construction pollutants from contacting stormwater, control off-site delivery of sediment and other construction-related pollutants, eliminate or reduce non-stormwater discharges to storm sewer systems and other jurisdictional waters, and inspect and monitor the success of all BMPs.

EISA Section 438 poses new requirements for stormwater runoff reduction for federally funded development projects. There are a variety of stormwater management design practices that can be used to meet the requirements including rain gardens, porous pavements, vegetated swales, and bioswales.

Future RBC site runoff is expected to decrease due to the LID and the sustainable design of the new campus. As portions of the RBC site are developed or redeveloped, new on-site stormwater drainage systems would be constructed. On-site stormwater drainage patterns would remain largely

unchanged: the RFS portion would continue draining to Meeker Slough and the Regatta portion would continue draining into the City storm drain system. The potential environmental effects associated with constructing new on-site stormwater drainage systems are evaluated in Sections 4.1 through 4.13. As indicated by the analysis in these sections, the impacts will be less than significant or will be reduced to less than significant with mitigation. Although the analysis in LRDP Impact CR-3 in Section 4.4, Cultural Resources, concludes a significant and unavoidable impact, the future storm drain systems would not require demolition of a historic building. While there would be other significant and unavoidable impacts of LRDP development related to operational criteria pollutant and toxic air contaminant emissions, operational GHG emissions, and traffic, due to the nature of storm drain systems, these improvements would not cause or contribute to these significant and unavoidable impacts. The NPDES permit for construction requires that stormwater runoff be the same or less than runoff under existing conditions. No changes to off-site storm drain systems are anticipated because the campus drainage patterns and volumes would remain substantially unchanged. Therefore, the environmental impacts from on-site stormwater drainage facilities construction would be less than significant.

Mitigation Measure: No mitigation measure is required.

Solid Waste

LRDP Impact UTL-7: Development under the 2014 LRDP would generate solid waste, but not enough to require new or expanded permitted landfill capacity. (*Less than Significant*)

Construction and Demolition

The 2014 LRDP campus would generate construction and demolition waste and debris as long as new development and renovation were to continue. The waste would be disposed of at the primary regional landfill serving the site, Potrero Hills Landfill. Additional landfills listed in Table 4.14-1, are also used by the WCCIWMA to dispose of waste. The Potrero Hills Landfill has a permitted daily intake limit—the maximum amount of waste that can be accepted at the landfill in one day—of 4,330 tons.

As reported in Chapter 2, demolition waste is estimated to be approximately 125 pounds per square foot of demolition. Construction waste is estimated at approximately 3.9 pounds per square foot of construction (EPA 1998). Without taking into account recycling, demolition of 750,000 square feet of existing buildings and construction of 5.1 million square feet of buildings on the RBC site would result in 56,825 tons of construction and demolition debris over the approximately 40 year planning period. Table 4.14-3 shows that amount of demolition and construction waste averaged over the 40 year planning period; it also shows the estimated peak debris amount that could be produced in any one year. Using these numbers, the average daily construction/demolition disposal requirement is estimated to be 5.5 tons. During a peak year of construction and demolition, the average daily volume is estimated to be 72.9 tons. These daily volumes were compared to the Potrero Hills Landfill's permitted daily intake limit of 4,330 tons. The comparison shows that campus demolition and construction waste requiring landfill disposal would represent between 0.12 and 1.7 percent of the permitted daily intake limit at the Potrero Hills Landfill. As needed, other landfills would be used to dispose of waste that would reduce the impact on the Potrero Hills Landfill.

Table 4.14-3
Demolition and Construction Waste Generated by the 2014 LRDP

Type of Activity	Anticipated Site-wide Average Annual Waste	Anticipated Site-wide Average Daily Waste[a]	Percent of Total Permitted Daily Intake[b]	Anticipated Peak Waste in One Year	Anticipated Peak Waste in Per Day[a]	Percent of Total Permitted Daily Intake[b]
Demolition (125 lbs/sf)	1,172 tons	4.5 tons	0.1%	15,625 tons	60.1 tons	1.4%
Construction (3.9 lbs/sf)	249 tons	1.0 ton	0.02%	3,315 tons	12.8 tons	0.3%
Total	**1,421 tons**	**5.5 tons**	**0.12%**	**18,940 tons**	**72.9 tons**	**1.7%**

Notes:
a Assuming waste is produced during the workweek only, 260 days a year.
b Assuming the Potrero Hills Landfill is open to receive waste only during weekdays, 260 days a year.
lbs/sf Pounds per square foot

Based on current UC Sustainability Practices Policy, a minimum of 75 percent of the construction waste would be diverted. The analysis above describes the worst case scenario of debris produced and transported to the landfill. Therefore, substantially less waste debris would be generated by RBC site construction and demolition.

As campus development construction and demolition debris would not result in an exceedance of the Potrero Hills Landfill's daily intake limit, construction related impacts to solid waste facilities would be less than significant. Implementation of LRDP ENVIRONMENTAL PROTECTION PRACTICE UTL-7 would further reduce this impact.

Operation

2014 LRDP development would increase RBC site population up to an additional 9,700 people who would operate and maintain the campus. This activity level would generate up to 21.3 tons of waste per day,[37] or 7,775 tons per year (CalRecycle 2012b). As the campus would comply with the UC Sustainable Practices Policy that requires UC facilities to attain a goal of 75 percent diversion by 2012 and a zero waste goal by 2020, the waste volume requiring landfill disposal would be considerably less than that estimated amount.

The Potrero Hills Landfill has a permitted daily intake limit of 4,330 tons. The increased RBC waste volume is projected to be less than 0.5 percent of the permitted daily intake limit. The WCCIWMA does deliver waste as needed to other landfills, listed in Table 4.14-1, which would further reduce the impact to any single landfill. Daily RBC waste volumes would not require expansion of regional landfills. Therefore, the 2014 LRDP development impact on regional landfills would be less than significant.

LRDP ENVIRONMENTAL PROTECTION PRACTICE UTL-7:

LBNL and UC Berkeley shall develop and implement a plan to maximize diversion of construction and demolition materials from landfill disposal. The plan would set a goal of a minimum of 75 percent diversion, consistent with the UC Sustainable Practices Policy.

[37] Based on the waste generation rate of 0.8 tons/employee/year from CalRecycle for "Services – Education."

LRDP Impact UTL-8: Development under the 2014 LRDP would comply with all applicable federal, State, and local statutes and regulations related to solid waste. (*Less than Significant*)

The University of California is not subject to AB 939. However, the University does reduce the amount of waste materials sent to landfills to the greatest extent possible. The RBC would comply with UC Sustainable Practices Policy that requires all University operations to prioritize waste reduction in the following order: reduce, reuse, then recycle. The University adopted a goal of zero waste by 2020. 2014 LRDP campus development would not violate any applicable state or federal statutes and would result in a less than significant impact.

Mitigation Measure: No mitigation measure is required.

Energy

LRDP Impact UTL-9: Development under the 2014 LRDP would require the construction of new or expanded electrical distribution facilities. The construction of new or expanded electrical distribution facilities would not result in significant environmental effects. (*Less than Significant*)

All RBC development would comply with the UC Sustainable Practices Policy. The Policy's green building goals stipulate that all new building projects, other than acute care facilities, shall be designed, constructed, and commissioned to outperform the CBC energy-efficiency standards by at least 20 percent; that all new buildings (except acute care facilities) will achieve at minimum a LEED Gold certification; and that the University will design, construct, and commission new laboratory buildings to achieve a minimum of LEED Gold certification and meet at least the prerequisites of the Labs21 EPC. All of these measures would minimize RBC site energy use.

Full campus development under the 2014 LRDP would result in a peak power demand of about 25 MW and would consume approximately 142,400 MWh annually, as shown in Table 4.14-2. The net electricity demand, factoring in the current energy use of the existing facilities on the RFS site, would be 138,700 MWh per year. Campus development would require on-site construction of 115 kv lines and a 115:12 kv substation that would supply a 12 kv distribution system. The substation would be built near the junction of Regatta Boulevard and 34th Street. The underground distribution system would include ductbanks, manholes, sectionalizing switches, and additional safety equipment generally in defined utility corridors. Each new facility would include transformers, switchgear, and a standby electrical generator with required capacity.

The potential environmental effects associated with upgrading and expanding the RBC site electrical power infrastructure are evaluated in Sections 4.1 through 4.13. As indicated by the analysis in these sections, the impacts will be less than significant or will be reduced to less than significant with mitigation. Although the analysis in LRDP Impact CR-3 in Section 4.4, Cultural Resources, concludes a significant and unavoidable impact, the future electrical power infrastructure development would not require demolition of a historic building. While there would be other significant and unavoidable impacts of LRDP development related to operational criteria pollutant and toxic air contaminant emissions, operational GHG emissions, and traffic, due to the nature of infrastructure upgrades and expansion, these improvements would not cause or contribute to these significant and unavoidable impacts.

No improvements to the off-site electrical infrastructure are anticipated. If improvements to off-site distribution lines are needed to serve the expanded campus, PG&E would evaluate the likely effects of these improvements and provide mitigation, as appropriate, for any significant environmental impacts.

Mitigation Measure: No mitigation measure is required.

LRDP Impact UTL-10: Development under the 2014 LRDP would require the construction of new or expanded natural gas distribution facilities. The construction of new or expanded natural gas distribution facilities would not result in significant environmental effects. (*Less than Significant*)

Campus development under the 2014 LRDP would result in a peak demand of about 240,300 kBtu/h and would annually consume approximately 6,600,000 therms of natural gas, as shown in Table 4.14-2. The net natural gas demand, factoring in the current energy use of the existing facilities on the RFS site, would be 6,526,400 therms/year. Natural gas would be provided to the campus by PG&E. To meet the demand, a new 8-inch gas pipeline would be installed in the eastern RBC site with three 5- or 6-inch laterals branching off of the main line to serve different clusters of facilities. A new 6-inch gas pipeline would be installed to serve development on the RBC's western portion. The underground distribution system would include piping, sectionalizing valves, and additional safety equipment generally in defined utility corridors. Each point of connection to PG&E would include new pressure reducers, meters, vaults, and safety equipment.

The potential environmental effects associated with upgrading and expanding the natural gas infrastructure are evaluated in Sections 4.1 through 4.13. As indicated by the analysis in these sections, the impacts will be less than significant or will be reduced to less than significant with mitigation. Although the analysis in LRDP Impact CR-3 in Section 4.4, Cultural Resources, concludes a significant and unavoidable impact, the future natural gas infrastructure development would not require demolition of a historic building. While there would be other significant and unavoidable impacts of LRDP development related to operational criteria pollutant and toxic air contaminant emissions, operational GHG emissions, and traffic, due to the nature of infrastructure upgrades and expansion, the impacts would not be significant and unavoidable.

No improvements to the off-site natural gas infrastructure are anticipated. If improvements to off-site distribution lines are needed to serve the expanded campus, PG&E would evaluate environmental impacts and, if appropriate, identify or provide any needed mitigation.

Mitigation Measure: No mitigation measure is required.

LRDP Impact UTL-11: Development under the 2014 LRDP would not result in the wasteful, inefficient, or unnecessary energy use. (*Less than Significant*)

Campus development under the 2014 LRDP would meet or exceed sustainability goals, including UC Sustainable Practices policies regarding green building, clean energy, and sustainable operations. The construction and renovation of facilities, and their operation and maintenance, would incorporate energy-efficient practices to reduce electricity and natural gas demand where possible. Any facility, such as a laboratory or data center, not required to meet code requirements for energy consumption would be designed to meet specific energy and carbon performance metrics, such as those defined by the Labs21. Laboratories for the 21st Century (Labs21) is a

voluntary partnership program cosponsored by EPA and DOE. LBNL is not required to participate in the Labs21 but could use the guidance to improve energy efficiency and environmental performance. RBC facility construction and operation would ensure that electricity and natural gas is used efficiently, so campus development under the 2014 LRDP would not result in the wasteful, inefficient, or unnecessary use of energy.

Mitigation Measure: No mitigation measure is required.

Cumulative Impacts and Mitigation Measures

Cumulative Impact UTL-1: Development under the 2014 LRDP, in conjunction with other regional growth, could increase the demand for utilities, service systems, and energy, the construction of which may result in significant environmental impacts. (*Potentially Significant; Less than Significant with Mitigation*)

As discussed above, with mitigation, campus development under the 2014 LRDP would not result in significant impacts on utilities and service systems. However, RBC development, in conjunction with reasonably foreseeable development in the City of Richmond and in nearby communities, could result in significant increases in demand for utilities and energy. The potential for significant cumulative impacts on utilities is discussed below.

Water Supply

EBMUD has indicated that the project site and its associated water demand are accounted for in the 2010 Urban Water Management Plan cumulative demand projections through 2040. Therefore, cumulative development, including the proposed project, would not result in the need for new, currently unplanned water supply facilities. There would be no significant environmental impacts from the development of new water supply facilities.

Wastewater

As analyzed above under the LRDP Impact UTL-4 analysis, the RSMD WWTP has enough wastewater treatment capacity to accommodate current and future dry weather flows, including under RBC development conditions. Wastewater service is provided on a first-come first-serve basis. During the 40-year campus development period, some of the available WWTP dry weather capacity may be taken up by other future development in the area. The proposed LRDP includes sustainability goals to minimize RBC water demand and wastewater; this would minimize the project's contribution to cumulative impacts. As a result of cumulative growth including the RBC project, some utility system improvements—especially to wastewater treatment capacity—could be necessary. The Richmond General Plan 2030 identifies the need for increased wastewater capacity by 2040 to accommodate projected dry weather wastewater flows. This would be addressed by constructing new wastewater facilities or expanding existing facilities. The Richmond General Plan EIR notes that because the specific nature of the needed improvements is not currently known, the types and significance of environmental impacts from WWTP improvements cannot be determined, so it conservatively finds that the impact would be significant and unavoidable.

In addition, as discussed for LRDP Impact UTL-4, due to I&I, wet weather flows exceed the WWTP's current wet weather treatment capacity. Because the campus would develop new on-site wastewater conveyance systems, it would not create new sources of I&I intrusion. However, project wastewater could contribute to WWTP capacity exceedances when added to regional, I&I-influenced wet weather flows and could contribute to localized sewer main overflows caused by I&I. To address this existing problem, the City of Richmond/Veolia Collection Systems

Master Plan has identified capacity improvement projects that would install larger diameter pipelines, parallel relief sewers, and wet weather storage. The cumulative impact related to sewer overflows into the harbor or in city streets is anticipated to be resolved by the City's actions of constructing wet weather storage facilities as well as making other improvements such as slip lining existing sewers and constructing relief sewers. When proposing future WWTP improvements or improvements to sewer mains and relief sewers, the City would presumably evaluate such projects for environmental impacts and mitigate as appropriate for potentially significant impacts. To the extent that the RBC would contribute to these impacts, pursuant to LRDP CUM MM UTL-1, the University would contribute its proportional share of the cost of environmental mitigation. Therefore, with mitigation, the contribution of the proposed LRDP to the cumulative impact related to wastewater treatment capacity improvements or improvements to sewer mains and relief sewers would not be cumulatively considerable.

Although CEQA does not consider a proposed project's fiscal impacts, Government Code Section 54999 authorizes public utilities to charge the University a limited capital facilities fee under certain circumstances (i.e., a non-discriminatory charge to defray the proportional cost of that public utility improvement directly benefiting the University). If the City incurs costs associated with wastewater facility improvements to serve the RBC, the University would defray appropriate costs as required by Section 54999. Capital facilities fees would compensate the utility provider for utility system improvement costs.

Energy

The proposed project, in conjunction with other foreseeable development in the surrounding area, would cumulatively contribute to electricity and natural gas demand increases. New development would occur in a largely built-out urban area served by existing utilities and service systems. These cumulative increases in demand would be individually addressed through appropriate CEQA review and by service provider assessments prior to new specific development approvals. The incremental 2014 LRDP increases in electricity and natural gas demand would not be substantial relative to overall service area demand; furthermore, existing utility delivery systems are expected to handle proposed RBC growth.

This far in advance, it is speculative whether cumulative development would trigger construction of new electricity generation facilities. Neither can any new generation facilities nor their potential environmental construction and operational impacts be known at this time. Before any new production and transmission facilities are approved for development, PG&E would analyze construction and operations and mitigate as appropriate any potentially significant impacts. Therefore, the cumulative electricity production and transmission facilities impact is not considered further in this Draft EIR. The 2014 LRDP includes sustainability goals to substantially minimize the Campus's energy use. The extensive programs focused on demand reduction would further minimize the project's cumulative impacts contribution.

Solid Waste

Cumulative City of Richmond development would produce additional quantities of solid waste, depending on net increases in population, building space, use intensity, and construction and demolition debris. This development would contribute to regional solid waste disposal and landfill capacity demands. There are 15 landfills available to serve the area, listed in Table 4.14-1, with a remaining aggregate capacity of 352,407,341 cubic yards.

The 2014 LRDP campus operations would generate an estimated 7,775 tons of solid waste per year. For the early years of campus development, about 75 percent of that solid waste would be recycled; with increased waste diversion in later years, that recycling percentage would grow. Considering the existing capacity in the disposal and recycling system and the extent of campus

efforts to decrease solid waste generation, the project contribution to this impact would not be cumulatively considerable.

Through City and private sector efforts, numerous source reduction, recycling, composting, and reuse programs have been implemented in the City of Richmond. These programs have increased waste diversion in City government and in the residential and commercial/industrial sectors. The City is currently diverting 50 percent of its solid waste. Given the City's record up to now, cumulative development in the City of Richmond would not hamper the City's ability to reach its waste diversion goals. The RBC would achieve a minimum 75 percent diversion rate with incorporation of solid waste diversion into campus practices. As all municipal jurisdictions are expected to meet the state-mandated diversion requirements and because the RBC would voluntarily reduce its solid waste for landfill disposal, there would not be a cumulative impact.

LRDP CUM MM UTL-1: The University will pay its proportional share of the environmental mitigation measures costs associated with required wastewater service improvements.

4.14.5 References

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CHAPTER 5
ANALYSIS OF RAW ACTIONS ADDRESSING RFS CONTAMINATION

This chapter discusses the environmental setting, impacts, and mitigation measures for the 14 fully evaluated environmental resource areas for the proposed RAW actions associated with RFS contamination described in Section 3.9.

The analysis of impacts presented in this chapter adheres to the approach and processes described in detail in Chapter 4. Chapter 4 defines the methodology, analytical approach, key assumptions and data used in the analysis. Chapter 4 presents the scope of the EIR, the levels of significance, thorough resource settings, regulatory considerations, impacts and mitigation measures, references, cumulative impact analysis, and cumulative plans and projects. While Chapter 4 addresses all activities presented in the project description for the proposed RBC (Chapter 3) including proposed RAW prescriptive and specific cleanup actions, this chapter more specifically evaluates impacts directly relevant to RFS contamination and the proposed RAW actions described in Section 3.9 Section 3.9 includes two categories of RAW actions. One category is site-wide prescriptive actions; the other category is specific cleanup actions. This chapter provides information to support DTSC's responsible agency CEQA determination on the proposed RAW for the developable areas of the RFS portions of the RBC site, as identified in Section 1.5, Intended Uses of the EIR. Regulatory considerations and references specific to each of the 14 environmental resource areas presented in Chapter 4 are not repeated in this chapter.

5.1 AESTHETICS AND VISUAL QUALITY

RAW Impact AES-1: Implementing the RAW would not have a substantial adverse effect on aesthetics and visual resources. (*Less than Significant*)

Views of the RBC site from public viewing points to the north are limited due to the presence of on- and off-site trees and the visual buffer of I-580. The most readily available public viewpoints are from the San Francisco Bay Trail and South 46th Street. Prescriptive and specific cleanup actions relevant to aesthetics and visual quality would consist of soil excavation and offsite disposal activities discussed in Section 3.9. Excavation and offsite disposal activities would be short-term and would be achieved using conventional excavation equipment such as backhoes and front-end loaders. Site preparation activities, such as clearing utilities, and clearing and grubbing, would also be conducted. Excavation depths would not exceed the depth of groundwater. Decontamination facilities for equipment and personnel would be located at a centralized decontamination area. Excavation and decontamination supplies and equipment would be stored such that -- to the extent practicable -- they would not be visually intrusive from off-site viewpoints. The proposed activities would not result in a substantial adverse effect on the scenic vista, create new sources of light or glare affecting day or nighttime views, damage scenic resources, or degrade the existing visual character. The aesthetic effects would be less than significant.

5.2 AIR QUALITY

RAW Impact AIR-1: Implementation of the RAW would generate emissions of criteria and toxic air contaminants that would not violate an air quality standard or contribute to an existing violation. (*Less than Significant*)

The CAA and the California Clean Air Act require that SIPs be developed for areas designated as nonattainment (with the exception of areas designated as nonattainment for the state PM10 standard), as discussed in Section 4.2. On September 15, 2010, BAAQMD adopted the 2010 Clean Air Plan. The 2010 Clean Air Plan updates the Bay Area 2005 Ozone Strategy in accordance with the requirements of the California Clean Air Act to implement all feasible measures to reduce ozone; provide a control strategy to reduce ozone, particulate matter, TACs, and GHGs in a single, integrated plan; and establish emission control measures. As discussed under LRDP Impact AIR-1, construction associated with RBC development under the 2014 LRDP would result in emissions that do not exceed BAAQMD CEQA thresholds. Therefore the emissions would not hinder the attainment of air quality standards.

Construction Criteria Pollutant Emissions

As discussed under LRDP Impact AIR-1, construction and demolition associated with campus development under 2014 LRDP would generate air pollutant emissions including airborne dust known as fugitive dust, emission from the operation of on- and off-road diesel construction equipment and vehicles, worker trips, architectural coatings such as paint, and paving off-gasses. Construction would typically begin with any necessary demolition, followed by site clearing and excavation. Soil-disturbing activities, such as site excavation, elevation, and grading and placement of infrastructure and structural foundations, would generate fugitive dust emissions that would contribute particulate matter to the local atmosphere.

Preliminary construction would include determining any special site or building conditions due to historic site contamination. If excavation is involved, soil that is suitable for commercial use may be shipped off site unless the project is a balanced cut-fill excavation that would reuse the soil on site. Contaminated soil would be excavated and removed by truck. Foundation work, building frame erection, and building finishing are the three major phases to follow.

Construction equipment would typically include large vehicles, stationary equipment, and hand-held equipment used on the building site and at nearby staging areas. They would be powered by diesel or gasoline engines or electricity. Such equipment would include cranes, scrapers, dozers, spreaders, compactors, loaders, drill rigs, haul trucks, cement trucks, bore drillers, rough terrain forklifts, pavers, rollers, and other rigs. The air quality analysis considered emissions from construction equipment during each phase of construction based on the number of pieces of equipment and the duration of their use. It also considered the number of truck trips to deliver supplies and equipment, to transport soil for site grading, and to remove contaminated soil. Vehicle trips by construction workers were also considered. Construction and demolition emissions were estimated using CalEEMod, version CalEEMod.2011.1.1.

The anticipated construction emissions are presented in Table 4.2-4 under LRDP Impact AIR-1. The estimates show that the maximum daily construction emissions from all overlapping phases of construction, including excavation and removal of contaminated soil under the RAW, would be well below the BAAQMD CEQA thresholds.

Fugitive dust would be generated by construction activities such as excavation, site elevation, and grading. BAAQMD does not have a quantitative threshold for fugitive dust emissions from

construction activities, but rather states that BMPs should be employed to control such fugitive dust emissions. Since there is no quantitative threshold for construction fugitive dust, these emissions were not quantified.

As stated in the LRDP Policy S3, fugitive dust from construction activities would be controlled by implementing the construction BMPs recommended in the BAAQMD CEQA Air Quality Guidelines. The BMPs relevant to controlling fugitive dust are:

- All exposed surfaces (e.g., parking areas, staging areas, soil piles, graded areas, and unpaved access roads) shall be watered two times per day.
- All haul trucks transporting soil, sand, or other loose material off-site shall be covered.
- All visible mud or dirt track-out onto adjacent public roads shall be removed using wet power vacuum street sweepers at least once per day. The use of dry power sweeping is prohibited.
- All vehicle speeds on unpaved roads shall be limited to 15 miles per hour (mph).
- All roadways, driveways, and sidewalks to be paved shall be completed as soon as possible. Building pads shall be laid as soon as possible after grading unless seeding or soil binders are used.

All excavated soils would be managed to prevent dust, spills to the ground or water, disposal into drains, and exposure risk to people or the environment. Excavation, transportation, and handling of all soil would be required to result in no visible dust at the fence line of the excavation. Any soil material proposed to be placed as fill, whether from an off-site source or on-site source, would be kept covered or moist to facilitate eventual compaction and to control dust during earthwork operations. A water truck, water tank, or hydrant would be available to supply water in sufficient quantity on the job site while earthwork operations are underway. Sufficient water would be applied to suppress dust while exercising care to avoid generating runoff to any area outside the project boundary. Dust control measures would be implemented, as appropriate and necessary, beginning with site mobilization and continuing during all phases of the construction activities. Water would not be applied if there was a possibility of spreading contaminated soil or leaching contaminants from the soil, or if it resulted in hazardous working conditions.

Construction emissions associated with the RAW would not exceed the BAAQMD CEQA thresholds and BMPs would be implemented to control fugitive dust, resulting in a less than significant impact.

Construction TAC Emissions

Human health effects from TAC emissions that would occur in association with construction and demolition activities under the 2014 LRDP were analyzed in a human health risk assessment (HRA). The TAC emissions from excavation and off-haul of soil under the RAW are included the construction HRA. The assessment calculated the estimated cancer risk, chronic and acute health hazards, and $PM_{2.5}$ concentrations that would be experienced at the maximally exposed individual on the project site as well as off-site in the nearby residential and non-residential areas. As shown in Table 4.2-6 under LRDP Impact AIR-3, construction and demolition TAC emissions under the 2014 LRDP would not result in human health risks or $PM_{2.5}$ concentrations for the maximally exposed individual that would exceed the BAAQMD CEQA thresholds and the impact would be less than significant. Therefore the TAC emissions associated with the excavation and off-haul of soil under the RAW would result in a less than significant impact.

Operational Criteria Pollutant and TAC Emissions

There would be no operational criteria pollutant or TAC emissions from the implementation of the RAW that would result in a cumulatively considerable net increase of criteria pollutants under the 2010 Clean Air Plan. Therefore, there would be no impact.

CO Hotspot

Under 40 CFR 93.123(c)(5) and the BAAQMD CEQA Guidelines, a CO hotspot analysis is not required for construction emissions as construction activities are short term and are considered unlikely to result in a CO hotspot.

Construction Emissions

Construction activities could generate temporary odors from fuel combustion and paving. These odors would be temporary and limited to the immediate project area and would be unlikely to affect a substantial number of people in the surrounding area. Therefore, the impact on air quality from construction-phase odors would be less than significant.

Naturally Occurring Asbestos

The RBC site is not in an area where naturally-occurring asbestos is likely to be present (California Department of Conservation 2000).

5.3 BIOLOGICAL RESOURCES

RAW Impact BIO-1: Implementing the RAW could have a substantial adverse effect on biological resources. (*Potentially Significant; Less than Significant with Mitigation*)

As described throughout Section 4.3.4, sensitive biological resources occur at the RBC site, including future areas impacted by implementation of the RAW. The RBC site includes natural areas such as the Western Stege Marsh and coastal grasslands (Figure 4-8). As shown in Figure 4-8, the proposed 2014 LRDP designates approximately 25 acres of the RBC site as Natural Open Space. This designation encompasses those areas the University plans to protect from development.. Disturbance of these natural areas would be limited under the LRDP and no activities associated with implementing the RAW would be conducted within the Natural Open Space; the RAW scope is limited to developable portions of the RFS within the proposed RBC.

With implementation of all 2014 RBC LRDP Mitigation Measures described in Section 4.3.4, adverse impacts would be less than significant. Long-term effects would be primarily beneficial as activities would reduce contaminants on the RBC site and thus reduce exposure of wildlife and vegetation to these potentially toxic substances. Specific discussions of biological resources are presented below.

Special Plant Species

Because no special-status plant species have been documented on the site during extensive botanical surveys (Amme 1993, Lidicker et al. 2003, URS 2007, WRA and Jane Valerius Environmental Consulting 2011a) or by the CNDDB, it is unlikely that protected species are present. Because the areas with the most suitable habitat for special-status plant species would be protected from development and no special-status species have been documented, impacts on special-status plant species are not likely to occur from RAW implementation.

Special-Status Bird Species

The RBC site includes natural areas such as the Western Stege Marsh and coastal grasslands and numerous older, wooden buildings that could be nesting or roosting sites for various bird species

(Figure 4-8). These areas provide potential nesting habitat for special-status bird species (Table 4.3-1). There is a high potential for nesting passerines, protected by the MBTA, to occur in multiple RBC site habitats. These include saltmarsh common yellowthroat and Alameda song sparrow in Western Stege Marsh; black phoebe on man-made structures; and western meadowlark in grasslands. California clapper rail, listed as endangered under the ESA and CESA, has been documented in Western Stege Marsh. Burrowing owl and California black rail, state threatened species, have not been documented on-site, but the site does contain potential owl (grasslands) and clapper rail (marsh) habitat. Raptors, protected by the MBTA and California Code Sections 3503 and 3503.5, are likely present as described in Section 4.3.2.

Because the RBC site provides suitable nesting habitat for MBTA, ESA, and/or CESA-protected birds, loud noise within 100 feet of nests during the nesting period (approximately March 1 through August 15) could result in nest abandonment and "take" of young. Such noise could be from building demolition and construction, site preparation, utilities rerouting, and tree removal during construction.

The proposed excavation activities would be outside of clapper rail habitat and thus minimize potential noise impacts. Nevertheless, noise and other human disturbance—especially related to construction and demolition activities—near the marsh could affect avian use and result in flushing, avoidance, or nest abandonment. Because RAW activities would not be located within the Natural Open Space areas, there are not likely to be direct effects on Western Stege Marsh. With implementation of LRDP MM BIO-2 as presented in Section 4.3.4 as part of the project, potential impacts on special-status birds from construction and operations would be tless than significant.

Bat Species

Several bat species may occur at the RBC site (Table 4.3-1). Brazilian free-tailed bat is the most likely to occur. No bat species federally or state-listed as threatened or endangered are likely to occur. One species, pallid bat, is a California species of concern. Bats may inhabit abandoned RBC buildings or exfoliating tree bark crevices or hollow tree cavities. This would most likely occur in the site's perimeter areas. Tree and building removal could result in direct bat mortality; however there are no tree or building removals anticipated as a result of RAW activities. Construction noise and human disturbance could cause maternity roost abandonment and subsequent death of young. With implementation of LRDP MM BIO-3 presented in Section 4.3.4 as part of the project, the proposed project would not result in a substantial adverse effect on bats, and the effect would be less than significant. This measure would apply to all areas containing trees and buildings suitable for bat roosts.

Monarch Butterflies

The monarch butterfly is not listed as threatened or endangered under either the ESA or CESA, but it is considered by the state of California to be either restricted in its distribution, declining throughout its range, or associated with declining habitats in California. This butterfly has been documented at the RBC site and occupies the eucalyptus stands and the developed, horticultural landscaped areas (Figure 4-8). This species uses the eucalyptus trees during the winter months for cover and thermal regulation. Eucalyptus tree removal would reduce the available habitat for monarch butterflies. As described earlier (Section 4.3.3, Eucalyptus Stands subsection), eucalyptus creates habitat that attracts monarchs, but that habitat may act as a "sink" - attracting monarchs to a habitat that can be harmful to the species. Therefore, eucalyptus removal would have a mixed effect that is neither exclusively adverse nor beneficial. The RAW activity impacts on the monarch butterfly would not be considered substantial adverse effects on the monarch butterfly because it is not a special-status species and there are no anticipated eucalyptus tree removals.

Sensitive Natural Communities

There are 22 acres of high quality grassland habitat, considered a sensitive natural community, at the RBC site. These are within the Big Meadow, Northwest Meadow, West Meadow, and EPA Meadow North (WRA and Jane Valerius Environmental Consulting 2013). In 15 of the 22 high quality grassland acres, comprising the majority of the area within the Big, West, and EPA North Meadows, there would be no anticipated direct impacts from the RAW activities as these acres would be part of the 25-acre Natural Open Space area.In the seven acres of high quality grassland in the RES area, prescriptive RAW activities would potentially cause direct impacts associated with soil disturbance including excavation or compaction from people and vehicles

In addition, RAW activities would potentially cause indirect impacts on high quality grasslands including increased potential weed intrusion and unintentional seed distribution from soil disturbance.

With implementation of LRDP Mitigation Measure BIO-5 presented in Section 4.3.4 as part of the project, impacts from RAW activities on sensitive natural communities would be less than significant.

Federally-Protected Wetlands

Wetlands and potential wetlands are described in Section 4.3.2. While Campus development under the 2014 LRDP could result in adverse impacts on potentially jurisdictional RBC site waters, including drainages and wetlands (Figure 4-8), the proposed RAW activities would have low potential to impact jurisdictional waters. No jurisdictional wetlands have been identified in the proposed excavation areas identified in Section 3.9.2. Some specific development could fill in or create a potential for accidental discharges to jurisdictional waters. Any RAW activity resulting in permanent or temporary fill of jurisdictional waters would most likely be subject to provisions of Sections 401 and 404 of the Clean Water Act, Sections 1600 through 1616 of the California Fish and Game Code, and the Porter Cologne Act. Such projects may qualify for a nationwide permit (NWP) issued by the USACE. The most likely applicable NWP for RBC projects would be NWP 39, Residential, Commercial, and Institutional Developments. Although nationwide permit specifications vary, NWP 39 typically applies where jurisdictional waters are less than 0.5 acre in area and no more than 300 linear feet of intermittent or perennial stream are to be filled. Even if these limitations are met, the USACE has discretion under certain circumstances to require a more stringent individual permit.

Any project requiring USACE authorization also must obtain a Section 401 RWQCB certification or waiver of certification. These must be obtained prior to project implementation and would stipulate approval conditions designed to minimize adverse effects on wetland resources. Acquisition of these permits is a regulatory requirement and is not considered mitigation for loss of waters of the US. However, the processes for obtaining any state or federal wetlands permits involve the development of compensatory actions similar to CEQA-derived mitigation in scope and intent. In addition to the acquisition of necessary permits, with implementation of the mitigation measure LRDP MM BIO-6 presented in Section 4.3.4 as part of the project potential impacts on jurisdictional waters would be less than significant.

5.4 CULTURAL RESOURCES

RAW Impact CR-1: Implementing the RAW could have a substantial adverse effect on cultural resources. (*Potentially Significant; Less than Significant with Mitigation*)

The University of California, Berkeley Museum of Paleontology conducted a record search for paleontological resources in the area and determined that there have been no prior fossil finds in the RBC, as presented in Section 4.4. As part of the consultation process with Native American organizations and individuals, the Native American Heritage Commission was contacted on January 24, 2013, with a request for information about any sacred lands related to the project site and for a list of interested Native American groups and individuals in Contra Costa County. The Native American Heritage Commission has not responded to date. There are no historic structures or resources in areas identified for cleanup under the RAW.

Although most, if not the entire RBC site, has been disturbed in conjunction with previous site uses, previously unknown archaeological resources or human remains may be encountered during soil-disturbing activities related to implementing the RAW. With implementation of LRDP MM CR-1 as part of the project, the impact would be less than significant.

5.5 GEOLOGY AND SOILS

RAW Impact GEO-1: Implementing the RAW would not have a substantial adverse effect on geology and soils. (*Less than Significant)*

Under the RAW, soil would be excavated or evaluated for contamination prior to on-site reuse or off-site disposal. Hazardous soil would be categorized for transport to appropriately permitted and licensed off-site facilities. Soil acceptable for commercial use would be placed and compacted in the excavation. All excavation fill materials would meet a minimum of 90 percent compaction using industry standard techniques and compliant with the University Seismic Safety Policy discussed in Section 4.5. RAW activities will not result in the construction of buildings or structures and therefore will not expose people or structures to adverse effects from the ruptures of known earthquake faults, strong seismic ground shaking, seismic-related ground failure, including liquefaction, or landslides.

Erosion control measures, monitoring, and reporting would be conducted in accordance with applicable State Water Resources Control Board General Construction Permit requirements for RAW actions. The limited amount of excavation specific to RAW activities would result in a minor increase in the potential for soil erosion during those activities; however, final site finishing would meet current site cover material requirements? and thereby limit future soil erosion.

5.6 GREENHOUSE GAS EMISSIONS

RAW Impact GHG-1: Implementation of the RAW would generate GHG emissions that would not result in a significant impact on the environment or conflict with applicable GHG plan. (*Less than Significant*)

Construction GHG Emissions

Excavation of the contaminated soil and subsequent placement of clean soil would require construction vehicles such as backhoes and front-end loaders, trucks to transport the soil to and from the RBC site, and construction worker vehicle trips. During construction, the proposed

project would generate GHGs from the exhaust of construction equipment and truck traffic. The excavation of the soil would occur on a project by project basis and would be spread out over many years.

As explained under LRDP Impact GHG-1, construction-phase GHG emissions were estimated based on the maximum amount of construction activity that is expected to occur at the RBC site, as presented in Section 4.6. Carbon dioxide emissions associated with the maximum annual construction activities under the 2014 LRDP are approximately 450 metric tons. This annual amount is too small to have a measureable effect on global climate and is well below the threshold of 1,100 MTCO2e developed by BAAQMD for evaluating the significance of a project's operational GHG emissions. The impact from LRDP-level construction emissions would be less than significant. As the scale of construction activities under the RAW would be substantially smaller than the estimated annual construction activities for LRDP development, the RAW would result in very low annual emissions of GHGs, and the impact from RAW construction emissions would be less than significant.

AB 32 and Executive Order S-3-05 are the basis for GHG emissions reductions in California. Local agencies such as BAAQMD base their planning and regulations on the AB 32 requirements, including a reduction of GHG emissions to 1990 rates by 2020. BAAQMD adopted its GHG significance thresholds specifically to meet AB 32 requirements in its jurisdiction, and so projects meeting those thresholds can be assumed to meet the requirements of AB 32. As the estimated construction GHG emissions from the RAW would be well below BAAQMD threshold, the project would not conflict with AB 32, and the impact would be less than significant.

Operational GHG Emissions

There would be no operational emissions from implementation of the RAW. Therefore, emissions would not exceed significance thresholds and would not conflict with AB 32. There would be no impact.

Mitigation Measure: No mitigation measure is required.

5.7 HAZARDS AND HAZARDOUS MATERIALS

RAW Impact HAZ-1: **Implementing the RAW would not have a substantial adverse effect related to hazards and hazardous materials (*Less than Significant)***

As discussed in Section 4.7.2, the RFS portion of the proposed RBC site includes some areas of contaminated soil and groundwater. The University has done substantial work in characterizing site contamination. Arsenic, copper, lead, mercury, PCBs, and polyaromatic hydrocarbons have been detected in the soil at levels exceeding commercial use standards. The RFS portion of the proposed RBC site is listed on the current California EPA Hazardous Waste and Substances Sites List, also known as the "Cortese list" (California Government Code Section 65962.5). This listing is due to prior site activities that resulted in soil contamination at specific site locations. The DTSC has been directing efforts to address the effects of this past contamination on the RFS portion of the RBC site If Under the proposed RAW, if approved by DTSC under Chapter 6.8 of the Health and Safety Code, soil would be excavated or evaluated for contamination prior to on-site reuse or off-site disposalHazardous soil would be categorized for transport to appropriately permitted and licensed off-site facilities. Contaminated groundwater would be treated to remove contamination] The impacts of such activities would not be expected to create a significant hazard to workers, the public, or the environment.

Dust and air monitoring activities during RAW actions would also be conducted to ensure protection of public health and safety. The proposed RAW identifies specific air monitoring activities, including sampling equipment, locations, and action levels . There are no existing or proposed schools within one quarter mile of the proposed RBC.

Compliance with all applicable federal, state, and local laws and regulations related to the remediation and transportation of hazardous materials would minimize the potential for a release and provide for prompt and effective cleanup if an accidental release occurred. Therefore, the impacts related to accidental release associated with any remediation and transportation pursuant to the proposed RAW would be less than significant. Safety plans, programs, practices, and procedures implementation, as defined in LRDP Impact HAZ-1 discussion presented in Section 4.7, would ensure these impacts remain less than significant.

As discussed in Section 4.7.3, emergency response plans are maintained at the Federal, State, and local level for all types of disasters, including human-made and natural. UC Berkeley and LBNL would coordinate with state and local authorities to develop a site-specific emergency response plan for the proposed new RBC facilities. The UC Berkeley EH&S Emergency Response Team and LBNL responders would be capable of responding to most RBC incidents and, if necessary, may arrange for appropriate assistance from the City of Richmond Fire Department, the LBNL Fire Department, and outside emergency response contractors. Because on-site activities that could trigger emergency response would generally be similar in nature to current types of LBNL and UC Berkeley activities, and because existing emergency control and avoidance programs would continue, implementation of RAW activities would not exceed emergency response capabilities and impacts would be less than significant.

5.8 HYDROLOGY AND WATER QUALITY

RAW Impact HYD-1: Implementing the RAW would not have a substantial adverse effect on hydrology and water quality. (*Less than Significant)*

The RAW activities primarily consist of excavating soil and the implementation of ongoing groundwater monitoring and stormwater pollution prevention control best management practices, which would not result in impacts to hydrology, water quality, or discharge requirements. The proposed installation of monitoring wells and continued groundwater monitoring would allow for increased evaluation of hydrology and water quality.

There are no anticipated groundwater extraction activities which would substantially deplete groundwater supplies or interfere with groundwater recharge. Excavation and fill activities will not alter the existing drainage pattern of the site and there are no streams or rivers at the site.

The RAW activities would not result in the permanent placement of any structures within a 100-flood hazard area. The RAW activities would not expose people or structures to significant risk of loss, injury, or death involving flooding or inundation by seiche, tsunami, or mudflow.

5.9 LAND USE AND PLANNING

RAW Impact LU-1: Implementation of the RAW would not have a substantial adverse effect related to land use and planning. *(Less than Significant)*

The RAW activities would be consistent with the land use plan managed at the University-owned land parcels comprising the RBC site, would not divide an established community and would not interfere with existing or future land uses on or adjacent to the RBC site.

RAW actions would be conducted in conjunction with future development under the 2014 RBC LRDP. RAW actions would not construct any facilities or involve any new land uses that may conflict with the 2014 LRDP, the City of Richmond General Plan, or the Eastshore State Park General Plan. The impact from RAW activities would be less than significant.

5.10 NOISE

RAW Impact NOISE-1: Implementing the RAW could have a substantial adverse effect on noise. (*Potentially Significant; Less than Significant with Mitigation*)

The activities conducted under the RAW would result in short-term noise and groundborne vibration at the levels described for construction under LRDP Impact NOISE-1 and presented in Tables 4.10-5 and 4.10-6. The distance from RAW sites to sensitive receptors would vary and would be no less than 150 feet. Noise levels at the nearest sensitive receptor and in other surrounding areas could exceed the Richmond Noise Ordinance noise limits for stationary construction equipment (i.e., equipment that is operated for more than 15 days).

Equipment and vehicles used for activities conducted under the RAW, such as backhoes, front-end loaders, and trucks, would not result in groundborne vibration. Therefore, groundborne vibrations would not exceed damage or annoyance thresholds and thus would be less than significant.

As described under LRDP Impacts NOISE-1 and NOISE-2, construction and demolition activities associated with the 2014 LRDP would not expose people to noise levels in excess of standards established in Richmond's Noise Ordinance or result in significant temporary or periodic increases in noise or vibration with the incorporation of mitigation measures LRDP MM NOISE-1a through 1c (Chapter 4.10) as part of the project.

Project construction noise and vibration would cumulatively overlap with construction noise from only one cumulative project in the area: the proposed redevelopment at Bio-Rad Laboratories west of the RBC site. The Bio-Rad Laboratories project is required to comply with the Richmond Noise Ordinance for construction noise limits. The City of Richmond prepared CEQA documentation for the proposed Bio-Rad project that includes imposition of noise mitigation measures. These measures limit noisy Bio-Rad project construction activities, including on-road truck trips near the project, to 7:00 a.m. to 7:00 p.m. on weekdays and 8:30 a.m. to 6:00 p.m. on Saturdays and legal holidays. No construction is permitted on Sundays. There is no indication that the proposed construction would include any unusual vibration-generating activities or equipment that would exceed vibration damage thresholds (City of Richmond 2010). Therefore, temporary noise and vibration impacts from the proposed Bio-Rad Laboratories project in combination with RAW activities would be less than significant. Accordingly, with implementation of LRDP MM

NOISE-1 as part of the project, there would not be a cumulatively considerable temporary increase in ambient noise levels and groundborne vibration in the project vicinity.

Long-term, permanent, temporary, or periodic ambient noise impacts would not occur from RAW activities.

With implementation of Mitigation measures LRDP MM NOISE-1a through -1c, noise associated with RAW activities would be reduced in accordance with the Richmond Community Noise Ordinance. With implementation of these mitigation measures as part of the project, RAW noise impacts would be less than significant.

5.11 POPULATION AND HOUSING

RAW Impact POP-1: Implementing the RAW would not have a substantial adverse effect on population and housing. (*Less than Significant*)

Cleanup actions under the RAW consist of soil excavation and groundwater monitoring, as presented in Section 3.9. These actions do not impact any existing buildings or structures and therefore, would not affect the RBC population, as discussed in Section 4.11. There would be no increase in permanent employees adding to the residential population of the City of Richmond, other nearby communities, or the region. Since no buildings are affected, there would be no displacement of housing or people. Impacts to population and housing would be less than significant.

5.12 PUBLIC SERVICES AND RECREATION

RAW Impact PS-1: Implementation of the RAW would not result in a substantial adverse effect on public services and recreational facilities. (*Less than Significant*)

The excavation and placement of soil associated with RAW activities would not increase demand for fire protection, police services, schools, public facilities, parks or other recreational facilities, as discussed cumulatively in Section 4.12. RAW construction-related activities would be short term, and construction crews would not relocate to Richmond or other nearby communities to work on the RAW activities. Therefore, the impact to public services and recreational facilities from the implementation of the RAW would be less than significant.

5.13 TRANSPORTATION AND TRAFFIC

RAW Impact TRA-1: Implementing the RAW would not have a substantial adverse effect on transportation and traffic. (*Less than Significant*)

The activities conducted under the RAW would result in short-term and temporary increases to traffic in the vicinity of the RBC site. These increases would result from temporary and intermittent impacts from truck movements and worker vehicles. The construction-related traffic may temporarily reduce area roadway capacities because of the slower movements and larger turning radii of construction trucks compared with passenger vehicles. Traffic from RAW activities would occur during daytime working hours and would not be concentrated during either the AM or PM peak hours; therefore, any impacts to study intersections would be less than significant. A complete detailed analysis of transportation and traffic for the proposed RBC activities is presented in Section 4.13.

Implementing the RAW would not involve the size or frequency of vehicles requiring temporary closure of nearby streets and paths that would impact vehicular, pedestrian or bicycle traffic, nor would traffic conditions result that would increase traffic hazards or impede emergency access.

5.14 UTILITIES, SERVICE SYSTEMS, AND ENERGY

RAW Impact UTL-1: Implementation of the RAW would not result in a substantial adverse effect on utilities, service systems, and energy. (*Less than Significant*)

Soil excavation and placement pursuant to the RAW would require minimal water for dust and particulate controls during construction. The cleanup efforts would not require any utilities or construction of utility infrastructure. No wastewater treatment plant services or storm water drainage facilities would be required for the RAW activities; therefore no wastewater treatment is necessary for these activities. Minimal water for decontamination would be required during RAW activities. Decontamination facilities for equipment and personnel would be located at a centralized decontamination area. All decontamination water would be containerized, sampled and disposed of off-site at a suitable disposal facility and therefore would have no impact on local utilities.

Under the propsed RAW, if approved by DTSC under Chapter 6.8 of the Health and Safety Code, soil excavated as part of RAW activities would be sampled and characterized for proper off-site disposal, or reused on site The estimated soil volume requiring off-site disposal in connection with future prescriptive RAW activities is between 1,000 and 5,500 cubic yards. For the specific RAW cleanup actions, the soil volume requiring off-site disposal at a Class 1 solid waste facility is estimated at between 1,200 and 2,000 cubic yards of mercury contaminated soil and 500 cubic yards of soil contaminated with PCBs and other compounds for a total of between 1,700 and 2,500 cubic yards of soil. Future RAW activities in conjunction with future redevelopment or construction activities occurring over many years as specific facilities are constructed might resulti in small amounts of soil requiring disposal in any one year. The impact to solid waste facilities would be less than significant. All soil sampling, characterization, and disposal actions would comply with federal, state, and local statutes and regulations related to solid waste.

Therefore, the impact to utilities, service systems, and energy from the RAW would be less than significant.

5.15 OTHER CEQA CONSIDERATIONS REGARDING RAW ACTIONS

This section presents the CEQA findings regarding significant and unavoidable effects, significant irreversible environmental changes, growth inducing impacts, and effects found not to be significant related to the RAW.

Significant and Unavoidable Effects

As identified and described above, RAW activities would not result in any significant and unavoidable impacts.

Significant Irreversible Environmental Changes

This section evaluates whether the proposed project would result in the irretrievable commitment of resources or cause irreversible changes in the environment. An example of an irreversible environmental change occurs when a general plan changes a land use by proposing the development of farmland or when a project extends utility and transportation infrastructure to an

area without those services. Because of the developed nature of the project site, the proposed RAW actions do not introduce significant irreversible changes.

Growth Inducing Impacts

As described in Section 5.11, Population and Housing, the project would not increase the employee population at the RBC site or induce substantial population growth in Richmond or elsewhere in the region, either directly or indirectly.

Effects Found to be Insignificant without Further Analysis

Project impacts to Agriculture and Forest Resources and Mineral Resources were determined to require no additional analysis. Impacts related to the following topic areas were determined to require no additional analysis and are discussed in the Initial Study in Appendix A:

- Substantial damage to scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings in a state scenic highway corridor (Aesthetics and Visual Quality)
- Conversion of Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use (Agriculture and Forest Resources)
- Conflicts with existing zoning for agricultural use, or a Williamson Act contract (Agriculture and Forest Resources)
- Changes in the existing environment which, due to their location or nature, could result in conversion of Farmland to non-agricultural use (Agriculture and Forest Resources)
- Conflicts with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code Section 12220(g) or timberland (as defined by Public Resources Code Section 4526) (Agriculture and Forest Resources)
- Loss of forest land or conversion of forest land to non-forest uses (Agriculture and Forest Resources)
- Conflicts with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other applicable habitat conservation plan (Biological Resources)
- Exposure of people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area, or based on other substantial evidence of a known fault. Refer to Division of Mines and Geology Special Publication 42. (Geology and Soils)
- Exposing people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving landslides (Geology and Soils)
- Soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water (Geology and Soils)
- For a project in an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, safety hazards for people residing or working in the project area (Hazards and Hazardous Materials)

- For a project near a private airstrip, safety hazards for people residing or working in the project area (Hazards and Hazardous Materials)
- Exposure of people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands (Hazards and Hazardous Materials)
- Housing in a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map (Hydrology and Water Quality)
- Conflicts with any applicable habitat conservation plan or natural community conservation plan (Land Use and Planning)
- Loss of availability of a known mineral resource that would be of value to the region and the residents of the state (Mineral Resources)
- Loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan (Mineral Resources)
- For a project in an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, exposure of people residing or working in the project area to excessive noise levels (Noise)
- For a project near a private airstrip, exposure of people residing or working in the project area to excessive noise levels (Noise)
- Displacement of substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere (Population and Housing)
- Displacement of substantial numbers of people, necessitating the construction of replacement housing elsewhere (Population and Housing)
- Change in air traffic patterns, including either an increase in traffic levels or a change in location, that results in substantial safety risks (Transportation and Traffic)

CHAPTER 6
ALTERNATIVES

6.1 INTRODUCTION

CEQA requires that an EIR evaluate the comparative effects of "a reasonable range of potentially feasible alternatives" to a project. Alternatives are deemed appropriate for EIR analysis if they "would feasibly attain most of the basic objectives of the project but would avoid or substantially lessen any of the significant effects of the project" (CEQA Guidelines Section 15126.6(a)). A recognized "rule of reason" holds that the EIR need only analyze those alternatives necessary to permit a reasoned choice (CEQA Guidelines Section 15126.6(f)). Evaluation of a No Project Alternative and identification of an environmentally superior alternative are required. The significant effects of the alternatives shall be discussed, but in less detail than the significant effects of the proposed project (CEQA Guidelines Section 15126.6(d)).

6.2 PROJECT OBJECTIVES

In order to accomplish the purpose and need, the University has the following project objectives for the LRDP. The project should:

- Be located within an approximately 20- to 25-minute commute from the existing LBNL main entrance at Blackberry Gate on Hearst Avenue; or an approximately 20 minute commute from UC Berkeley's main entrance at Oxford and University Avenue.
- Have development capacity for approximately 5.4 million gsf of laboratory, office, and support facilities and related utility and transportation infrastructure to support the University's research, teaching, and public service mission.
- Be located in a safe and welcoming community with a positive civic expression of interest in development of the site.
- Be readily accessible to a variety of modes of public transportation, inclusive of local buses, mass transit (BART, Amtrak, and AC Transit), and shuttle services, and allow safe bicyclist access from designated bicycle routes.
- Allow for electrical, natural gas, and water utilities for the lowest possible cost.
- Allow consolidation of LBNL bioscience programs.
- Allow for establishment of a design framework for development of a state-of-the-art research campus that will be the location of choice for internationally recognized researchers.
- Foster synergy and collaboration between UC Berkeley and LBNL and within and across disciplines and institutions in both the public and private sectors.
- Provide sustainable land use and circulation patterns which maximize density to reduce overall building footprints and conserve open space, and maximize bicycle, pedestrian and shuttle services allow for placement and massing of buildings to maximize shared views.
- Facilitate efficient constructability of facilities (buildings, parking structures, bridges, etc.), infrastructure development (roads, underground utilities, pedestrian walkways, etc.), and open space.
- Foster connectivity with the surrounding community.

- Leverage capital investment for environmental stewardship

The proposed project is expected to have significant and unavoidable adverse impacts on air quality, cultural resources, greenhouse gas emissions, and transportation and traffic. The significant impacts on aesthetics and visual quality, biological resources, geology and soils, noise, and utilities, service systems, and energy could be mitigated to less than significant. Less than significant impacts are anticipated for hazards and hazardous materials, hydrology and water quality, land use and planning, population and housing, and public services and recreation.

6.3 RANGE OF ALTERNATIVES CONSIDERED

The EIR alternatives were selected in consideration of one or more of the following factors:

- The extent to which the alternative would accomplish most of the basic project objectives (identified in Section 6.2 above);
- The extent to which the alternative would avoid or lessen any of the project's significant adverse environmental effects;
- Feasibility, taking into account site suitability, economic viability, infrastructure availability, regulatory consistency, and the project sponsor's ability to acquire or control the site;
- Contribution toward assembling a "reasonable range" of alternatives necessary to permit a reasoned choice;
- CEQA Guidelines requirements, including for the analysis of "no project" and "environmentally superior" alternatives (CEQA Guidelines Section 15126.6); and
- Scoping requests and suggestions from the public, groups, and/or agencies.

The following project alternatives to full 2014 LRDP development of the RBC site are considered in this EIR:

- Alternate Development Program;
- Reduced Growth Program;
- Development at one of the locations considered during the site selection process; and
- No Project Alternative.

6.4 ALTERNATIVES CONSIDERED BUT REJECTED

None of the alternatives presented in Section 6.3 were rejected. Alameda Point was selected as representative of a group of sites that were considered during the process that led to identification of the University's Richmond properties as the preferred location for a new research campus.

6.5 ALTERNATIVES CONSIDERED IN DETAIL

This section provides detailed descriptions and analyses of the following alternatives to full RBC development:

- Alternate Development Program (Alternative 1);
- Reduced Growth Program (Alternative 2);
- Alameda Point Alternative (Alternative 3); and
- No Project Alternative (Alternative 4).

A description of these alternatives, as well as a discussion of their potential impacts compared to those of the proposed project, is provided in the sections that follow. The attributes of these alternatives are presented in Table 6-1.

Table 6-1
Comparison of the LRDP Alternatives

	Proposed Project	Alternative 1	Alternative 2	Alternative 3
Total Acreage	134	134	134	124
Development Acreage	109	109	109	124
Natural Open Space Acreage	25	25	25	0
Development Square Footage	5.4M gsf	5.4M gsf	3.6M gsf	5.4M gsf
Employee Population	10,000	10,000	8,400	10,000
Building Demolition	0.75M gsf	0.75M gsf	0.75M gsf	TBD

6.5.1 Alternative 1: Alternate Development Program

Description

Under the Alternate Development Program, the 2014 LRDP would be modified to include a large-scale future scientific facility or machine with certain unique features/characteristics and utility demands. Such facilities exist at LBNL and other National Laboratories; they are often cutting-edge "user facilities" that attract nationwide and international researchers. These facilities are typically unique and take many forms; at LBNL, user facilities include an electron microscope facility, a light-source synchrotron, a supercomputing center, and a nanoscience laboratory. For this RBC alternative, the University has no particular type of scientific facility in mind, but to keep a wide variety of future options open, there are certain characteristics that would be assumed for planning purposes: the future scientific facility would be housed in a large, dedicated building or buildings; it would likely require generous amounts of utilities, particularly energy for heating, cooling, back-up power, and heavy machinery; and it should have the ability to lay out in a lengthy footprint that could include tunneling or trenching.

Including this facility as part of the RBC would not exceed the total building space that is anticipated under the proposed project, an increase from approximately 1,050,000 gsf at the present time to 5,400,000 gsf at full implementation. Also, this alternative would demolish and retain the same amount of existing building space as would the proposed project. The campus population would also increase in the same manner as the proposed project from approximately 300 persons in 2012 to approximately 10,000 persons in 2050. Under this alternative, approximately 108 acres of the RBC upland parcels would be developed, and approximately 25 acres of the upland parcels would be preserved as natural open space. Land uses under this alternative would be the same as those depicted in proposed project Figure 3-3.

The Alternate Development Program would satisfy all of the University's project objectives. As described below, it would result in impacts similar to those of the proposed project in most resource areas, but would result in potentially greater impacts in the areas of biological resources, air quality, and greenhouse gas emissions.

Impacts

Aesthetics and Visual Quality

Aesthetic impacts under the Alternate Development Program would be substantially the same as that of the proposed project. As with the proposed project, this alternative has the potential to result in potentially significant impacts to the visual character of the campus site through an increase in buildings that are visible from off-site.(LRDP Impact AES-1). Similarly, the Alternate Development Program would not result in significant impacts to the view of scenic vistas in the vicinity (LRDP Impact AES-2) and the impact on artificial light and glare was evaluated to be less than significant due to the existing industrial character of the area and existing facilities in the vicinity of the proposed site (LRDP Impact AES-3). Mitigation measures applicable to the proposed project would apply to this alternative. Impacts of this alternative would be less than significant with mitigation.

Air Quality

The Alternative Development Program would include approximately the same square footage and the total daily site population; the major difference would be inclusion of a large-scale "future scientific facility" with this alternative. The future scientific facility could include research operations that emit criteria air pollutants and TACs. Because the specific nature of such a facility would be based on future proposals, specific details about facility construction and operations cannot be known, and no quantitative analysis has been done to account for these projected uses. Future scientific facility operations could increase air emissions beyond the levels identified and analyzed for the proposed project. The mitigation measures applicable to the proposed project would be incorporated for this alternative, and although these mitigation measures would minimize emissions and address potential long-term health risk, air quality impacts are assumed to remain significant and unavoidable.

Biological Resources

Impacts related to demolition and building construction and increased projected campus populations would be the same.

The proposed project would preserve approximately 15 acres of high quality coastal terrace prairie grassland habitat in the Big Meadow, West Meadow, and EPA Meadow North within the Natural Open Space area. These meadows would not be impacted by project development as approximately 19 acres of the coastal terrace prairie grassland within these meadows would be designated Natural Open Space and would be protected from development and maintained in their natural condition. In comparison, Alternative 1 would likely reduce and/or fragment the area preserved as open space in the Big Meadow and the West Meadow; this could potentially result in a significant impact. The underground tunnel portion of a future scientific facility would be constructed using cut and cover construction techniques, resulting in surface disturbance across the tunnel alignment. Staging areas for equipment and vehicles would be at various locations at the site, including along the tunnel alignment.

Mitigation measures would be as described under the proposed project. Additional mitigation would be required to mitigate the loss of high quality coastal terrace prairie grasslands in the Natural Open Space area.

Cultural Resources

As the area to be developed under this alternative would be substantially the same as under the proposed project, anticipated impacts and mitigation measures for the Alternate Development Program would be the same as the proposed project.

Geology and Soils

Geology and soils impacts under the Alternate Development Program would generally be the same as described for the proposed project. Mitigation measures applicable to the proposed project would apply to this alternative. Impacts of this alternative would be less than significant with mitigation.

Greenhouse Gas Emissions

The Alternate Development Program is essentially the same as the proposed project in terms of the building space that would be constructed and the total daily population that would be on the site. Therefore, GHG emissions associated with construction and operations would be similar to those under the proposed project. This alternative includes a future scientific facility that could have unique features and high utility demands, including water and electricity. The specific details of such a scientific facility are not known at this time and are unavailable for evaluation of operational GHG emissions under this alternative. It is reasonable to assume that this alternative would increase the operational GHG emissions per service person and result in a greater effect on the environment. The same mitigation measure described for the proposed project would apply, and, as with the proposed project, the impact would be significant and unavoidable.

Hazards and Hazardous Materials

Hazards and hazardous material impacts under the Alternate Development Program would be potentially greater than under the proposed project because a future scientific facility could result in higher levels of on-site hazardous materials and an escalation in other hazards, including those associated with specialized scientific equipment. For example, the facility could house a large-scale high-energy lasers or a linear accelerator. Such a facility could generate additional quantities of hazardous wastes, and in the case of an accelerator, could generate low-level radioactive waste associated with activation of materials. Implementation of safety plans, programs, practices, and procedures should ensure that hazards and hazardous materials impacts to the public or the environment would be less than significant.

Hydrology and Water Quality

Under this alternative, there would be no net increase in the maximum 5.4 million gross square feet of proposed development. There would be no change in any of the factors affecting surface or groundwater. The hydrology and water quality impacts would be the same as those of the proposed project and the same mitigation measures would apply. Impacts of this alternative would be less than significant with mitigation.

Land Use and Planning

Under this alternative, there would be no net increase in the maximum 5.4 million gross square feet of proposed RBC development. The land use impacts would be the same as the impacts of the proposed project. Impacts of this alternative would be less than significant.

Noise

Construction. This alternative would involve construction at the same RBC site locations as the proposed project, so the distance between the construction sites and the nearest sensitive receptors also would be the same. Construction of this alternative, including the future scientific facility, would employ the same construction phases described for the proposed project (see Table 4.10-4). Construction noise levels could exceed the limits in the Richmond Noise Ordinance at the nearest sensitive receptor, resulting in a potentially significant impact. The same mitigation measures (LRDP MM NOISE-1a through 1c) would apply and construction noise impacts would be reduced to less than significant.

As with the proposed LRDP, construction would not cause vibration levels at nearby buildings to exceed the damage threshold of 0.5 PPV (in/sec); nor would vibration annoyance thresholds be exceeded in nearby neighborhoods. Vibration would result in a less than significant impact.

Operation. Operation of this alternative, including operation of the future scientific facility, would result in long-term noise impacts from increased site population and traffic volumes and operation of new building cooling towers, air compressors, emergency generators, and new HVAC equipment (see Table 4.10-8). With the exception of generators, operational noise levels would not exceed the limits in the Richmond Noise Ordinance, and the generators would rarely be used. Therefore, operational noise impacts would be less than significant.

Traffic volumes would increase less than 20 percent at the intersections studied (Fehr and Peers 2013). Therefore, the increase in traffic noise would be less than 3 dBA and would not be readily perceivable by the average person so the impact on traffic noise levels would be less than significant.

If vibration-sensitive equipment were to be located at the RBC site, this would be accounted for through the laboratory design process and appropriate vibration-dampening measures would be incorporated as needed.

Population and Housing

Under this alternative, the RBC site population would increase in the same manner as the proposed project from approximately 300 persons in 2012 to approximately 10,000 persons in 2050. The population and housing impacts under the Proposed Project are found to be less than significant. Therefore, population and housing impacts under this alternative also would be less than significant.

Public Services and Recreation

Under this alternative, the RBC population and space increases would be the same as those for the proposed project. Accordingly, public service and recreation impacts would be the same as the impacts of the proposed project. Impacts of this alternative therefore would be less than significant.

Transportation and Traffic

Under the Alternate Development Program, RBC site increases in population and space would be the same as the proposed project. Therefore, impacts to transportation and traffic would be significant and unavoidable and the same as with the proposed project.

Utilities, Service Systems, and Energy

Under this alternative, RBC site increases in population and space would be the same as the proposed project. The utilities and energy impacts of this alternative would be substantially the same as the proposed project, although depending on the specific attributes of the large-scale scientific facility, substantially more water and energy may be used. As the exact nature and specifics of a future scientific facility are not available at this time, it cannot be determined whether provision of additional water and electricity (to account for the future scientific facility) would require the construction of new water and power delivery infrastructure. The wastewater flows from the RBC site would be substantially the same as under the proposed project because the population under this alternative would be the same as the population under the proposed project. The alternative development could potentially contribute to the existing RMSD WWTP and sewer main overflows caused by I&I during wet weather. This would be a potentially significant impact. Impacts of this alternative would be less than significant with LRDP Mitigation Measure UTL-4.

6.5.2 Alternative 2: Reduced Growth Program

Description

Under the Reduced Growth Program, the 2014 LRDP growth parameters for RBC development and population would be lower than those for the proposed project. The amount of building space under this alternative would increase from the RBC site's current 1,050,000 gsf to 3.6 million gsf at full 2014 LRDP implementation. The total site population would increase from its current 300 persons to an estimated 8,400 persons at full implementation of this alternative. Under this alternative, approximately 108 acres of the upland parcels on the RBC would be developed, and approximately 25 acres of the upland parcels would be preserved as natural open space. Land uses under this alternative would be the same as those depicted in Figure 3-3 for the proposed project. As less building space would be constructed on the site's 108 acres designated for development, development density under this alternative would be lower than under the proposed project.

The Reduced Growth Program alternative would satisfy most of the project objectives, but it would not meet the University's objective to provide campus development capacity of up to approximately 5.4 million square feet of new facilities. As described below, it would result in impacts similar to those of the proposed project in most resource areas, but would result in potentially lesser impacts in some resource areas as a result of the smaller development program.

Impacts

Aesthetics and Visual Quality

Aesthetic impacts under the Reduced Growth Alternative would generally be the same as described for the proposed project. However, since this alternative would result in less development at RBC, the visual impacts would be somewhat reduced relative to the proposed project due to a lower density of development under this alternative. Mitigation measures applicable to the proposed project also would apply to this alternative. Impacts of this alternative would be less than significant with mitigation.

Air Quality

The Reduced Growth Program would have less square footage and a smaller daily population than the proposed project. Overall research operations and daily vehicle trips would be reduced, resulting in fewer overall air quality impacts throughout development and implementation of this alternative. Research operations resulting in criteria air pollutant emissions would still occur and require mitigation. Application of the proposed project mitigations for this alternative would minimize air quality impacts; however, impacts would remain significant and unavoidable.

Biological Resources

Compared with the proposed project, impacts on biological resources would be slightly reduced under the Reduced Growth Program Alternative. Impact types would be the same as under the proposed project and Alternative 1 but would be of less magnitude due to the smaller amount of development and smaller project campus population. Natural open space acreage would be the same as under the proposed project and Alternative 1, but landscaped areas in the Research, Education, and Support zone would be greater due to less square footage of buildings. This would provide for a somewhat larger area of marginal habitat for common wildlife species that tolerate human altered landscapes. Mitigation measures applicable to the proposed project would apply to this alternative. Impacts of this alternative would be less than significant with mitigation.

Cultural Resources

Anticipated impacts and mitigation measures for the Reduced Growth Program Alternative would be the same as the proposed project.

Geology and Soils

Geology and soils impacts under the Reduced Growth Program Alternative would generally be the same as described for the proposed project. However, since this alternative would result in less development at RBC, the exposure to geologic and seismic hazards would be marginally reduced. Mitigation measures applicable to the proposed project would apply to this alternative. Impacts of this alternative would be less than significant with mitigation.

Greenhouse Gas Emissions

The Reduced Growth Program would add a smaller amount of building space to the RBC site, and a smaller daily population would be associated with this alternative. Consequently, construction and operational GHG emissions would be somewhat less. As with the proposed project, the impact associated with construction GHG emissions would be less than significant. With respect to the operational GHG emissions, although the emissions would be smaller, they would still result in a rate per service person that would exceed the applicable threshold. The same mitigation measure described for the proposed project would apply, and, as with the proposed project, the impact would be significant and unavoidable.

Hazards and Hazardous Materials

Hazards and hazardous material impacts under the Reduced Growth Program Alternative would generally be the same as described for the proposed project. However, since this alternative would result in less RBC development, the potential impacts would be somewhat reduced. Implementation of safety plans, programs, practices and procedures would ensure that public and environmental impacts from hazards and hazardous material would be less than significant.

Hydrology and Water Quality

The RBC impermeable surfaces area would be reduced under this alternative resulting in somewhat reduced potential for impacts to surface and groundwater. Otherwise the impacts to hydrology and water quality would be the same as described for the proposed project and same mitigation measures would apply. Impacts of this alternative would be less than significant with mitigation.

Land Use and Planning

Under this alternative, the RBC would be developed at the Richmond site, but with a reduction in the total building space and employee population. The land use impacts would be the same as the impacts of the proposed project. Impacts of this alternative would be less than significant.

Noise

Construction. This alternative would involve construction at the same RBC site locations as the proposed project, so the distance between the construction sites and the nearest sensitive receptors would also be the same. Construction for this alternative would employ the same construction phases described for the proposed project (see Table 4.10-4). Construction noise levels could exceed the limits in the Richmond Noise Ordinance at the nearest sensitive receptor, resulting in a potentially significant impact. Mitigation measures LRDP MM NOISE-1a and 1b would apply and construction noise impacts would be reduced to less than significant.

As with the proposed 2014 LRDP project, vibrations associated with construction equipment would not cause vibration levels at nearby buildings to exceed the damage threshold of 0.5 PPV

(in/sec), nor would they exceed established vibration annoyance thresholds at the nearest sensitive receptors, so vibration would result in a less than significant impact.

Operation. Operation of this alternative would result in long-term noise impacts by adding noise-producing site population and traffic volumes and from installing new building cooling towers, emergency generators, and HVAC equipment (see Table 4.10-8). With the exception of generators, operational noise levels would not exceed the limits in the Richmond Noise Ordinance, and the generators would rarely be used. Therefore, operational noise impacts would be less than significant. Because this alternative would produce less noise-producing growth at the RBC site, noise impacts are expected to be marginally less as well.

Traffic volumes would increase less than 20 percent at the intersections studied (Fehr and Peers 2013). Therefore, the increase in traffic noise would be less than 3 dBA and would not be readily perceivable by the average person, so the impact on traffic noise levels would be less than significant.

If vibration-sensitive equipment would be located at the site, existing sources of vibration would be considered during the laboratory design process and appropriate vibration-dampening measures would be incorporated to protect research data quality.

Population and Housing

The population and housing impacts under the Proposed Project would be less than significant. The total site population would increase from an existing 300 persons to an estimated 8,400 persons at full implementation of this alternative. The Reduced Growth Program would reduce the RBC population growth in comparison to the Proposed Project, and the impacts associated with population and housing would be reduced and would remain less than significant.

Public Services and Recreation

Under this alternative, the RBC would be developed at the Richmond site as proposed, but it would provide for the development of a maximum 3.6 million gross square feet of building space. The campus population would increase to an estimated 8,400 persons. Therefore less than significant public service and recreation impacts of the proposed project would be further reduced under this alternative.

Transportation and Traffic

Under this alternative, the RBC would result in a total site population of 8,400 at full implementation. Traffic trips accessing the site would still affect the same study intersections and freeway segments as with the proposed project. Trip generation and distribution would be reduced commensurate with the reductions in total site population as compared with the proposed project. Therefore, impacts to study intersections and freeway sections serving the site would be reduced. Impacts to transit, pedestrian, and bicycle facilities would be reduced by a proportionate level as well and would be less than significant.

Utilities, Service Systems, and Energy

Under this alternative, the RBC would be developed at the Richmond site as proposed, but it would provide for the development of a maximum of 3.6 million gross square feet of building space. The campus population would increase from approximately 300 persons in 2012 to approximately 8,400 persons in 2050. The impacts of this alternative on utilities and energy would be reduced compared to the impacts of the proposed project. The alternative development could potentially contribute to the existing RMSD WWTP and sewer main overflows caused by I&I during wet weather. This would be a potentially significant impact. Impacts of this alternative would be less than significant with implementation of LRDP Mitigation Measure UTL-4.

6.5.3 Alternative 3: Alameda Point Alternative

Description

Under the Alameda Point Alternative, the new campus would be developed in the City of Alameda at Alameda Point (which is a portion of the former Naval Air Station Alameda). The site consists of approximately 124 acres. Development at this site would also be guided by an LRDP which would provide for the development of 5.4 million gsf of building space at full implementation. The campus population would be approximately 10,000 persons in 2050. Development at this location would be guided by planning principles and objectives similar to those identified for the proposed project. Under this alternative, all 124 acres of the site would be developed. Figure 6-1 shows the development footprint for this alternative.

The Alameda Point Alternative would satisfy all of the University's project objectives. As described below, it would result in impacts similar to those of the proposed project in several resource areas, but potentially greater impacts than the proposed project in the areas of traffic and transportation, noise, aesthetics and visual quality, and hydrology and water quality.

Impacts

Aesthetics and Visual Quality

The region surrounding Alameda Point site has a dense urban and industrial character set at the edge of San Francisco Bay. Topography is essentially flat. Alameda site has approximately 6 miles (10 kilometers) of primarily rock-reinforced shoreline. The project site is at the former Naval Air Station (NAS) Alameda Point (Alameda Point) and is roughly bounded by West Atlantic Avenue to the north, Orion Street to the east, and West Hornet Avenue to the south, and adjoining former Naval Air Station properties to the west. The area encompasses approximately 124 acres and includes several buildings, some unpaved areas, paved parking lots, and portions of the paved roadways West Atlantic Avenue, West Pacific Avenue, West Oriskany Avenue, West Ticonderoga Avenue, and Viking Street. The neighboring properties as observed from public streets and sidewalks appear to be occupied with a mix of vacant buildings and some commercial businesses. Signage indicated that areas south of the Site were developed as a park.

This alternative would have potentially significant impacts to the visual character of the site through an increase in constructed area and development. Except for the San Francisco-Oakland Bay Bridge (I-80), no views of the site are available from major highways. Visibility from I-980 is blocked by foreground buildings. Site campus development would result in a significant impact to surrounding scenic vista views. The impressive views of San Francisco Bay, offsite areas, Oakland Inner Harbor, and the surrounding region would be blocked. Because the area has vacant buildings and few commercial businesses, campus development would have a potentially significant impact related to light and glare. Mitigation measures applicable to the proposed project would apply to this alternative. Impacts of this alternative would be significant even with mitigation.

Air Quality

Under this alternative, the Alameda Point site would be developed with the same square footage and daily population as would the proposed project at RBC. Proposed research uses and development would be similar with this alternative, as would assumptions for the phased LRDP growth.

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Alameda Point Campus Site

Legend

Alameda Point Campus Site Boundary

Alameda, California

TETRA TECH

Figure 6-1

The air quality setting for this alternative would be similar to that of the proposed project because the Alameda Point site is also in the same air basin and is subject to the same ARB and BAAQMD provisions and significance thresholds. Although the City of Alameda has adopted the Local Action Plan for Climate Protection, this plan is based on similar goals and timetables as the City of Richmond General Plan 2030 Energy and Climate Change Element; therefore, consistency determination with local programs and policies would also be similar.

The mitigation measures similar to those for the proposed project would be applicable to this alternative, and although these mitigation measures would minimize emissions and address potential long-term health risk, air quality impacts would remain significant and unavoidable.

Biological Resources

Under Alternative 3, fewer biological impacts would occur than under the proposed project or Alternatives 1 and 2 because the site is largely developed. No significant impacts would occur. Site areas that do not contain infrastructure are nevertheless highly altered and contain fill material; these are often vegetated with weeds and nonnative grasses (WRA and Jane Valerius Environmental Consulting 2011b). No sensitive habitats are present. Primary impacts would involve the potential presence of nesting birds and roosting bats in existing buildings.

Bird species that use man-made structures include passerines, such as barn swallow and black phoebe, and raptors, such as barn owl. Bats may roost in these structures, too. Bat species typically found using buildings in this region include pallid bat, Townsend's big-eared bat, big brown bat, western long-eared myotis, fringed myotis, long-legged myotis, Yuma myotis, and Mexican free-tailed bat. No special status plant species are likely to occur. Special status species are likely limited to the potential for CSC bats. Movement corridors in the project area include the estuarine habitat and the open spaces in the developed lands. Developed lands provide an open area for movement of raccoon, skunk, and opossum. Oakland Harbor is a jurisdictional Water of the US. Mitigation measures to address nesting birds and bat roosts would be as described under the proposed project. Impacts on biological resources would be less than significant with mitigation.

Cultural Resources

Historically marshland and tidal flats, the NAS Alameda site was a rich larder where Ohlone would catch fish, hunt waterfowl, and gather shellfish. Due to the fact that most of the land was at least partially submerged, it is unlikely that any permanent settlements were located within the boundaries of the former air station. However, permanent Ohlone settlements were not far away. Until it was quarried to provide surfacing for San Francisco Bay Airdrome runways, a prehistoric midden or refuse heap called Sather Mound was located approximately two miles southeast of NAS Alameda. Consisting of huge mounds of discarded shells, the middens were excavated in 1900 by an amateur archaeologist known as Captain Clark, who found them to contain flaked stone tools and burials. In addition to Sather Mound, five other known Ohlone sites have been identified in what is now the City of Alameda (Page & Turnbull 2005).

As the Alameda Point site is underlain by engineered fill, the potential to encounter previously unknown subsurface archaeological resources and/or human remains during ground-disturbing construction activities is low. Nonetheless, mitigation measures identical to those of the proposed project would avoid any potential impacts.

Under this alternative, there could be significant adverse impacts to historic architectural properties. The Alameda Point site contains the NAS Alameda Historic District, which is located within the former Naval station. This historic district includes 99 contributing buildings and structures, and one contributing site: a historic designed landscape. Significant adverse impacts

could result directly from demolition, relocation, or alteration to any of the 100 historic district contributors. The Alameda Point Alternative may also cause indirect impacts through visual intrusion in the proposed alternative's area of potential effect. Such an impact could result from project introduction of modern construction elements in the areas visually connected to (e.g., adjacent to) the historic district. Implementing a mitigation measure similar to LRDP MM CR-2 would reduce these adverse impacts to historic properties under this alternative to less than significant.

Geology and Soils

The Alameda Point site is constructed on filled tidelands west of Alameda Island in the eastern San Francisco Bay basin. The land surface is low-lying and nearly flat. Elevations are less than 15 feet (5 meters) above mean sea level.

Site borehole logs indicate that the soil profile is relatively horizontal and uniform. A boring near Building 23 (an aircraft maintenance hangar north of the Seaplane Lagoon) showed 16 feet of loose sandy fill underlain by 30 feet of Bay Mud. Below that, 45 feet of Merritt Sand is underlain by 331 feet of stiff clay and another 44 feet of gravel, sand, and clay of the Alameda Formation. The base of the San Antonio Formation was found at a depth of about 256 feet; Franciscan bedrock was encountered at a depth of 466 feet; groundwater was encountered at a depth of 8 feet. Almost the entire site was constructed on engineered fill materials placed over submerged lands or tidal flats.

In the San Francisco Bay Area, the San Andreas fault system stretches across a zone approximately 44 miles wide, consisting of mostly right-lateral strike-slip faults. The Alameda Point site is less than 12 miles from the San Andreas fault. The nearest active fault to the Alameda site is the Hayward fault, approximately 5 miles east.

The entire Alameda Point site lies within an area shown to have liquefaction potential on the State of California Seismic Hazard Zone Map (Alameda Point Site Characteristics). Additionally, based on a 20-foot wave runup at the Golden Gate Bridge, a portion of the Alameda site may be subject to tsunami inundation (Alameda Point Site Characteristics). No known active faults cross the Alameda site, and it is not mapped within a "Special Study Zone" as defined by the Alquist-Priolo Special Studies Zones Act. The site is also not within a landslide hazard zone.

The RBC site is located approximately 2.2 miles from the Hayward fault and within 1 mile of the Bay on flat-lying alluvium. In comparison, the Alameda Point site is about 5 miles from the Hayward fault. Although the effects of locating the project closer to the fault (in the case of RBC) would be mitigated by building design, the Alameda Point site is slightly further from an active fault which may result in a slight reduction in exposure to seismic hazard. Similar to the RBC site, the Alameda Point site is in proximity to the Bay margins. However, the potential for liquefaction is likely greater at Alameda Point (due to the widespread presence of fill material) compared to the proposed project. Additionally, a portion of the Alameda Point site may be subject to tsunami inundation. Mitigation measures applicable to the proposed project would apply to this alternative. Overall, the impacts resulting from this alternative would be similar to those of the proposed project and less than significant with mitigation.

Greenhouse Gas Emissions

The Alameda Point Alternative is essentially the same as the proposed project in terms of the building space that would be constructed and the total daily population that would be on the campus site. Therefore, construction and operational GHG emissions would be similar to those under the proposed project. As with the proposed project, the impact associated with construction GHG emissions would be less than significant and the impact from operational GHG emissions

would be significant. The same mitigation measure described for the proposed project would apply, and, as with the proposed project, the impact would be significant and unavoidable.

Hazards and Hazardous Materials

Implementation of the 2014 LRDP at the Alameda Point Alternative would not result in any significant changes in hazards or hazardous material compared to the impacts presented for the proposed project. Hazards would not be any different at the Alameda Point site than at the RBC and the types and quantities of hazardous materials would not change. Implementation of safety plans, programs, practices, and procedures would ensure that impacts to the public or the environment from hazards and hazardous material would be less than significant.

Hydrology and Water Quality

The Alameda Point site is located on the southwestern corner of Alameda Island. Under Alternative 3,124 acres of land that is currently largely developed would be redeveloped for the campus. This proposed site currently contains approximately 25 buildings and encompasses several fallow fields, paved parking lots, storage/manufacturing sites, and portions of paved roadways.

The proposed site is on engineered fill that was created between 1953 and 1975. Placement of this fill material has resulted in the loss of tidal wetlands and marshes. Edges of the Bay front have been altered through riprapping, Bay fill, and other hard surfaces. The Seaplane Lagoon borders the site to the west. The land is mostly level at 1 meter in elevation. There are no natural streams (WRA and Jane Valerius Environmental Consulting 2011b). Stormwater runs off into culverts that drain into the Bay.

The level of impacts associated with construction runoff and stormwater runoff at the Alameda Point site would be the same (with implementation of the same mitigations) as discussed for the proposed project. Federally funded development would necessarily follow EISA stormwater development strategy to retain all stormwater onsite, as it would not be technically feasible to restore the area's predevelopment hydrology. The dewatering activities under Alternative 3 would also potentially involve the groundwater contaminant plumes from sites to the north of the proposed development. While long-term or high-volume dewatering could affect these plumes, the plumes are not likely to be affected by dewatering required for this construction. The level of impacts (with mitigations) would be the same as discussed for proposed project.

Alameda Point site development would not alter the course of any stream, and would not result in increased erosion from on- or off-site runoff. The Alameda Point site is flat and at a lower elevation than the RBC site.

Land Use and Planning

Under this alternative, the RBC would be developed in the southeastern portion of Alameda Point in the City of Alameda. Alameda Point is a portion of the former NAS Alameda, which the US Navy closed in 1997; the base is currently being transferred to the City for civilian use. The City completed a Reuse Plan for Alameda in 1996. The Plan establishes a vision and direction for Alameda Point development consistent with Alameda's character, historic resources, employment development opportunities, and other aspects. In 2003, the City adopted the Alameda Point General Plan Amendment, which incorporated the Reuse Plan's Alameda Point vision and recommendations into the City's General Plan. Given the transportation constraints of Alameda, the vision calls for a transit-oriented mixed use development at Alameda Point. The City is currently working on developing a Precise Plan for a Town Center and Waterfront Area.

As the new Alameda Point campus site is identified in the Reuse Plan as an employment development area, the proposed alternative would not conflict with City land use plans. Impacts of this alternative related to land use and planning would be less than significant.

Noise

Construction. This alternative would employ the same construction phases described for the proposed action (see Table 4.10-4). The nearest sensitive receptor to the Alameda Point site is the Encinal High School. The high school's property boundary is 25 feet east of the Alameda Point site boundary. Construction noise at this distance from the source could reach a maximum of approximately 72 dBA.[38] Although this would exceed the noise limits found in the Alameda Noise Ordinance (Alameda Municipal Code Section 4-10), the noise ordinance contains an exemption for construction that takes place during certain hours. Implementing mitigation measures similar to LRDP MM NOISE-1a and -1c would minimize construction noise. Implementing other proposed project noise reducing measures would further reduce potential impacts on the school, so construction noise would result in a less than significant impact.

Operation. Operation of this alternative would result in long-term noise impacts from more people at the site and traffic volumes and the installation of cooling towers, emergency generators, and new HVAC equipment associated with the new buildings (see Table 4.10-8). The generators would exceed the limits in the Alameda Noise Ordinance (Alameda Municipal Code Section 4-10) at the nearest sensitive receptor (Encinal High School 25 feet east); however, they would not operate under normal conditions. The other operational equipment noise levels would not exceed the limits in the Alameda Noise Ordinance, which the exception of transformers, which could exceed the nighttime noise limits, resulting in a potentially significant impact. The noise limits in the ordinance are in Table 6-2.

Table 6-2
Alameda Municipal Code Noise Limits

Minutes the Noise Limit can be exceeded in 1 Hour	Noise limit (dBA) for Residences, Schools, Hospitals, Churches, and Public Libraries		Noise Limit (dBA) for Commercial Properties	
	Daytime (7 a.m. to 10 p.m.)	Nighttime (10 p.m. to 7 a.m.)	Daytime (7 a.m. to 10 p.m.)	Nighttime (10 p.m. to 7 a.m.)
30	55	50	65	60
15	60	55	70	65
5	65	60	75	70
1	70	65	80	75
0	75	70	85	80

Source: Alameda Municipal Code Section 4-10.4

dBA A-weighted decibel scale

Mitigation measures could be imposed to reduce operational noise in accordance with the Alameda Noise Ordinance.

[38] This calculation assumes an attenuation rate of 6 dBA for every doubling of distance and a 5 dBA attenuation overall since there is not a clear line of sight between the site and the school.

Traffic volumes would increase approximately 20 percent or less at the intersections studied (Fehr and Peers 2013). Therefore, the increase in traffic noise would be less than 3 dBA and would not be readily perceivable by the average person, so the impact on traffic noise levels would be less than significant.

If vibration-sensitive equipment would be located at the site, existing sources of vibration would be considered during the laboratory design process and appropriate vibration-dampening measures would be incorporated to protect research data quality.

Population and Housing

Growth under the proposed 2014 LRDP would increase the average daily population at the Alameda Point campus site, but it would not result in any substantial population growth in the surrounding Bay Area. The population and housing impacts under the proposed project would be less than significant. The Alameda Point Alternative would involve the same amount of population growth as the Proposed Project. Therefore, population and housing impacts under this alternative would be comparable and also less than significant.

Public Services and Recreation

Under this alternative, the RBC would be developed at the Alameda Point site and would entail the development of 5.4 million gross square feet of building space and a campus population of 10,000 persons. UC Police would provide law enforcement services and the City of Alameda would provide fire services to the campus site, until the results of required emergency and security assessments and plans indicate the need for additional services. In the long run it might become desirable and/or necessary for the University to house security and emergency service equipment and personnel on the campus. The LBNL Protective Services Department would retain responsibility for all security, fire protection, and emergency service requirements for all DOE facilities, assets, and personnel. This alternative's public services and recreation impacts would be substantially the same as the proposed project's projected impacts and would be less than significant.

Transportation and Traffic

Development of the LRDP at Alameda Point would occur at a site that has been designated for long-term development by the Alameda General Plan, Reuse Plan, and various other planning documents. The Alameda Point Element of the General Plan addresses the long range development of the site through policies that promote a mixture of uses, as well as a mix of transportation choices and alternatives to promote transit, bicycle and pedestrian trips. In addition, the Alameda Point Transportation Strategy, last revised in 2009, includes policies for bus rapid transit, new ferry station and expanded service, BART shuttles, light-rail, and a transit hub on the point.

Development at Alameda Point would occur incrementally, similar to planned development at the site as represented in the General Plan and related documents. The proposed uses would differ in that the campus would not include housing, retail, hotel, and similar uses as proposed in the General Plan. However, potential impacts to transit, pedestrian and bicycle facilities would be similar since the expansion of these facilities and development of new facilities serving Alameda Point would occur incrementally throughout the development of the campus, similar to the anticipated timetable for development in adopted planning documents. Therefore, any impacts from development would be less than significant because the transportation infrastructure would be implemented as the requirements of each stage of new development occurs.

The Alameda Point Element promotes the expansion and development of transit, bicycle, and pedestrian trip choices because automobile traffic is already impacted at key intersections and

tunnels and bridges serving Alameda are likewise operating near capacity during peak hours. In Oakland, campus-generated traffic would contribute to LOS F conditions at the Harrison Street/7th Street intersection during both AM and PM peak hours. Traffic generated by the campus would also contribute to LOS E conditions at the Jackson Street/7th Street intersection in Oakland and would potentially degrade the cumulative operation at this intersection to LOS F. Based on the City of Oakland's significance criteria, this would result in a significant and unavoidable impact at one or both of these intersections.

Utilities, Service Systems, and Energy

As with the proposed RBC site campus, EBMUD would also provide potable water for the Alameda Point Alternative. Water supplied to the City of Alameda area is treated at the Orinda WTP and conveyed via pipeline to Alameda.

EBMUD would collect and treat wastewater generated by the Alameda Point Alternative. Alameda is served by EBMUD's Special District No. 1, which treats domestic, commercial, and industrial wastewater for the cities of Alameda, Albany, Berkeley, Emeryville, Oakland, and Piedmont, and for the Stege Sanitary District, which includes El Cerrito, Kensington, and part of Richmond. The primary wastewater treatment plant used by EBMUD is the Main Wastewater Treatment Plant (MWWTP), which treats wastewater from Special District No. 1.

Waste generated at the Alameda Point Site is transported to the Davis Street Transfer Station in San Leandro. The waste is then hauled to the Altamont Landfill in Livermore, California. In 2000, the Altamont Landfill received a total of 1,491,958 tons of refuse from all sources, or an approximate daily average of 4,100 tons per day (City of Alameda 2006). The Altamont Landfill has a permitted maximum daily disposal of 11,500 tons per day with 45,720,000 cubic yards of remaining capacity. The landfill is expected to operate through 2025 (CalRecycle 2012c).

Alameda Municipal Power (formerly Alameda Power & Telecom) provides electricity to the Alameda Point Alternative site and the City of Alameda. Approximately 80 percent of the electricity is generated from clean and renewable sources, a large portion of which comes from geothermal energy, in addition to wind, solar, landfill gas, and hydroelectric sources (Alameda Municipal Power 2013).

Natural gas is delivered by the PG&E system to the Alameda Point Alternative site.

The projected utility demand associated with the Alameda Point Site Alternative in 2050 from 5,400,000 gsf of development and 10,000 on-site employees is presented below in Table 6-3.

This alternative's water supply impacts would be substantially the same as those of the proposed project; both would have the same water demand and EBMUD would be the water supplier. The Alameda Point Alternative would require about 340 mgy, or 9.3 mgd, of water and the maximum flow rate for the project would be 2,230 gpm. Because EBMUD has indicated that it can serve the proposed project, it is assumed that EBMUD would be able to serve this alternative as well. The impact related to water supply would be less than significant.

Table 6-3
Alternative 3 Annual and Peak Utility Demand

Utility	Projected Demand (2050)	Existing Demand at Leased Buildings[1]	Difference in Demand
Potable Water	340 mgy (peak demand – 2,230 gpm)	29.9 mgy	310.1 mgy
Firefighting Water	(peak demand – 6,000 gpm)	NA	NA
Wastewater	273 mgy (peak demand – 2,140 gpm)	23.92 mgy[1]	NA[2]
Electrical energy	142,400 megawatt hours/year (peak demand – 24.7 MW)	12,000 megawatt hours/year	130,400 megawatt hours/year
Standby Power	peak demand – 16 MW (installed capacity –20 MW)	NA	NA
Natural Gas	6,600,000 therms/year (peak demand – 240,300 kBtu/h)	548,000 therms/year	6,052,000 therms/year

Notes:
[1] Wastewater was determined to be 80 percent of the potable water demand.
[2] Wastewater flows cannot be netted out because the leased facilities do not all contribute their wastewater to the same wastewater treatment plant.

gpm	Gallons per minute
kBtu/h	Kilo-British thermal unit hour
kW	Kilowatt
Mgy	Million gallons per year
MW	Megawatt
NA	Not Applicable

The Alameda Point Alternative is estimated to produce 104 mgy, or 284,932 gpd, of wastewater, as shown above in Table 6-3. The MWWTP has a dry weather capacity of 120 mgd and a wet weather wastewater treatment capacity of 168 mgd to secondary treatment standards and 320 mgd to primary treatment standards. The annual average daily flow at the MWWTP is 65 mgd (EBMUD 2011b). If the flows projected to result from the Alameda Point Alternative development of 284,932 gpd were added to the current influent flows of 65 mgd, the total influent would still be substantially below the WWTP's dry weather treatment capacity of 120 mgd. The incremental flows from the Alameda Point alternative would not take up a substantial amount of the WWTP's dry weather treatment capacity. Therefore, similar to the proposed project impacts related to wastewater treatment under this alternative would also be less than significant, as adequate treatment capacity exists at the EBMUD MWWTP to handle the additional flows.

Similar to the conditions in Richmond, wet weather flows in Alameda are affected by high levels of I&I and the MWWTP has inadequate treatment capacity to handle wet weather flows. The City of Alameda and EBMUD are working together to reduce the amount of I&I entering the wastewater collection system, including I&I in the Alameda Point area of the City. Therefore, similar to the proposed project, this alternative would have the potential to discharge wastewater into a system with inadequate wet weather treatment and could potentially add wastewater flows to sewer mains that are at capacity due to I&I and result in localized system overflows. A mitigation measure similar to LRDP MM UTL-4 could be implemented, which would reduce the impact to a less than significant level.

The existing site is a paved parking lot which prevents any infiltration of storm runoff. The Alameda Point Site Alternative would construct landscaping and storm drainage features on the site, in addition to facilities and parking lots, which would result in a reduction of impervious surfaces and consequently of storm runoff from the site. To comply with NPDES requirements, the site runoff would be controlled and new stormwater drainage systems would be developed. No changes to off-site storm drain systems are anticipated. Impacts from storm runoff would be less than significant.

The Alameda Point Alternative would support a population of up to 10,000 persons. The on-site population is expected to generate up to 2.2 tons of waste per day[39] from maintenance and operational activities (CalRecycle 2012b). As stated above, the Altamont Landfill has a permitted daily intake limit of 11,500 tons. The projected increase in Alameda Point Site daily waste disposal would represent 0.2 percent of the peak permitted daily capacity of the Altamont Landfill. The increase would not require regional landfill capacity expansion. The impact related to solid waste would be less than significant.

The Alameda Point Alternative facilities would have a peak power demand of about 24.7 MW, which corresponds to 128,508 MWh of power consumption per year. As stated above, natural gas is delivered by the PG&E system to the Alameda Point Alternative site. The Alameda Point Alternative would have a peak demand of about 240,3000 kBtu/h of natural gas for a total demand of 5,973,877 therms of natural gas per years. Construction on the site would include utilities sized adequately to serve up to the 5,400,000 gsf of research laboratory and office. Impacts related to provision of electricity and natural gas would be similar to those of the proposed project as the same amount of electricity and natural gas would be required. Alameda Municipal Power would supply power to the alternative site. The impacts would be less than significant.

6.5.4 Alternative 4: No Project Alternative

Description

State CEQA Guidelines require consideration of the No Project Alternative. The No Project Alternative would essentially mean that the 2014 LRDP would not be adopted for the RBC or any other site. The amount of building space and the employee population at the University's Richmond properties would remain at their current levels.

Should any development or environmental remediation activities be proposed by UC Berkeley or LBNL at the RBC site, any required CEQA documentation would be prepared on a project-specific basis.

The No Project Alternative would fail to meet the University's stated need and purpose for a new campus, and as such, would not satisfy the project objectives set forth for such a campus. As described below, it would result in no impacts for any of the resource areas, and all impacts of the proposed project would be avoided.

[39] Based on the waste generation rate of 0.8 tons/employee/year from CalRecycle for "Services – Education."

Impacts

Aesthetics and Visual Quality
Under the No Project Alternative, new development would not occur at the RBC site or at any other offsite location. Therefore, this alternative would not result in impacts to aesthetics and visual quality.

Air Quality
No new development would occur at the site with the No Project Alternative. No new air quality impacts would result, and no mitigations would be required.

Biological Resources
Under this alternative, the project would not be implemented, and the existing biological resources environment would not be altered. Therefore, no new impacts would occur from construction of new facilities, and no new impacts from changed operations and altered landscapes would occur. No mitigation measures would be necessary.

Cultural Resources
Under this alternative, there would be no impacts to archaeological or architectural resources at the Richmond Bay Campus because existing buildings would remain and in their current locations. No disturbance, destruction, or demolition of the cultural resources sites and buildings would occur at the RBC site. No potentially existing subsurface resources would be affected.

Geology and Soils
Under the No Project Alternative, new development would not occur at the RBC site. Therefore, this alternative would not result in impacts to geology and soils.

Greenhouse Gas Emissions
As no new development would occur on the RBC site, no new GHG emissions would be generated, and no impact would occur.

Hazards and Hazardous Materials
Under the No Project Alternative, new development would not occur at the RBC site, so this alternative would not result in hazard impacts or hazardous material impacts.

Hydrology and Water Quality
Under this alternative, the LRDP would not be implemented, and the Richmond Field Station and other components of the Richmond site would continue their current operations.

None of the developed portion of the site is currently within a 100-year flood hazard zone. A flood hazard zone exists along the margin of the site due to the potential for offshore winds in combination with high tides to increase water elevations along the shore. An increase in the flood zone will make buildings at the southern margin of the site more vulnerable to inundation. The No Project Alternative would not replace any of the existing buildings nor increase shoreline flood protection for the existing buildings. The placement of fill along the western margin of the site would not occur and there would be potential flood hazards associated with the predicted rise in sea levels. In addition, without new fill to raise the elevation of the land surface along the western margin of the site, the risk of damage from tsunamis is higher under this alternative than for the proposed project

Land Use and Planning

Under this alternative, the project would not be implemented and there would be no impact related to land use and planning. However, maintaining the RBC site with the current level of development and employment would not be consistent with the City's vision for the project vicinity.

Noise

Under this alternative, the project would not be implemented and the existing noise environment would not be altered so there would be no impact.

Population and Housing

Under this alternative the 2014 LRDP would not be adopted for the RBC site. There would be no increase the average daily population at the campus. Therefore, there would be no impacts to population and housing under this alternative.

Public Services and Recreation

Under this alternative the 2014 LRDP would not be adopted for the RBC site. There would be no increase the average daily population at the campus or building space. Therefore, there would be no impacts to public service and recreation under this alternative.

Transportation and Traffic

Under the No Project Alternative, building space and the employee population would remain at their current levels. The existing traffic and circulation levels and patterns would continue for vehicles, transit, pedestrians, and bicycles. No impacts would occur, and no mitigation would be required.

Utilities, Service Systems, and Energy

Under this alternative, there would be no increase in the RBC site's average daily population or building space. Therefore, there would be no impacts to utilities and energy sources under this alternative.

6.6 ENVIRONMENTALLY SUPERIOR ALTERNATIVE

The environmentally superior alternative is the alternative that would result in the least environmental impact. Of the action alternatives analyzed in this EIR, the Reduced Growth Program is the environmentally superior alternative because it would reduce the magnitude of the impacts associated with construction and operation activities relative to the other action alternatives, while achieving some of the project objectives.

CHAPTER 7
OTHER CEQA CONSIDERATIONS

7.1 INTRODUCTION

This section presents the CEQA findings regarding significant and unavoidable effects, significant irreversible environmental changes, growth inducing impacts, and effects found not to be significant.

7.2 SIGNIFICANT AND UNAVOIDABLE EFFECTS

As identified and described in Chapter 4, implementing the 2014 LRDP would result in the following significant impacts that cannot be mitigated to a less than significant level.

Below is a summary of those impacts:

- Operational activities associated with development under the 2014 LRDP would result in criteria pollutant emissions that would exceed BAAQMD CEQA thresholds and therefore potentially violate an air quality standard or contribute substantially to an existing or projected air quality violation (Air Quality)
- Operational activities associated with 2014 LRDP implementation would expose people to substantial levels of TACs or expose sensitive receptors to substantial pollution concentrations in excess of the relevant BAAQMD thresholds. (Air Quality)
- Development under the 2014 LRDP would conflict with or obstruct implementation of the applicable air quality plan. (Air Quality)
- Development under the 2014 LRDP would result in significant impacts on historic Buildings 150 and 175 through demolition or visual intrusion from new building construction. (Cultural Resources)
- Development under the 2014 LRDP could result in significant impacts on historic structures that have not been identified or that would become of historic age over the life of the plan. (Cultural Resources)
- Development under the 2014 LRDP would generate GHG emissions that would result in a significant impact on the environment. (Greenhouse Gas Emissions)
- Development under the 2014 LRDP would conflict with an applicable plan, policy, or regulation adopted for the purpose of reducing GHG emissions. (Greenhouse Gas Emissions)
- Development under the 2014 LRDP would conflict with an applicable plan, ordinance, or policy establishing effectiveness measures for circulation system performance and would cause an exceedance of a level of service standard established for the study intersections under 2035 conditions. (Transportation and Traffic)
- Development under the 2014 LRDP would conflict with an applicable plan, ordinance. or policy establishing effectiveness measures for circulation system performance and would cause an exceedance of a level of service standard established for the study intersections under existing conditions. (Transportation and Traffic)
- Development under the 2014 LRDP would conflict with an applicable plan, ordinance, or policy establishing effectiveness measures for circulation system performance and would

cause an exceedance of a level of service standard established for CMP facilities (freeways) under 2035 conditions. (Transportation and Traffic)

7.3 SIGNIFICANT IRREVERSIBLE ENVIRONMENTAL CHANGES

Section 15126.2(c) of the *State CEQA Guidelines* states that an EIR must include a discussion of any significant irreversible environmental changes that would be caused by a proposed project. Generally, a project would result in irreversible environmental changes if:

- The primary and secondary impacts would generally commit future generations to similar uses, such as when a project extends transportation or other infrastructure to an area previously without those services;
- The project would involve a large commitment of nonrenewable resources; or
- The project involves uses in which irreversible damage could result from any potential environmental accidents associated with the project.

7.3.1 Commitment of the RBC Site to Institutional Use

The proposed project does not involve the extension of transportation or utility infrastructure to any areas currently not served by such infrastructure. The RBC site is served by existing roadway network and utilities, and is currently used for academic and research purposes by the University. Implementation of the 2014 LRDP would not fundamentally alter land use at the site, which would continue to serve the academic and scientific uses of the University. It would continue to commit the RBC site to institutional uses. Because the site is already disturbed and developed, the proposed project would not result in a significant irreversible commitment of future generations to any new uses.

7.3.2 Consumption of Resources, including Nonrenewable Resources

Resources that would be permanently and continually consumed by project implementation include water, electricity, natural gas, and fossil fuels. In addition, construction activities related to the proposed 2014 LRDP would consume nonrenewable energy resources, primarily in the form of fossil fuels (including fuel oil, natural gas, and gasoline) for automobiles and construction equipment. However, the consumption of these resources during the construction and operation of campus facilities would not represent unnecessary, inefficient, or wasteful use of resources.

The University plans to develop the RBC as a showcase of sustainable design and operations. In August 2011, the University updated its UC Sustainable Practices Policy,[40] which set environmental practices goals for both construction and operation in eight areas: green building, clean energy, transportation, climate protection, sustainable operations, waste reduction and recycling, environmentally preferable purchasing, and sustainable food service. All RBC projects would meet or exceed the goals defined in this, or any successor, UC sustainability policy. In addition to satisfying the UC sustainability policy, all DOE funded projects at the RBC would meet or exceed the goals defined in DOE Order 436.1, which identifies requirements and responsibilities for managing sustainability within DOE facilities.

As described in Section 3.6.5, RBC physical development would incorporate energy efficiency principles in all construction and demolition projects, renovation projects, operations, and maintenance within budgetary constraints. In cases where certain facility types, such as a laboratories or data centers, are not required to meet energy consumption code requirements, the projects would be designed to meet specific energy and carbon performance metrics such as those

[40] http://www.universityofcalifornia.edu/sustainability/policy.html

defined by the "Labs21" (DOE and EPA), "Smart Labs" (UC Irvine), or similar applicable programs.

In order to minimize water use, the RBC projects would include such measures as installation of water-efficient landscaping and drip or other efficient irrigation systems, water-efficient fixtures, and rainwater and stormwater capture for irrigation use.

The RBC would support bio-diversity and habitat conservation by using native plants wherever possible. In addition, the RBC would use low-impact development design techniques and Bay-Friendly landscape design (see www.stopwaste.org) and make stormwater management a site feature.

The RBC would also comply with the UC Sustainable Practices Policy for zero municipal solid waste by 2020 by creating a robust on-site recycling program for diverting municipal solid waste from landfills. Building materials would be selected to reduce embodied energy, maximize building lifespan, and be recyclable or reusable. Material use overall would be minimized, whether in buildings or in other site operations (e.g., paper), and recycled wherever practicable. Materials would be locally sourced and from renewable sources to the degree feasible, including demolition materials re-use and recycling.

In addition to improving shuttle access, the RBC would implement a TDM program that would include alternate mode use incentives such as discounted transit passes, parking cash-out, Guaranteed Ride Home, and flexible car share programs.

In addition, RBC would comply with all applicable building codes, including CALGreen standards, and would ensure that all natural resources are conserved to the maximum extent feasible. It is also possible that new technologies or systems will emerge, or will become more cost-effective or user-friendly, to further reduce the campus' reliance upon nonrenewable energy resources. Overall, the consumption of natural resources would increase at a lesser rate than the projected population increase due to the variety of energy and water conservation measures that the University has implemented and would continue to implement.

In summary, the project would not result in a significant irreversible consumption of nonrenewable resources. Consumption of both renewable and non-renewable resources during the construction and operation of campus facilities would not be inefficient, wasteful, or unjustified.

7.3.3 Irreversible Damage from Environmental Accidents or Other Irreversible Environmental Changes

The *State CEQA Guidelines* also require a discussion of the potential for irreversible environmental damage caused by an accident associated with the project. While future development at the RBC site would involve the use, transport, storage, and disposal of hazardous wastes, as described in Section 4.7, Hazards and Hazardous Materials, the RBC would comply with all applicable state and federal laws and existing and new campus programs, practices, and procedures related to hazardous materials, which would reduce the likelihood and severity of accidents that could result in irreversible environmental damage. Thus, the potential for RBC development pursuant to the 2014 LRDP to cause irreversible environmental damage from an accident involving hazardous materials is not reasonably foreseeable.

The 2014 LRDP would result in one significant irreversible change, demolition of historical resources that, once gone, cannot be replaced. As described in Section 4.4, Cultural Resources, implementation of the proposed 2014 LRDP would cause a substantial adverse change on

historical resources, including historical resources that have not yet been identified. At a minimum, demolition of Buildings 150 and 175 is anticipated during the lifetime of the 2014 LRDP. This is identified as a significant, unavoidable impact in Section 4.4.

7.4 GROWTH INDUCING IMPACTS

As described in Section 4.11, Population and Housing, the project would increase the employee population at the RBC site, but it would not induce substantial population growth in Richmond or elsewhere in the region, either directly or indirectly. The proposed 2014 LRDP, in conjunction with other projects that could be developed in Richmond, would induce population growth in Richmond and the Bay Area, but the 2014 LRDP's contribution to this impact would not be cumulatively considerable.

7.5 EFFECTS FOUND TO BE INSIGNIFICANT WITHOUT FURTHER ANALYSIS

Project impacts to Agriculture and Forest Resources and Mineral Resources were determined to require no additional analysis. Impacts related to the following topic areas were determined to require no additional analysis and are discussed in the Initial Study in Appendix A:

- Substantial damage to scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings in a state scenic highway corridor (Aesthetics and Visual Quality)
- Conversion of Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use (Agriculture and Forest Resources)
- Conflicts with existing zoning for agricultural use, or a Williamson Act contract (Agriculture and Forest Resources)
- Changes in the existing environment which, due to their location or nature, could result in conversion of Farmland to non-agricultural use (Agriculture and Forest Resources)
- Conflicts with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code Section 12220(g) or timberland (as defined by Public Resources Code Section 4526) (Agriculture and Forest Resources)
- Loss of forest land or conversion of forest land to non-forest uses (Agriculture and Forest Resources)
- Conflicts with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other applicable habitat conservation plan (Biological Resources)
- Exposure of people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area, or based on other substantial evidence of a known fault. Refer to Division of Mines and Geology Special Publication 42. (Geology and Soils)
- Exposing people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving landslides (Geology and Soils)
- Soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water (Geology and Soils)

- For a project in an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, safety hazards for people residing or working in the project area (Hazards and Hazardous Materials)
- For a project near a private airstrip, safety hazards for people residing or working in the project area (Hazards and Hazardous Materials)
- Exposure of people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands (Hazards and Hazardous Materials)
- Housing in a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map (Hydrology and Water Quality)
- Conflicts with any applicable habitat conservation plan or natural community conservation plan (Land Use and Planning)
- Loss of availability of a known mineral resource that would be of value to the region and the residents of the state (Mineral Resources)
- Loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan (Mineral Resources)
- For a project in an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, exposure of people residing or working in the project area to excessive noise levels (Noise)
- For a project near a private airstrip, exposure of people residing or working in the project area to excessive noise levels (Noise)
- Displacement of substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere (Population and Housing)
- Displacement of substantial numbers of people, necessitating the construction of replacement housing elsewhere (Population and Housing)
- Change in air traffic patterns, including either an increase in traffic levels or a change in location, that results in substantial safety risks (Transportation and Traffic)

CHAPTER 8
LIST OF PREPARERS/ORGANIZATIONS CONSULTED

8.1 LIST OF PREPARERS

8.1.1 University of California LRDP EIR Management Team

Erin Beardsley: LRDP and EIR Project Coordinator

Colleen Lee: LRDP and EIR Project Engineer

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Jennifer McDougall: RBC LRDP Project Lead (UC Berkeley)

Jeff Philliber: RBC EIR Project Manager

Nancy Ware: RBC LRDP & EIR Lead Environmental Counsel

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Morrough O'Brien, Regional Oral History Office, University of California, Berkeley

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Appendix A

Notice of Preparation, Comments, and Scoping Meeting Transcript

Notice of Preparation

Ernest Orlando Lawrence
Berkeley National Laboratory

One Cyclotron Road, MS76-225
Berkeley, California 94720

January 4, 2013

State of California
Office of Planning and Research
1400 Tenth Street
Sacramento, California 95814

NOTICE OF PREPARATION
DRAFT ENVIRONMENTAL IMPACT REPORT

Project Title:	Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development
Project Location:	Richmond Bay Campus, Richmond Field Station
County:	Contra Costa

Project Description:
The University of California (UC) proposes to establish a new major research campus at properties it owns in Richmond, California, for consolidation of biosciences programs of the Lawrence Berkeley National Laboratory (LBNL) and for development of additional research-related facilities for both LBNL and UC Berkeley. This campus would jointly serve UC LBNL and UC Berkeley. The proposed 2013 Long Range Development Plan (LRDP) for the Richmond Bay Campus (RBC) would guide campus development through 2050. Initial development under Phase 1 would occur through 2018. More information appears in the project description included in the Initial Study attached to this Notice of Preparation.

Agency Review and Comments:
In compliance with the State and University of California Guidelines for implementation of the California Environmental Quality Act (CEQA), this Notice of Preparation is hereby sent to inform you that UC is preparing a Draft Environmental Impact Report (EIR) on the RBC 2013 LRDP and Phase 1 development. The EIR will provide program-level analysis of the full LRDP development and project-level analysis of Phase 1 development.

As Lead Agency, UC needs to know the views of your agency as to the scope and content of the environmental information that is germane to your agency's statutory responsibilities in connection with the proposed project (anticipated areas of analysis are identified in the attached Initial Study). Please designate a contact person in your agency and send your response to the address below.

Environmental Review Process:
UC will be the Lead Agency and will prepare a Program/Project EIR to evaluate and disclose the potential environmental effects of implementing the proposed 2013 LRDP and Phase 1 development. The EIR will include a program-level environmental review of RBC development through 2050 and a project-specific analysis of the environmental effects from construction and operation of Phase 1. The LRDP and EIR would also inform decisions of the state Department of Toxic Substances Control regarding workplans for remediation of legacy pollutants at portions of the RBC site that are subject to a site investigation and remediation order and are proposed for development.

The LRDP EIR will programmatically analyze a series of related actions at the University of California's Richmond properties as part of the RBC 2013 LRDP. The programmatic evaluation will serve as the base environmental review for tiering purposes when implementing the 2013 LRDP. Future projects proposed within the scope of the RBC 2013 LRDP will be analyzed to determine whether there are any impacts requiring further CEQA documentation or whether any documentation is required in addition to the LRDP EIR.

The EIR's project-specific analysis will provide a comprehensive and detailed evaluation of the environmental impacts of implementing the Phase 1 development.

An Initial Study was prepared pursuant to the UC CEQA Guidelines to identify the environmental issues that will be addressed in the RBC 2013 LRDP EIR. The Initial Study is attached to this Notice of Preparation. Copies of the Initial Study are available for review at the main branch of the Richmond Public Library, 325 Civic Center Plaza, Richmond; the UC Berkeley Doe Memorial Library; and online at http://www.lbl.gov/Community/env-rev-docs.html.lbl.gov.

Due to time limits mandated by State law, this Notice of Preparation will include a 30-day comment period that extends from January 4, 2013, to February 4, 2013. Comments must be received before 5:00 PM on February 4, 2013, to be considered in the preparation of the RBC 2013 LRDP EIR. They may be e-mailed to LRDP-EIR@lbl.gov or mailed to:

Jeff Philliber
Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

A public scoping meeting for the RBC 2013 LRDP EIR will be held from 7:00 to 9:00 PM on January 23, 2013, at the Richmond City Council Chambers, 403 Civic Center Plaza. The US Department of Energy may use this scoping meeting to fulfill requirements under the National Environmental Policy Act and under 10 CFR Part 1022 regarding floodplain and wetland analysis.

Sincerely,

Jeff Philliber
LBNL Environmental Planning Group

Ernest Orlando Lawrence
Berkeley National Laboratory

One Cyclotron Road, MS 76-225
Berkeley, California 94720

January 4, 2013

INITIAL STUDY
RICHMOND BAY CAMPUS
2013 LONG RANGE DEVELOPMENT PLAN
AND PHASE 1 DEVELOPMENT

I. PROJECT INFORMATION

Project Title: Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development

Lead Agency: University of California

Contact Person: Jeff Philliber, (510) 486-5257

Project Location: 1301 South 46th Street, Richmond, California 94804

II. PROJECT DESCRIPTION

See below.

III. ENVIRONMENTAL FACTORS POTENTIALLY AFFECTED

The environmental factors checked below may be potentially affected by this project and will be carried forward for full analysis in the 2013 Long Range Development Plan and Phase 1 Development Environmental Impact Report:

■ Aesthetics	□ Agriculture/Forest Resources	■ Air Quality
■ Biological Resources	■ Cultural Resources	■ Geology/Soils
■ Greenhouse Gas Emissions	■ Hazards & Haz. Materials	■ Hydrology/Water Quality
■ Land Use/Planning	□ Mineral Resources	■ Noise
■ Population/Housing	■ Public Services	■ Recreation
■ Transportation/Traffic	■ Utilities/Service Systems	■ Mandatory Findings of Significance

IV. DETERMINATION: (To be completed by the Lead Agency)

On the basis of the initial evaluation that follows:

_____ I find that the proposed project COULD NOT have a significant effect on the environment, and a NEGATIVE DECLARATION will be prepared.

_____ I find that although the proposed project could have a significant effect on the environment, there will not be a significant effect in this case because revisions in the project have been made by or agreed to by the project proponent. A MITIGATED NEGATIVE DECLARATION will be prepared.

■ I find that the proposed project MAY have a significant effect on the environment, and an ENVIRONMENTAL IMPACT REPORT is required.

_____ I find that the proposed project MAY have a "potentially significant impact" or "potentially significant unless mitigated" impact on the environment, but at least one effect 1) has been adequately analyzed in an earlier document pursuant to applicable legal standards, and 2) has been addressed by mitigation measures based on the earlier analysis as described on attached sheets. A TIERED ENVIRONMENTAL IMPACT REPORT is required, but it must analyze only the effects that remain to be addressed.

_____ I find that although the proposed project could have a significant effect on the environment, because all potentially significant effects (a) have been analyzed adequately in an earlier EIR or NEGATIVE DECLARATION pursuant to applicable standards, and (b) have been avoided or mitigated pursuant to that earlier EIR or NEGATIVE DECLARATION, including revisions or mitigation measures that are imposed upon the proposed project, no further environmental document is required. FINDINGS consistent with this determination will be prepared.

Signature J Phillber Date 12-30-12

Jeff Philliber LBNL Environmental Planner

Printed Name

Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development PROJECT DESCRIPTION

Contents

1.0 Introduction
2.0 Project Location and Surrounding Land Uses
3.0 Existing Site Conditions
4.0 2013 Long Range Development Plan
5.0 Phase 1 Development
6.0 Alternatives

1.0 Introduction

The University of California (UC or the University) proposes to establish a new major research campus, at properties it owns in Richmond, California, for consolidation of biosciences projects and activities managed or led by the University of California Lawrence Berkeley National Laboratory (UC LBNL) and for development of additional facilities for both LBNL[1] and UC Berkeley for research and development focused on energy, environment, and health. The University proposes to rename the properties as the "Richmond Bay Campus" (hereinafter "RBC").

The University is preparing a Long Range Development Plan (LRDP) in support of the research and academic goals for this proposed new research campus. An LRDP is defined by statute (Public Resources Code 21080.09) as a "physical development and land use plan to meet the academic and institutional objectives for a particular campus or medical center of public higher education." The proposed RBC 2013 LRDP is being prepared to guide the growth and development of the campus through the year 2050. The University and State law also require an Environmental Impact Report (EIR), pursuant to the California Environmental Quality Act (CEQA), to be prepared for any new or updated LRDP.

The University is also developing Phase 1 development plans that would involve constructing three buildings and associated infrastructure on the RBC. Two of these buildings would be approximately 110,000 to 150,000 gross square feet (gsf) each, and one of these buildings would

[1] Lawrence Berkeley National Laboratory is a federally funded research and development center managed and operated by the University of California under a contract with the Department of Energy.

be up to 300,000 gsf for a total of up to 600,000 gsf. These facilities would house the following institutions:

- **Joint Genome Institute (JGI)**, which UC LBNL manages for the U.S. Department of Energy (DOE)
- **Joint BioEnergy Institute (JBEI)**, a multi-institutional partnership led by UC LBNL
- **Advanced Biofuels Process Development Unit (ABPDU)**, which UC LBNL manages for DOE
- **Knowledge Base (KBase)**, a multi-institutional collaboration led by UC LBNL.

In addition, the facilities would house other LBNL biosciences projects and activities, and a conference facility, a dining facility, and various support facilities. Construction of Phase I would commence in 2014 and the buildings would be occupied starting in 2017 or 2018. Development of Phase I would add approximately 1,000 to the average daily population (adp) of the site, increasing the adp from 300 to 1,300.

The LRDP EIR will provide a comprehensive program-level analysis of the RBC 2013 LRDP and its potential impacts on the environment, in accordance with Section 15168 of the CEQA Guidelines. In accordance with Section 15161 of the CEQA Guidelines, the LRDP EIR will also include project-specific analysis of the first phase of development to be built and operated under the RBC 2013 LRDP. The 2013 LRDP would establish RBC growth parameters through 2050; LRDP amendment(s) would be required in order to exceed those growth parameters. Subsequent proposals for specific development at the RBC would be reviewed for consistency with the LRDP, its EIR, and any necessary further compliance with CEQA.

The RBC LRDP is a unique joint proposal of UC LBNL and UC Berkeley. While LBNL and UCB have a close existing partnership and both are managed under the auspices of the Regents of the University of California, the institutions are distinct administrative entities. Upon determination by the Regents to approve the 2013 LRDP and certify the EIR, however, UC LBNL and UC Berkeley expect to establish a joint operating committee to oversee the Richmond Bay Campus and implement the LRDP. The committee would advise the UC Berkeley Chancellor and the LBNL Director.

As of fall 2012, the University has conducted three community-wide meetings related to its planning for the RBC and its LRDP.[2] This Notice of Preparation commences the University's

[2]While not the topic of this Notice of Preparation, the University recognizes that a key concern voiced at community meetings is whether the RBC will create jobs for the Richmond community. UC LBNL and UC Berkeley expect the new

CEQA process and invites interested agencies and members of the public to comment on the scope of the environmental analysis and evaluations of alternatives. A Draft LRDP EIR is expected to be available for public and agency review in early or mid-2013. The University expects to submit the draft 2013 LRDP and Final LRDP EIR to The Regents of the University of California for their consideration for approval in late 2013. The Department of Energy expects to conduct a National Environmental Policy Act (NEPA) review of this project concurrently and in coordination with the timing of this CEQA process. The LRDP and LRDP EIR would also inform decisions of the state Department of Toxic Substances Control regarding workplans for remediation of legacy pollutants at portions of the RBC site subject to a site investigation and remediation order and proposed for development (see section 3.1, below).

2.0 Project Location and Surrounding Land Uses

The approximately 133-acre RBC site is located at 1301 South 46th Street in the South Shoreline area of the City of Richmond, approximately 5 miles northwest of the UC Berkeley campus and the LBNL site in Berkeley.[3] The properties are bounded on the west by a Pacific Gas and Electric (PG&E) service station, on the northwest by Regatta Boulevard, on the northeast by Meade Street, on the east by South 46th Street, and on the south by the San Francisco Bay. Interstate 580 (I-580) runs parallel to Meade Street along the northeastern boundary of the site.

Land uses surrounding the RBC site include industrial/office uses and a major interstate freeway, with low-/medium-density residential neighborhoods. Regatta Boulevard, along the northern boundary of the RBC, is adjacent to a railroad spur and a business complex developed with one- to two-story buildings. Bio-Rad Laboratories, a private research equipment manufacturing company, is located immediately west of the uplands parcel. The adjacent property to the east is the location of former chemical production operations previously owned by several entities, including Stauffer and Zeneca, and is currently owned by Cherokee Simeon Venture I, LLC.

The Marina Bay residential neighborhood, across Meeker Slough and southwest of the RBC site, consists of a mix of multi- and single-family residences. Low- and medium-density residential uses are also located across I-580, north of the Meade Street boundary of the RBC site.

campus to be a catalyst for new innovation and clean industries in the area that would generate jobs; and both institutions expect to partner with the City and community to bring job training and opportunity to the area.

[3] The University owns properties in Richmond that total 194.6 acres. The properties are composed of four parcels: a 109.5-acre parcel that contains the currently developed upland portion known as the Richmond Field Station; a recently acquired 23.4-acre developed parcel along Regatta Boulevard immediately west of the upland area; and two submerged parcels in San Francisco Bay made up of 46.1 and 15.6 acres, respectively. Only the Richmond Field Station and Regatta Boulevard parcels would be developed under the 2013 LRDP.

3.0 Existing Site Conditions

3.1 Site Conditions

The 133-acre RBC site consists of upland areas developed with buildings that are used for academic teaching and research activities and spaces leased by private entities, a north-south oriented planting of eucalyptus trees in the central portion of the site, areas of coastal grasslands, a tidal salt marsh (known as the Western Stege Marsh), and a transition zone between the upland areas and marsh. Grasslands occur in a number of meadows on the RBC site. The Bay Trail is south of the site.

The University purchased the original Richmond Field Station landholdings in 1950. From 1870 to 1950, much of the property belonged to the California Cap Company, which manufactured explosives. The southeast portion of the uplands area was used for explosive materials manufacturing from the 1870s until 1948. Levels of contamination that exceed regulatory agency screening criteria have been found on the site. The primary contaminants of concern include metals, volatile organic compounds, and polychlorinated biphenyls (PCBs). The University is currently conducting an investigation and remediation of the site in accordance with a California Environmental Protection Agency, Department of Toxic Substances Control, Site Investigation and Remedial Action Order No. I/SE-RAO 06-07-004. On-site contamination and remediation is discussed in many reports completed under the Order, and addressed in an earlier CEQA document, all available on the web at rfs-env.berkeley.edu.

3.2 Existing On-Site Land Uses

The two upland parcels are currently developed with approximately 80 one- and two-story buildings, roadways, parking lots, and landscaped areas. The uplands area, which has been the location of a variety of industrial enterprises dating back to the mid-19th century, also contains previously disturbed, currently undeveloped open space. The site is currently developed with 1,050,000 gsf of facilities, including more than 500,000 assignable square feet of research space; the Northern Regional Library Facility (NRLF), which serves as an archive for 7.7 million volumes of lesser-used books for the four northern UC campuses; one of the world's largest earthquake shaking tables; test facilities for advanced transportation research; and a regional laboratory for the US Environmental Protection Agency (US EPA). The University purchased the Regatta parcel (former Price Club site) in 2007, which added 23.4 acres to its Richmond properties. The Regatta parcel is developed with a warehouse building and surface parking. The warehouse building currently housing University archives and other uses

As of late 2012, the RBC site has a daily population of approximately 300 persons.

3.3 Transportation, Circulation, and Parking

The existing main entrance to the RBC site is located at South 46th Street and the junction of Seaver Avenue and Robin Drive, accessed via the junction of Meade Street and Seaver Avenue. The site is accessible via interstate freeways I-80 and I-580. There are three interchanges on I-580 that provide access to the RBC site—Marina Bay Parkway interchange, Regatta Boulevard interchange, and Bayview Avenue interchange. The Regatta Boulevard and Bayview interchanges are both about 0.35 miles from the main entrance and provide the most direct access to and from the freeway. The Marina Bay Parkway and Regatta Boulevard interchanges provide the most direct access between the freeway and the Regatta property. Side-street access to the RBC is provided via overpasses at Bayview Avenue, Regatta Boulevard/Juliga Woods Street, Marina Bay Parkway/South 23rd Street, Marina Way, Harbor Way and others further west. Bay Trail access to the RBC is provided to bicyclists and pedestrians via underpasses/overpasses at Central Avenue, Buchanan Street, Gilman Street, University Avenue, the Berkeley bicycle and pedestrian bridge, and others further south. Bay Trail access to the RBC is also provided to bicyclists and pedestrians along the length of the entire Southern Gateway district in the City of Richmond.

The major vehicular circulation routes within the RBC site include east-west-running Robin Drive and Lark Drive, and north-south-running Egret Way. The primary vehicular entries into the RBC are:

- South 46th Street and the junction of Seaver Avenue and Robin Drive;
- South 46th Street at Building 194;
- Regatta Boulevard near South 34th Street; and
- Regatta Boulevard (multiple locations) for the western property.

Parking is accommodated in several surface lots. There are currently a total of 760 parking spaces on the site. UC Berkeley operates a shuttle bus that runs hourly between the UC Berkeley main campus and the Richmond Field Station.

3.4 Utilities and Infrastructure

The RBC site is connected to the local utility companies for electrical power, natural gas, water, and telecommunications services and to the City of Richmond wastewater system. PG&E provides electricity to the site through multiple overhead 12-kilovolt electrical lines, with both aerial and underground power lines comprising the electrical service infrastructure on the site. PG&E also provides natural gas service to the site through multiple high-pressure gas mains, with underground gas lines serving the larger facilities on site. The East Bay Municipal Utility District

(EBMUD) provides potable and firefighting water via multiple high-pressure water mains, with underground potable and firefighting water lines distributed throughout the site. AT&T provides communications service to the site. Site sanitary sewer discharge flows to the City of Richmond publicly-owned wastewater treatment plant, located approximately three miles to the west on Canal Boulevard.

4.0 2013 Long Range Development Plan

4.1 Main Features of the LRDP

The proposed 2013 LRDP addresses sustainability, land use, access and circulation, utilities and infrastructure, and open space and landscaping, and provides a policy and design framework to guide the development of up to 5.4 million square feet of new research, education, and support space at the site. Design principles in the proposed LRDP feature preservation of the site's important natural open spaces including the Bay, marsh, and coastal grasslands. The site plan organizes development into distinctive groupings to promote a sense of community within the site, particularly during initial phases of campus growth.

Building heights across the RBC are expected to vary, with lower buildings at the Bay front edge and taller buildings behind them. Four and five story buildings are expected to be a common building module, with heights of 100 feet providing for a five story building with tall floor-to-floor heights that allow building systems to be easily altered as laboratory uses change over time. Neighborhoods within the campus may also feature iconic buildings that help establish a sense of place. An example would be Sather Tower (the Campanile) at UC Berkeley, which measures 303 feet to the top.

The proposed LRDP demonstrates commitment to sustainability through site design, building design, and infrastructure. As the RBC site is developed, the campus itself would be open to the community, providing community resources such as auditorium, exhibit, and event space for educational programs. The proposed LRDP describes and highlights the multiple connections to the site by road, bicycle, and pedestrian path, and incorporates a robust transportation demand management system to facilitate site access.

The RBC would be the centerpiece of the Southern Gateway district of the City of Richmond, envisioned as a revitalized hub of innovation, and the proposed RBC 2013 LRDP emphasizes connectivity beyond the site, and the importance of the campus as a catalyst for its vicinity.

4.2 Anticipated Research Programs

In the near term, research at the RBC would focus on cleaner biofuel development processes; an advanced understanding of the genomics of plants, microbes, and microbial communities; production of nonpetroleum based essential materials and chemicals; advanced diagnostic equipment and techniques for bioscience; industrial process development; and cancer research. Existing research programs at the RBC site in sustainable transportation and earthquake engineering, among others, would continue; the site would also continue to house important collections of the University library and UC Berkeley museums. In addition, the bioscience programs at the RBC would maintain a close connection to the research conducted on the main campuses of LBNL and UC Berkeley. In the longer term, the RBC research would span the biosciences, energy and environmental sciences and technology, computing sciences, engineering and materials sciences, chemical sciences, climate sciences, and other disciplines. UC Berkeley expects that student research and teaching programs would also occur at the site, as part of the educational mission of the campus.

4.3 Campus Population Projections

The University expects the campus population to increase incrementally over time as the RBC is developed over the approximately 40-year horizon of the 2013 LRDP, from approximately 300 persons in 2012 to approximately 10,000 persons in 2050. Phase 1 development is projected to add 1,000 people.

4.4 Building Space Projections

Total building space on the RBC is projected to increase from approximately 1,050,000 gsf at the present time to 5,400,000 gsf at full implementation of the 2013 LRDP. Of the existing 1,050,000 gsf of building space, about 750,000 gsf would be demolished and about 300,000 gsf would be retained. The retained space includes the US EPA building (46,000 gsf) and NRLF (254,000 gsf). The new building space that would be added to the RBC site includes about 350,000 gsf for the expansion of the NRLF and about 4,750,000 gsf of research, education, and support facilities for occupancy by UC LBNL, UC Berkeley, and partner institutions. UC LBNL and UC Berkeley would explore ways to accommodate existing programs housed in space to be demolished at the site in new space at the RBC.

4.5 Sustainability

The sustainability vision is for the RBC to be a showcase of sustainable design and operations to motivate and inspire staff, the community, the nation, and the world. The RBC would assert and grow the University's reputation as a hub of energy efficiency research and best practices. The

facilities would demonstrate building efficiency technology innovations developed by the University and its industry partners in a fully functional laboratory environment.

In August 2011, the University adopted the most recent update of the UC Sustainable Practices Policy[4], which set goals to advance environmental practices in eight areas: green building, clean energy, transportation, climate protection, sustainable operations, waste reduction and recycling, environmentally preferable purchasing, and sustainable food service. All projects and operations at the RBC would meet or exceed the goals defined in this, or any successor, sustainability policy.

4.5.1 Energy

Physical development at the RBC would incorporate principles of energy efficiency in all capital projects, renovation projects, operations, and maintenance within budgetary constraints. In cases where the type of facility, such as a laboratory or data center, is not required to meet code requirements for energy consumption, the project would be required to meet specific energy and carbon performance metrics such as those defined by the "Labs21" (LBNL), "Smart Labs" (UC Irvine), or similar successor programs.

4.5.2 Water

In order to minimize the use of water to the extent practicable, the RBC would implement measures such as installing water-efficient landscaping and drip or other efficient irrigation systems, using water-efficient fixtures in new construction, and capturing rainwater and storm water for use in irrigation.

4.5.3 Municipal Solid Waste

The RBC would comply with the UC Sustainable Practices Policy for zero municipal solid waste by 2020.

4.5.4 Materials

Building materials would be selected to reduce embodied energy, maximize building lifespan, and be recyclable or reusable. Material use overall would be minimized, whether in buildings or in other site operations (e.g., paper), and recycled wherever practicable. Materials would be locally sourced and from renewable sources to the degree feasible, including re-use and recycling of materials from structures proposed for demolition.

[4] http://www.universityofcalifornia.edu/sustainability/policy.html

4.5.5 Transportation

In addition to providing shuttle access improvements, the RBC would implement a Transportation Demand Management program that would include alternate mode use incentives such as discounted transit passes, parking cash-out, Guaranteed Ride Home, and flexible car share programs.

4.5.6 Landscape

The RBC would support bio-diversity and habitat conservation through the use of native plant materials wherever possible. In addition, the RBC would utilize low-impact development design techniques and Bay-Friendly landscape design (see www.stopwaste.org) and make storm water management a site feature. As described below, natural open spaces would also be maintained.

4.6 Land Use Plan

The proposed 2013 LRDP identifies two land use designations to inform the pattern of development at the RBC: (1) Research, Education, and Support, and (2) Natural Open Space. Definitions for each land use designation are provided below. **Figure 1, LRDP Land Use Plan,** shows proposed land uses under the 2013 LRDP. A possible layout of the site is shown in **Figure 2, LRDP Conceptual Layout**.

4.6.1 Research, Education, and Support

The Research, Education, and Support land use designation applies to land areas on the RBC site that are either currently developed with facilities that would remain in their present form or be expanded, and areas that would be developed with new facilities. This land use would include approximately 108 acres of the RBC site, which would be sufficient to meet projected program needs. The types of facilities that would be allowed in designated Research, Education and Support areas would include:

- Laboratory, classroom, office, and administration buildings for researchers, faculty, postdocs, students, and non-University public and private entities.
- Product and process development space for private sector startups, small businesses, and industry counterparts that are synergistic with UC Berkeley and LBNL research areas.
- Support infrastructure and facilities for operations, transportation, utilities, renewable power generation, firefighting, security, safety, hazardous materials management, and corporation yard uses including vehicle and materials shops and storage. Support facilities for specialized research programs such as plant and animal research facilities, greenhouses, and clinical spaces.
- Community outreach and education uses including exhibit, lecture, and event spaces as well as conference facilities and meeting rooms focused on public education.

- Amenities such as dining, short-term accommodation facilities (for visiting researchers), retail, and recreation facilities.
- Transportation-related facilities including parking lots and structures; bus and shuttle stops; and roadways/circulation pathways. Parking structures might house transportation administration offices, bicycle support facilities, and utility structures such as distributed central plants.
- Developed open spaces that would be usable by the campus population and visitors, ranging from courtyards, terraces, and quad-like spaces, to walkways, tree groves and recreational fields. Existing landscaping, including non-native eucalyptus trees in these areas, may be removed and replaced. Open spaces in this zone might be paved or landscaped, with or without seating or other site furnishings. They would range in scale from larger areas for outdoor gatherings to smaller spaces for small group interaction or individual reflection. Storm water would be managed within these zones in swales and other landscaping. Small structures such as pavilions or overlook platforms might be located in these areas.
- Transition zones would buffer site buildings from the Natural Open Space areas, allowing for maintenance access and minimizing the transference of non-native species or noise or light intrusions. Permanent structures within 25 feet of the Natural Open Space areas would not be allowed.
- Throughout the RBC, paving would be pervious wherever practicable, stormwater would be carefully managed to protect natural areas, and any planting would consist of native or non-invasive species.

Childcare would not be considered an appropriate use in the Research, Education and Support land use designation; if childcare is proposed for the RBC the LRDP would be amended to identify or create an appropriate zone.

4.6.2 Natural Open Space

The RBC site includes natural areas such as the San Francisco Bay, Stege Marsh, and coastal grasslands. Human engagement and disruption to these spaces would be limited, with the intent to protect, restore, and maintain these resources in their natural condition. Activities would be limited to access for interpretation, education, maintenance, and research. Improvements in this zone would be limited to minor access roads for maintenance vehicles and limited boardwalks or pathways, consistent with education and conservation goals. Approximately 25 acres within the upland portion of the RBC site and 62 acres within the Bay portion of the site for a total of approximately 87 acres would be designated Natural Open Space to encompass those natural areas that the University plans to protect from development and maintain in their natural condition.

4.7 Circulation and Parking

4.7.1 Vehicle Access and Circulation

Vehicle access would continue to be provided from the existing exits from I-580. The existing ingress and egress points at the site would likely remain as primary or service access points. New points of ingress and egress would be added from the east off of South 46th Street, from the north off of Meade Street, and from the west at multiple locations off of Regatta Boulevard. A calm, mixed use street would potentially extend the existing Lark Drive to connect with Regatta Boulevard east and west. Roadways within the RBC would provide calm, mixed-use streets for internal circulation, direct access to facilities, pedestrians, bicycles, and utilities pathways. Regatta Boulevard would be rerouted to the west to allow the eastern and western portions of the RBC site to be unified. The existing north-south alignment of Egret Way would link the main entrance to the Phase 1 buildings. Phase 1 would utilize all existing roads and would not require any re-routing or new access.

4.7.2 Bicycle Circulation

Bicycle access to and from the RBC would be provided via overpasses at Bayview Avenue, Regatta Boulevard/Juliga Woods Street, Marina Bay Parkway/South 23rd Street, Marina Way, Harbor Way and others further west. Extended Lark Drive would provide bicycle connectivity to downtown Richmond and neighborhoods west of the RBC. Additional bicycle access to the RBC on the Bay Trail would be provided via underpasses/overpasses at Central Avenue, Buchanan Street, Gilman Street, University Avenue, the Berkeley bicycle and pedestrian bridge, and others further south Bicycle lanes would be provided on any new roads within the RBC site. A bike sharing system may also be implemented both for circulation within the RBC site and for travel to retail and other points nearby during the day.

4.7.3 Parking

Approximately 690 of the existing 760 vehicle parking spaces located in surface parking lots would be removed and, as needed over time, replaced in strategic locations. Surface parking would continue to be provided as a short term measure to serve the first few facilities. Later, parking structures would be constructed to provide for the majority of the approximately 6,000 vehicle parking spaces projected to be needed in the long term. Parking structures would be located at the periphery to support a more pedestrian-friendly, vehicle-free interior district with similarities to a traditional higher education campus. Small surface parking lots would be located adjacent to all new facilities for disabled access, shipping/receiving, and short-term visitor

parking. All parking areas would be provided with an appropriate system designed to treat stormwater runoff from parking areas in conformance with the Clean Water Act.

Bicycle parking would be provided at a rate of at least 20 percent of the RBC population at any given time period, in accordance with Leadership in Energy and Environmental Design (LEED) requirements; this would amount to approximately 2,000 spaces at full LRDP implementation. New buildings would have indoor secure bicycle parking, showers and clothes lockers, as well as outdoor bicycle racks, some of which may be secure and/or covered.

4.7.4 Transit

Two shuttle lines are proposed for the RBC. The LBNL-UC Berkeley-RBC Shuttle would provide a no-transfer 20-minute ride from LBNL to the RBC with a single stop at the main UC Berkeley campus en route. The Bay Area Rapid Transit (BART)-RBC Shuttle would run continuously between the El Cerrito Plaza BART station and the RBC, providing a nonstop nine-minute ride from BART to the RBC. The El Cerrito Plaza BART station would also serve as a connection point to the Alameda-Contra Costa Transit District (AC Transit) system.

5.0 Phase 1 Development

The University proposes to demolish 25 existing structures totaling approximately 107,000 gsf and consolidate existing LBNL bioscience programs currently in leased space into three new buildings totaling up to 600,000 gsf with an occupancy of approximately 1,000 adp. Building demolition and site preparation work would occur on a 16-acre portion of the RBC site. The facilities that would be developed under Phase 1 are shown in **Figure 3, Phase 1 Site Plan**.

5.1 Utilities Rerouting and Building Demolition

The Phase 1 development would first disconnect all utility services from, and demolish, 25 existing structures totaling approximately 107,000 gsf. This work would include all existing buildings south of Lark Drive, with the exception of Building 201, the US EPA laboratory. Storm and sanitary sewer drains required to continue flowing through the Phase 1 area would be rerouted to the eastern and western perimeters of the Phase 1 area in accordance with the utility corridor plan in the LRDP.

5.2 Tree Removal and Landscaping

Approximately 170 immature and mature pine and eucalyptus trees would be removed as part of the Phase 1 site preparation work. The remainder of the existing site trees would not be disturbed during Phase 1 development. Approximately 75 immature drought-resistant trees would be planted as a feature of the Phase 1 development.

5.3 Earthwork

The southern portion of the Phase 1 is in an area which is potentially subject to water inundation due to projected sea level rise, a tsunami, or a 100-year flood. In order to protect the Phase 1 facilities from this potential water inundation, the base elevation of the Phase 1 area would be increased from an average of approximately 10 feet above sea level (asl) to approximately 15 feet asl and the base elevation of the facilities would be constructed at 15 feet asl. This would require adding approximately 70,000 cubic yards of soil at varying depths over an area of approximately 12 acres.

5.4 Utilities Infrastructure

All-new utility services would be required to serve the Phase 1 area facilities. The points of connection to the utilities to serve the Phase 1 area facilities would be near the main entrance of the RBC at Meade and 46th Streets. Secondary points of connection would be located at Regatta Boulevard and 32nd Street. Utilities would be connected to the new facilities, and sized adequately to serve up to 800,000 gsf, providing capacity for some additional future development in the area.

5.5 New Construction

Three new research buildings totaling up to 600,000 gsf would be constructed to house a mix of laboratory, office, and interaction space. The facility to be constructed at the southernmost end of the RBC developable area is referred to hereinafter as Building 2 (“Energy building” on Figure 3). The facility to be constructed to the north of Building 2 is referred to hereinafter as Building 1 (“BIF building” on Figure 3). The facility to be constructed to the east of Building 2 is referred to hereinafter as Building 3 (“Health building” on Figure 3). Building 1 would house JGI, ABPDU, and KBase, an imaging center, and a conference facility. Building 2 would house LBNL’s JBEI and closely-related programs as well as a dining facility. Building 3 would house UC LBNL biosciences projects and activities, closely related projects and activities, and synergistic research institutions. Building 1 would likely be a three-story facility totaling 110,000 to 150,000 gsf. Building 2 would likely be a two-story facility totaling 110,000 to 150,000 gsf. Building 3 would likely be a three- to four-story facility totaling up to 300,000 gsf. Two new surface parking lots would be constructed on approximately 7 acres of land to accommodate approximately 870 vehicles associated with the new employees. These surface parking lots would become the locations for new facilities and a parking structure over time.

5.6 Sustainability

The Phase 1 buildings would incorporate green building strategies with goals of design, construction, and commissioning to achieve a minimum LEED Silver level for non-energy measures rating from the US Green Building Council. As appropriate, each building would meet specialized energy performance metrics and Environmental Performance Criteria credits developed for laboratories and data centers by the Labs21 Program.

The buildings would be oriented with their long facades facing south and north and short facades facing east and west in order to minimize solar gain in summer, maximize passive solar heating in the winter, and maximize natural light in the interior spaces. The buildings would also be positioned to provide wind protection in winter, encourage natural ventilation in summer, and benefit from western sun shading. The exterior material of the building would be compatible with the surrounding environment and maritime elements. The exterior cladding is anticipated to include a mix of concrete, metal, and glass.

5.7 Stormwater

Because the proposed Phase 1 site would be “downstream” of and at a lower elevation than the balance of the RBC, the Phase 1 area drainage would be sized for ultimate buildout conditions to accommodate the rest of the site’s stormwater runoff through the Phase 1 area. Phase 1 development would incorporate State Water Resources Control Board post-construction standards for storm water runoff in addition to other local and regional requirements. Runoff treatment facilities would be installed and other permanent best management practices (BMPs) would be implemented commensurate with regulatory requirements and sustainability policies established in the RBC LRDP. For Phase 1, this would primarily consist of bioswales and retention ponds between the building and parking lot stormwater drainage systems and the marsh area.

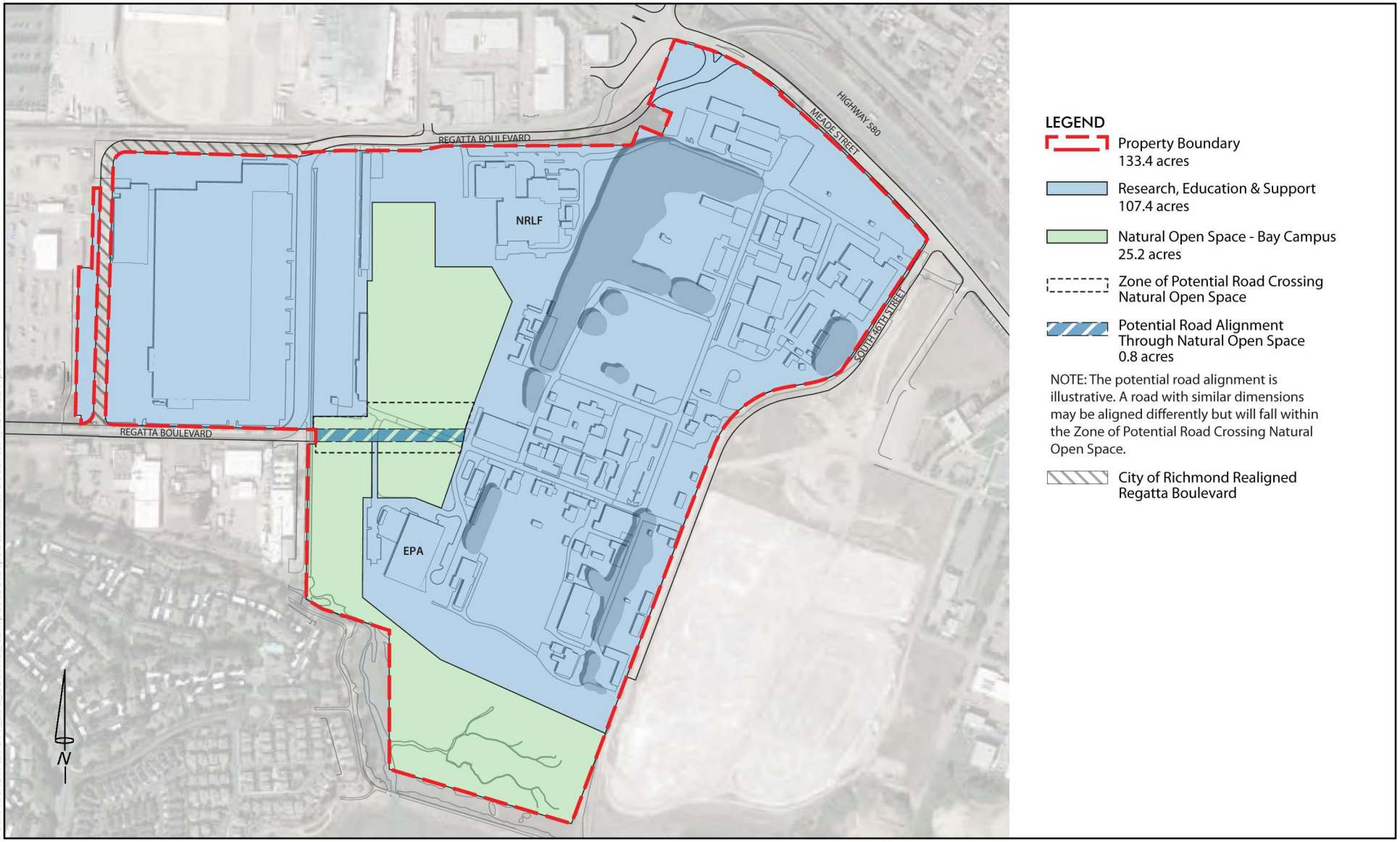
5.8 Construction Schedule

Phase 1 construction is anticipated to occur over a four-year period beginning in 2014 and continuing through 2018.

6.0 Alternatives

The LRDP EIR will include an examination of alternatives to the proposed 2013 LRDP, including the “no project” alternative required by CEQA. While the final list of alternatives will be developed in conjunction with the environmental analyses, alternatives likely to be considered for inclusion in the EIR are:

- **Reduced Growth Program:** Under this alternative, the RBC would be developed at the Richmond site, but with a reduction in the total building square footage and employee population.
- **Alternate Development Program:** Under this alternative, the RBC would be developed at the Richmond site as proposed, but it would provide for the development of a large-scale scientific facility or machine (referred to hereinafter as a "Future Scientific Facility.") with no net increase in the maximum 5.4 million gross square feet of development proposed..
- **Off-site Alternative:** Under this alternative, the LRDP would be implemented at another site, such as Alameda Point in the City of Alameda. The LRDP's building square footage, projected uses, and employee population would be the same.
- **No Project:** Under this alternative, the LRDP would not be implemented, and the Richmond Field Station and other components of the Richmond site would continue their current operations. UC LBNL would continue to lease off-site space for ongoing bioscience research and related programs.



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LRDP Land Use Plan

Richmond, California

TETRA TECH

Figure 1

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LRDP Conceptual Layout

Richmond, California

TETRA TECH

Figure 2

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Phase 1 Site Plan

Richmond, California

TETRA TECH

Figure 3

Potential Effects

The following is a preliminary assessment of potential environmental issues that may be analyzed in the LRDP EIR. This assessment will be used to help determine the scope of the EIR.[5] The EIR will consider all areas below. Topic areas that are expected to be impacted by the proposed project will be fully analyzed. Topic areas not expected to be impacted will be addressed briefly or in appropriate depth.

	Will be Analyzed in EIR	No Additional Analysis Required
1. AESTHETICS -- Would the project:		
a) Have a substantial adverse effect on a scenic vista?	☒	☐
Public views of the RBC site are limited from public viewing points north of the site due to tree cover and distance imposed by I-580; private property owners in the hills above the site have broad views that include the Richmond properties, the bay and San Francisco beyond. The chief public viewpoint of the site is from the Bay Trail. Although the visual conditions of the project site and surroundings are not expected to present major aesthetic issues, the EIR will include an evaluation of the project location and massing to determine if campus development under the LRDP, including Phase 1, will have substantial adverse effects on scenic vistas.		
b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?	☐	☒
The RBC site does not contain scenic resources, nor is it on or near a state scenic highway. Regional access to the site is by I-80 and I-580. Portions of I-580 are designated as scenic, but these occur from its junction with State Route 24 to the San Leandro city limit, and a portion in eastern Alameda County away from the project area. Therefore, no impact would occur to scenic resources present within a state scenic highway and further analysis in the EIR is not required.		
c) Substantially degrade the existing visual character or quality of the site and its surroundings?	☒	☐
The RBC site to date has retained its industrial character. The site and vicinity, however, is designated a “Change Area” in the City of Richmond General Plan 2030. The existing physical and visual configuration of buildings would be gradually replaced by a mixture of buildings and facilities with greater massing and density than those currently on site. The EIR will analyze the potential for campus development under the proposed LRDP, including Phase 1, to degrade the visual character and quality of the site and its surroundings.		
d) Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?	☒	☐
With the inclusion of new buildings and facilities, development of the RBC, including Phase 1, could create new sources of light and glare visible from off-site viewpoints. The EIR will analyze the potential impacts of these new light and glare sources.		

[5] Brief explanations are provided in shaded boxes. These explanations represent a best estimate based on the current preliminary understanding of the proposed LRDP, including Phase 1, and its likely effects.

	Will be Analyzed in EIR	No Additional Analysis Required
2. AGRICULTURE AND FOREST RESOURCES -- In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Dept. of Conservation as an optional model to use in assessing impacts on agriculture and farmland. In determining whether impacts to forest resources, including timberland, are significant environmental effects, lead agencies may refer to information compiled by the California Department of Forestry and Fire Protection regarding the state's inventory of forest land, including the Forest and Range Assessment Project and the Forest Legacy Assessment project, and forest carbon management methodology provided in Forest Protocols. Would the project:		
a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?	☐	☒
No active agriculturally-used lands are on the RBC site; therefore, further analysis in the EIR is not required.		
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?	☐	☒
The RBC site is not zoned for agricultural use and is not subject to a Williamson Act contract; therefore, further analysis in the EIR is not required.		
c) Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland to non-agricultural use?	☐	☒
No agricultural lands are adjacent or near the RBC site. Therefore, the development of the RBC site into a research campus will not result in the conversion of any farmland to a non-agricultural use. Further analysis in the EIR is not required.		
d) Conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code Section 12220(g) or timberland (as defined by Public Resources Code Section 4526)?	☐	☒
The site is not zoned for timber production or forest land; the proposed RBC does not conflict with existing zoning and would not cause rezoning related to forest land or timberland. Further analysis in the EIR is not required.		
e) Result in a loss of forest land or conversion of forest land to non-forest uses?	☐	☒
The RBC site contains eucalyptus trees planted by previous owners to reduce impacts from explosives once manufactured at the site; these trees are not forest land. Further analysis in the EIR is not required.		

	Will be Analyzed in EIR	No Additional Analysis Required
3. AIR QUALITY -- Where available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. Would the project:		
a) Conflict with or obstruct implementation of the applicable air quality plan?	☒	☐
The US EPA and the California EPA have established ambient air quality standards for certain pollutants referred to as criteria pollutants. The federal standards are known as the National Ambient Air Quality Standards and the state standards are known as the California Ambient Air Quality Standards. For each standard, air basins are classified as attainment, unclassified, or nonattainment. The project site is in the San Francisco Bay Area Air Basin (SFBAAB) that is currently designated as a nonattainment area for state and national ozone standards, state and national fine particulate matter ($PM_{2.5}$), and state inhalable particulate matter (PM_{10}). For all other standards, the SFBAAB is designated as attainment or unclassified. LRDP-related increases in staff, laboratory space, equipment, and construction activities, including site remediation conducted in accordance with agency-approved work plans, would likely add incrementally to regional ambient air pollutant emissions, including short- and long-term emissions of criteria air pollutants from mobile and stationary sources, including PM_{10} and ozone. The impact of these air emissions will be evaluated in the EIR. Standard emission control and reduction measures, such as dust control for excavation, use of alternative fuel vehicles on-site, shuttle service to public transportation, filtration on exhaust systems, etc., will be identified in the EIR where appropriate.		
b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation?	☒	☐
The EIR will examine the potential for mobile, area, and stationary source emissions from campus development under the LRDP, including Phase 1, to violate state and federal air quality standards or contribute to existing air quality violations. The potential for mobile source, construction and operational emissions from the LRDP implementation to influence air quality will be examined. The analysis will include examination of criteria pollutants that could result from project implementation.		
c) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)?	☒	☐
The SFBAAB is designated as a non-attainment area for ozone and PM_{10} standards. The EIR will examine the total emissions through 2050 that would result from campus development under the LRDP, including Phase 1, and determine whether increases in nonattainment criteria pollutants would be cumulatively considerable.		
d) Expose sensitive receptors to substantial pollutant concentrations?	☒	☐
The EIR will evaluate whether LRDP-related remediation, construction and development activities, including Phase 1, would expose sensitive receptors, including nearby schools, to substantial pollutant concentrations.		
e) Create objectionable odors affecting a substantial number of people?	☒	☐
Ongoing activities from the proposed project are not expected to create nuisance or objectionable odors affecting substantial numbers of people, on or off the site. The RBC would house research and office facilities that would not contain large scale manufacturing or industry that might be a source of objectionable odors affecting substantial numbers of people. Actions at the RBC that might create objectionable odors include asphalt-laying and other related construction activities. Because construction of the RBC is expected to occur periodically over several decades, the EIR will analyze potential impacts related to construction under the proposed LRDP, including Phase 1, and recommend mitigation measures where applicable.		

	Will be Analyzed in EIR	No Additional Analysis Required
f) Expose people to substantial levels of toxic air contaminants (TACs), such that the exposure could cause an incremental human cancer risk greater than 10 in one million or exceed a hazard index of one for the maximally exposed individual?	☒	☐
Development of the RBC would add research facilities, entail site remediation conducted in accordance with agency-approved work plans, and expand existing campus uses that are potential sources of low levels of toxic air contaminants and airborne radionuclides. The EIR will include estimates of emissions from full implementation of the RBC, including Phase 1, and will incorporate the results of a human health risk analysis conducted to determine if the project would expose people on or off the site to levels of toxic air contaminants that could cause a health risk.		
4. BIOLOGICAL RESOURCES -- Would the project:		
a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	☒	☐
The RBC site contains sensitive habitats, including seasonal wetlands, a native cordgrass marsh, coastal terrace prairie grassland, habitat for the federally listed endangered California clapper rail, as well as tidal mudflats and eelgrass beds. The EIR analysis will include potential project impacts to candidate, sensitive, or special status plant and animal species present in these habitats from the development of the campus under the LRDP, including Phase 1. In addition, potential impacts to primary habitat and transitory and migratory habitats will be addressed.		
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Game or US Fish and Wildlife Service?	☒	☐
As discussed under item a) above, the RBC site contains sensitive habitats. The EIR will examine possible impacts from campus development under the proposed LRDP, including Phase 1, to riparian habitat and other sensitive natural communities.		
c) Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?	☒	☐
Seasonal wetlands and marsh habitat are present on the RBC site. The EIR will examine possible impacts to wetlands on the site as a result of development of the RBC including Phase 1, in accordance with federal requirements and statutes.		
d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?	☒	☐
The EIR will evaluate the potential impacts of campus development under the proposed LRDP, including Phase 1, to migratory species and areas on the site that are potential wildlife corridors or may include native wildlife nursery sites.		
e) Conflict with any local applicable policies protecting biological resources?	☒	☐
The EIR will evaluate the consistency of the LRDP with federal and state plans, policies, laws and regulations, such as the Migratory Bird Treaty Act, that are relevant to potentially occurring biological resources. Although local ordinances would not apply to the project, the EIR will include a determination of consistency with local policies concerning the protection and conservation of biological resources, including the City of Richmond General Plan 2030.		

	Will be Analyzed in EIR	No Additional Analysis Required
f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other applicable habitat conservation plan?	☐	☒
The RBC site is not known to be subject to or designated for any adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved conservation plan. Further analysis in the EIR is not required.		
5. CULTURAL RESOURCES -- Would the project:		
a) Cause a substantial adverse change in the significance of a historical resource as defined in §15064.5?	☒	☐
Campus development under the proposed LRDP would result in the demolition of several existing buildings at the RBC site. Some of these buildings are 45 years old or greater and are associated with current and previous uses at the site. A survey is being conducted to assist in determining which structures that would be demolished for Phase 1 development may be historical resources as defined in CEQA Section 15064.5 and which may be eligible for the National Register of Historic Places pursuant to the National Historic Preservation Act. The results of this survey and other investigations will be included in the EIR analysis and will be used to evaluate whether implementation of the LRDP, including Phase 1, could cause a substantial adverse change in the significance of a historic resource.		
b) Cause a substantial adverse change in the significance of an archaeological resource pursuant to §15064.5?	☒	☐
There are no known archaeological resources at the RBC site. No archaeological artifacts have been discovered during past excavations and grading on the RBC site, and no archaeological sites have been recorded at the RBC site. However, given the size of the LRDP area and the site disturbance necessary for excavation and construction, and given the inclusion of the Regatta property in the area of the LRDP, the potential for discovery of unexpected archaeological resources during construction will be addressed and standard best practices and mitigations proposed in the EIR.		
c) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	☒	☐
There are no known unique paleontological resources or unique geologic features at the RBC, and none are anticipated. However, given the size of the LRDP area and the site disturbance necessary for excavation and construction, the potential for discovery of unanticipated paleontological resources during construction will be addressed and standard best practices and mitigations proposed in the EIR.		
d) Disturb any human remains, including those interred outside of formal cemeteries?	☒	☐
There is no known evidence of prehistoric habitation of the RBC site, or any indication that the site has been used for burials in the recent or distant past. However, given the size of the LRDP area and the site disturbance necessary for excavation and construction, the potential for discovery of human remains during construction will be addressed and standard best practices and mitigations proposed in the EIR.		

	Will be Analyzed in EIR	No Additional Analysis Required
6. GEOLOGY AND SOILS -- Would the project:		
a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:		
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.	☐	☒
A portion of the Hayward Fault Zone occurs within the City of Richmond, more than two miles northeast of the site. However, no fault is present on the RBC site and there is no potential for fault rupture. Further analysis in the EIR is not required.		
ii) Strong seismic ground shaking?	☒	☐
The EIR will analyze the stability of the underlying geologic materials in a strong earthquake on the Hayward Fault and other Bay Area faults, and the potential impacts of strong seismic ground shaking to campus development under the proposed LRDP, including Phase 1.		
iii) Seismic-related ground failure, including liquefaction?	☒	☐
The site has not been officially assessed by the State of California for its liquefaction potential but based upon the soil type, the relatively young age of the soil, and the shallow depth to groundwater, the sandy site areas could potentially be susceptible to liquefaction during an earthquake. The areas dominated by clay are less susceptible to liquefaction. The EIR will address the stability of the underlying geologic materials in a strong earthquake, including ability to resist lateral forces associated with a maximum credible magnitude earthquake near the project, and the potential for subsidence, differential settlement, and liquefaction impacts to campus development under the proposed LRDP, including Phase 1.		
iv) Landslides?	☐	☒
The RBC site is relatively flat, at the distal end of an alluvial plain. There is no potential for landslide risk at the site. Further analysis in the EIR is not required.		
b) Result in substantial soil erosion or the loss of topsoil?	☒	☐
The RBC site is relatively flat and not at risk for substantial soil erosion. All of the properties are previously disturbed and not a source of quality topsoil. Standard construction regulation and best practices, including implementation of National Pollutant Discharge Elimination System permit requirements, would mitigate any risk of substantial soil erosion or loss of topsoil. However, given the size of the LRDP area and the site disturbance necessary for raising the ground level, excavation and construction, standard best practices and mitigations will be discussed in the EIR to reduce risk of soil erosion.		
c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?	☒	☐
The EIR will analyze the stability of the underlying geologic materials in a strong earthquake, including ability to resist lateral forces associated with a large magnitude earthquake near the project, the potential for subsidence, differential settlement, and liquefaction.		
d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1997), creating substantial risks to life or property?	☒	☐
The EIR will analyze the potential effects of the soil types of the site to development of the RBC under the proposed LRDP, including Phase 1.		

	Will be Analyzed in EIR	No Additional Analysis Required
e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?	☐	☒
The Richmond properties are served by the City of Richmond wastewater treatment system, and RBC is not proposed to be served by septic systems or alternate waste water disposal systems; therefore, this topic will not be further analyzed in the EIR.		
7. GREENHOUSE GAS EMISSIONS -- Would the project:		
a) Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?	☒	☐
The EIR will estimate the level of greenhouse gas (GHG) emissions anticipated with the development of the campus under the proposed LRDP, including Phase 1, to determine whether these emissions would result in a significant impact requiring mitigation.		
b) Conflict with any applicable plan, policy or regulation adopted for the purpose of reducing the emissions of greenhouse gases?	☒	☐
Assembly Bill 32, the California Global Warming Solutions Act, requires a statewide GHG emission cap for 2020 based on 1990 emission levels. Senate Bill 375 requires local land use and transportation planning to achieve the state's GHG reduction goals. The Bay Area Air Quality Management District, charged with regulating GHGs in the region, has established CEQA air quality standards that are currently under legal review. The EIR will evaluate the development of the RBC in the context of state, regional and local laws and UC Sustainable Practices Policy requirements concerning the reduction of GHGs.		
8. HAZARDS AND HAZARDOUS MATERIALS -- Would the project:		
a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?	☒	☐
The RBC site includes some areas of contaminated soil and groundwater. The University is in the process of investigating and remediating site contamination in accordance with a California Department of Toxic Substances Control (DTSC) Order. These actions are ongoing, and further site development would in some instances require site remediation conducted in accordance with agency-approved work plans. Current operations at the RBC site include the use of solvents, adhesives, cements, paints, cleaning agents, degreasers, and vehicle fuels. Arsenic, copper, lead, mercury and polychlorinated biphenyls have been detected in the soil at levels exceeding hazardous waste criteria. Development of the RBC would spur development of additional facilities that would use, store, and require the transportation of additional hazardous materials and disposal of hazardous waste (including mixed waste, combined waste, and radioactive waste). The EIR will characterize anticipated new and expanded on-site hazardous materials remediation use, transport and disposal, will identify projected increases in these activities that could occur under the LRDP program, including Phase 1, and will evaluate potential impacts associated with these increased activities.		
b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?	☒	☐
The EIR will characterize hazardous waste, mixed waste, combined waste, and radioactive waste handling and hazardous materials use in research, operations, maintenance, and construction, and their transport, handling and disposal. It will identify projected increases in these activities that could occur under development of the RBC, including Phase 1, and will evaluate associated potential impacts, including potential risks from reasonably foreseeable accidents or upset conditions.		

	Will be Analyzed in EIR	No Additional Analysis Required
c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?	☒	☐
The RBC site is not within one-quarter mile of an existing or proposed school per CEQA Guideline 15186. While the RBC would handle certain hazardous materials, these materials and their handling protocols are subject to extensive regulations, procedures and oversight. Although the proposed RBC (including Phase 1) and remediation conducted in accordance with agency-approved work plans as the site is developed is not anticipated to be a major new source of on-site hazardous materials or handling, the EIR will include an analysis of anticipated materials and the potential impacts of their use.		
d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?	☒	☐
The RBC site is listed on the current California EPA Hazardous Waste and Substances Sites List, also known as the "Cortese list." This listing is due to prior site activities that resulted in soil contamination at specific site locations. As discussed above in Sec. 8.a, the DTSC is directing remediation efforts to address the effects of this past contamination. Information regarding the background, remediation activities, and current status may be found at: http://www.envirostor.dtsc.ca.gov/public/profile_report.asp?global_id=07730003. These remediation activities, their status, and current and future remediation efforts will be discussed in the EIR, as well as any additional measures if necessary due to development of the RBC, including Phase 1.		
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard for people residing or working in the project area?	☐	☒
The RBC site is neither within an airport land use plan nor within two miles of a public airport; therefore, further analysis in the EIR is not required.		
f) For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working in the project area?	☐	☒
The RBC site is not near a currently operating or planned private airstrip; therefore, further analysis in the EIR is not required.		
g) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	☒	☐
Emergency response plans are maintained at the Federal, State and local level for all types of disasters, including human-made and natural. Emergency response plans for existing and new facilities would be the responsibility of the operation and management at the RBC; however, the EIR will analyze development of the RBC, including Phase 1, in consultation with all applicable emergency response providers and identify if any impacts to their adopted response plans would occur.		
h) Expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?	☐	☒
The RBC is not near wildlands and the risk of wildland fires is low. There are numerous open space and wetland areas at the site, but these are not considered moderate or high-risk for wildland fires due to their limited and non-contiguous setting away from large open or natural areas that are susceptible to wildland fires. Further analysis in the EIR is not required.		

	Will be Analyzed in EIR	No Additional Analysis Required
9. HYDROLOGY AND WATER QUALITY -- Would the project:		
a) Violate any water quality standards or waste discharge requirements?	☒	☐
Development of the RBC could increase the impermeable surface area, which could produce additional volume and pollutant loading of urban runoff. Increased water use from the RBC could cause increases in wastewater discharges that could exceed waste discharge requirements for water quality or quantity. The EIR will evaluate impacts to water quality from runoff and characterize current waste discharge volumes of the site and wastewater treatment capacity at the City of Richmond's wastewater treatment plant, and evaluate whether development of the RBC, including Phase 1, would cause a violation of applicable standards or waste discharge requirements.		
b) Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?	☒	☐
Potable water at the site and in Richmond is supplied by EBMUD, and not from groundwater wells; groundwater in the area does not support existing or planned land uses. Groundwater contamination has been detected on portions of the site. Shallow groundwater is expected to be encountered during construction of the RBC. While additional site development may somewhat reduce percolation of stormwater into the shallow groundwater due to the addition of impervious surface area, the project would not substantially deplete supplies or interfere with groundwater recharge. However, given the size of the LRDP area and the scale of development anticipated at the horizon year, standard best practices and mitigations will be discussed in the EIR to address groundwater recharge.		
c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site?	☒	☐
The project site includes a channelized storm drain that flows into the bay and directly affects the existing drainage pattern of the site. Development of the RBC will increase the impervious area of the site and could increase the rate of site runoff. The EIR will include analysis of the proposed site and development pattern of the project to ascertain how the siting of buildings and facilities could further affect the drainage patterns of the site, and the potential impacts pertaining to drainage, erosion, and on- and off-site siltation from campus development under the proposed LRDP, including Phase 1.		
d) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?	☒	☐
There are no natural streams or rivers on the site and the site has existing stormwater and drainage systems, including the channelized storm drain, that address flooding concerns. Development of the RBC, including Phase 1, would increase the area of impervious surface that could increase the volume of surface water; systems would, however, be sized and improvements planned to reduce the risk of flooding or increase in levels of urban contaminants in stormwater runoff, as part of the 2013 LRDP improvements. However, given the size of the LRDP area and the scale of development anticipated at the horizon year, standard best practices and mitigations will be discussed in the EIR to address drainage and risks of flooding.		
e) Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?	☒	☐

	Will be Analyzed in EIR	No Additional Analysis Required
In the short term, the project will likely increase the amount of impervious surface at the site that could increase the volume of surface water runoff. The EIR will evaluate if the existing and planned drainage system could accommodate increased runoff from campus development under the proposed LRDP, including Phase 1; the analysis will include potential impacts associated with stormwater runoff.		
f) Otherwise substantially degrade water quality?	☒	☐
Expansion of research operations associated with development of the RBC, including Phase 1, could result in activities that could impact water quality. Improvements would, however, be planned to reduce the risk of water quality degradation, including bioswales and other stormwater filtration and retention measures. However, given the size of the LRDP area and the scale of development anticipated at the horizon year, standard best practices and mitigations will be discussed in the EIR to address water quality.		
g) Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?	☐	☒
While the RBC could include temporary lodging, it would not include temporary or permanent housing within the 100-year flood hazard area; therefore, this topic will not be discussed further in the EIR.		
h) Place within a 100-year flood hazard area structures which would impede or redirect flood flows?	☒	☐
A portion of the site is within a Federal Emergency Management Agency VE Zone. This designation denotes coastal areas with a one percent or greater chance of flooding and an additional hazard associated with storm waves; these areas have a 26 percent chance of flooding over a 30-year period. Given the size of the LRDP area and the scale of development anticipated at the horizon year, the EIR will consider existing flood control structures on the site and the adequacy of these structures and the possible need for additional flood control components.		
i) Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam?	☒	☐
The RBC site is not downstream of or near a levee or dam. As described in response to item d) above, systems would be sized and improvements planned to reduce the risk of flooding due to stormwater flows and risk from other sources of flooding (see item h) above). A flood control channel on the site addresses current water flows, including those related to stormwater. Given the size of the LRDP area and the scale of development anticipated at the horizon year, standard best practices and mitigations will be discussed in the EIR to address drainage and risks of flooding due to campus development under the proposed LRDP, including Phase 1.		
j) Inundation by seiche, tsunami, or mudflow?	☒	☐
Portions of the RBC site are within a mapped tsunami inundation zone; however, these locations are not proposed for development. According to the City of Richmond General Plan 2030 EIR, portions of the site along the Bay could be subject to projected sea level rise as a result of global warming. The EIR will examine potential impacts due to rising sea levels and discuss any mitigations, if necessary, to address sea level rise.		
10. LAND USE AND PLANNING -- Would the project:		
a) Physically divide an established community?	☒	☐
The RBC would be located on the existing Richmond properties. The site is currently somewhat disconnected from the Richmond community, by the barriers of I-580 freeway and railroad lines north and east of the properties. The RBC LRDP would not expand the campus site into the surrounding community and would not physically divide any established communities; the project may instead improve linkages with the community. The EIR will include a discussion of adjacent and nearby land uses and land use patterns and applicable land use and zoning ordinances and policies.		

	Will be Analyzed in EIR	No Additional Analysis Required
b) Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the LRDP, general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?	☒	☐
The RBC would be located on land owned by the University of California which has land use jurisdiction over the site, as prescribed by Article IX Section 9 of the California Constitution, As such, the project is not subject to local land use planning jurisdiction, but rather, the Long Range Development Plan acts as a general plan for the site. The EIR will include as context a discussion of local land use ordinances and policies, including the recently adopted City of Richmond General Plan 2030, as the University seeks to be a good neighbor. The parcels of the RBC site closest to San Francisco Bay are within the jurisdiction of the San Francisco Bay Conservation and Development Commission (BCDC) and would be subject to the policies and development guidelines of the San Francisco Bay Plan. The jurisdictional boundary of BCDC was amended in October 2011 to reflect climate change issues and projected sea level rise. Development of the RBC, including Phase 1, would include infrastructure components within the BCDC's jurisdictional area; therefore, the EIR will include a discussion of the LRDP's conformance with BCDC development policies and guidelines as directed by the San Francisco Bay Plan.		
c) Conflict with any applicable habitat conservation plan or natural community conservation plan?	☐	☒
The RBC site is not located within any adopted federal, state or local habitat conservation plan or natural community conservation plan. Therefore, no additional analysis in the EIR is required.		
11. MINERAL RESOURCES -- Would the project:		
a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?	☐	☒
Because the site is in an area where there are no significant mineral or aggregate deposits and there are no known mineral resources that would present major issues for development of the RBC, no further discussion is required in the EIR.		
b) Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?	☐	☒
The RBC site does not include any locally-important mineral resource recovery sites as delineated on a local general plan, specific plan or land use plan, so no further discussion is required in the EIR.		
12. NOISE -- Would the project result in:		
a) Exposure of persons to or generation of noise levels in excess of standards established in any applicable plan or noise ordinance, or applicable standards of other agencies?	☒	☐
The RBC would cause increases in traffic volumes, mechanical equipment associated with new building and related structures, and increases in daily site populations that could cause potential long-term increases in noise levels. Operation of construction equipment could cause substantial short-term noise increases that might include short-term, temporary exceedances of noise ordinances in nearby areas. The EIR will analyze the anticipated magnitude of these noise increases, and will evaluate whether the increased noise levels associated with campus development under the proposed LRDP, including Phase 1, would exceed applicable ambient noise standards.		
b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?	☒	☐

	Will be Analyzed in EIR	No Additional Analysis Required
Operational activities associated with the RBC are not likely to result in activities that generate excessive groundborne vibration or noise levels. Construction of buildings or other support structures under the LRDP, including Phase 1, might require the use of pile drivers or other heavy construction machinery that could generate excessive groundborne vibration or groundborne noise levels noticeable to both on- and off-site receptors. The EIR will address vibration and groundborne noise levels from anticipated construction activities, and discuss potential impacts and mitigation measures.		
c) A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?	☒	☐
Activities at the RBC, including Phase 1, would cause increases of on-site population and general operations that could produce permanent ambient noise level increases. The EIR will evaluate whether any increased permanent noise levels would exceed applicable ambient noise standards.		
d) A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?	☒	☐
Operation of construction or other equipment could cause substantial temporary or short-term noise increases. The EIR will use current noise modeling methods to predict their magnitude, and will evaluate whether the increased temporary noise levels associated with implementation of the RBC would exceed applicable noise standards.		
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?	☐	☒
The RBC site is not in a current or proposed airport land use plan or Airport Influence Area, as defined by Assembly Bill 2776 and is not within two miles of a public airport. Therefore, no further discussion is required in the EIR.		
f) For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?	☐	☒
The RBC site is not near a current or planned private airstrip. Therefore, no further discussion is required in the EIR.		
13. POPULATION AND HOUSING -- Would the project:		
a) Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?	☒	☐
No housing is proposed at the RBC. Employment growth and housing demand attributable to the RBC would occur over several decades and, based on current commute patterns of existing employees at the site and LBNL and UC Berkeley employees, demand would be dispersed over a broad area of the East Bay and the greater Bay Area. Further, a portion of employees at the new RBC would be existing LBNL or UC Berkeley employees whose work is moved to a new location, and those employees would not be new employees contributing to population growth. The EIR will analyze the anticipated increase in jobs in relation to the population and housing policies and projections for the City of Richmond, as well as neighboring jurisdictions, to determine whether the level of impact that would occur with development of the RBC, including Phase 1.		
b) Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?	☐	☒
The RBC site does not include housing or any related residential uses, and no housing would be displaced, so further discussion is not required in the EIR.		

	Will be Analyzed in EIR	No Additional Analysis Required
c) Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?	☐	☒
The RBC site does not include housing or any related residential uses, and no housing would be displaced, so further discussion is not required in the EIR.		
14. PUBLIC SERVICES --		
a) Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services:		
Fire protection?	☒	☐
Development of the RBC, including the permanent increase in on-site personnel, would increase the potential need for emergency fire protection services, including hazardous materials response units. The EIR will analyze the site's fire response equipment, water storage and distribution, and firefighting response capability to address any increases in demand at full implementation of the proposed LRDP as well as upon completion of Phase 1. In addition, the EIR will evaluate whether significant impacts would occur should the project result in the need for new or physically altered facilities.		
Police protection?	☒	☐
RBC-related increases in development and on-site personnel would increase the potential need for police services, which are provided by the UC Police Department. The site's on-site security forces likely would be expanded as needed to accommodate the increases in demand at full implementation of the proposed LRDP as well as upon completion of Phase 1. The EIR will evaluate the anticipated demand on police services and whether significant impacts would arise from any new or physically altered police facilities.		
Schools?	☒	☐
RBC-related increases in personnel could draw more families with school-aged children to the vicinity of the site. The EIR will analyze the potential impacts of this population to nearby primary and secondary schools. This analysis will include data and projections from the City of Richmond General Plan 2030 and projections from local school districts to determine potential impacts and the need for expanded school facilities.		
Parks?	☒	☐
RBC-related increases in personnel will draw more people into the area and increase demand for parks and recreational facilities. There are several existing parks and recreational facilities nearby. The EIR will analyze impacts to parks and recreational facilities.		
Other public facilities?	☒	☐
RBC-related increases in personnel could draw more people into the area and increase demand for additional public facilities. The EIR will analyze potential impacts to public facilities, including libraries and planned facilities identified in the City of Richmond General Plan 2030.		

	Will be Analyzed in EIR	No Additional Analysis Required
15. RECREATION --		
a) Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?	☒	☐
There are several parks within one mile of the RBC site. These include Shimada Friendship Park, Rosie the Riveter Park, Laurel Park, Booker T. Anderson Community Center, and the Point Isabel Regional Shoreline. The Bay Trail is adjacent to the site, and provides a pedestrian and bicycle link along the shoreline that ultimately will provide a continuous link around San Francisco Bay. RBC related growth, including Phase 1, could increase demand for parks and recreational facilities in the area. The EIR will evaluate this issue in the context of current and proposed parkland and open space facilities in the area.		
b) Does the project include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment?	☒	☐
Recreational facilities may be developed at the RBC. The EIR will discuss the existing and proposed inventory of recreational facilities in the vicinity and identify any potential impacts to these facilities by the increased daily population resulting from campus development under the proposed LRDP, including Phase 1.		
16. TRANSPORTATION/TRAFFIC -- Would the project:		
a) Conflict with an applicable plan, ordinance or policy establishing measures of effectiveness for the performance of the circulation system, taking into account all modes of transportation including mass transit and relevant components of the circulation system, including, but not limited to intersections, streets, highways, and freeways, pedestrian and bicycle paths, and mass transit?	☒	☐
The EIR will analyze the impact of the development of the RBC, including Phase 1, on the local and regional road and highway network, including Routes of Regional Significance as defined for the vicinity of the RBC. Impacts analyzed for transit will include impacts to local bus service and BART lines and connectors. The EIR will also examine potential impacts to pedestrian and bicycle facilities such as the Bay Trail and the local and regional bicycle and pedestrian network.		
b) Exceed, either individually or cumulatively, a level of service standard established by the county congestion management agency for designated roads or highways?	☒	☐
Campus development under the proposed LRDP, including Phase 1, is expected to generate increased vehicular traffic that could result in impacts to the local and regional road network. The EIR will analyze local streets and regional highway corridors to determine whether level of service standards would be impacted due to the project. The analysis will utilize the City of Richmond General Plan 2030 to identify proposed and planned changes to the circulation network in and around the RBC. Traffic modeling and forecasting for AM and PM peak hours will be conducted using the most recent version of the Countywide Travel Demand Model developed by the Contra Costa Transportation Authority, the designated congestion management agency.		
c) Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that result in substantial safety risks?	☐	☒
Development of the RBC would not alter existing air traffic patterns; therefore, this does not require further study in the EIR.		

	Will be Analyzed in EIR	No Additional Analysis Required
d) Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)? Create unsafe conditions for pedestrians or bicycles?	☒	☐
The EIR will analyze the circulation features for access to and within the site with development of the RBC. This analysis will include location and site clearance for signalized and unsignalized intersections, traffic calming features, and related circulation elements. The EIR will discuss the proposed traffic circulation network as it relates to bicycle and pedestrian circulation and access to determine if any potential safety impacts would occur.		
e) Result in inadequate emergency access?	☒	☐
The EIR will analyze existing and proposed access and circulation for emergency vehicles in coordination and consultation with emergency service providers.		
f) Conflict with adopted policies, plans, or programs regarding public transit, bicycle or pedestrian facilities, or otherwise decrease the performance or safety of such facilities?	☒	☐
Both LBNL and UC Berkeley have robust transportation demand management programs to encourage use of alternative commute modes. As described in item a), above, the EIR would examine potential impacts to alternative commute systems and facilities due to implementation of the LRDP.		
17. UTILITIES AND SERVICE SYSTEMS -- Would the project:		
a) Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?	☒	☐
No wastewater treatment requirements are directly applicable to the proposed project because the wastewater generated on the RBC will not be treated on-site. Wastewater generated on the campus will discharge to the City of Richmond wastewater treatment plant. The EIR will analyze the wastewater output anticipated due to development of the RBC, to determine the ability of the project to comply with the wastewater treatment requirements imposed on the City's wastewater treatment plant by the Regional Water Quality Control Board.		
b) Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☒	☐
The EIR will evaluate the increased demand on wastewater treatment and conveyance facilities under the proposed LRDP, including Phase 1, and evaluate potential impacts associated with any new or expanded facilities, if any would be required to meet this demand.		
c) Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☒	☐
Development of the RBC, including Phase 1, would increase impervious surface coverage of the Richmond properties; this in turn may increase the volume of stormwater flow. The EIR will examine and describe the existing site-wide drainage patterns and infrastructure, analyze the increased demand for stormwater drainage facilities with the RBC, and the potential impacts associated with any new or altered drainage facilities required to meet this demand.		
d) Have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed?	☒	☐

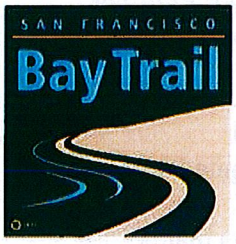
	Will be Analyzed in EIR	No Additional Analysis Required
Development of the RBC would include up to 5.4 million square feet of buildings and approximately 10,000 adp. Development of Phase 1 would involve up to 600,000 gsf of new building space and increase the on-site population to 1,300 persons. This would increase the water use on the site; therefore, the EIR will evaluate the projected water demand for the campus relative to the planned water supply and delivery entitlements from EBMUD. The EIR will evaluate potential environmental impacts from expanded or new entitlements.		
e) Result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?	☒	☐
The EIR will evaluate whether projected wastewater increases generated at the full implementation of the proposed LRDP, including Phase 1, would be served by existing capacity and identify any environmental impacts should additional wastewater entitlements be required.		
f) Be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs?	☒	☐
The EIR will discuss the current solid waste generation at the project site and the volume of waste that would be generated at Phase 1 and at full implementation of the proposed LRDP, including Phase 1. The analysis will include projected solid waste disposal needs—including wastes generated from the demolition of existing buildings and structures—and determine whether or not existing landfill capacity would be able to accommodate the waste disposal needs of the RBC. The EIR will discuss the solid waste demands in context of solid waste recycling and composting requirements and guidelines, including the UC Sustainable Practices Policy.		
g) Comply with applicable federal, state, and local statutes and regulations related to solid waste?	☒	☐
The EIR will discuss compliance of the proposed project with applicable statutes and regulations regarding solid waste, including the UC Sustainable Practices Policy.		
18. MANDATORY FINDINGS OF SIGNIFICANCE --		
a) Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?	☒	☐
Implementation of the 2013 LRDP, including Phase 1, has the potential to have significant impacts that could degrade the quality of the environment. The LRDP EIR will evaluate the potential for campus development under the 2013 LRDP to result in significant impacts that could degrade the quality of the environment, as described in the above checklist.		
b) Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)?	☒	☐

	Will be Analyzed in EIR	No Additional Analysis Required
Development of the RBC pursuant to the proposed LRDP, including Phase 1, could cause impacts to several resource areas that will be fully analyzed in the EIR. The project will be evaluated in the cumulative setting. The City of Richmond recently adopted its General Plan 2030 that anticipates new growth and development in the area. This plan, along with other applicable plans and polices from Richmond and other neighboring communities, could contribute to a range of cumulative impacts in the area. The EIR will evaluate whether impacts associated with growth under the 2013 LRDP, in combination with past, current, and reasonably foreseeable future projects, have the potential to be cumulatively considerable.		
c) Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?	☒	☐
The proposed 2013 LRDP has the potential to cause significant impacts. The EIR will evaluate whether these impacts have the potential to result in substantial adverse effects on human beings, either directly or indirectly.		

List of Acronyms and Abbreviations

AC Transit	Alameda-Contra Cost Transit District
adp	average daily population
ABPDU	Advanced Biofuels Process Development Unit
BART	Bay Area Rapid Transit
BCDC	Bay Conservation and Development Commission
BMP	best management practice
CEQA	California Environmental Quality Act
EBMUD	East Bay Municipal Utility District
EIR	Environmental Impact Report
GHG	greenhouse gas emissions
gsf	gross square feet
I	Interstate
JBEI	Joint Bio Energy Institute
JGI	Joint Genome Institute
KBase	Knowledge Base
LBNL	Lawrence Berkeley National Laboratory
LEED	Leadership in Energy and Environmental Design
LRDP	Long Range Development Plan
NEPA	National Environmental Policy Act
PCB	Polychlorinated Biphenyls
PG&E	Pacific Gas and Electric
PM_{10}	inhalable particulate matter
$PM_{2.5}$	fine particulate matter
RBC	Richmond Bay Campus
SFBAAB	San Francisco Bay Area Air Basin
UC	University of California
US EPA	US Environmental Protection Agency

Comments



University of California
Lawrence Berkeley National Laboratory

JAN 15 2013

Facilities Capital Projects

January 15, 2013

Jeff Philliber, Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

Subject: **Comments on the Notice of Preparation (NOP) for the Draft Environmental Impact Report (DEIR) for the Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development Project**

Dear Mr. Philliber:

On behalf of the San Francisco Bay Trail Project, I am writing to submit comments on the NOP for the DEIR for the Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development Project (LRDP Project) located in the City of Richmond. The Bay Trail Project is a nonprofit organization administered by the Association of Bay Area Governments (ABAG) that plans, promotes, and advocates for the implementation of the Bay Trail. The Bay Trail is a planned 500-mile continuous network of multi-use bicycling and hiking paths that, when complete, will encircle San Francisco and San Pablo Bays in their entirety. It will link the shoreline of all nine Bay Area counties, as well as 47 cities. To date, 333 miles of the proposed Bay Trail system has been developed.

When the LRDP Project is fully built, it is expected to generate a significant number of daily vehicular trips to and from the Richmond Bay Campus (RBC) by both employees of the Lawrence Berkeley National Laboratory (LBNL) and visitors to the campus. These daily vehicular trips will result in significant impacts to parking demand, transportation infrastructures, greenhouse gas emissions, and air quality that will need to be addressed and mitigated in the DEIR. We also expect an increased demand in the use of the Bay Trail as both an alternative transportation corridor and recreational opportunity for RBC employees and visitors. As a result, the DEIR needs to evaluate the impacts of the LRDP project on demand for the Bay Trail and provide mitigation for those impacts.

Due to the LRDP Project's proximity to the significant stretch of completed Bay Trail alignments in the City of Richmond, the LRDP Project is in a unique position to mitigate its impacts resulting from the high levels of vehicular trips that it is expected to generate. The LRDP Project can mitigate the parking, traffic, greenhouse gas, and air quality impacts that it will generate by improving the existing Bay Trail and the connections to the Bay Trail between Central Avenue and Garrard Boulevard in order to encourage RBC employees and visitors to shift travel modes and use the Bay Trail as a non-motorized mode of travel to and from the RBC.

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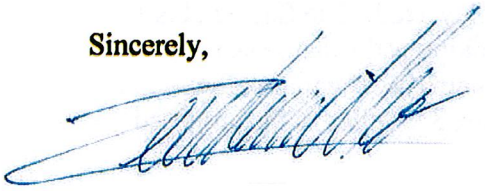
The Bay Trail Project appreciates the opportunity to comment on the NOP for the LRDP DEIR and looks forward to working with the Lawrence Berkeley National Laboratory to improve the Bay Trail in Richmond for LBNL employees and the public. Please do not hesitate to call me at (510) 464-7915 if you have any questions regarding the above comments or the Bay Trail.

Sincerely,



Lee Chien Huo
Bay Trail Planner

University of California
Lawrence Berkeley National Laboratory
JAN 17 2013
Facilities Capital Projects

From: **John Taylor** <jtaylor@berkeley.edu>
Date: Wed, Jan 16, 2013 at 4:23 PM
Subject: Richmond Bay Campus Comment, invasive plants
To: LRDP-EIR@lbl.gov
Cc: "Tom Kelly (KyotoUSA)" <kyotousa@sbcglobal.net>, Delia Taylor <deliataylor@mac.com>

LRDP-EIR@lbl.gov
Jeff Philliber
Chief Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road MS 76-225
Berkeley CA 94720

Dear Chief Environmental Planner Philliber:

I have a specific comment regarding the Notice of Preparation and Initial Study for the Richmond Bay Campus project.

It concerns Biological Resources Sections 4a-species, 4b-riparian habitat and 4c-wetlands in Meeker Slough and the Western Stege Marsh.

Noxious and invasive plants (Italian fennel and pampas grass) that are invading the newly rehabilitated slough and marsh pose a threat to biological resources that easily could be solved *now* but will be a headache later for the new Richmond Bay Campus.

My wife, Delia, and I saw the problem on a bike ride and then contacted one of two key persons in invasive plant control along the Bay Trail, Tom Kelly. Kelly has close contacts with the East Bay Regional Park District, who own and manage the trail, which is a prime source of the invasive plants at the RFS. Given that the marsh and slough abut EBRPD trails, a logical partner in weed control would be Scott Possin, the Supervisor at Miller-Knox, the park that covers that part of the Bay Trail, spossin@ebparks.org.

Tom took us on a tour and I snapped some photos which show the problem in the attached pdf.

Sincerely,

John

Professor John Taylor
Plant and Microbial Biology
111 Koshland Hall
University of California
Berkeley, CA 94720-3102
jtaylor@berkeley.edu
http://nature.berkeley.edu/taylorlab/

Invasive plants threatening the beautifully remediated marsh at the Richmond Bay Campus.

Given that remediation cost $18 million, and that, “Examples of the research that will be housed at the Richmond site include developing low-cost malaria drugs, enhanced urban runoff strategies, wetlands restoration, polluted lands remediation and genetics research to fight cancer [1],” it seems prudent to prevent a massive return of the invasive plants.

The invasive plants have returned on the Richmond Field Station, on the property of the neighbors on either side, and on the right-of-way of the East Bay Regional Parks District trail. This right-of-way extends a few meters past the fences that border either side of the trail.

A relatively small effort could check this threat. If unchecked, the invasive plants will take over much of the Richmond Field Station land and require a massive effort to remove. Note that once checked, maintenance will be needed to keep the invasive plants in check. Looks like a great opportunity for UC and the East Bay Parks to join forces.

-- John Taylor, Delia Taylor and Tom Kelly’s survey of the site on September 6, 2012 on the SF Bay side of the Richmond Field Station

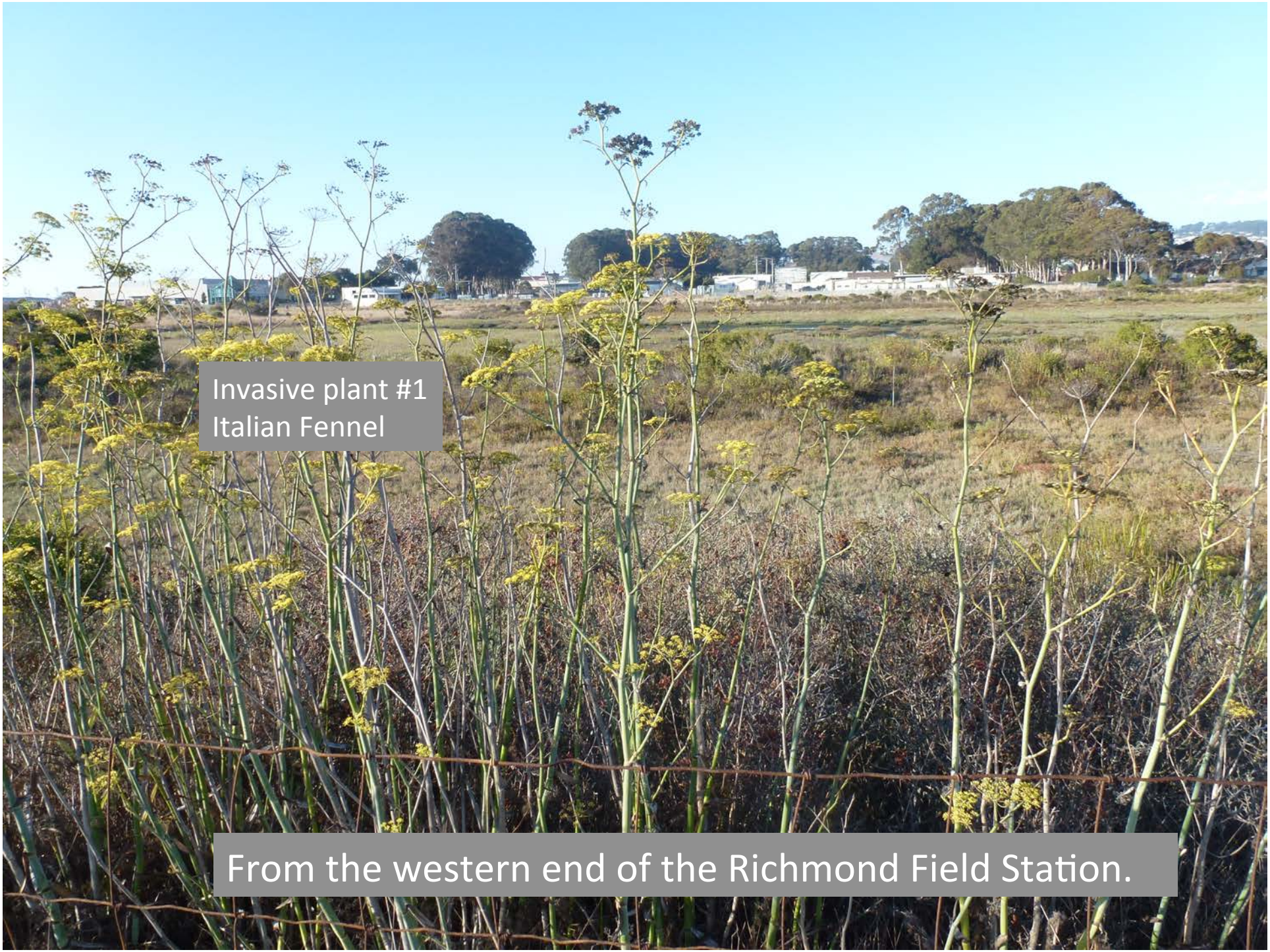
[1]Robert Rogers, Contra Costa Times, September 6, 2012, rrogers@bayareanewsgroup.com.

From the trail connecting Channel Avenue and the East Bay Parks District bay trail.

From the southeast trail to the Richmond Field Station.

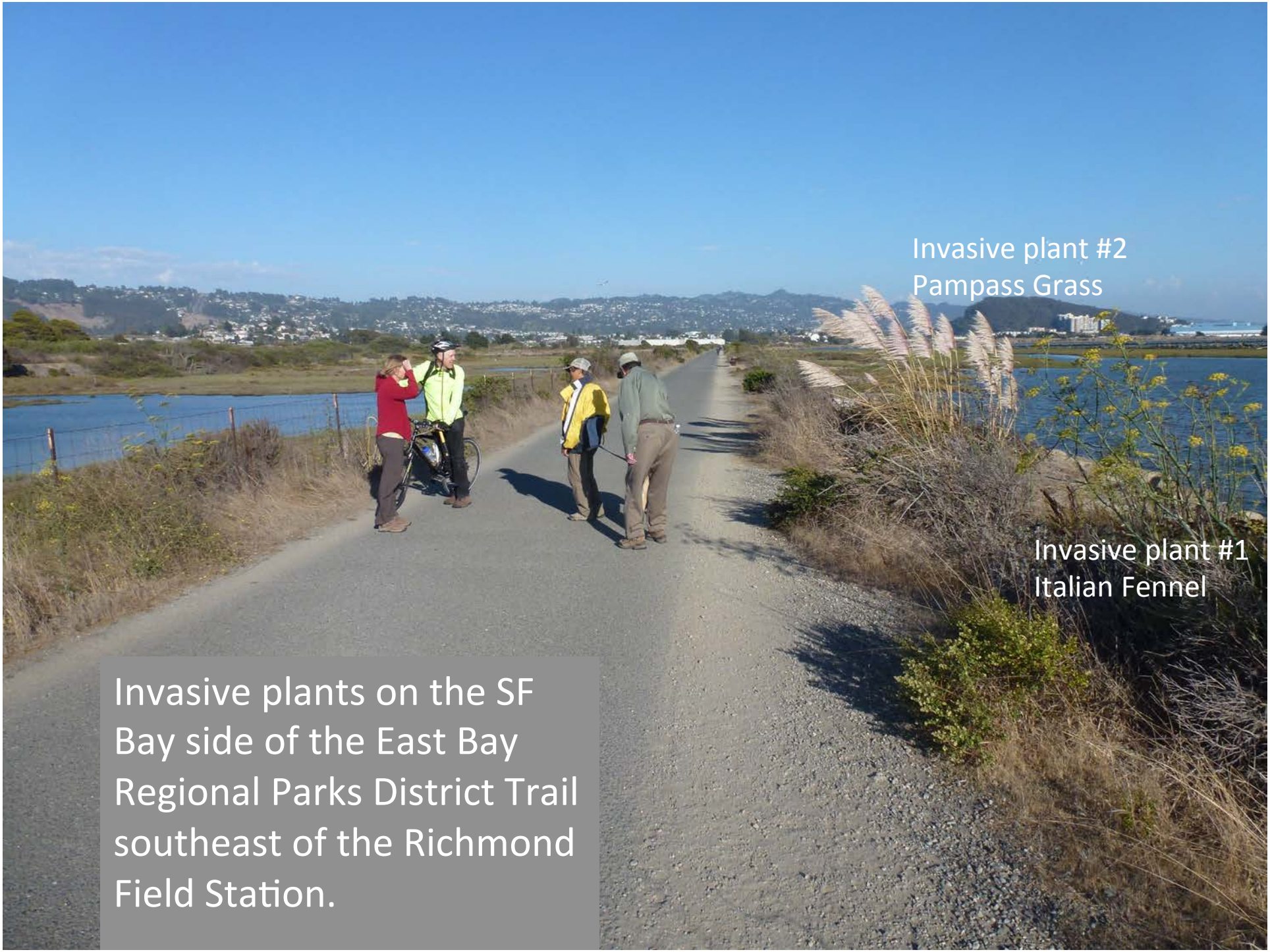
From the southeast trail to the Richmond Field Station.

From the western end of the Richmond Field Station.


Invasive plant #1
Italian Fennel
From the western end of the Richmond Field Station.

Invasive plant #2
Pampass Grass
From the western end of the Richmond Field Station.

Invasive plant #2
Pampass Grass
From the western end of the Richmond Field Station.



Invasive plants on the SF Bay side of the East Bay Regional Parks District Trail southeast of the Richmond Field Station.

Invasive plants on the SF Bay side of the East Bay Regional Parks District Trail southeast of the Richmond Field Station.

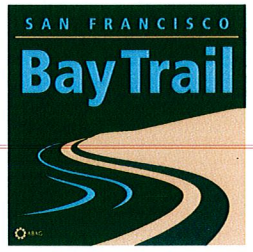
Invasive plant #2
Pampass Grass
Invasive plants on both sides of Meeker Slough, west of the Richmond Field Station.
Invasive plant #1
Italian Fennell

Invasive plants threatening the beautifully remediated marsh at the Richmond Bay Campus.

John Taylor, jtaylor@berkeley.edu Professor, Plant and Microbial Biology, UC Berkeley

Delia Taylor, deliataylor@mac.com California Native Plant Society, East Bay Chapter

Tom Kelly, kyotousa@sbcglobal.net Restoration volunteer with experience at invasive plant removal on the Bay Trail and other EBRPD properties



University of California
Lawrence Berkeley National Laboratory
JAN 17 2013
Facilities Capital Projects

January 15, 2013

Jeff Philliber, Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

Subject: **Comments on the Notice of Preparation (NOP) for the Draft Environmental Impact Report (DEIR) for the Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development Project**

Dear Mr. Philliber:

On behalf of the San Francisco Bay Trail Project, I am writing to submit comments on the NOP for the DEIR for the Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development Project (LRDP Project) located in the City of Richmond. The Bay Trail Project is a nonprofit organization administered by the Association of Bay Area Governments (ABAG) that plans, promotes, and advocates for the implementation of the Bay Trail. The Bay Trail is a planned 500-mile continuous network of multi-use bicycling and hiking paths that, when complete, will encircle San Francisco and San Pablo Bays in their entirety. It will link the shoreline of all nine Bay Area counties, as well as 47 cities. To date, 333 miles of the proposed Bay Trail system has been developed.

When the LRDP Project is fully built, it is expected to generate a significant number of daily vehicular trips to and from the Richmond Bay Campus (RBC) by both employees of the Lawrence Berkeley National Laboratory (LBNL) and visitors to the campus. These daily vehicular trips will result in significant impacts to parking demand, transportation infrastructures, greenhouse gas emissions, and air quality that will need to be addressed and mitigated in the DEIR. We also expect an increased demand in the use of the Bay Trail as both an alternative transportation corridor and recreational opportunity for RBC employees and visitors. As a result, the DEIR needs to evaluate the impacts of the LRDP project on demand for the Bay Trail and provide mitigation for those impacts.

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The existing Bay Trail in Richmond already has a high level of use for both transportation and recreation purposes, and the LRDP Project would need to mitigate the increase in demand for use of the Bay Trail for both transportation and recreational purposes by widening the existing Bay Trail in order to increase the volume of bicycle and pedestrian traffic that the Bay Trail is capable of carrying. In addition, for the Bay Trail to be effectively utilized as a non-motorized transportation option, the LRDP Project must improve the connections to the Bay Trail from the RBC and from the streets connecting the surrounding communities to the Bay Trail. Of particular importance are the street connections from the Bay Trail to the communities across the Interstate 80 and 580 corridors. As a result, we request that the LRDP Project either incorporate the improvements to the Bay Trail and the connections to the Bay Trail described above as part of the LRDP Project or require these improvements as mitigation for the parking, traffic, greenhouse gas, air quality, and recreational impacts that will be generated by the LRDP Project.

The Bay Trail Project appreciates the opportunity to comment on the NOP for the LRDP DEIR and looks forward to working with the Lawrence Berkeley National Laboratory to improve the Bay Trail in Richmond for LBNL employees and the public. Please do not hesitate to call me at (510) 464-7915 if you have any questions regarding the above comments or the Bay Trail.

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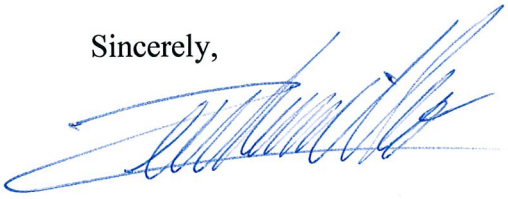


Lee Chien Huo
Bay Trail Planner

University of California
Lawrence Berkeley National Laboratory

JAN 22 2013

Facilities Capital Projects

TRAC
Trails for Richmond Action Committee

73 Belvedere Avenue
Richmond, CA 94801
Phone/Fax 510-235-2835
tracbaytrail@earthlink.net

January 17, 2013

Mr. Jeff Philliber, Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

Dear Mr. Philliber:

TRAC, the Trails for Richmond Action Committee, appreciates the opportunity to comment in response to the Notice of Preparation and Initial Study for the Proposed Richmond Bay Campus (RBC) 2013 Long Range Development Plan and Phase I Development. Our comments focus on the San Francisco Bay Trail and related multi-use trails.

Overall, the EIR must undertake a comprehensive and detailed evaluation of the project's potential environmental impacts, identification of mitigation measures for those impacts, and formulation of alternatives to the project that would involve fewer and less severe environmental impacts. Project definition will be critical for assessing environmental effects of the project. To the extent that the EIR is programmatic in nature without clear project definition, it will be necessary to formulate and adopt mitigation measures to avoid significant effects where feasible. It will be especially important to evaluate the growth-inducing and cumulative impacts of this project, especially in terms of increased traffic on roads & trails, recreational impacts and the need for improving Bay Trail safety, utility, connectivity and enjoyment in the area.

Land Use & Planning

Consistency with adopted plans is a major factor for CEQA review. For example, CEQA requires the DEIR to discuss inconsistencies with general and regional plans (Guidelines §15125(d)).

Area-specific requirements of Richmond's General Plan 2030, Pedestrian Plan and Bicycle & Pedestrian Plan are cited below under Transportation, Traffic, Air Quality & Greenhouse Gas Impacts. In addition, the General Plan contains numerous citywide provisions requiring that new projects incorporate the Bay Trail and maximum feasible public access to the shoreline, e.g.:

> Policy CR1.5: "... require new development and redevelopment projects to provide pedestrian and bicycle amenities, streetscape improvements and linkages to planned and completed City and regional multi-use trails ...."
> Action CR1.D: "Require new development and redevelopment projects to be pedestrian and bicycle-friendly, and to provide adequate connections to the existing and proposed bicycle and and pedestrian network." "Include provisions that require owners of property along the shoreline to provide maximum feasible access to the shoreline and to complete the Bay Trail as part of any project approval process."

Action CR1.E: "Expand multi-use trails and greenways in the City. Provide connector trails and linkages to improve access from neighborhoods in Central Richmond to the regional open space in the hills and along the shoreline."
Action CN2.H: "Initiate and carry through on coordinated planning to provide public access at points along Richmond's southern shoreline, from Point Isabel to and including the Marina Bay."

TRAC Recommendation: The EIR should demonstrate that **Phase I** of the RBC project will fully implement the above General Plan 2030 policy and actions for the entirety of the Long Range Development Plan, as well as the specific trail and staging area provisions described below from the General Plan, Bicycle Master Plan and Pedestrian Plan. If it is not feasible to fully incorporate these plan requirements in Phase 1, enforceable mitigation measures should be formulated and adopted to ensure that they are implemented as soon as possible in subsequent phases.

Transportation, Traffic, Air Quality & Greenhouse Gas Impacts

Motor vehicle traffic and congestion on roads with associated air pollutant and greenhouse gas emissions has the potential for very significant impacts, because Phase I development "would add approximately 1,000 to the average daily population of the site" growing to an estimated 10,000 as the site is fully developed per LBNL's presentation during the October 4 community workshop. Thus, it is very important that the project be designed to facilitate and encourage bicycling and walking for commuting, errands and recreation by both employees and visitors.

An important consideration is that Richmond's over 31 miles of San Francisco Bay Trail shown on the attached map will allow RBC employees and visitors to walk and bike to/from the campus, thus reducing motor vehicle congestion and air pollution as well as parking needs. Many already use the Bay Trail to commute by bicycle to/from locations between Point Richmond and Emeryville. Connectivity improvements will be important to facilitate non-motorized transportation for both employees and visitors.

To illustrate, TRAC's Feb. 18, 2011 letter of support for RBC stated:
•"... employees at a satellite campus .... would be able to use the Bay Trail to walk or bicycle and enjoy virtually all sites in Rosie the Riveter WWII Home Front National Historical Park, Eastshore State Park, Point Isabel and Miller/Knox Regional Shorelines and five City of Richmond shoreline parks":
•"... the planned multi-use trail along the Stege Marsh frontage of these properties could connect with the existing Meeker Tidal Creek Trail offering LBNL employees a convenient walking and bicycling route to five cafes and other services near the intersection of Marina Bay Parkway and Meeker Ave., as well as to Amini's By the Bay and Salute Ristorante in Marina Bay"; and
•".... the multi-use Meeker Tidal Creek Trail connects with a large vacant lot at the intersection of Regatta Blvd. and Marina Bay Parkway on the north side of Meeker Tidal Creek ... might be considered as a complimentary site for cafes, restaurants and other services."

Richmond's General Plan 2030, Bicycle Master Plan and Pedestrian Plan provide important guidance as to the needed improvements for safe, convenient pedestrian and bicyclist access. The project should include the following Class I multi-use trails and trail staging areas in the vicinity as specified in the General Plan:

a. Trail staging areas at the southern ends of both S. 32nd and S. 46th streets with multi-use trails providing access to the San Francisco Bay Trail spine between Pt. Isabel and Marina Bay and

b. A Class I multi-use trail inland of Stege Marsh between S. 46 St. and the existing Meeker Tidal Creek Trail.

These trails are shown on the attached General Plan Map 4.1 Planned Pedestrian and Bicycle Improvements and also specified as follows:

Action CR1.E: "Create a Class I multi-use trail loop north of Meeker Tidal Creek and Stege Marsh as a transportation and scenic route. Also provide trailhead staging areas at the south end of 32nd and 46th streets with bridges across Meeker Tidal Creek and the unnamed creek east of South 32nd Street."
Action CN2.H: " Require the dedication of trailheads at the ends of South 46th and South 32nd Streets as part of any plans to redevelop the lands adjacent to the existing University of California Field Station."

The following additional trail improvements surrounding the campus are specified in the Bicycle Master Plan and Pedestrian Plan:

1. Remedy the unduly wide and dangerous Bay Trail crossing of Central Ave. at Rydin Rd., which will be used by RBC bicycle commuters, per Pedestrian Plan page 98 last bullet;
2. Provide pedestrian and bicycle improvements at I-580 interchanges with Harbour Way, Marina Way, Marina Bay Parkway, Bay View Ave., Regatta Blvd. & Central Ave., e.g. see Pedestrian Plan pp. 104 - 106 and Bicycle Master Plan p. 72; and
3. Improve Key Corridors as "complete streets" for bicyclist and pedestrian safety, e.g. see Bicycle Master Plan pp. 59 - 60 and Pedestrian Plan pp. 47, 50, 55 - 56, 59 - 60, 98 & 104 - 108.

TRAC Recommendation: Mitigate impacts related to traffic, automotive air pollution, greenhouse gases and land use for parking by designing **Phase 1** of the project to implement the 2030 General Plan, Bicycle Master Plan and Pedestrian Plan improvements listed above. Each phase of the Long Range Development Plan also should include the following mitigation measures:

1. mesh RBC's bicycle/pedestrian network seamlessly with the Bay Trail and other surrounding access points and
2. emulate SunPower Corporation's Richmond facility in providing secure, indoor bicycle storage for employees who commute by bicycle and bike-sharing facilities at convenient locations so that visitors and employees may borrow RBC bicycles for running errands, visiting nearby retail stores and restaurants, and/or recreating during breaks from work.

Recreational Impacts

The EIR should evaluate and mitigate for impacts on shoreline parks, as well as recreational and transportation usage of the Bay Trail between Central Avenue and Garrard Blvd., including growth-inducing and cumulative effects. For example, Bay Trail sections between Central Ave. and Harbour Way are popular with bicyclists, hikers, joggers, dog walkers, baby strollers, skaters with and without poles, bird watchers, etc. After establishing baseline usage, the EIR should predict future traffic for recreation and transportation and evaluate the potential need for mitigating improvements to allow safe, enjoyable use of the Bay Trail. For example, existing Class I trail sections at best only satisfy Bay Trail minimum width standards for a two-way multi-use trail.

TRAC Recommendation: Determine existing bicycle and pedestrian level of service on the Bay Trail, analyze impacts on the trail system of additional users generated by the RBC project and provide mitigations for these impacts to eliminate or bring them to a less than significant level.

Growth-Inducing & Cumulative Impacts

It will be especially important to evaluate the growth-inducing impacts for the entire phased project cumulatively with all other new developments it is likely to stimulate, especially in terms of increased traffic, recreational usage and transportation needs for improving Bay Trail connectivity with the site (CEQA Guidelines §§15126(d) & 15126.2(d)). An EIR also must discuss the cumulative impacts of a project when the incremental effects of a project are considerable viewed in connection with the effects of other past, current, and probable future projects (CEQA Guidelines §§15130(a) & 15130(b)). All probable future projects should be considered. Projects anticipated beyond the near future should be analyzed for their cumulative effect if they are reasonably foreseeable (See *Bozung v. Local Agency Formation Comm'n*, 13 Cal. 3d 263, 284 (1975)).

The analysis of cumulative impacts is particularly important in the context of long-range planning or programmatic documents because the growth allowed under such plans is often substantial and because they set forth the policies that will guide the development of future individual projects for many years. As noted in the CEQA Guidelines, one requirement of an EIR for planning documents is that they provide a more thorough analysis of cumulative impacts than is required for individual projects (CEQA Guidelines §15168).

TRAC Recommendation: Evaluate and mitigate for growth-inducing and cumulative impacts of the long range development plan, including but not limited to satellite R&D enterprises, supply and manufacturing facilities, hotels, restaurants and service businesses such as convenience stores.

TRAC hopes that these comments will be helpful and would appreciate receiving a copy of the DEIR.

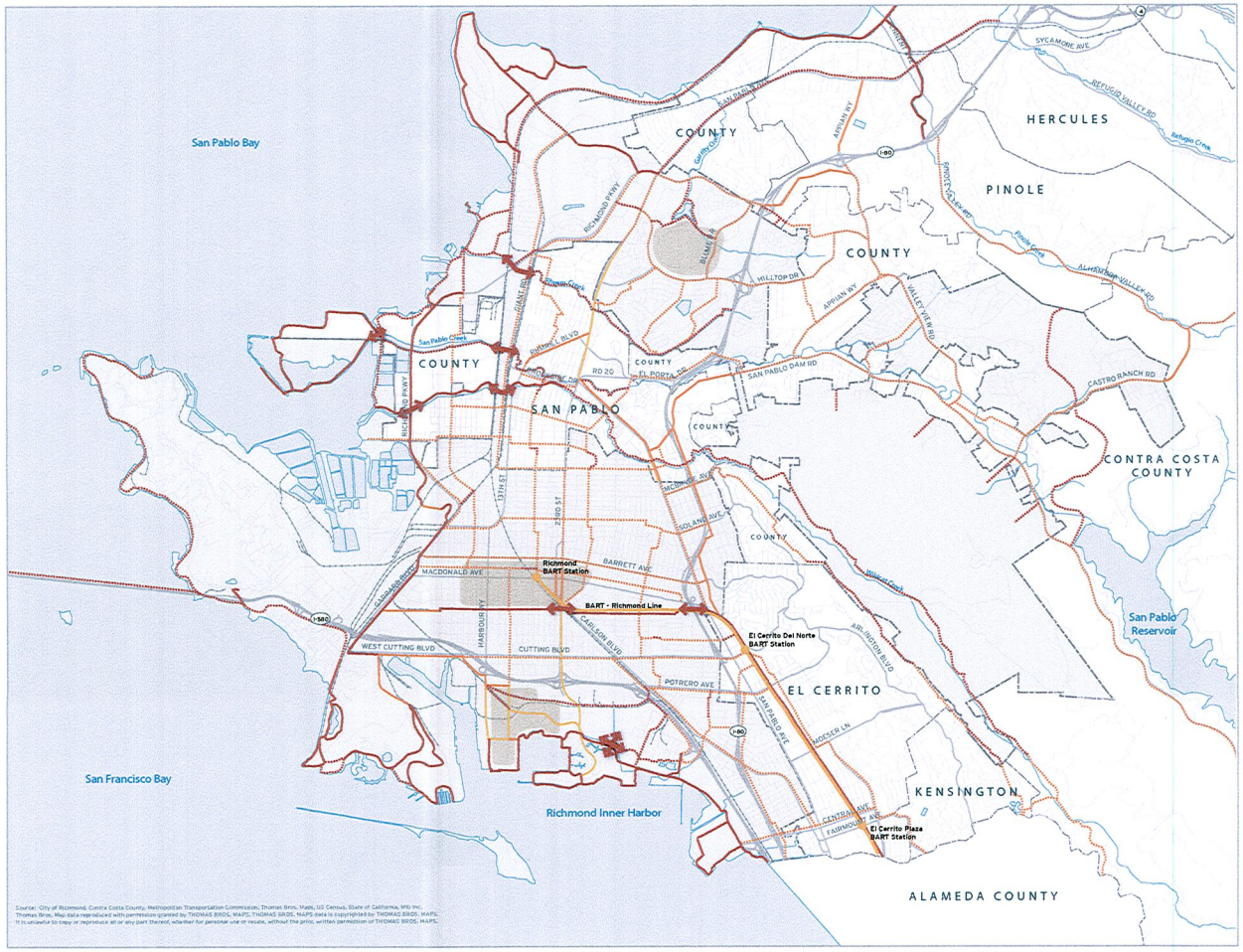
Sincerely,

Bruce Beyaert, TRAC Chair

Attachments:
Richmond Bay Trail Map
General Plan 2030 Map 4.1 Planned Pedestrian and Bicycle Improvements

cc: Richard Mitchell, Lina Velasco, Brad McCrae & Greg Haet

SAN FRANCISCO
BAY TRAIL PROJECT
Richmond
Bay Trail
Complete
Incomplete
Connector trails
Complete
Incomplete
P Parking
Parks/Open Space
Water Bodies
Point Wilson
Point Pinole Regional Shoreline
UP rail corridor
Atlas Road
San Pablo Avenue
Goodrick Ave
Richmond Parkway
Point San Pablo
Point San Pablo Yacht Harbor
Terminal 4
West County Landfill
Parr
San Pablo Creek
SAN PABLO
Wildcat Creek Trail
Davis Park
Wildcat Creek Viewpoint
Gertrude
Point Molate NFD
Point Molate
Western Drive
Hensley St
23rd Street
San Pablo Avenue
Pennsylvania
Castro Point
Castro Street
Richmond BART Station
West Macdonald
RICHMOND
Richmond-San Rafael Bridge
Garrard Blvd
Ohio Ave
Richmond Greenway
El Cerrito del Norte BART Station
Ohlone Greenway Trail
Chevron Long Wharf
Cutting Blvd
Hoffman
580
Marina Bay Pkwy
Keller Beach
Canal
Marina Wy
Regatta
Marina Bay Park
Miller-Knox Regional Shoreline
Dornan Dr
Seacliff Dr
Brickyard Cove
Harbour Wy South
Hall
Marina Bay
Meeker Tidal Creek
51st St
80
Eastshore State Park
Ferry Point
Lucretia Edwards Park
Vincent Park
Shimada Park
Shipyard 3
Central
Point Isabel Regional Shoreline
Brooks Island Regional Preserve
N
0 0.3 0.6 0.9 1.2
Miles
April 9, 2012



Map 4.1

Planned Pedestrian and Bicycle Improvements

Existing Bicycle Routes
- Class I
- Class II
- Class III

Planned Pedestrian Improvements and Bicycle Routes
- Class I Bicycle Route
- Class II and III Bicycle Route
- Bicycle and Pedestrian Connector
- Pedestrian Improvement District

50
10
ACRES

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MILES

Note: Larger format maps are available for view or purchase at the Planning and Building Services Department.

University of California
Lawrence Berkeley National Laboratory
JAN 20 2013
Facilities Capital Projects

Subject: Qs re comments to Notice of Preparation
From: Ellen Sasaki <ejsasaki@comcast.net>
Date: 1/20/2013 6:58 PM
To: LRDP-EIR@lbl.gov

Greetings -- I am not clear on the EIR process.

Does "public comments" mean comments from individuals residing in Richmond? Or only from agencies?

I live in Richmond and am concerned about the impact on wildlife during demolition, tree removal, construction and restoration activities to restore "natural habitat" activities in developing the new LBNL campus. I don't see that "Wildlife" as an area of proposed study in the Notice document. Is this the appropriate stage of EIR development for submitting my comments?

Thanks, Ellen Sasaki

STATE OF CALIFORNIA

Governor's Office of Planning and Research

State Clearinghouse and Planning Unit

Edmund G. Brown Jr.
Governor

Ken Alex
Director

University of California
Lawrence Berkeley National Laboratory
JAN 08 2013
Facilities Capital Projects

Notice of Preparation

January 3, 2013

To: Reviewing Agencies

Re: Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development
SCH# 2013012007

Attached for your review and comment is the Notice of Preparation (NOP) for the Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development draft Environmental Impact Report (EIR).

Responsible agencies must transmit their comments on the scope and content of the NOP, focusing on specific information related to their own statutory responsibility, within 30 days of receipt of the NOP from the Lead Agency. This is a courtesy notice provided by the State Clearinghouse with a reminder for you to comment in a timely manner. We encourage other agencies to also respond to this notice and express their concerns early in the environmental review process.

Please direct your comments to:

Jeff Philliber
University of California
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

with a copy to the State Clearinghouse in the Office of Planning and Research. Please refer to the SCH number noted above in all correspondence concerning this project.

If you have any questions about the environmental document review process, please call the State Clearinghouse at (916) 445-0613.

Sincerely,

Scott Morgan
Director, State Clearinghouse

Attachments
cc: Lead Agency

Document Details Report
State Clearinghouse Data Base

SCH# 2013012007
Project Title Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development
Lead Agency University of California

Type NOP Notice of Preparation

Description The University of California (UC) proposes to establish a new major research campus at properties it owns in Richmond, California, for the consolidation of biosciences programs of the Lawerence Berkeley National Laboratory (LBNL) and for development of additional research-related facilities for both LBNL and UC Berkeley. This campus would jointly serve UC LBNL and UC Berkeley. The proposed 2013 Long Range Development Plan (LRDP) for the Richmond Bay Campus (RBC) would guide campus development through 2050. Initial development under Phase 1 would occur through 2018.

Lead Agency Contact

Name Jeff Philliber
Agency University of California
Phone 510 486-5257 **Fax**
email
Address One Cyclotron Road, MS 76-225
City Berkeley **State** CA **Zip** 94720

Project Location

County Contra Costa
City Richmond
Region
Cross Streets S. 46th Street and Seaver Avenue
Lat / Long 37° 54' 58" N / 122° 19' 49" W
Parcel No. 5600600008
Township **Range** **Section** **Base**

Proximity to:

Highways I-580, I-80, SR 123
Airports
Railways UPRR, Bart
Waterways San Francisco Bay
Schools Kennedy, Coronado
Land Use 1 million gsf research/dev. Zoning-Specific Plan. GP- Business/Light Industrial

Project Issues Aesthetic/Visual; Agricultural Land; Air Quality; Archaeologic-Historic; Biological Resources; Coastal Zone; Drainage/Absorption; Economics/Jobs; Flood Plain/Flooding; Forest Land/Fire Hazard; Geologic/Seismic; Minerals; Noise; Public Services; Recreation/Parks; Schools/Universities; Septic System; Sewer Capacity; Soil Erosion/Compaction/Grading; Solid Waste; Toxic/Hazardous; Traffic/Circulation; Vegetation; Water Quality; Water Supply; Wetland/Riparian; Growth Inducing; Landuse; Cumulative Effects

Reviewing Agencies Resources Agency; Office of Historic Preservation; Department of Parks and Recreation; San Francisco Bay Conservation and Development Commission; Department of Water Resources; Department of Fish and Game, Region 3; Native American Heritage Commission; California Highway Patrol; Caltrans, District 4; Department of Toxic Substances Control; Regional Water Quality Control Board, Region 2

Date Received 01/03/2013 **Start of Review** 01/03/2013 **End of Review** 02/01/2013

Note: Blanks in data fields result from insufficient information provided by lead agency.

NOP Distribution List

County: Contra Costa SCH# 2013012007

Resources Agency

- [x] Resources Agency
  Nadell Gayou
- [ ] Dept. of Boating & Waterways
  Nicole Wong
- [ ] California Coastal Commission
  Elizabeth A. Fuchs
- [ ] Colorado River Board
  Gerald R. Zimmerman
- [ ] Dept. of Conservation
  Elizabeth Carpenter
- [ ] California Energy Commission
  Eric Knight
- [ ] Cal Fire
  Dan Foster
- [ ] Central Valley Flood Protection Board
  James Herota
- [x] Office of Historic Preservation
  Ron Parsons
- [x] Dept of Parks & Recreation
  Environmental Stewardship Section
- [ ] California Department of Resources, Recycling & Recovery
  Sue O'Leary
- [x] S.F. Bay Conservation & Dev't. Comm.
  Steve McAdam
- [x] Dept. of Water Resources Resources Agency
  Nadell Gayou

Fish and Game

- [ ] Depart. of Fish & Game
  Scott Flint
  Environmental Services Division
- [ ] Fish & Game Region 1
  Donald Koch
- [ ] Fish & Game Region 1E
  Laurie Harnsberger
- [ ] Fish & Game Region 2
  Jeff Drongesen
- [/] Fish & Game Region 3
  Charles Armor
- [ ] Fish & Game Region 4
  Julie Vance
- [ ] Fish & Game Region 5
  Leslie Newton-Reed
  Habitat Conservation Program
- [ ] Fish & Game Region 6
  Gabrina Gatchel
  Habitat Conservation Program
- [ ] Fish & Game Region 6 I/M
  Brad Henderson
  Inyo/Mono, Habitat Conservation Program
- [ ] Dept. of Fish & Game M
  George Isaac
  Marine Region

Other Departments

- [ ] Food & Agriculture
  Sandra Schubert
  Dept. of Food and Agriculture
- [ ] Depart. of General Services
  Public School Construction
- [ ] Dept. of General Services
  Anna Garbeff
  Environmental Services Section
- [ ] Dept. of Public Health
  Jeffery Worth
  Dept. of Health/Drinking Water
- [ ] Delta Stewardship Council
  Kevan Samsam

Independent Commissions,Boards

- [ ] Delta Protection Commission
  Michael Machado
- [ ] Cal EMA (Emergency Management Agency)
  Dennis Castrillo
- [x] Native American Heritage Comm.
  Debbie Treadway
- [ ] Public Utilities Commission
  Leo Wong
- [ ] Santa Monica Bay Restoration
  Guangyu Wang
- [ ] State Lands Commission
  Jennifer Deleong
- [ ] Tahoe Regional Planning Agency (TRPA)
  Cherry Jacques

Business, Trans & Housing

- [ ] Caltrans - Division of Aeronautics
  Philip Crimmins
- [ ] Caltrans - Planning
  Terri Pencovic
- [x] California Highway Patrol
  Suzann Ikeuchi
  Office of Special Projects
- [ ] Housing & Community Development
  CEQA Coordinator
  Housing Policy Division

Dept. of Transportation

- [ ] Caltrans, District 1
  Rex Jackman
- [ ] Caltrans, District 2
  Marcelino Gonzalez
- [ ] Caltrans, District 3
  Gary Arnold
- [/] Caltrans, District 4
  Erik Alm
- [ ] Caltrans, District 5
  David Murray
- [ ] Caltrans, District 6
  Michael Navarro
- [ ] Caltrans, District 7
  Dianna Watson
- [ ] Caltrans, District 8
  Dan Kopulsky
- [ ] Caltrans, District 9
  Gayle Rosander
- [ ] Caltrans, District 10
  Tom Dumas
- [ ] Caltrans, District 11
  Jacob Armstrong
- [ ] Caltrans, District 12
  Marlon Regisford

Cal EPA

Air Resources Board

- [ ] Airport/Energy Projects
  Jim Lerner
- [ ] Transportation Projects
  Douglas Ito
- [ ] Industrial Projects
  Mike Tollstrup
- [ ] State Water Resources Control Board
  Regional Programs Unit
  Division of Financial Assistance
- [ ] State Water Resources Control Board
  Student Intern, 401 Water Quality Certification Unit
  Division of Water Quality
- [ ] State Water Resouces Control Board
  Phil Crader
  Division of Water Rights
- [x] Dept. of Toxic Substances Control
  CEQA Tracking Center
- [ ] Department of Pesticide Regulation
  CEQA Coordinator

Regional Water Quality Control Board (RWQCB)

- [ ] RWQCB 1
  Cathleen Hudson
  North Coast Region (1)
- [x] RWQCB 2
  Environmental Document Coordinator
  San Francisco Bay Region (2)
- [ ] RWQCB 3
  Central Coast Region (3)
- [ ] RWQCB 4
  Teresa Rodgers
  Los Angeles Region (4)
- [ ] RWQCB 5S
  Central Valley Region (5)
- [ ] RWQCB 5F
  Central Valley Region (5)
  Fresno Branch Office
- [ ] RWQCB 5R
  Central Valley Region (5)
  Redding Branch Office
- [ ] RWQCB 6
  Lahontan Region (6)
- [ ] RWQCB 6V
  Lahontan Region (6)
  Victorville Branch Office
- [ ] RWQCB 7
  Colorado River Basin Region (7)
- [ ] RWQCB 8
  Santa Ana Region (8)
- [ ] RWQCB 9
  San Diego Region (9)

- [ ] Other _____
- [ ] _____ Conservancy

Last Updated 8/14/2012

University of California
Lawrence Berkeley National Laboratory

JAN 28 2013

Facilities Capital Projects

January 22, 2013

Jeff Philliber
Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720
LRDP-EIR@lbl.gov

Dear Mr. Philliber,

We are writing to raise concerns about the proposed second campus of the Lawrence Berkeley National Laboratory (LBNL) and the U. C. Berkeley Synthetic Biology Institute (SBI) that is being considered. Much of the research that will be conducted in this laboratory will be on the emerging technology called synthetic biology. Synthetic biology is an extreme form of genetic engineering that is attempting to create novel, potentially self-replicating artificial life forms from synthesized DNA. The risks this research poses to worker safety, public health and the environment are currently being ignored.

While some find promise in synthetic biology for manufacturing new products and helping us to better understand biological processes, it is an inherently risky technology. Synthetic biology research could result in enhanced virulence in existing hosts, heightened ability to infect a wider range of hosts, and resistance to antimicrobials, antivirals, vaccines and other treatment or containment modalities.

Laboratory accidents are much more common in the U.S. than most people realize and often go unreported. If there were an accidental release of engineered organisms in this lab, the health of workers, the environment and entire communities could be put at risk. Already, the current lack of adequate safety protocols and biocontainment within rDNA labs has caused serious illness and death. Since synthetic biology's objective lies in engineering novel life forms and products with the potential to interact with human biology and other cellular processes, we believe this research poses dangers (both from accidental and deliberate uses) unforeseen in the regulatory framework of standard rDNA research.

Therefore, before any decisions are made on a specific site for this new lab, we believe a comprehensive, independent and transparent safety and risk analysis capable of assessing these threats must be completed. It is simply unacceptable to allow the laboratory to self-regulate. Moreover, it must be ascertained whether such research is even appropriate near urban centers. Safety regulations and procedures must be created and tailored to address the novel aspects of this new science, including whistleblower protections and forums for workers to raise concerns, and the costs to any municipality of an appropriate public safety infrastructure must be identified.

Finally, independent regulatory oversight must be assured, particularly because both public and private entities will be operating at the lab. Every stage of this process must be open to and involve the public, including town hall meetings to discuss and address health and safety issues.

The Lawrence Berkeley National Laboratory and the U. C. Berkeley Synthetic Biology Institute must undertake the burden of proof as to whether their laboratory will be safe before any community can make an informed decision about inviting it to break ground in their backyard.

Sincerely,

Alliance for Humane Biotechnology

BioFuel Watch

California Coalition for Worker's Memorial Day

Center for Food Safety

Center for Genetics and Society

Council for Responsible Genetics

Friends of the Earth

Global Justice Ecology Project

International Center for Technology Assessment

Movement Generation Justice and Ecology Project

National Injured Worker's Network

National Workrights Institute

Pesticide Action Network of North America

*If you have any questions or need any additional information, please do not hesitate to contact:

M. L. Tina Stevens, Ph.D.
Executive Director
Alliance for Humane Biotechnology

and

Jeremy E. Gruber, J.D.
President
Council for Responsible Genetics

at 609-610-1602 or jeeg@concentric.net

BERKELEY PATH WANDERERS ASSOCIATION

Dedicated to the creation, preservation and restoration of public paths, steps and walkways in Berkeley for the use and enjoyment of all.

1442A Walnut St. #269
Berkeley, CA 94709
info@berkeleypaths.org
www.berkeleypaths.org

University of California
Lawrence Berkeley National Laboratory

JAN 25 2013

Facilities Capital Projects

January 22, 2013

Mr. Jeff Philliber
Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

Dear Mr. Philliber,

The Berkeley Path Wanderers Association (BPWA) is a volunteer organization that builds and maintains pedestrian paths as well as promotes a variety of pedestrian activities both in Berkeley and the greater Bay Area. We would like to offer our comments in response to the Notice of Preparation and Initial Study for the Proposed Richmond Bay Campus (RBC) 2013 Long Range Development Plan.

Since our concerns center around pedestrian access and safety, we would like to focus primarily on those parts of the proposed plan. However, we have also reviewed TRAC's comments on this matter as reflected in their January 10, 2013 letter to you and completely agree with "Recommended Bicycle & Pedestrian Access Improvements" beginning on page 3 of the letter. For your convenience, I've included those recommendations below.

In addition to the TRAC recommendations, BPWA offers the following comments:

Since pedestrians are generally traveling at slower speeds than bicyclists, their needs are often more pronounced. This is particularly true at the busy and dangers intersections identified in the TRAC letter. A intersection like Central and Rydin is hazardous for a bicycle but even more treacherous for someone on foot. I am attaching a letter from TRAC's Bruce Brubaker to the Contra Costa Transportation Agency in which he makes a sound recommendation for mitigating the safety issues at this intersection. BPWA supports this recommendation.

One of the most pervasive threats to pedestrians at intersections such as the I-580 exchange at Central is from cars turning right on red. Whenever possible, right turns of that nature should either be prohibited or controlled by a pedestrian-activated flashing light.

Thank you for your consideration,

Keith Skinner, President, Berkeley Path Wanderers Association

TRAC
Trails for Richmond Action Committee

Amin AbuAmara
Contra Costa Transportation Authority
3478 Buskirk Avenue, Suite #100
Pleasant Hill, CA 94523

May 30, 2010

RE: Central Avenue / I80 Interchange Improvement Project

Amin,

The Central Avenue / I80 project site occupies a strategic location in regards to the San Francisco Bay Trail in Richmond. As advocates for the Bay Trail in Richmond, TRAC respectfully submits the following comments regarding plans for this important site. Please review the attached Richmond Bay Trail map.

Bay Trail access thorough this area currently runs up from Berkeley on Class I off-street trail to the southwest corner of Central and Rydin Road. From there it crosses Central across to the northwest corner, crosses Rydin Road to the northeast corner, and then proceeds north along Rydin Road approximately 100 feet to a Class I off-street developed trail heading north to Point Isabel and points north. Bay trail use in this area is heavy, with families and bicycle commuters alike enjoying the trail.

Currently intersection improvements at Central Avenue and Rydin Road are being considered. The project proposes a new traffic signal at this intersection. As part of the design of the signalization the following measures should be provided at the intersection:

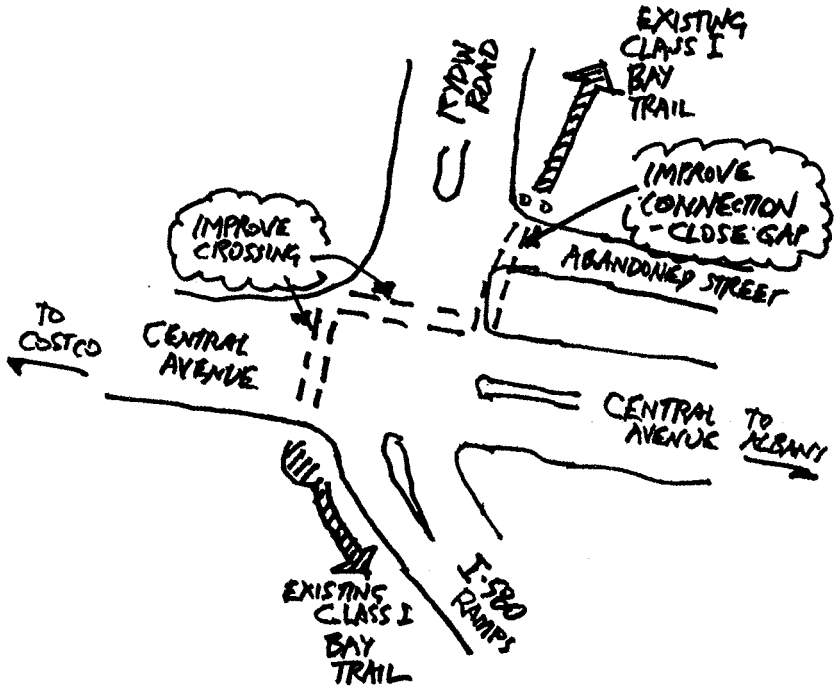
A) Crosswallks should be highly visible and should incorporate pedestrian refuges in the middle if medians will be provided.

B) Pedestrian and bicycle friendly signal activation should also be provided at the three corners where Bay Trail passes through.

C) Improvements should include wayfinding signage.

D) Improvements at the east side of Rydin. There is currently an unclear route to proceed from the northwest corner of Central and Rydin to the Class I trail 100' to the north. Most bicyclists cut diagonally across Rydin to access the Class I trail. With the new signal it will be dangerous or impossible to cut diagonally. For this reason the Class I Bay Trail should be

extended from the northeast corner of Central and Rydin northward about 100 feet to the beginning of Class I trail. See the attached Sketch below for details.



Thank you for taking into account maintaining and improving this important segment of Bay Trail while developing the plans for the Central Avenue / 180 Interchange project. Please do not hesitate to call if you have any questions.

Sincerely,

Bruce Brubaker
TRAC Steering Committee
Associate Principal
Design, Community & Environment
1625 Shattuck Avenue
Berkeley CA 94709
510.848.3815

State of California – The Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Bay Delta Region
7329 Silverado Trail
Napa, CA 94558
(707) 944-5500
www.wildlife.ca.gov

EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

University of California
Lawrence Berkeley National Laboratory
JAN 25 2013
Facilities Capital Projects

January 24, 2013

Mr. Jeff Philliber
University of California
One Clyclotron Road, MS 76-225
Berkeley, CA 94720

Dear Mr. Philliber:

Subject: Richmond Bay Campus 2013 Long Range Development Plan and Phase I Development, Notice of Preparation of Draft Environmental Impact Report, SCH #2013012007, City of Richmond, Contra Costa County

The California Department of Fish and Game (CDFW) has reviewed the documents provided for the subject project, and we have the following comments.

Please provide a complete assessment (including but not limited to type, quantity and locations) of the habitats, flora and fauna within and adjacent to the project area, including endangered, threatened, and locally unique species and sensitive habitats. The assessment should include the reasonably foreseeable direct and indirect changes (temporary and permanent) that may occur with implementation of the project. Rare, threatened and endangered species to be addressed should include all those which meet the California Environmental Quality Act (CEQA) definition (see CEQA Guidelines, Section 15380). CDFW recommended survey and monitoring protocols and guidelines are available at http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/Protocols_for_Surveying_and_Evaluating_Impacts.pdf.

Please be advised that a California Endangered Species Act (CESA) Permit must be obtained if the project has the potential to result in take of species of plants or animals listed under CESA, either during construction or over the life of the project. Issuance of a CESA Permit is subject to CEQA documentation; therefore, the CEQA document must specify impacts, mitigation measures, and a mitigation monitoring and reporting program. If the project will impact CESA listed species, early consultation is encouraged, as significant modification to the project and mitigation measures may be required in order to obtain a CESA Permit.

For any activity that will divert or obstruct the natural flow, or change the bed, channel, or bank (which may include associated riparian resources) of a river or stream, or use material from a streambed, CDFW may require a Lake and Streambed Alteration Agreement (LSAA), pursuant to Section 1600 et seq. of the Fish and Game Code, with the applicant. Issuance of an LSAA is subject to CEQA. CDFW, as a responsible agency under CEQA,

will consider the CEQA document for the project. The CEQA document should fully identify the potential impacts to the stream or riparian resources and provide adequate avoidance, mitigation, monitoring and reporting commitments for completion of the agreement. To obtain information about the LSAA notification process, please access our website at http://www.dfg.ca.gov/habcon/1600/; or to request a notification package, contact the Lake and Streambed Alteration Program at (707) 944-5520.

If you have any questions, please contact Ms. Randi Adair, Senior Environmental Scientist, at (707) 944-5596; or Mr. Craig Weightman, Acting Environmental Program Manager, at (707) 944-5577.

Sincerely,

Scott Wilson
Acting Regional Manager
Bay Delta Region

cc: State Clearinghouse

Department of Toxic Substances Control

Deborah O. Raphael, Director
700 Heinz Avenue
Berkeley, California 94710-2721

Matthew Rodriquez
Secretary for
Environmental Protection

Edmund G. Brown Jr.
Governor

University of California
Lawrence Berkeley National Laboratory
JAN 28 2013
Facilities Capital Projects

January 24, 2013

Mr. Jeff Philliber
Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

RE: RICHMOND BAY CAMPUS 2013 LONG RANGE DEVELOPMENT PLAN AND PHASE 1 DEVELOPMENT NOTICE OF PREPARATION, DRAFT ENVIRONMENTAL IMPACT REPORT; SCH #2013-012007

Dear Mr. Philliber:

Thank you for the opportunity to review and comment on the Notice of Preparation (NOP) for the Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development (LRDP). As proposed, the University of California (UC) would establish a new major research campus at properties it owns in the City of Richmond, California, for consolidation of biosciences programs of the Lawrence Berkeley National Laboratory (LBNL) and for development of additional research related facilities for both LBNL and UC Berkeley. The Richmond Bay Campus (RBC) would jointly serve UC LBNL and UC Berkeley. The proposed LRDP for the RBC would guide campus development through 2050.

The California Department of Toxic Substances Control (DTSC) oversees the cleanup of hazardous substances sites pursuant to the California Health and Safety Code, Division 20, Chapter 6.8. As a Responsible Agency, DTSC is submitting comments to ensure that the environmental documentation prepared under the California Environmental Quality Act (CEQA) for this Project adequately addresses the remediation of hazardous substance releases that would be required as part of the Project.

DTSC's Abandoned Site Program discovered the Project site in 1980. The Project site was a former explosive facility which produced mercury fulminate used for blasting caps and detonators. UC currently owns the property and uses the existing structures as administrative offices and research/analytical labs. The San Francisco Regional Water Quality Control Board had oversight until May 2005 when oversight was then

transferred to DTSC. DTSC's Site Investigation and Remediation Order, issued September 15, 2006 (Docket Number I/SE-RAO 06/07-004), requires the investigation and remediation of the RBC. The NOP identified that a remedy document will be prepared concurrently with the Draft Environmental Impact Report (DEIR) for the RCB. DTSC intends to utilize the EIR to fulfill its requirements under CEQA in making its determination on a remedy document.

DTSC submits the following comments to be addressed in the Draft Environmental Impact Report:

1. Site Characterization: The Site Investigation and Remediation Order describes the project site as 152 acres and the NOP states 133 acres. The DEIR project boundary description should be explain why the description is not consistent with the Remediation Order. In addition, if previously unidentified hazardous substances are encountered, they would also need to be addressed as part of the Project.

2. Site Background: Identify the current and historic uses at the Project site that may have resulted in a release of hazardous wastes/substances, and any known or potentially contaminated sites within the proposed project area.

3. Greenhouse Gasses: A discussion of all aspects of remediation, including on-site construction equipment and emissions from trucks hauling hazardous materials away from the Project site consistent with the San Francisco Bay Area Air Basin requirements.

4. Hazards and Hazardous Materials: The extent of known contamination that may be present at the Project site should be identified and proposed alternative remedies which may be contemplated for inclusion in the remedy document subject to DTSC approval. In addition, if it is determined that hazardous wastes are, or will be, generated by the proposed project, the wastes must be managed in accordance with the California Hazardous Waste Control Law (California Health and Safety Code, Division 20, Chapter 6.5) and the Hazardous Waste Control Regulations (California Code of Regulations, Title 22, Division 4.5). If it is determined that hazardous wastes will be generated as a result of the Project, discussion should be included describing the requirements for the facility in obtaining a United States Environmental Protection Agency Identification Number. In addition, a discussion of worker health and safety risks and proposed mitigation measures should be included.

5. Hydrology and Water Quality/Soils: The extent of known groundwater and soil contamination that may be present at the Project site should be identified, as well as proposed alternative remedies which may be contemplated for inclusion in the remedy document subject to DTSC approval.

6. Transportation/Traffic: A discussion should be included regarding the estimated number of truck trips associated with the removal of hazardous materials from the Project site pursuant to a remedy document. In addition, figures depicting the proposed truck transportation route to the proposed treatment or disposal facility should be included.

If you have any questions or would like to discuss these comments please contact me at (510) 540-3839 or email lynn.nakashima@dtsc.ca.gov.

Sincerely,

Lynn Nakashima

Lynn Nakashima
Senior Hazardous Substances Scientist
Cleanup Program
Berkeley Office

cc: Ms. Candace Hill
Department of Toxic Substances Control
Office of Environmental Planning & Analysis
OPEA/CEQA/MS 11A
1001 "I" Street
P.O. Box 806
Sacramento, CA 95182-0806

University of California
Lawrence Berkeley National Laboratory

JAN 28 2013

Facilities Capital Projects

TRAC
Trails for Richmond Action Committee

73 Belvedere Avenue
Richmond, CA 94801
Phone/Fax 510-235-2835
tracbaytrail@earthlink.net

January 28, 2013

Mr. Jeff Philliber, Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

Dear Mr. Philliber:

TRAC's January 17 letter responding to the Notice of Preparation and Initial Study for the Proposed Richmond Bay Campus 2013 Long Range Development Plan and Phase I Development focused on impacts related to Land Use, Planning, Recreation, Transportation, Traffic, Air Quality and Greenhouse Gas Emissions. In doing so, it highlighted the importance of the City of Richmond's General Plan, Bicycle Master Plan and Pedestrian Plan in providing guidance for safe, convenient and enjoyable bicycle and pedestrian trails, which will reduce impacts on transportation, traffic, air quality and greenhouse gases.

TRAC is concerned about the statement in Section 10.b of the IS that "the project is not subject to local land use planning jurisdiction" because it is "located on land owned by the University." We can't find such an exemption in the cited Article IX, Section 9 of the California Constitution. Therefore, we ask that the DEIR explain the basis for this exemption from local plans and cite the relevant legal authority.

If the Constitution does exempt from City plans those facilities "located on land owned by the University", the DEIR should discuss with cited legal authority whether the project is subject to the requirement of State CEQA law to avoid significant conflicts with local plans with regard to **both** "lands owned by the University" **and** surrounding lands owned by others. Recognizing that the bulk of the recreation, traffic, congestion, air quality and greenhouse gas impacts will occur off site, it would seem irresponsible to flout provisions of the City's General Plan, Bicycle Master Plan and Pedestrian Plan designed to reduce those impacts.

TRAC requests that the DEIR recognize the importance of the City's adopted plans and commit to comply with their letter and spirit. This will lead to a better project with reduced environmental impacts and increased public support

Sincerely,

Bruce Beyaert

Bruce Beyaert, TRAC Chair

cc: Bruce Reed Goodmiller, Richard Mitchell & Lina Velasco

Subject: Added TRAC Comments on NOP/IS for LBNL's RBC 2013 LRDP & Phase I Development
From: Sandra Beyaert <sbeyaert@earthlink.net>
Date: 1/28/2013 10:06 PM
To: Jeff Philliber <lrdp-eir@lbl.gov>
CC: Bruce Goodmiller <Bruce_Goodmiller@ci.richmond.ca.us>, Richard Mitchell <richard_mitchell@ci.richmond.ca.us>, Lina Velasco <lina_velasco@ci.richmond.ca.us>, Doug Lockhart <delockhart@lbl.gov>, Jennifer McDougall <jmcdougall@berkeley.edu>, Barbara Maloney <Maloney@bmsdesigngroup.com>, Joy Glasier <glasier@bmsdesigngroup.com>, Elizabeth Foster <Foster@bmsdesigngroup.com>, Armando Viramontes <AViramontes@lbl.gov>

Jeff,
Please find attached TRAC's Jan. 28 letter following up the earlier Jan. 17 letter commenting on the Notice of Preparation and Initial Study for LBNL's Proposed Richmond Bay Campus 2013 Long Range Development Plan and Phase I Development. This new letter raises issues concerning compliance with the City of Richmond's General Plan, Bicycle Master Plan and Pedestrian Plan. TRAC hopes that these comments in preparing the DEIR.

Bruce

Bruce Beyaert, TRAC Chair
tracbaytrail@earthlink.net
phone/fax 510-235-2835

Websites >>
TRAC: http://www.pointrichmond.com/baytrail/
City of Richmond Bay Trail: http://www.ci.richmond.ca.us/TRAC
Richmond Bay Trail Slideshows:
http://sfbaytrailinrichmond.shutterfly.com/pictures/5
Richmond Convention & Visitors Bureau:
http://www.explorerichmondca.com/baytrail.htm

Attachments:

LBNL_RBC_NOP_TRAC012413.pdf	55.1 KB

Richmond Southeast Shoreline Area Community Advisory Group

EXECUTIVE COMMITTEE

University of California
Lawrence Berkeley National Laboratory

FEB 04 2013

Facilities Capital Projects

February 4, 2013

Jeff Philliber
Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720 via email: LRDP-EIR@lbl.gov

Re: Richmond Bay Campus 2013 Long Range Development Plan & Phase 1 Development, Richmond Bay Campus, NOP

Dear Mr. Philliber:

The Richmond Southeast Shoreline Area Community Advisory Group brings the California Department of Toxic Substances Control, property owners, and community members together to ensure that the interests of the entire community are included in plans for cleanup of this shoreline area. Our goal is to ensure that current and future users of this area (human as well as wildlife), are protected from site pollution, preferably through cleanup that removes the need for long term institutional controls and deed restrictions.

Richmond's new comprehensive General Plan identifies the southeast shoreline as a community gateway, and the community looks forward to the implementation of a LBNL project that reflects the values of livability, sustainability, and balance, especially as this is one of the more spectacular East Bay sites, drawing large numbers of visitors from both inside and outside the community for recreational purposes.

The RSSA CAG and participating community members have a continuity with this area and an expertise in its challenges; we look to the long term, and encourage this project's decision makers to consider the following points:

- Prior cleanups that left toxics in place have proven mostly ineffective. Research continues to support lower screening levels, causing earlier cleanups to fall out of compliance. In addition, a number of pollutants left in the southeast shoreline soils and water move and mix via plumes, and remediation short of complete source removal has proven ineffective.
- The pollutants on the Zeneca-Stauffer Chemical Plant property significantly impact neighboring properties. Past waste handling practices, including toxins brought from the UC Field Station have left the property highly toxic. And since some of these toxins are showing up in plumes migrating off-site adjacent properties may need to use a more aggressive discovery process than would be typical for a cleaner, less complicated area.
- The most recent, and more comprehensive, sea-level study is Sea Level Rise for the Coasts of California, Oregon and Washington: Past, Present and Future by the National Research Council of the National Academies. The report concludes that for the Bay Area, sea level rise (relative to the year 2000) will range from 1.5 - 12 inches by 2030, 5 - 24 inches by 2050, and 17 - 66 inches (i.e. up to five and a half feet) by 2100. The high figures are twenty percent higher than the previous high projections of 16 inches by 2050 and 55 inches by 2100 in the report cited by the Bay Conservation and Development Commission (BCDC) in its 2009 draft staff report entitled Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline. Sea-level rise based on either report will cover areas impacted by the many toxics left from past historical industrial use.

This will increase the movement of toxics into Bay waters via solubility and/or motion, and increase the mixing of the toxins, which can magnify risks.

In addition, we support the comments provided to you by the following organizations:

- TRAC, January 13, 2013
- TRAC January 28, 2013
- Sierra Club, January 30, 2013
- California Native Plant Society, East Bay Chapter, February 4, 2013
- Citizens for Eastshore Parks, February 4, 2013

The RSSA CAG shares the view that while the scoping document Section 10.b states "the project is not subject to local land use planning jurisdiction because it is located on land owned by the University" the project would gain community support if the goals of Richmond's General Plan 2030 were acknowledged and implemented to a greater extent than currently indicated. To this point, we support the suggestion for a joint EIR/EIS process and compliance with NEPA.

We urge you to work with the us and the groups noted above to address the issues we have raised. We hope these comments help this project meet the longterm goals of LNBL, the University, and the community.

Sincerely,

Eric Blum
Chair
Richmond Southeast Shoreline Area Community Advisory Group

SAN FRANCISCO BAY AREA RAPID TRANSIT DISTRICT
300 Lakeside Drive, P.O. Box 12688
Oakland, CA 94604-2688
(510) 464-6000

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Lawrence Berkeley National Laboratory
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7TH DISTRICT

James Fang
8TH DISTRICT

Tom Radulovich
9TH DISTRICT

February 1, 2013

Jeff Philliber
Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

Re: BART District Comments on Notice of Preparation for the Draft Environmental Impact Report for the Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development

Dear Mr. Philliber:

We have reviewed the Notice of Preparation (NOP) for the Draft Environmental Impact Report (DEIR) for the Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development (LRDP). We are submitting the following comments for your consideration in proceeding with the LRDP DEIR.

Overall Comments

- Recognizing that UC's prior ownership of the site was undoubtedly a factor in the decision to locate the Lawrence Berkeley National Lab (LBNL) lab expansion at the Richmond Field Station (RFS), we note that this location is a difficult location to serve with public transit, and has a number of sustainable transportation challenges. This location is isolated from the regional transit network by the I-580 freeway and the Union Pacific Railroad right-of-way, and is not directly served by any AC Transit lines or within walking distance of any BART stations. Locating a major employment center in a location that is so inaccessible by existing public transit means that the bulk of access will undoubtedly be by single-occupant auto.

  We note that, at build-out in 2050, UC is planning for a minimum of a 60% mode share for autos to this campus (6000 parking spaces anticipated, with 10,000 employees onsite anticipated). If the lab expansion were to occur in a location better served by public transit, a lower auto mode share could be anticipated and actively facilitated. As it is, the location will contribute to the generation of a significant number of VMTs in the region, with the resulting emissions. Running shuttles and providing bike facilities may ameliorate somewhat the transit-inaccessibility of the location, but a job center at this isolated location will have a significant challenge to achieve mode splits comparable with locations that are adjacent to existing, high capacity and frequent transit services.

BART 40TH ANNIVERSARY

www.bart.gov

Specific Comments

Shuttle bus services

- There is currently an hourly shuttle bus from Berkeley to RFS from approximately 730am-6pm. The NOP notes that an additional shuttle will be provided to El Cerrito Plaza BART with the project for access to AC Transit and BART. We suggest that UC consider running the new shuttle to El Cerrito del Norte Station instead of El Cerrito Plaza. At El Cerrito del Norte Station, in addition to BART and AC Transit, the shuttles could connect directly with buses operated by three additional agencies - WestCAT, Golden Gate Transit and Vallejo (SolTrans) buses. This would be much more convenient for any employees at RFS commuting from the north or west by bus, and would offer employees more transit options with fewer transfers, and would save paying an additional fare to connect between El Cerrito del Norte and El Cerrito Plaza. El Cerrito del Norte Station is also actually closer to RFS than El Cerrito Plaza is - 2.1 miles versus 2.9 miles, so the travel time would be shorter, and UC could potentially offer more frequent service with the same number of vehicles due to the faster cycle times.
- The new shuttle should start as part of Phase 1 of the project.
- The NOP notes that 10,000 employees will be onsite by 2050 (up from 300 today). The frequencies and span of service will likely have to increase dramatically on the shuttles by then to handle additional riders. As part of this EIR, UC will need to estimate future ridership demand and the frequencies needed to serve that demand. UC should meet with both BART and AC Transit to look at El Cerrito del Norte Station and/or El Cerrito Plaza Station and work out with the two agencies where the shuttles would stop and how the riders would be handled at the station. Any layover needs at the station should also be described.

Transit services

- The EIR should estimate future ridership demand generated by the project on all existing and future transit services (BART, AC Transit, and other regional and local carriers), and assess if there are any capacity issues created by the additional riders.
- The EIR should assess how walk access to the closest AC Transit route to the site could be improved. The 74-line serves a location approximately 1/4 mile away, at Regatta and Marina Bay Parkway.
- The Metropolitan Transportation Commission (MTC) published the *San Francisco Bay Area Regional Rail Plan* (2007) that identified a long-term concept for a Diesel Multiple Unit (DMU)-light rail overlay transit service on, or adjacent to, the existing Union Pacific/Capitol Corridor rail alignment. This alignment is directly across I-580 from the RFS site. BART is preparing a conceptual look at potential long-term improvements in this corridor, which is also known as the Eastshore Corridor, or wBART. Capacity improvements would need to be made to the Union Pacific alignment in order to implement the project. Station sites have not been picked and no planning, design or environmental work has been done on this corridor yet, but a station in the vicinity of the RFS would be a logical station location for the local service, given the number of jobs at the site. If this project were to move forward, it would require a new pedestrian bridge across I-580 for access to the RFS site.

Bikes

- The EIR should analyze the need to improve bicycle access to the site, including a robust and safe bicycle connection to and from BART. The path will need to get past two freeways to access the site.
- The project should include onsite facilities for bike riders such as showers and locker rooms, and secure bike parking.

- BART supports the suggestion for intra-campus bike sharing on the campus, similar to the Lawrence Livermore National Labs.
- BART supports the suggestion to offer transit discounts, guaranteed ride home services, car sharing services, and other Transportation System Management (TSM) /Transportation Demand Management (TDM) measures for employees at the site.

Transportation Demand Management

- Consistent with the mission of the Lawrence Berkeley National Labs, the EIR should consider a robust Transportation System Management (TSM) and Transportation Demand Management (TDM) program to reduce auto emissions. The program should incentivize and prioritize the use of sustainable transportation options, such as public transit. Onsite parking should be paid parking for employees and visitors, as part of a comprehensive TSM/TDM program. This would allow UC to offer a parking cash-out for employees who use transit or bike to work.

Sea-Level Adaptation

- The EIR should consider how the site and critical infrastructure can adapt and respond to sea-level / bay rise and storm surges.

Thank you for the opportunity to comment on this NOP. Please call Duncan Watry in BART Planning at (510) 287-4840 if you have any questions, or to arrange any meetings with BART or site visits during the EIR process.

Sincerely,

Val Menotti
Planning Department Manager

cc: Nathan Landau, AC Transit
Doug Johnson, MTC
Bob Franklin, BART Customer Access
Duncan Watry, BART Planning

Making San Francisco Bay Better

University of California
Lawrence Berkeley National Laboratory
FEB 04 2013
Facilities Capital Projects

February 4, 2013

Jeff Philliber
University of California
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

SUBJECT: Notice of Preparation for the Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development
(SCH No. 2013012007)

Dear Mr. Philliber:

We have received a copy of the Notice of Preparation for the Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development, dated January 3, 2013, and prepared pursuant to the California Environmental Quality Act (CEQA). The document describes a proposed new research campus at properties located at 1301 South 46th Street in the South Shoreline area of the City of Richmond, Contra Costa County.

The San Francisco Bay Conservation and Development Commission ("Commission" or "BCDC") staff reviews such documents on behalf of its Commission to assess, among other things, the project's consistency with the McAteer-Petris Act, the Commission's *San Francisco Bay Plan*, the Commission's federally-approved management plan for the San Francisco Bay, and the federal Coastal Zone Management Act (CZMA), and the project's relationship to the Commission's jurisdiction.

At this site, the Commission has permit jurisdiction over all tidal areas of the Bay up to the mean high tide line or to the inland edge of wetland vegetation in marshlands up to five feet above Mean Sea Level; all areas formerly subject to tidal action that have been filled since September 17, 1965; and a 100-foot shoreline band extending 100 feet inland from and parallel to the Bay jurisdiction.

Commission permits are required for placing and grading fill, construction, dredging, dredged material disposal, and substantial changes in use within its jurisdiction. Permits are issued when the Commission finds proposed activities to be consistent with its laws and policies. In addition to any needed permits under its state authority, federal actions, permits, and grants affecting the coastal zone are subject to review by the Commission, pursuant to the federal CZMA, for their consistency with the Commission's federally-approved management program for the Bay.

From reviewing the subject document, it appears that the proposed project would be located partially within the Commission's jurisdiction and, thus, would require

authorization via a Commission permit. Please visit our website at www.bcdc.ca.gov for the relevant laws and policies that should be considered when evaluating your project under CEQA. It is likely that a primary issue for the Commission in reviewing this project will be an evaluation of the public access to and along the shoreline of the Bay provided as part of the project. The Commission's law and policies require that proposed development provide the maximum feasible public access consistent with the project. Furthermore, public access should be sited, designed, managed and maintained to avoid significant adverse effects to wildlife as well as to be designed to be able to adapt or be resilient to sea level rise and shoreline flooding. Please feel free to contact us at your earliest convenience to discuss the type of approval necessary for the proposed project, the process for obtaining Commission authorization, and whether, as proposed, the project would be consistent with the Commission's laws and policies.

If you have any questions, please contact me at the Commission's office at 415-352-3668 or elliek@bcdc.ca.gov.

Sincerely,

Ellie Knecht
Coastal Analyst

EK

University of California
Lawrence Berkeley National Laboratory
FEB 04 2013
Facilities Capital Projects

February 4, 2013

Comments on Notice of Preparation of Draft Environmental Impact Report for LBNL proposed Richmond Bay Campus

Mr. Philliber,

We (Golden Gate Audubon Society) are writing with regard to the Notice of Preparation (NOP) for the Draft Environmental Impact Report (DEIR) on LBNL's second campus (the Campus).

Our organization's mission includes helping to preserve and improve the habitat and populations of Bay Area birds and other wildlife. Several aspects of LBNL's proposed Richmond development are therefore of concern to us.

We note that the NOP mentions the California Clapper Rail, a federally listed endangered species, which has bred recently in the marsh adjacent to the project. The NOP also mentions a portion of coastal prairie that is present on the development site. We will be especially interested in how thoroughly the DEIR assesses impacts or potential impacts to these resources.

In addition to impacts to the natural environment, we have an organizational interest in the aesthetic values of the site. The Bay Trail and its tributary walking paths adjacent to the Campus are often visited by birders, and we have docent programs that use these areas to teach people about birds and wildlife. The Bay Trail between Point Isabel and the Marina Bay development is one of the few nearby bay-front areas that is not heavily developed, and LBNL's new buildings may have a significant aesthetic impact if they are not carefully designed and integrated into the landscape.

Below we list development issues that are of special concern to our organization, as well as suggestions for mitigation:

1. Lighting. Outdoor lighting disturbs bird and wildlife sleep cycles; it also allows predators (including cats and raccoons) to hunt at night. Outdoor lighting should be avoided as much as possible; when it cannot be avoided all of the light should be directed downwards by "full cut-off" light fixtures, and fixtures should be as low to the ground as possible.
2. Raptor perches. Light poles, utility poles, some types of building roofs, and certain types of trees provide attractive perches for hawks and owls. These birds, though a natural and indeed desirable part of the ecosystem in many areas, would not naturally be common in a shoreline marsh due to lack of perching spots. Having such species in abundance along the shoreline is undesirable because they prey upon ground-nesting birds such as Clapper Rail, so potential perches should not be used. When light poles and other perches are necessary they should be designed so as to discourage perching birds, and they should be as far from marsh and shoreline areas as possible.

3. Human presence. Human presence disturbs many types of birds and wildlife, with some types more impacted than others. Human-tolerant species such as crows, ravens, opossum, and raccoon are thereby promoted relative to other species. To the extent possible, human presence should be restricted near sensitive areas such as marshland. For example, in the context of the site it would be desirable to have employees use the existing Bay Trail for recreation rather than to create an additional walking path on the LBNL property adjacent to the marsh.
4. Trash, especially edible trash. Edible trash attracts predators such as cats, raccoons, and ravens that prey on other species. Cafeteria trash control is important, and all trash cans should be scavenger-safe.
5. Noise. Construction noise and operating noises (including ventilation fans and fume hood fans) should be reduced as far as possible, and should be shielded from natural areas.
6. Bird strike. We understand that LBNL is already committed to using "bird-safe building" standards to reduce deaths due to collisions with windows. We encourage this mitigation and others to reduce the risk to birds.

We intend to participate attentively in the EIR process and look forward to reviewing the DEIR.

Sincerely,
Phillip Price
Chair, Golden Gate Audubon Society East Bay Conservation Committee

Subject: RBC 2013 LRDP EIR
From: Mary Selva <maryspond@sbcglobal.net>
Date: 2/4/2013 4:51 PM
To: LRDP-EIR@lbl.gov

University of California
Lawrence Berkeley National Laboratory
FEB 04 2013
Facilities Capital Projects

February 4, 2013

Jeff Philliber

Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

RE RBC 2013 LRDP EIR

Dear Mr. Philliber:

The Richmond Annex Neighborhood Council is submitting comments to above titled project:

Climate Change and Sea Level Rise
The LBNL must analyze what will happen to their project area and adjacent to the South Shoreline area with regards to sea level rise. The LBNL should take a very conservative approach and by that we mean the LBNL should not assume that sea level rise will be the lowest that is projected, but should assume higher sea level rise figures in order to ensure that it properly analyzes the impact of sea level rise on any LBNL proposed development. Included in any such analysis must be impact of sea level rise on LBNL's toxic nature of substances found on the site. Any impact or inundation from sea level rise, the amount, if any, of any leakage of the toxics from the site due to sea level rise, and the impacts of such leakage on the Bay and the flora and fauna of the Bay.

The LBNL must also analyze whether if it approves development of that site, sea level rise will require later construction of levees or dikes to protect that development from sea level rise inundation. Again, the LBNL must use the most conservative numbers for sea level rise, i..e., the highest level that is reasonably projected and not some rosy figure that currently floats around. The reasonably projected highest number the Sierra Club has seen is around 2 meters or over 6 feet over the course of the next 100 years. The EIR for the general plan must take this potential rise into account.

Second, the LBNL must analyze the impact of any development on the adjacent wetlands. We know that large developments close to wetlands can have a devastating impact on wetland wildlife due to human intrusion, domestic pet intrusion, and the intrusion from vermin creatures such as rats that are attracted to any human development. The entire area of the shoreline of Richmond must be analyzed for these impacts from any proposed development.
Third, impacts to birds and other wildlife from lighting must be analyzed. We know that night time lighting from development near wetlands and other protected habitat can have a secondary impact on wildlife by enabling nocturnal predators to better hunt and capture prey. These impacts must be analyzed.

Fourth, the LBNL must analyze the impact to birds smashing into buildings. This impact has long been ignored, but more and more we are now realizing that many birds are unable to distinguish the glass of a building from the environment around them and fly into buildings and die. These impacts must also be analyzed.

Fifth, the LBNL should provide setbacks from the shoreline of at least 500 feet from the mean high tide mark for any development in order to ensure the full protection of wetland flora and fauna from any development impacts.

Sixth, the LBNL should provide for setbacks from creeks of at least 500 feet on each bank of a creek to protect the creek habitat and flora and fauna from any impacts from development.

Liquefaction

A magnitude 6.7 earthquake has a 99.7% chance of striking somewhere in California over the next 30 years.
In San Francisco, the probability is 63%; in Los Angeles it's 67%.
In the Bay Area, the biggest threat is the Hayward Fault and its northern extension, the Rodgers Creek Fault. The probability went from 27% in 2003 to 31% in 2008.
The probability of a 7.5 earthquake in California is 15% in the north and 37% in the south.

Threat to Shoreline and LBNL Project— A team of geologists at the USGS in Menlo Park found that much of the East Bay fill would turn into soup if a 1906-sized quake were to reoccur today. Much of the East Bay shoreline is made up of the worst possible kind of artificial fill—loose sandy soil primarily dredged from the Bay. Treasure Island and the East Bay are the fill capitals of the Bay Area. It's estimated that a magnitude 6.6 quake or greater on the Hayward fault, which runs along the East Bay hills from San Pablo to Fremont, could subject more than half of the fill land to liquefaction. But it is the San Andreas fault, 10-15 miles away on the San Francisco peninsula that poses the greatest threat to the East Bay filled land. This is because that fault is capable of much larger earthquakes, such as the magnitude 7.8 quake of 1906, than the Hayward fault.
The U.S. Geological Survey findings basically guarantee a large earthquake is going to happen.
The Hayward fault is in close proximity to the Richmond South Shoreline area—approximately 3 miles away. The Hayward fault runs along the Arlington and through the Mira Vista Golf Course in the El Cerrito Hills.

Synthetic Biology

Special Guests:
Ø Jeff Conant, Global Justice Ecology Project (www.globaljusticeecology.org);
Ø M. L. Tina Stevens, PH.D., Alliance for Humane Biotechnology (www.humanebiotech.com);
Ø Gopal Dayaneni, Movement Generation Justice & Ecology Project (www.movementgeneration.org) **. . .**
gave informative presentation on Synthetic Biology, Health, Justice, and Communities at Risk. The LBNL 2nd campus on Richmond's South Shoreline will be the world's largest synthetic biology lab. It will be made up of three different divisions, including the Joint BioEnergy Institute (JBEI), a Department of Energy lab working on development of fuels from plant crops. Research at the new facility would focus heavily on creating genetically modified organisms, with the labs to be brought onto the new campus focusing in three related areas: "Genomics, Life Sciences, and Physical Biosciences." In addition to the Emeryville-based JBEI, other projects to be relocated on the new site include the Joint Genome Institute, currently located in Walnut Creek, the National Energy Research Scientific Computing Center in downtown Oakland and "much of the Life Sciences Division in West Berkeley." Nanotechnology, the study of manipulating matter on an atomic and molecular scale, may also be built on the site. The following are some of the issues discussed and major concerns**:**
-4 according to the risks of harm they pose, with levels of increasing danger. BL1 labs perform research on non-human infectious agents; BL2 labs use biological agents that could infect humans, but are assumed to cause only "moderate harm," BL3 labs experiment with bio-agents capable of killing humans, which there are known antidotes; BL4 labs conduct research using agents that could kill humans for which there are no known antidotes.
Ø Bio-releases can spread through the air.
Ø Synthetic Biology and Nanotechnology are not properly regulated and lack adequate oversight, transparency or protections.
Ø One of the facilities did not report leak—eventually the employees did. 3 employees were infected with deadly virus.
Ø Involves a lot of people in many fields not familiar with bio-safety.
Ø LBNL – Environmental reviews are historically limited.
Ø Cal Osha requirements under Chemical Hazards Regulations are lacking biological hazards regulations.
Ø The City of Berkeley's Planning Commission and Design Review Board are exempt from reviewing the Lawrence Berkeley National Laboratory (LBNL) main campus, which is located at Strawberry Canyon. The LBNL is also exempt from Berkeley's Zoning Ordinance—Development Standards (height, setbacks, parking requirements, etc.). Likewise, the City of Richmond's Planning Commission and Design Review Board and Richmond City Council are exempt from reviewing and approving the architectural and project plans of any LBNL development in Richmond. Because it's a **"National"** Lab, it is only required to follow the National Environmental Policy Act (NEPA), which is outdated and does not include regulations for Synthetic Biology or Nanotechnology. Revisions to NEPA are done by the federal government and must get approved by Congress, which hasn't happened yet.

Other organizations involved in the movement for **responsible** synthetic biology and nanotechnology are**:**
Ø Council for Responsible Genetics (www.councilforresponsiblegenetics.org - **see Worker Safety in Biological**

Laboratories—Limitations of Osha Regulations Governing Bio-Laboratory Safety);
Ø Friends of the Earth, Center for Ecological Agriculture (www.foe.org - **see The Principles for the Oversight of Synthetic Biology**);
Ø Center for Environmental Health;
Ø Center for Food Safety, ETC Group;
Ø Injured Workers national Network;
Ø International Center for Technology Assessment;
Ø California Coalition for Workers Memorial Day;
Ø ETC Group, Global Justice Ecology Project;
Ø West County Toxic Coalition in Richmond, CA
Note: www.synbiowatch.org should include all of the above organizations regarding efforts to get regulation in place for synthetic biology and nanotechnology. The "wait and see" approach is increasingly becoming a dangerous way to determine the risks. Potential hazards to humans are inhalation, ingestion, absorption through the skin, and airborne particulates. Hazards to fish and wildlife are through contaminated creeks, soil, and potential leaks into the bay.

Wetlands and Marshlands Impacts

The Meeker Slough Wetland area and the restoration of both East and West Stege Marsh will be affected or impacted by development of the LBNL. Currently, this area is quiet solitude and has very little human activity. It is much further north than the Pt. Isabel area and people rarely go down there and know to keep out of these sensitive areas. This is where the California Clapper Rail lives and other wild habitat.

LBNL development and urban growth will account for significant historical losses of wetlands.

Degradation of wetlands is less obvious than outright loss, and can occur as a direct or indirect consequence of many human activities and dramatically increased human foot traffic as a result of the LBNL project. Large LBNL developments, for example, can result in wetlands degradation by increasing the volume of runoff and the amount of pollutants that the runoff carries. Hydrologic disruptions, such as the diversion of surface water or the withdrawal of groundwater, are major causes of wetlands degradation in urban areas.

Losing Ground: The sad irony in all this is that our human activities would create the environmental need for more wetland resources even if they did not damage or destroy our existing wetlands. Our roads, houses, commercial buildings, parking lots – essentially all of our development – cause some disruption in the functioning of our watersheds.

The hard surfaces prevent water from infiltrating into the soil, **and one result is more faster runoff**. If there were more rather than fewer wetlands to handle these consequences of our development, we might be able to maintain the original hydrologic balance. As it is, we not only create the need for more of the environmental functions of wetlands, **we also destroy or damage the resources that provide those functions.**

Other Important Issues that the RBC 2013 LRDP EIR must address:

Traffic Impacts

Infrastructure—Sewer, water, new roads, etc.

Grand Size of the Overall LBNL Project—The building plans proposed for the Lawrence Berkeley Lab on the South Richmond Shoreline have been changed. The new plan more than doubles the density of their building project, from 2-million sqft (square feet) floor area worth of buildings for 5,000 employees **to 5.4-million sqft floor area worth of buildings for 10,000 employees**. The original proposal of 2-million sf ft was considered massive. But 5.4-million sf ft would be considered overdeveloped and create major impacts.

Thank you for opportunity to submit comments,

Mary Selva, President

Richmond Annex Neighborhood Council

University of California
Lawrence Berkeley National Laboratory
FEB 04 2013
Facilities Capital Projects

Comments on: 30 JANUARY 2013

NOTICE OF PREPARATION
DRAFT ENVIRONMENTAL IMPACT REPORT
↑
This title is subsequently referred to as 'EIR'. Are not the Draft Environmental Impact Report and the Final Environmental Impact Report separate documents? It is difficult to follow the sequence of documents that will be forthcoming when 2013 LRDP and Final LRDP EIR are mentioned in the same sentence, without explanation. Is this a NOP or a DEIR or a LRDP... is it an EIR for a LRDP? Please be consistant. Also helpful would be a graph or time-table that explains when new documents will be issued.

You could add a section explaining CEQA, NEPA, EIRs, NOP, LRDP and so forth. People newly affected by the University's plans need to know what is being planned, in order to respond to your documents and at your meetings. Also, please explain the difference between a "Program" and a "Project". there are important differences that will affect people, but the words are often used interchangeably in every day speech. Be clear about this. "Tiering" is also very important to understand. It can come as a shock to find out that a benevolent-sounding Long Range Development Plan can be tiered off into a totally unexpected result.

How many of these Notice of Preparation documents were circulated among the concerned public? Giving copies to the Agencies such as PG and E, EBMUD and others just requires that an administrator says "Yes, we can provide that service".

An Initial Study was prepared because of CEQA requirements, and even a legal reporter was present, but the question remains: did that satisfy the concerns of the community, or did it merely satisfy the legal requirements. How many affected entities figured out when and where the meeting was to be held (no address given, just Civic Center Plaza), and attended, and gained anything from their time. Posters, with a goal of informing the public, were surrounded by paid employees before the meeting, and inaccessible. At the beginning of the speakers, all posters were removed. Why was that?

Section 1.0 says "the University proposes to rename the properties as the "Richmond Bay Campus". Renaming from what? the former name is not mentioned. Spell out the former name in full, with some history, so that people will know what youre talking about. the name "Richmond Field Station" is mentioned in footnote #3 on page 5 but you should be clear and open about things, and not play hide-and-seek with your readers.

POTENIAL EFFECTS, page 18.
The report contains a helpful section with sub-sections. this is nicely arranged with the Question in white color, and the Answer on light gray, with a line to separate the topics. This easy-to-read plan falls apart later, for example e) on page 20, c) on page 22, a) on page 24 and it continues to deteriorate all the way to the end. Let's fix this.

Copies of all subsequent documents for this project should be more widely distributed. Certainly copies should be readily available at Marina Bay residential neighborhood.

LAND USE.
Even though the Richmond Bay Campus is somewhat isolated from neighbors, going from a million square feet of building space to 5 million squarefeet seems extreme, especially when one considers the height of the buildings with their extra-high ceilings. A vague term like "iconic buildings" does little to inform the public what might be planned.

Your report needs to examine the possibility of putting 100 foot-tall buildings on marshy or filled land. In order to not sink into the bay mud, substantial footings will need to be provided, raising the cost of construction. Since this will likely fall to tax-payers, costs cannot be ignored. Please provide a detailed engineering report on building foundations, and costs.

LBNL seems to have gone from earthquake-prone sites on the hills, complete with landslide problems etc., to a site on the Bay with encroaching water problems. Much more attention needs to be paid to this in your forthcoming documents. Also worrysome is the fact that U.C. plans to add so much fill to raise the area above the tides, storms, sea-level rise and so forth. It is surprising to read about U.C.s plans for parking, water-efficient landscaping and other projects which really don't affect us all, that much, while giving so little attention to qvite important issues such as toxics, building heights, earth-fill, water table andso forth. It would be a good plan to add a map or diagram to show the height above mean sea level of this property. Calling part of the Field Station "up-lands" does not give readers a clear picture of what is involved.

Legacy Pollutants.
How does the University propose to deal with the pollutants currenty on the property? Will "clean-up" involve disturbing the soil and releasing toxics into the air? Will toxics be transported on the public roads, and taken to some other locale and deposited there? Please give details about this, and also whether, like at the Labs Hill Site, pollutants will be generated anew. This is probably the most worrisome part of U.C.s plans, as research nowadays involves unknown particles and combinations and inventions.
The Precautionary Principal should be observed very rigorously. Unfortunately it seems clear that a competition is on between scientific organizations to carry out their science, and to publish and develop their innovations before the next group, to gain market-edge. Much more important than that is to proceed safely and cautiously. Some science projects are going to turn out to be detrimental in the long run. History proves that.

As a side issue, is U.C. worried at all about the legacy pollution at the Stauffer-Zeneca site? That would certainly enter into the ground water, and if it too was 'cleaned-up' how would that affect R.B.C.

TREES and LANDSCAPING:
In general, trees are natural and they help to regulate the earth eco-systems. Try to keep as many mature trees as possible. In the case of the Marina Bay residential area, a substantial tree-screen is necessary. A child tossing a ball in his backyard could easily land the ball in the R.B.C.- it is that close. The housing is already established in Marina Bay. Please be respectful of that.

To end these comments on a positive note, I should say thank you for sending me a paper copy of the document. I would also like to receive paper copies of other documents to come, that the public needs to comment upon.
Your colored maps are nice, I might add.

the list of acronyms and abbreviations is helpful. (though some are missing, for example C.F.R., D.O.E, N.R.L.F., R.A.O., R.F.S.)

Barbara Robben
1964 El Dorado
Berkeley CA 94707
510-524-2383

University of California
Lawrence Berkeley National Laboratory
FEB 04 2013
Facilities Capital Projects

Subject: re: EIR for Richmond LBNL campus
From: Margot Cunningham <cunningham.margot@gmail.com>
Date: 2/4/2013 3:19 PM
To: LRDP-EIR@lbl.gov

Please consider the following comments regarding biological resources in the EIR for the Richmond campus of Lawrence Berkeley Nat'l. Laboratory.

1)The Richmond Field Station contains remnant native coastal prairie grasslands. This habitat exists in very few places today and should be preserved in its entirety.

2) Another remnant field exists at the entrance to the current RFS at Meade St. and S. 46th St. Remnant populations of California poppies (*Eschscholzia californica)*, a perennial, and rancheria clover (*Trifolium albopurpureum*), an annual, grow in the grassy area along the west side of Mead St at the entrance. The rancheria clover also grows along the eastern boundary of the RFS up to the railroad crossing along the western side of Meade. These flowers should be preserved in any landscaping plans for this area. Seed can also be collected from them and used in landscaping projects throughout the new lab construction.

Thank you,
Margot Cunningham
1727 Santa Clara St
Richmond, CA 94804

California Native Plant Society
East Bay Chapter P O Box 5597, Elmwood Station, Berkeley, CA 94705

February 4, 2013

University of California
Lawrence Berkeley National Laboratory
FEB 04 2013
Facilities Capital Projects

Jeff Philliber
Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

RE: Notice of Preparation for Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development Environmental Impact Report

Dear Mr. Philliber:

The California Native Plant Society's East Bay Chapter (EBCNPS) appreciates the opportunity to comment on the *Notice of Preparation for Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development Environmental Impact Report.*

The California Native Plant Society (CNPS) is a statewide non-profit organization that works to protect California's native plant heritage and preserve it for future generations. The Society's mission is to increase the understanding and appreciation of California's native plants and to preserve them in their natural habitat. We promote native plant appreciation, research, education, and conservation through our 5 statewide programs and 33 regional chapters in California. The East Bay Chapter covers Alameda and Contra Costa Counties and represents some 1100 members.

Pursuant to the mission of protecting California's native plant species and habitats, CNPS submits the following comments and recommendations for the NOP and General Plan/EIR:

General Considerations:

In 2010, the East Bay Chapter of CNPS published a Guidebook to the Botanical Priority Protection Areas of the East Bay. These fifteen protection areas (BPPAs) have been selected as those areas within Alameda and Contra Costa Counties that contain high value botanical resources that should be protected. The guidebook was created with the expert advice of many professional botanists to aid city and county planners in locating important native plant species and communities. The proposed project at the Richmond Field Station falls within the "Richmond Shoreline" BPPA and is thus of major concern to EBCNPS. The Richmond Field Station is recognized by CNPS for priority protection because it contains what is believed to be the last undisturbed native coastal prairie grassland adjacent to the San Francisco Bay Shoreline. This native grassland is an intact remnant stand that functions as a reference assemblage - invaluable for the study of how this threatened ecosystem functions and as an example of its community type for restoration ecologists. Today, less than one percent of California's original native grassland ecosystems remain intact.

Due to the rarity of this native plant community, EBCNPS recommends complete avoidance of the native coastal prairie grassland at the project site. It is critical that areas of native prairie be avoided during any/all construction projects. These "projects" include using the native prairie as a "construction materials staging area", as a "drive on / drive through" area, as an area where accidental spilling or spraying of harmful materials could occur, or where any other access which would create soil compaction, and/or killing of characteristic plant species could occur. Figure 2 of the NOP shows a proposed soccer field abutting the northwest edge of the known coastal prairie. Please note that building a sports field (regardless of whether it contains natural or artificial turf) will likely result in significant impacts to the coastal prairie adjacent to it, both in potential damage during construction and as a result of runoff/irrigation after completion. Any constructed area needs to be adequately set back from areas of native prairie so as to ensure the continued viability of this rare plant community during construction and after the Lab is completed.

Since the proposed environmental review process will involve completion of both a program and project level EIR, the EIR must explicitly state that it is only analyzing the initial phase of the Long Range Development Plan and that further project EIRs need to be prepared for later development phases. Also, since the proposed campus is a joint project of both a State and Federal agency, the University of California and Lawrence Berkeley National Laboratory must analyze the project and alternatives in a Joint EIS/EIR process and comply with NEPA.

Specific Comments:

Need for Thorough Botanical Surveys of Project Site

In order to ensure that the areas of native grassland are properly considered and planned around, updated botanical surveys need to be completed. The most recent botanical surveys of the Richmond Field Station were completed in 2007 by URS. While the results of these surveys will no doubt be a helpful starting point, they can not substitute for updated surveys completed over several years. ECNPS requests that plant population densities and distributions at the site be surveyed for and compiled as part of this effort. Complete botanical surveys for the entire project site need to be carried out as part of the EIR for Phase 1 of this project and to inform the Long Range Development Plan. These surveys will help create a contemporary environmental baseline. Such an environmental baseline for plant species would be accomplished through well timed botanical surveys at the appropriate time of year for several consecutive years. A reference list of target species, including their population densities and distributions across the site, that are known to occur or have the potential to occur on site will allow future land managers at the site to ensure the native grassland in not being harmed as a result of the development and ongoing activities at the proposed new lab site.

Transition Zone Between Construction and Building Areas and Coastal Prairie

It is imperative that any plans for building location and design near areas of native coastal prairie grassland include transition zones between, but outside the areas that are to be

preserved for their natural resource value and areas that are to be developed. These zones will help minimize the potential for unforeseen impacts to the prairie such as the transportation of invasive species and will help create a buffer between project landscaping and the natural environment.

Weed Management Plan

Besides the construction and ongoing use of the proposed buildings at the site, the main threat to the native grasslands is the invasion and potential site conversion of the native grasslands by invasive grasses and other invasive weedy species. Hardinggrass (*Phalaris aquatica*) is already invading areas of coastal prairie at the site, and the EIR for this project needs to specify a weed management plan to ensure this imminent threat to the native grassland is prevented. Furthermore, such a plan would help mitigate the potential for construction and building activities to spread weeds around the site including into the areas of native grassland. Such a plan must be accompanied by an endowment in perpetuity to ensure the grassland remains free from weed invasion and other damage associated with this project.

Surface drainage

A "Draft Concept Plan" rendering from October 2012 showed the cement drainage on the Western side of the Field Station as being "restored" to a meandering creek at surface level. EBCNPS has since heard from project planners that the drawing was purely conceptual and that there are currently no plans to create a waterway on the project site. However, if such an action is considered, it is critical that the construction of a natural-style waterway not affect the intact coastal prairie which could be irreparably harmed by creek construction activities and increased ground water supply. The present roadway, Regatta Blvd, parallels the canal immediately adjacent to the west. If the canal is restored to a more natural meandering state, locating it there, away from any sensitive natural resources could be a solution that EBCNPS would support.

Landscaping Considerations

Section 4.5.6 of the NOP reads:

4.5.6 Landscape

The RBC would support bio-diversity and habitat conservation through the use of native plant materials wherever possible. In addition, the RBC would utilize low-impact development design techniques and Bay-Friendly landscape design (see www.stopwaste.org) and make storm water management a site feature. As described below, natural open spaces would also be maintained.

EBCNPS recommends that local-endemic ecotypes be used wherever native plant material is called for in the landscape design of this project. Such local ecotypes are best suited for this particular location and they will prevent contaminating the gene-pool of other native plants on the site. In the case that non-native ornamental plants are used in the landscape design, we recommend the plants be non-invasive and drought tolerant. Any irrigation for landscaped areas on the site must be planned so as to avoid impacts to the native coastal prairie and any other rare plant resources at the site.

We look forward to continuing to follow this project and commenting in the future. If you have any questions, please contact me at conservation@ebcnps.org .

Sincerely,

Mack Casterman
Conservation Analyst
California Native Plant Society, East Bay Chapter

Citizens for East Shore Parks

Mail: PO Box 6087, Albany, Ca 94706 Office: 520 El Cerrito Plaza, El Cerrito CA 94530
Ph: 510. 524.5000 Fax: 510.524.5008 eastshorepark@hotmail.com www.eastshorepark.org

February 4, 2013

University of California
Lawrence Berkeley National Laboratory
FEB 04 2013
Facilities Capital Projects

Jeff Philliber
Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720 ***via email: LRDP-EIR@lbl.gov***

Re: Richmond Bay Campus 2013 Long Range Development Plan & Phase 1 Development, Richmond Bay Campus, NOP

Dear Mr. Philliber:

Citizens for East Shore Parks (CESP) is an environmental non-profit organization that was instrumental in creating McLaughlin Eastshore State Park which is on the west side of the Second Campus project. Because this property is adjacent to what little is left of our undeveloped San Francisco Bay shoreline, it is important that you strive to see that this project sets a high standard as a public and natural resource for generations to come. While past generations thought nothing of trashing our Bay and shoreline, we now know that we can do better. We look forward to a project that respects the Park and the shoreline in terms of habitat conservation, public access and community health.

Our supporting organizations have already submitted thoughtful comments on this project, so we ask that you give those letters careful consideration as you move forward. The letters we support include:

- TRAC, January 13, 2013
- TRAC January 28, 2013
- Sierra Club, January 30, 2013
- California Native Plant Society, East Bay Chapter, February 4, 2013

We urge you to work with the environmental community to address the various issues pointed out in the above comments. In particular, we would like to highlight the following areas of concern which are explained in more detail in the above letters and should be addressed in the EIR:

- Three spheres of potential impacts (Sierra Club)
- Addressing toxic contamination (Sierra Club)
- Impacts on wetlands, birds, fauna, creek (Sierra Club)
- Impacts of sea level rise (Sierra Club)

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Sylvia McLaughlin
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Hon. Whitney Dotson

Executive Director:
Patricia V. Jones

- Protection and restoration of the "last undisturbed native coastal prairie grassland adjacent to the San Francisco Bay Shoreline... Today, less than one percent of California's original native grassland ecosystems remain intact." (CNPS)
- To conduct a complete study of the impacts of your project requires: thorough botanical surveys of project site; alternatives for transition zone between development and coastal prairie; weed management plan. (CNPS)
- Conduct meaningful alternatives to protect the coastal prairie (Sierra Club)
- Recreational impacts, such as: "...evaluate and mitigate for impacts on shoreline parks, as well as recreational and transportation usage of the Bay Trail between Central Avenue and Garrard Blvd., including growth-inducing and cumulative effects." (TRAC)
- Transportation, trail and air quality impacts: the project should make non-vehicular connectivity improvements to, from and through the facility; address how the project will implement the recommendations of Richmond's General Plan 2030 and Bicycle Master Plan and Pedestrian Plan. (TRAC)

In addition, CESP shares the concern raised in TRAC's January 28, 2013 letter which quotes the scoping document Section 10.b that "the project is not subject to local land use planning jurisdiction because it is located on land owned by the University." Further, CESP echoes the Sierra Club's call for a joint EIR/EIS process and to comply with NEPA.

CESP looks for this project to be a welcome addition to Richmond and the surrounding community. CESP hopes that our comments will be helpful and lead to a respectful project with reduced negative impacts and increased public support.

Sincerely,

Patricia V. Jones

Patricia Vaughan Jones
Executive Director

CC: CESP Board, Sierra Club, CNPS, TRAC, RANC, RSSA CAG, GGAS
Mayor Gayle McLaughlin, Richmond City Council, Richard Miller & Lina Velasco, Armando Viramontes

EAST BAY BICYCLE COALITION

Working for safe, convenient and enjoyable bicycling for all people in the East Bay

University of California
Lawrence Berkeley National Laboratory
JAN 29 2013
Facilities Capital Projects

January 29, 2013

Jeff Philliber
Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road MS 76-225
Berkeley CA 94720

To Whom it May Concern:

The East Bay Bicycle Coalition has reviewed your Notice of Preparation of Environmental Impact Report for the Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development Project. Thank you for keeping us on your mailing list. We want to first acknowledge the comment letters submitted by our partner organizations TRAC and the Association of Bay Area Governments and incorporate by reference their comments and concerns herein.

We provide the following comments to help direct your environmental review:

1. Please ensure that your EIR team reviews the new Richmond Bicycle Master Plan, the Bay Trail Plan and the Contra Costa Countywide Bicycle Plan for conformance of your project to these plans. We are particularly concerned about ensuring safe, comfortable and inviting bike access to and from the new campus for people of all ages and bicycling abilities. The new campus should be a model for the world to follow in terms of encouraging its staff and visitors to bicycle to the facility;
2. The Bay Area and the State of California have a goal of reducing greenhouse gases to 1990 levels by 2020. Since vehicle emissions contribute anywhere from 30%-40% of the greenhouse gases in the Bay Area, it is imperative that the new Richmond Bay Campus reduce its vehicle miles traveled per capita as much as possible. The Metropolitan Transportation Commission and the Contra Costa Transportation Authority are already realizing that in order to achieve the GHG reduction targets of AB 32, the Bay Area is going to have to make a significant shift from single occupant driving to public transit, walking and bicycling. Given the remote location of the new Richmond Bay Campus from transit, bicycling is going to play an even greater role. We look forward to your team developing a plan and strategies that reduce GHG's as a result of transportation to and from the new campus;
3. To the extent there are vehicle trips to and from the campus, we specifically request that your team closely study the *safety impacts* to people bicycling from these additional vehicle trips. Specifically, we want to know more about how bicyclists of all ages and abilities will safely navigate the roadways and intersections around the campus given the future vehicle trips

added. This is our most important concern. We want to know how the East Bay is going to encourage more people to bicycle to the new campus, and to bicycle more in general, if there are going to be added vehicle trips due to this project. You should take a close look at turning movement conflicts at major intersections around the campus, how bicyclists will safety make left turns into and out of roadways on key bike routes, what are the transitions like from pathways to roadways, and what level of awareness, slow traffic speeds and courtesy can be expected of roadway users of the new transportation network of the campus and the immediately adjacent roadway network of the type will promote more bicycling;

4. Access to and from the Bay Trail should be maximized, including providing lighting of main pathways at night so that bike commuters can make commute trips after work and during the limited daylight hours of Winter. Good directional signage to and from the campus for bike commuters is also needed;

5. Bike access from BART, AC Transit Rapid Bus Service, and future ferry service should also be world class, in terms of safety, design, inviting nature, and low-stress bikeway designs that will encourage a significant mode shift from driving to bicycling. No potential employee, staff member, faculty member or visitor should have the excuse of not bicycling to the campus because a nearby roadway is too dangerous and unviting;

We look forward to this project setting an example for the world to follow when it comes to eliminating the need for any employees, staff and visitors to regularly drive to the new campus.

Thank you for your consideration of these important concerns about bike safety and the promotion of bicycling in the East Bay.

Cordially yours,

Dave Campbell

Program Director
East Bay Bicycle Coalition

Subject: EIR Scoping Comments from East Bay Bicycle Coalition
From: Dave Campbell <dave@ebbc.org>
Date: 1/29/2013 3:54 PM
To: LRDP-EIR@lbl.gov
CC: TRAC <tracbaytrail@earthlink.net>, alan_wolken@ci.richmond.ca.us

Jeff,

Attached as a pdf is the comment letter from the East Bay Bicycle Coalition on the Notice of Preparation of Environmental Impact Report for the Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development Project. Thank you in advance for taking these comments and concerns into account in your environmental work for this important project. Please let me know if you have any questions about our comments and we will look forward to the start of the environmental process and subsequently to a walkable, bikeable and transit-friendly new Richmond Research Facility.

Dave Campbell
Program Director
East Bay Bicycle Coalition
email: dave@ebbc.org
office: 510.845.7433
cell: 510.701.5971

Bikeway innovation comes back to the East Bay in 2013, as several cities are planning new types of bikeways that are innovative and designed to significantly improve your bike commute by making it much safer, more comfortable and much more attractive to new riders. You can help bring this modern bikeway network to the East Bay by supporting our work. Join the EBBC at www.ebbc.org/join

Attachments:

EBBCcomments_RichmondLBNL.pdf 82.4 KB

EAST BAY
MUNICIPAL UTILITY DISTRICT

University of California
Lawrence Berkeley National Laboratory

FEB 04 2013

Facilities Capital Projects

February 4, 2013

Jeff Philliber, Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

Re: Notice of Preparation of a Draft Environmental Impact Report for the Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development, Richmond

Dear Mr. Philliber:

East Bay Municipal Utility District (EBMUD) appreciates the opportunity to comment on the Notice of Preparation of a Draft Environmental Impact Report (EIR) for the Richmond Bay Campus (RBC) 2013 Long Range Development Plan (LRDP) and Phase 1 Development Project (Project) located in the City of Richmond that will serve the University of California (UC) and the Lawrence Berkeley National Laboratory (LBNL). EBMUD has the following comments.

WATER SERVICE

Pursuant to Section 15155 of the California Environmental Quality Act Guidelines, and Section 10910-10915 of the California Water Code, a Water Supply Assessment (WSA) will be required for the project. The project sponsor should submit a written request to EBMUD to prepare a WSA for all planned development within the entire RBC site. Preparation of the WSA will require EBMUD contacting the project sponsor to gather data and estimates of future water demands for the project area. Please be aware that the WSA can take up to 90 days to complete from the day the request was received.

EBMUD's Central Pressure Zone with a service elevation between 0 and 100 feet serves the existing LRDP project site. Main extensions, at the project sponsor's expense, will be required to serve the Phase 1 Development and may be required to serve future development phases. In addition, off-site pipeline improvements, also at the project sponsor's expense, may be required to meet domestic demands and fire flow requirements set by the local fire department. Off-site pipeline improvements include, but are not limited to, replacement of existing water mains to the project site. When the development plans are finalized, the project sponsor should contact EBMUD's New Business Office and request a water service estimate to determine costs and conditions for providing water service to the proposed development. Engineering and installation of water mains and services requires substantial lead-time, which should be provided for in the project sponsor's development schedule.

The project sponsor should be aware that EBMUD will not inspect, install or maintain pipeline in contaminated soil or groundwater (if groundwater is present at any time during the year at the depth piping is to be installed) that must be handled as a hazardous waste or that may pose a health and safety risk to construction or maintenance personnel wearing Level D personal protective equipment. Nor will EBMUD install piping in areas where groundwater contaminant concentrations exceed specified limits for discharge to sanitary sewer systems or sewage treatment plants. Project sponsors for EBMUD services requiring excavation in contaminated areas must submit copies of existing information regarding soil and groundwater quality within or adjacent to the project boundary.

In addition, the project sponsor must provide a legally sufficient, complete and specific written remedial plan establishing the methodology, planning and design of all necessary systems for the removal, treatment, and disposal of all identified contaminated soil and/or groundwater. EBMUD will not design the installation of pipelines until such time as soil and groundwater quality data and remediation plans are received and reviewed and will not install pipelines until remediation has been carried out and documentation of the effectiveness of the remediation has been received and reviewed. If no soil or groundwater quality data exists or the information supplied by the project sponsor is insufficient, EBMUD may require the project sponsor to perform sampling and analysis to characterize the soil being excavated and groundwater that may be encountered during excavation or perform such sampling and analysis itself at the project sponsor's expense.

WATER RECYCLING

EBMUD's Policy 9.05 requires that customers use non-potable water, including recycled water, for non-domestic purposes when it is of adequate quality and quantity, available at reasonable cost, not detrimental to public health and not injurious to plant, fish and wildlife to offset demand on EBMUD's limited potable water supply.

The size and nature of the proposed development along with the thousands of people that will be employed within the RBC present several opportunities for the use of recycled water for landscape irrigation, commercial and industrial process uses, toilet and urinal flushing in non-residential buildings and other applications. EBMUD's current recycled water transmission pipeline terminates approximately 3 miles from the project site at the intersection of Buchanan Street and Highway 580 in the City of Albany. As part of the long-term water supply planning, EBMUD may investigate expanding the existing recycled water infrastructure or constructing a localized satellite facility that utilizes onsite waste and rain water treatment to provide recycled water to the RBC site. Other sources of local waste water delivery and related treatment could also become available to serve future development. EBMUD recommends that the UC and LBNL as well as their developers maintain continued coordination and consultation with EBMUD as they plan and implement the various projects as they get identified within the LRDP, regarding the feasibility of providing recycled water for appropriate non-potable uses.

WATER CONSERVATION

The proposed project presents present opportunities to incorporate water conservation measures. EBMUD would request that LBNL include requirements for the project to incorporate WaterSmart technology and design standards in the landscape and building design. At a minimum the landscape design should be designed to a water budget as described in the California Model Water Efficient Landscape Ordinance (Division 2, Title 23, California Code of Regulations, Chapter 2.7, Sections 490 through 495). Provisions should be established to monitor the water budget for compliance after project completion. EBMUD reviews applications for new standard water services and applications for expanded service for compliance with EBMUD Water Service Regulation Section 31, Water Efficiency Requirements. Section 31 requirements identify specifications for toilets, urinals, showerheads, lavatory and kitchen faucets, cooling towers, commercial refrigeration, outdoor landscaping and irrigation.

EBMUD recommends that LBNL coordinate the development of this project closely with EBMUD to incorporate the most water efficient appliances and fixtures practical, even if not specifically noted in Section 31. Note that some of EBMUD's Section 31 requirements exceed the Uniform Plumbing Code requirements. EBMUD staff would appreciate the opportunity to meet with applicant's staff. A key objective of this discussion will be to explore timely opportunities to expand water conservation via early consideration of EBMUD's conservation programs and best management practices applicable to the project.

If you have any questions concerning this response, please contact David J. Rehnstrom, Senior Civil Engineer, Water Service Planning at (510) 287-1365.

Sincerely,

William R. Kirkpatrick
Manager of Water Distribution Planning

WRK:AMW:sb
sb13_021.doc

Subject: NoP Richmond Bay Campus Public Comment
From: Peter Rauch <peterar@berkeley.edu>
Date: 2/4/2013 6:09 PM
To: lrdp-eir@lbl.gov

University of California
Lawrence Berkeley National Laboratory
FEB 04 2013
Facilities Capital Projects

Jeff Philliber
Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

RE: Notice of Preparation for Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development Environmental Impact Report

Dear Mr. Philliber:

I would like to bring attention to three features shown in the NoP for the LBNL Richmond Bay Campus plan.

1. The basketball court that intrudes upon the coastal prairie site. This recreation feature should be sited elsewhere, where it will not consume space of, nor cause impacts to, the coastal prairie.

2. The section of coastal prairie --still with remnant characteristic native prairie species-- which runs parallel and adjacent to the concrete/channelized drainage creek, should be included as part of the coastal prairie conservation site, and not be designated as a planted/tree-populated alternative open space. The coastal prairie habitat at the Richmond Field Station is a very small remnant, deserving of the utmost respect for what it is, with no requirement or need to transform it into a different, non-native "mall-like" cultural element of the Plan, as shown in the figure attached to the NoP.

3. The channelized creek paralleling Regatta Blvd --a road which the Plan indicates will be removed and apparently planted to a landscaped open space-- should be elevated to ground surface level, put into a meander, and spread out over the existing canal and boulevard (not, as had been depicted in one earlier rendering, on top of the also-adjacent coastal prairie). This treatment would create a biological filter for the channel waters flowing in large part from urban runoff directly into the Bay; and, it would present an opportunity to provide for a typical Bayside ecological habitat of willows and other native vegetation. The recreational value provided by bird-watching, the educational value derived from exemplary water quality treatment, and the sound- and view-scapes all promote a more friendly, welcoming campus surrounding, and complement the coastal prairie setting as well.

Peter Rauch
105 Ardmore Road
Kensington, CA
510-526-8155

Subject: Comments on Richmond Bay Campus draft EIR
From: Marla Miyashiro <pido.editor@gmail.com>
Date: 2/4/2013 2:05 PM
To: LRDP-EIR@lbl.gov
CC: pido.editor@gmail.com

University of California
Lawrence Berkeley National Laboratory
FEB 04 2013
Facilities Capital Projects

Jeff Philliber
Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720
LRDP-EIR@lbl.gov

Feb. 4, 2013

Dear Mr. Philliber,

I am the vice chair of Point Isabel Dog Owners (PIDO), a nonprofit group that has been working to keep Point Isabel Regional Shoreline clean and off-leash since 1985. We have approximately 5,000 members.

My group would like to submit a few comments regarding UC's draft environmental impact report on the Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 development. The RBC site lies a short distance north of Point Isabel Regional Shoreline. Point Isabel is heavily used; the East Bay Regional Park District has estimated that the park is visited by more than 1 million people per year.

Major issues that we think should be addressed:

The prevention of, and planned response to, any possible release of pollutants and biohazards into the environment in the event of a disaster such as an earthquake, fire, or flood.

The impact of development on the nearby marshes and wildlife. Many visitors to Point Isabel also walk along the adjacent Bay Trail. Concerns include adverse effects from windblown litter as well as lighting and noise that can disturb wildlife.

Thank you for taking the time to consider our comments.

Sincerely,

Marla Miyashiro
Vice Chair
Point Isabel Dog Owners
P.O. Box 8282
Berkeley, CA 94707
pido.editor@gmail.com

Subject: Comments on the Richmond Bay Campus 2013 Long Range Development Plan and Phase One
From: Loulena Miles <loulena@gmail.com>
Date: 2/4/2013 2:49 PM
To: LRDP-EIR@lbl.gov
CC: cdchas@att.net, "johnny12@comcast.net" <johnny12@comcast.net>

University of California
Lawrence Berkeley National Laboratory
FEB 04 2013
Facilities Capital Projects

Richmond Residents for Responsible Development

February 4, 2013

Jeff Philliber

Environmental Planner

Lawrence Berkeley National Laboratory

One Cyclotron Road, MS 76-225

Berkeley, CA 94720

LRDP-EIR@lbl.gov

The University of California (UC) proposes to establish a new major research campus at properties it owns in Richmond, California, for consolidation of biosciences programs of the Lawrence Berkeley National Laboratory (LBNL) and for development of additional research related facilities for both LBNL and UC Berkeley. This campus would jointly serve UC LBNL and UC Berkeley. The proposed 2013 Long Range Development Plan (LRDP) for the Richmond Bay Campus (RBC) would guide campus development through 2050.

On behalf of Richmond Residents for Responsible Land Use, we are writing to express concerns about the proposed RBC complex. We are local residents living in the City of Richmond that are concerned about the health, safety and environmental impacts of the proposed project. We are neighbors that are proud of our City's resolution to make all decisions guided by the precautionary principle. We care deeply about promoting sustainable growth to improve the economic and social outlook for the City while ensuring that we do

not jeopardize our future with dangerous or poorly planned projects. We have several serious concerns that need to be addressed in the Environmental Impact Report, including:

The EIR must adequately consider sea-level rise

The 2013-2050 Long Range Development Plan (LRDP) names the Joint Genome Institute (JGI), the Advanced Biofuels Process Demonstration Unit (ABPDU), and the Systems Biology Knowledgebase (Kbase) as facilities that comprise Phase I Development at the Richmond Bay Campus (RBC) complex. The LRDP proposes earthworks that raise the height of the RBC complex from 10 feet above sea level (asl) to 15 feet asl. News reports and climate models indicate that sea level rises of greater than 5 feet are expected in the coming decades and century; the proposed earthworks are therefore inadequate and the RBC complex needs to be at least 20 feet asl.[1]

Given these considerations, the EIR needs to analyze the individual and cumulative impacts of raising the height of the RBC complex to 20 feet asl, 25 feet asl, and 30 feet asl on communities (residents and workers) and the environment (air, water, soil and land) in Richmond, in the San Francisco Bay Area, and within a 200-mile radius of the RBC complex.

The EIR must carefully consider toxic, radioactive and bio-hazardous releases

Much of the research that will take place at the RBC will be on a suite of emerging technologies referred to as synthetic biology. Given that synthetic biology's objective is to engineer novel life forms and products with the potential to interact with human biology and other cellular processes, this research poses unforeseen dangers (both from accidental and deliberate uses). The rapidly developing nature of this laboratory research and its applications are largely beyond the existing regulatory framework of standard rDNA research and biotechnology generally.

An accidental release of engineered organisms could result in extreme and unmanageable risks to the health of workers, the environment and the neighboring community. Therefore, the EIR needs to analyze the individual and cumulative impacts of the following scenarios on communities (residents and workers) and the environment (air, water, soil, and land) in Richmond, in the San Francisco Bay Area, and within a 200-mile radius of the RBC complex:

- Release of biological materials from named and potential facilities at the RBC complex – especially engineered organisms and/or their embedded genetic material from the ABPDU and the JGI;

- Release of chemicals (including nanomaterials) from named and potential facilities at the RBC complex;

- Containment failures of named and potential facilities at the ABPDU and the entire RBC complex.

The EIR should also disclose and study the accidental or intentional release of nuclear materials. The EIR should contain a description of the type and reason for radionuclides at the site and the EIR should provide the building quantity limits for these materials. Further, the EIR should explain why the Initial Study anticipates potential airborne radionuclide releases. The EIR should also provide the type and quantity of potential toxic airborne contaminants.

Releases and failures may be a direct result of incidents – accidental, deliberate, or otherwise – at the RBC complex, or an indirect result of incidents at other research and development laboratories (public and private) and companies in Richmond. For example, given the fire that occurred at the Richmond Chevron Refinery complex in August, 2012, the EIR should pay particular attention to the impacts of fires and subsequent releases of biological, chemical and other materials. Moreover, the EIR should study the pathways and potential consequences for insiders to intentionally remove dangerous materials from the facilities.

The EIR must consider the Institutional Biosafety Committee

The Project operations will require the establishment of an institutional committee created under the National Institute of Health Guidelines to review research involving recombinant DNA and other biohazardous research. The Institutional Biosafety Committee (IBC) is one body that ensures that the operation of the Project does not result in dangerous environmental impacts and are therefore should be considered in the environmental review of the Project. The EIR should specify that the IBC meetings will be open to the public to the greatest extent possible and that meeting times and minutes be available on a publically available designated webpage. We request that the IBC's public member be appointed with input from the City Council and local residents (at a City Council meeting) to ensure transparency and accountability.

The EIR must adequately study the traffic impact

The approximately 133-acre RBC site is located at 1301 South 46th Street in the South Shoreline area of the City of Richmond, approximately 5 miles northwest of the UC Berkeley campus. Development of Phase I would add approximately 1,000 to the average daily population (adp) of the site, increasing the adp from 300 to 1,300. The University expects the campus population to increase incrementally over time as the RBC is developed over the approximately 40-year horizon of the 2013 LRDP, from approximately 300 persons in 2012 to approximately 10,000 persons in 2050. The Initial Study projects that 6,000 vehicle parking spaces will be needed in the long term. This number of added vehicles on the 580 and 80 corridors would cripple these already clogged major arteries key to the economic viability of the region. The draft EIR must propose additional transit options including a system of low emission high occupancy buses that would transport persons from major metropolitan areas. Both Google and Genentech have similar systems of buses in the Bay Area. Their systems should be studied as models for this project. Bus networks should be studied as a way to facilitate reduction of traffic on major highways and to reduce pollution.

The EIR should discuss fiscal impact

Finally, the RBC needs to analyze the fiscal impacts of construction, operation and maintenance (including insurance) of the RBC complex on residents of Richmond, Alameda County, and the State of California. What are the financial costs of the project? What funding mechanisms will be used (taxation, bonds issued by the State, bonds issued by the University of California, and so on)?

The Project should be governed by the Precautionary Principle

On May 17, 2011, the City Council of the City of Richmond passed Resolution No. 38-11, declaring that the City of Richmond adopted the precautionary principle as a policy to which it will adhere. This Resolution requires the City to undertake careful analysis of available alternatives and strongly encourages the selection of the alternative product or action, including no action, that presents the least threat to human health, the natural environment and overall quality of life; and requires democratic transparent and public engagement in the decision making process. We request that the EIR consider and describe how the Project will adhere to the precautionary principle to inform decisions during construction and operation.

Thank you.

On behalf of Richmond Residents for Responsible Development

/s/ 2/4/2012

Loulena Miles Date

/s/ 2/4/2012

Trudy Chastain Date

/s/ 2/4/2012

Chuck Chastain Date

/s/ 2/4/2012

John Chastain Date

[1] http://www.planning.org/planning/2012/jan/waterwarriorsside2.htm

http://www.eenews.net/public/climatewire/2012/12/20/1

http://www.eenews.net/public/climatewire/2012/09/10/1

http://www.sfgate.com/bayarea/place/article/Rising-seas-shift-bay-agency-s-mission-4227915.php

http://dels.nas.edu/resources/static-assets/materials-based-on-reports/reports-in-brief/sea-level-rise-brief-final.pdf

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University of California
Lawrence Berkeley National Laboratory
FEB 04 2013
Facilities Capital Projects

REPLY TO: 802 Balra Drive
El Cerrito, CA 94530

January 30, 2013

Jeff Philliber
Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

Re: Richmond Bay Campus 2013 Long Range Development Plan & Phase 1 Development
Richmond Bay Campus, NOP

Dear Mr. Philliber:

The Sierra Club makes the following comments regarding the NOP for the Richmond Bay Campus EIR.

General Concerns in Regard to Three Spheres of Potential Impact

The EIR needs to address these three "spheres" of potential general negative and positive impacts: A. the proposed site itself; B. its surrounding community; and, C. the entire East Bay region.

A. The Specific Site and its Immediate Borders

We expect that LBNL will play a positive conservation role in both avoiding degradation of existing natural resources and improving and expanding them.

To these ends, LBNL's Development plan needs to analyze alternatives that:

A1. Do not require unacceptable or unmitigated degradation

of existing site habitat and natural resources.

A2. Minimize negative impacts upon abutting natural areas and wildlife habitats from both buildings and potential increased human access.

A3. Integrate newly-built natural or park-like areas into the overall site design, with special attention to fragile wetlands.

A4. Include a credible plan to eliminate any remaining toxic hazards.

A5. Feature buildings that do not dominate or overwhelm their immediate surroundings in such respects as: height, massing/FAR, facing materials, night illumination, view corridors, noise, etc.

A6. Conform to emerging "bird safe" design standards.

A7. Conform to local zoning and approved local land-use policies to the maximum degree feasible.

A8. Accommodate the potential impact of future sea-level rise.

B. The Surrounding Community

The second campus cannot be an isolated island but rather must be part of an urban community and an existing community. That community can benefit both as the recipient of new LBNL amenities and as the provider of nearby housing and services to LBNL employees—a potential mutual win.

To these ends, LBNL's Development plan should analyze those alternatives that:

B1. Implement, with the active help of the host city or cities, SB375's preferred "complete communities" approach to fostering livable and walkable neighborhoods nearby.

B2. Analyze and plan so as to minimize local housing and commuting impacts resulting from the expected concentration of employment.

B3. Provide access to and help create a range of nearby retail and service businesses emphasizing "daily needs" of both workers and residents.

B4. Provide access to an existing or committed network of safe bicycle and pedestrian routes linking the site and the community.

B5. Increase local-community access to natural/park areas and to recreational opportunities.

B6. Provide shuttle or other shared-transportation to nearby transit hubs and retail zones.

C. The Regional Environment

While we could elaborate upon multiple potential regional environmental impacts from a second LBNL campus, one is so predominant that we will mention it alone: The impact on greenhouse gases, transit and traffic from concentrating more than 1000 employees in a single location. SB375 and all the local Climate Action Plans agree that minimizing work-related vehicle miles traveled (VMT) is the single most important means of meeting our GHG-reduction goals.

To these ends, LBNL's Development plan should analyze those alternatives that:

C1. Have carefully analyzed the host city's Climate Action Plan and respect it in their design.

C2. Minimize total VMT generated by inter-campus travel, especially by private automobile.

C3. Minimize total VMT generated by worker commuting in private vehicles, especially via solo driving along freeway corridors.

C4. Provide significant access to both regional and local transit as well as contribute to general improvements in local and regional transit infrastructure to offset any increase in VMT due to the second campus.

C5. Recommend affirmative ideas and effective programs to generate dense worker housing near new LBNL jobs, and ensure that the host city or cities have an adequately supportive certified Housing Element in their general plans.

C6. Have the potential to support meaningful LBNL "traffic demand management" programs such as car share and vanpooling.

C7. Reduce the predominance of free employee parking by under-sizing parking facilities compared to traditional office-park standards.

C8. Avoid the collateral construction of "attractor" shopping malls or similar developments that encourage more regional VMT.

Increasing the Bottom-up Engagement

Most of the potential host cities have a long history of citizen engagement in local planning and development issues, and most have received ballot approval for existing environmental policies and land-use plans. We hope that these vigorous local commitments will prove to be one of the starting-points for your deliberations, and not just receive a "communications opportunity" at the end of the road. Front-loading meaningful citizen participation will make the rest of the process go much more smoothly.

Transparency

An inclusive and transparent process for a large development like the LBNL second campus can build public understanding and support for a project and maintain that support for the long-term. Therefore, LBNL needs to make sure its process is fully transparent.

The Richmond Field Station Site:

For 20 years the Sierra club has been involved with issues related to the south Richmond shoreline area and worked to protect habitat and open space. The Richmond Field Station includes a large area of coastal prairie that is one of the last remaining expanses of such prairie in the Bay Area.

This prairie habitat must be protected. Therefore, LBNL, the University, and any private developer need to agree to relocate buildings and landscaping to ensure that this coastal prairie is protected and preserved to a standard acceptable to CESP, the Sierra Club, and the California Native Plant Society (CNPS). Those organizations must be third party beneficiaries to any development agreement and thus retain the right to enforce any agreement as to the preservation, restoration, enhancement, and protection of the coastal prairie. Working with the environmental community can ensure the preservation of the coastal prairie habitat as an important asset for the site, one which would be extremely beneficial to LBNL.

Agreement to Comply with Local Zoning and Measures Governing Land Use

The following elements need to be in a development agreement with the host city:

1. LBNL/UC will agree to comply with the Climate Action Plans that all of the potential host cities have separately been implementing; and incorporating

the goals and policies of California programs intended to reduce greenhouse gas contributions and encourage "complete communities," as part of SB375 and AB32.

2. LBNL/UC will agree to pay the equivalent of all property and parcel taxes on any private parcels that it should take ownership of or purchase the stock or controlling interest in any company that owns those parcels at the same values and rates as a private landowner.

3. LBNL/UC will agree to be bound by any local ordinances that require votes of the people for any changes to zoning or other reasons as if they were a private property owner.

4. LBNL/UC will agree to comply with all local zoning ordinances as if it were a private property owner for any future development of the site should it desire to initiate any changes to the zoning for the site that is selected.

Sea Level Rise

The NOP does not appear to adequately address the issues of sea level rise. While the NOP discusses adding 10 feet of soil to 12 acres, it does not address the longer range impacts of sea level rise as they relate to the Long Range Development Plan. Nor does it appear that the NOP will address the impacts that adding 10 feet of soil to 12 acres will have in regard to visual impacts, storm water run-off, impacts on the coastal prairie, traffic, to name a few.

Most particularly, the NOP does not address the impact of sea level rise on the potential release and spread of contaminants that are known to exist at the Richmond Field Station site.

Toxic Contamination

The NOP does not address the issue of the impact of sea level rise on the areas of known to contain hazardous and toxic materials. Inundation of contaminated lands will mean that water will cover areas that contain toxics. The EIR must address the ability of caps and seals to withstand complete and continued inundation due to sea level rise, the amount, if any, of any seepage or discharge of the toxics from the site due to sea level rise, and the impacts of such seepage on the Bay and the flora and fauna of the Bay.

Creek Restoration

UC/LBL should analyze the creation of a meandering creek which is now in the concrete channel and how it can provide for setbacks from creeks of at least 200 feet on each bank of a creek to protect the creek habitat and flora and fauna from any impacts from development.

Protection of Flora and Fauna

The EIR should provide for a transition zone between the protected zone and development in order to ensure full protection of habitat.

Compliance with the City, County, and Regional Land Use Laws and Regulations

Sierra Club maintains that UC and LBNL must comply with all local and regional land use laws and regulations. If UC/LBNL maintains that it does not have to comply, then it must include an analysis of the preferred project assuming it did comply in order for the decision maker and public to understand the significant adverse environmental impacts that result from such non-compliance and the mitigation measures that will be necessary to avoid those adverse impacts.

Limits to the EIR

The EIR should also make it explicit that it is only analyzing the initial phase of the Long Range Development Plana and that full Project EIRs need to be and will be prepared for later phases of development.

Alternatives

The proposed alternatives are not adequate for analyzing the impacts from the project and whether they can or cannot be mitigated. The reduced growth alternative is not adequately described and more than one reduced growth alternative should be included in the EIR. Similarly, the alternate Development program is not adequately described. Moreover, purpose of the off-site alternative is unclear. This alternative is not realistic because it will not be carried out and the proposed site is too distant from the Richmond Field to be useful and meaningful as an alternative. Indeed, the fact that UC and LBNL did not select the Alameda site makes it an infeasible alternative.

Meaningful alternatives would address issues of coastal prairie preservation and maximizing protection of the existing open space and also analyze the impacts of major

population increase to Richmond and the surrounding communities that will have to deal with the impacts of any development of the size and scale that is proposed for the Richmond Field Station site.

Joint EIS

The proposed second campus is a joint project of both a State and Federal agency. Therefore, the UC/LBNL must analyze the project and alternatives in a Joint EIS/EIR process and comply with NEPA.

Sincerely yours,

Norman La Force

Norman La Force, Chair
West County Group and
Chair Chapter Legal Committee

SPRAWLDEF

Sustainability, Parks, Recycling And Wildlife Legal Defense Fund

802 Balra Drive, El Cerrito, CA 94530
510 526-4362 www. sprawldef.org n.laforc@comcast.net

University of California
Lawrence Berkeley National Laboratory
FEB 04 2013
Facilities Capital Projects

January 30, 2013

Jeff Philliber

Environmental Planner

Lawrence Berkeley National Laboratory

One Cyclotron Road, MS 76-225

Berkeley, CA 94720

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Phase 1 Development

Richmond Bay Campus, NOP

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SPRAWLDEF has been involved with issues related to the Richmond shoreline area and

worked to protect habitat and open space. It successfully sued the City of Richmond, the proposed developer of the Indian Casino and the tribe over that project. The Richmond Field Station includes a large area of coastal prairie that is one of the last remaining expanses of such prairie in the Bay Area.

This prairie habitat must be protected. Therefore, LBNL, the University, and any private developer need to agree to relocate buildings and landscaping to ensure that this coastal prairie is protected and preserved to a standard acceptable to CESP, the Sierra Club, and the California Native Plant Society (CNPS). Those organizations must be third party beneficiaries to any development agreement and thus retain the right to enforce any agreement as to the preservation, restoration, enhancement, and protection of the coastal prairie. Working with the environmental community can ensure the preservation of the coastal prairie habitat as an important asset for the site, one which would be extremely beneficial to LBNL.

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Diking

The UC/LBL must also analyze whether the sea level rise will require later construction of levees or dikes to protect that development from sea level rise inundation. Again, the UC must use the most conservative numbers for sea level rise, i.e., the highest level that is reasonably projected and not some rosy figure that currently floats around. The reasonably projected highest number the Sierra Club has seen is around 2 meters or over 6 feet over the course of the next 100 years. The EIR for the Long Range Development Plan must take this potential rise into account.

The EIR also needs to address the potential impacts on Field Station workers of the continuing toxic contamination on the Zeneca site and how UC and LBNL propose to protect their workers from the toxic impacts from that site.

Impacts on Wetlands

The EIR must also analyze the impact of any development on the adjacent wetlands. Development close to wetlands can have a devastating impact on wetland wildlife due to human intrusion, domestic pet intrusion, and the intrusion from vermin creatures such as rats that are attracted to any human development. The entire area of the shoreline of Richmond must be analyzed for these impacts from any proposed development.

UC/LBL should provide setbacks from the shoreline of at least 500 feet from the mean high tide mark for any development in order to ensure the full protection of wetland flora and fauna from any development impacts.

Impacts on Birds

Impacts to birds and other wildlife from lighting must be analyzed. We know that night time lighting from human development near wetlands and other protected habitat can have a secondary impact on wildlife by enabling nocturnal predators to better hunt and capture prey. These impacts must be analyzed.

UC/LBL must analyze the impact to birds smashing into buildings. This impact has long been ignored, but more and more we are now realizing that many birds are unable to distinguish the glass of a building from the environment around them and fly into buildings and die. These impacts must also be analyzed

Creek Restoration

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Limits to the EIR

The EIR should also make it explicit that it is only analyzing the initial phase of the Long Range Development Plana and that further Project EIRs need to be prepared for later phases of development. Statements to the effect that Supplemental EIRs or Tiered EIRs or other environmental reviews less than full project EIRs are insufficient.

Alternatives

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the alternate Development program is not adequately described. Moreover, purpose of the off-site alternative is unclear. This alternative is not realistic because it will not be carried out and the proposed site is too distant from the Richmond Field to be useful and meaningful as an alternative. Indeed, the fact that UC and LBNL did not select the Alameda site makes it an infeasible alternative.

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Sincerely yours,

Norman La Force

Norman La Force,

President & General Counsel

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Facilities Capital Projects

February 1, 2013

Jeff Philliber
Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720
LRDP-EIR@lbl.gov

Dear Mr. Philliber,

We are writing to raise concerns about the proposed Richmond Bay Campus, which includes a second campus of the Lawrence Berkeley National Laboratory (LBNL) and the UC Berkeley Synthetic Biology Institute (SBI), which will conduct experimentation, research and development in the field of synthetic biology in Richmond, California.

Conspicuously absent from the proposed research lab's environmental impact report is a discussion of the synthetic biology research that will be conducted at the lab or a consideration of the unique risks that this research poses to public health, the environment, worker safety, biological resources, recreation and a host of other societal dimensions.

Synthetic biology is an extreme form of genetic engineering that is attempting to create novel, potentially self-replicating artificial life forms from synthesized DNA. The substantial risks this research poses to worker safety, public health and the environment have not been adequately addressed by federal or state regulators or appropriately studied by experts in the field of risk assessment. Proceeding with the development of these research facilities without a substantial review of the risks posed to workers and the surrounding community is irresponsible.

While some find promise in synthetic biology for manufacturing new products and helping us to better understand biological processes, this research could also result in enhanced virulence in existing hosts, heightened ability to infect a wider range of hosts, and resistance to antimicrobials, antivirals, vaccines and other treatment or containment modalities.

Laboratory accidents are relatively common in the United States and an unknown, but likely substantial, number of these accidents go unreported, as sickened or injured workers may fear reprisals for reporting problems. One example of this is the case of Becky McClain, who claimed she was fired for raising safety concerns to her employer Pfizer. McClain won $1.37 million in damages from Pfizer in a 2010 whistle-blower case.

McLain, who says she was sickened by the biotechnology materials in her lab, noted widespread safety problems. These and other accounts have prompted OSHA to promise to expand biotechnology worker protections, but such regulations have been slow to come into effect or inadequate.

Clearly regulations have not kept pace with the risks of modern biotechnology experimentation. Because synthetic biology's objective lies in engineering novel life forms and products with the potential to interact with human biology and other cellular processes, we believe this research poses dangers (both from accidental and deliberate uses) unforeseen in the regulatory framework of standard rDNA research.

Safety regulations and procedures must be created and tailored to address the novel aspects of this new science, including whistleblower protections and forums for workers to raise concerns. Additionally, the costs to any municipality of an appropriate public safety infrastructure must be identified. Until these steps are complete, expanding the use of synthetic biology in any setting is irresponsible.

Before any decisions are made on a specific site for this new lab, we believe a comprehensive, independent and transparent safety and risk analysis capable of assessing these threats must be completed. This should include an assessment of whether existing occupational safety guidelines are sufficient for research on synthetic biology and also an assessment of the appropriateness of conducting this kind of research next to an urban center, where the impact of an accident on public health and human lives can be greatly magnified. The proposed lab is located in the San Francisco metro area, one of the country's most populous urban centers, home to more than seven million people.

These assessments should include ample public participation, including stakeholder outreach, extensive consultation with nearby communities, and continuous opportunities for public comment. There should also be significant measures of independent regulatory oversight, particularly because both public and private entities will be operating at the lab. Every stage of this process must be open to and involve the public, including town hall meetings to discuss and address health and safety issues.

The Lawrence Berkeley National Laboratory and the UC Berkeley Synthetic Biology Institute must meet the burden of proof as to whether their laboratory will be safe before any community can make an informed decision about inviting it to break ground in their backyard.

Sincerely,

Wenonah Hauter
Executive Director

DEPARTMENT OF TRANSPORTATION
111 GRAND AVENUE
OAKLAND, CA 94612
PHONE (510) 286-6053
FAX (510) 286-5559
TTY 771

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February 1, 2013

CCVAR015

SCH#2013012007

Mr. Jeff Philliber
University of California
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

Dear Mr. Philliber:

Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development – Notice of Preparation (NOP)

Thank you for including the California Department of Transportation (Caltrans) in the environmental document (ED) review process for the project referenced above. We have reviewed the NOP and have the following comments to offer.

Traffic Impact Study (TIS)
One of Caltrans' ongoing responsibilities is to collaborate with local agencies to avoid, eliminate, or reduce to insignificance potential adverse impacts by local development on State highways. We recommend using the Caltrans *Guide for the Preparation of Traffic Impact Studies* (TIS Guide) for determining which scenarios and methodologies to use in the analysis. The TIS Guide is a starting point for collaboration between the lead agency and Caltrans in determining when a TIS is needed. The appropriate level of study is determined by the particulars of a project, the prevailing highway conditions, and the forecasted traffic. The TIS Guide is available at the following website address: http://dot.ca.gov/hq/tpp/offices/ocp/igr_ceqa_files/tisguide.pdf.

The TIS should include:

1. Vicinity map, regional location map, and a site plan clearly showing project access in relation to nearby State roadways. Ingress and egress for all project components should be clearly identified. The State right-of-way (ROW) should be clearly identified. The maps should also include project driveways, local roads and intersections, parking, and transit facilities.

2. Project-related trip generation, distribution, and assignment. The assumptions and methodologies used to develop this information should be detailed in the study, and should be supported with appropriate documentation.

3. Average Daily Traffic, AM and PM peak hour volumes and levels of service (LOS) on all roadways where potentially significant impacts may occur, including crossroads and controlled intersections for existing, existing plus project, 2035 cumulative, 2035 cumulative plus project, **and, particularly, 2050 (complete development) scenarios for the 2013 Long Range Development Plan**.

   Calculation of cumulative traffic volumes should consider all traffic-generating developments, both existing and future, that would affect study area roadways and intersections. The analysis should include turning traffic diagrams under project only, 2035 cumulative conditions, and 2035 cumulative plus project conditions. Furthermore, the analysis should clearly identify the project's contribution to area traffic and any degradation to existing and cumulative LOS including. Caltrans' LOS threshold, which is the transition between LOS C and D, and is explained in detail in the TIS Guide, should be applied to all State facilities.

4. Schematic illustration of traffic conditions including the project site and study area roadways, trip distribution percentages and volumes as well as intersection geometrics (i.e., lane configurations) for the scenarios described above.

5. The project site building potential as identified in the General Plan. The project's consistency with both the Circulation Element of the General Plan and the Congestion Management Agency's Congestion Management Plan should be evaluated.

6. Identification of mitigation for any roadway mainline section or intersection with insufficient capacity to maintain an acceptable LOS with the addition of project-related and/or cumulative traffic. As noted above, the project's fair share contribution, financing, scheduling, implementation responsibilities and lead agency monitoring should also be fully discussed for all proposed mitigation measures.

Caltrans is particularly concerned about traffic impacts to: (1) Interstate (I-)580; (2) the I-580/Meade/Regatta Interchange and its intersections; and (2) the I-580/Marina Bay Parkway Interchange and its intersections.

Traffic Impact Fees

Interstate 580, I-80 and State Route 123 are critical to regional and interregional traffic in the San Francisco Bay region. Interstate 580, in particular, is vital to commuting, freight, and recreational traffic and is of the most congested regional freeway facilities. The traffic generated by this proposed project, together with other projects in the vicinity, will have a significant cumulative regional impact to the already congested State Highway System. Therefore, Caltrans invites the University of California (UC) to work with the West Contra Costa Transportation Advisory Committee on the sub-regional transportation mitigation fee program to mitigate and plan for the impact of future growth on the regional transportation system.

Please identify traffic impact fees to be used for project mitigation. Development plans should require traffic impact fees based on projected traffic and/or based on associated cost estimates for

public transportation facilities necessitated by development. Scheduling and costs associated with planned improvements on the State ROW should be listed, in addition to identifying viable funding sources correlated to the pace of improvements for roadway improvements, if any.

Lead Agency
As the lead agency, UC is responsible for all project mitigation, including any needed improvements to State highways. The project's fair share contribution, financing, scheduling, implementation responsibilities and lead agency monitoring should be fully discussed for all proposed mitigation measures.

This information should also be presented in the Mitigation Monitoring and Reporting Plan of the ED. Required roadway improvements should be completed prior to issuance of the Certificate of Occupancy. Since an encroachment permit is required for work in the State ROW, and Caltrans will not issue a permit until our concerns are adequately addressed, we strongly recommend that UC work with Caltrans to ensure that our concerns are resolved during the environmental process, and in any case prior to submittal of an encroachment permit application. Further comments will be provided during the encroachment permit process; see the end of this letter for more information regarding encroachment permits.

Transportation Management Plan (TMP)
If it is determined that traffic restrictions and detours are needed on or affecting State highways, a TMP or construction TIS may be required of the developer for approval by Caltrans prior to construction. Traffic Management Plans must be prepared in accordance with Caltrans' *Manual on Uniform Traffic Control Devices.* Further information is available for download at the following web address: http://www.dot.ca.gov/hq/traffops/signtech/mutcdsupp/pdf/camutcd2012/Part6.pdf.

Please ensure that such plans are also prepared in accordance with the transportation management plan requirements of the corresponding jurisdictions. For further TMP assistance, please contact the Office of Traffic Management Plans at (510) 286-4647.

Vehicle Trip Reduction
Caltrans encourages you to locate any needed housing, jobs and neighborhood services near major mass transit centers, with connecting streets configured to facilitate walking and biking, as a means of promoting mass transit use and reducing regional vehicle miles traveled and traffic impacts on the State highways. Caltrans requests that all transit options be reviewed and considered, not just the proposed traffic shuttle connection to El Cerrito Plaza, but also to other BART stations in the vicinity (i.e., Richmond BART and El Cerrito Del Norte BART stations). The proposed shuttle to El Cerrito Plaza is not go the nearest BART station, nor is it the one with the most AC Transit and other regional connections.

We also encourage you to develop Travel Demand Management (TDM) policies to promote usage of nearby public transit lines and reduce vehicle trips on the State Highway System. These policies could include lower parking ratios, car-sharing programs, bicycle parking and showers for employees, and providing transit passes to residents and employees, among others. For information about parking ratios, see the Metropolitan Transportation Commission (MTC) report *Reforming*

Parking Policies to Support Smart Growth or visit the MTC parking webpage: http://www.mtc.ca.gov/planning/smart_growth/parking.

In addition, secondary impacts on pedestrians and bicyclists resulting from any traffic impact mitigation measures should be analyzed. The analysis should describe any pedestrian and bicycle mitigation measures and safety countermeasures that would in turn be needed as a means of maintaining and improving access to transit facilities and reducing vehicle trips and traffic impacts on State highways.

Cultural Resources

Caltrans requires that a project ED include documentation of a current archaeological record search from the Northwest Information Center of the California Historical Resources Information System if construction activities are proposed within State ROW. Current record searches must be no more than five years old. Caltrans requires the records search, and if warranted, a cultural resource study by a qualified, professional archaeologist, and evidence of Native American consultation to ensure compliance with California Environmental Quality Act (CEQA), Section 5024.5 and 5097 of the California Public Resources Code, and Volume 2 of Caltrans' Standard Environmental Reference (http://www.dot.ca.gov/ser/vol2/vol2.htm).

These requirements, including applicable mitigation, must be fulfilled before an encroachment permit can be issued for project-related work in State ROW; these requirements also apply to National Environmental Policy Act (NEPA) documents when there is a federal action on a project. Work subject to these requirements includes, but is not limited to: lane widening, channelization, auxiliary lanes, and/or modification of existing features such as slopes, drainage features, curbs, sidewalks and driveways within or adjacent to State ROW.

Hazardous Materials

All motor carriers and drivers involved in transportation of hazardous materials must comply with the requirements contained in federal and State regulations, and must apply for and obtain a hazardous materials transportation license from the California Highway Patrol (CHP). When transporting certain types of hazardous materials including inhalation hazards, safe routing and safe stopping places are required. A route map must be carried in the vehicle. More information is available on the CHP website: http://www.chp.ca.gov/publications/#hazmat.

Habitat Restoration and Management

Project level activities related to habitat restoration and management should be done in coordination with local and regional Habitat Conservation Plans and with Caltrans, where our programs share stewardship responsibilities for habitats, species and migration routes.

Sea Level Rise

The effects of sea level rise may have impacts on transportation facilities located in the project area. Executive Order (EO) S-13-08 directs State agencies planning construction projects in areas vulnerable to sea level rise to begin planning for potential impacts by considering a range of sea level rise scenarios for the years 2050 and 2100. According to the Association of Bay Area Governments (ABAG), portions of the Richmond Bay Campus may be vulnerable to sea level rise.

Please discuss in the upcoming Draft Environmental Impact Report how the project would address this potential hazard.

Higher water levels may increase erosion rates, change environmental characteristics that affect material durability, lead to increased groundwater levels and change sediment movement along shores and at estuaries and river mouths, as well as affect soil pore pressure at dikes and levees on which transportation facilities are constructed. All these factors must be addressed through geotechnical and hydrological studies conducted in coordination with Caltrans, if State ROW might be affected.

Bridges, Trestles, Culverts and Other Structures in Riparian or Tidal Environments
Some project level activities, including but not limited to earthworks, may affect riparian or tidal flow patterns upstream of bridges, trestles, culverts or other structures for which Caltrans holds responsibility. Please ensure your project level EDs include hydrological studies to determine whether such impacts will occur, and to identify appropriate mitigation measures.

Berm, Dike and Levee Maintenance, Repair, Upgrade and Removal
Activities involving demolition, reinforcement or rehabilitation of berms, dikes or levees on which transportation facilities are built or which are adjacent or near to such facilities may potentially affect those State facilities. Also, built features on top of berms, dikes and levees may contribute additional engineering considerations related to weight loading or compaction. These factors must be addressed through geotechnical and hydrological studies conducted in coordination with Caltrans at the project level.

Mitigation Reporting Guidelines
The California Environmental Quality Act requires the adoption of reporting or monitoring programs when public agencies include environmental impact mitigation as a condition of project approval. Reporting or monitoring takes place after project approval to ensure implementation of the project in accordance with mitigation adopted during the CEQA review process.

Some of the information requirements detailed in the attached Guidelines for Submitting Transportation Information from a Reporting Program include the following:

- Name, address, and telephone number of the CEQA lead agency contact responsible for mitigation reporting;

- Type of mitigation, specific location, and implementation schedule for each transportation impact mitigation measure; and

- Certification section to be signed and dated by the lead agency certifying that the mitigation measures agreed upon and identified in the checklist have been implemented, and all other reporting requirements have been adhered to, in accordance with Public Resources Code Sections 21081.6 and 21081.7.

Further information is available on the following website:
http://www.dot.ca.gov/hq/tpp/offices/ocp/igr_ceqa.html.

Transportation Permit
Project work that requires movement of oversized or excessive load vehicles on State roadways requires a transportation permit that is issued by Caltrans. To apply, a completed transportation permit application with the determined specific route(s) for the shipper to follow from origin to destination must be submitted to: Caltrans Transportation Permits Office, 1823 14th Street, Sacramento, CA 95811-7119. See the following website for more information:
http://www.dot.ca.gov/hq/traffops/permits.

Encroachment Permit
Please be advised that any work or traffic control that encroaches onto the State ROW requires an encroachment permit that is issued by Caltrans. To apply, a completed encroachment permit application, environmental documentation, and five (5) sets of plans clearly indicating State ROW must be submitted to the address below. David Salladay, District Office Chief, Office of Permits, California Department of Transportation, District 4, P.O. Box 23660, Oakland, CA 94623-0660. Traffic-related mitigation measures should be incorporated into the construction plans prior to the encroachment permit process. See the website linked below for more information:
http://www.dot.ca.gov/hq/traffops/developserv/permits.

Should you have any questions regarding this letter, please call Brian Brandert of my staff at (510) 286-5505.

Sincerely,

ERIK ALM, AICP
District Branch Chief
Local Development - Intergovernmental Review

c: Scott Morgan (State Clearinghouse)

Bicycle Trails Council of the East Bay

PO Box 9583, Berkeley, California 94709-0583
510-466-5123
www.BTCEB.org

University of California
Lawrence Berkeley National Laboratory
FEB 01 2013
Facilities Capital Projects

January 31, 2013

Jeff Philliber
Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road MS 76-225
Berkeley CA 94720

To Whom It May Concern:

The Bicycle Trails Council of the East Bay is interested in the development effect of the Richmond Bay Campus. Our membership considers placement of the campus in old Seaport a thoughtful reclamation of an abused ecological jewel renewing access in concert with other ongoing civic efforts.

Part of our support is a recognition of the potential campus's bicycle communication with the Bay Trail. The positive health effects for people and the environment are well known, as are the special economies of parking accommodation and automobile operation. What is seldom appreciated is the ad hoc nature of extant infrastructure to support bicycles, including the support of bicycling at the terminus, in this case your campus. These aspects deserve an attention designed to support the specific needs for cyclists.

While reclaimed rail and industrial lands beside the Bay have provided a safe, beautiful communication for bicycles from Emeryville to Richmond, access to the Bay Trail is problematic. Excepting Berkeley's I-80 Bicycle/Pedestrian Bridge, access to the Trail for bicycles is an blithe relegation to rebate margins of hazardous auto routes serving I-80. South, accesses via Powell, Gilman, Buchannan, and Central, are mazes confounded by multiple on/off ramps and frontage roads. North, surfaces are challenged by industrial use. Nearby, access from the Bayview direction has incumbent cultural stresses. Each of these accesses need to appreciated for mitigation though signage, lighting, and traffic flow.

Consideration must be given to surface conditions, weather extremes, limited hours of daylight, fatigue, consequent perspiration, chill/overheating, and damp clothing, all deserve support at the terminus. Areas for showering facilities, clothes changing and the privacy associated with such behaviors, secure bike parking and cleaning, out of weather pre-/post-ride staging, storage of associated gear/clothing, deserve our best attention as they directly effect the probabilities of cycling performance. Attention to such factors will promote frequent, secure travel in a decent, humane fashion. It will foster an inviting experience delivering a variety of energized people safely to the campus, assuring their safe return home.

We welcome your participation in the cycling community and your support for these factors.

Michael Mejia

Michael Mejia , President, Bicycle Trails Council of the East Bay

EDWARD C. MOORE
ATTORNEY AT LAW[1]

2436 Ninth Street
Berkeley, California 94710

Tele: (510) 531-7272
E-mail: ecmoorelaw@gmail.co

February 1, 2013

University of California
Lawrence Berkeley National Laboratory
FEB 01 2013
Facilities Capital Projects

Jeff Philliber
Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road MS 76-225
Berkeley, California 94720

RE: Scope of CEQA/NEPA Environmental Review Pertaining to 2d LBNL Campus

Dear Mr. Philliber:

I am writing on behalf of myself as a member of the public to insist that if any aspect of the proposed second campus for Lawrence Berkeley National Laboratory (2d campus LBNL) is proposed to be sited on any part of Golden Gate Fields in Albany and/or Berkeley as an "off-site alternative" to the preferred Richmond site (see Notice of Preparation, par. 6.0, pp. 16-17), that a Section 106 inquiry within the meaning of the federal Historic Preservation Law, 16 U.S.C. § 470f be undertaken as the investigatory protocol specifies (e.g., see 36 CFR 800 et seq.) In short I contend the Waterfront in Berkeley and Albany as a unified whole is "eligible for inclusion in the National Register" because it satisfies on several independent grounds for National Criteria for listing (see 36 CFR 800.16).

Because I am a long-time public proponent of the waterfront in Berkeley and Albany as a Cultural Landscape *currently eligible* under federal criteria for listing on the National Register of Historic Places, I ask to be put on a your list of people to notify of significant events pertaining to the environmental-impact analysis and reporting regarding the proposed 2d campus for LBNL. I was assured this would be done many months ago by LBNL personnel and they dropped the ball. I only learned of your Notice of Preparation and its deadline for input through lately discovered other sources.

Thank you for your anticipated attention to my requests.

Very truly yours,

EDWARD C. MOORE

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[1]Voluntarily inactive as of March 1, 2010

DEPT. OF PLANNING AND BUILDING SERVICES

City of Richmond

University of California
Lawrence Berkeley National Laboratory

FEB 05 2013

Facilities Capital Projects

February 5, 2013

Jeff Philliber
Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

VIA MAIL and EMAIL

RE: COMMENTS ON THE NOP FOR THE RICHMOND BAY CAMPUS 2013 LRDP AND PHASE 1 DEVELOPMENT

Dear Mr. Philliber:

The City of Richmond ("City") is undertaking a community planning effort to develop a Specific Plan around the proposed Richmond Bay Campus. We look forward to the University of California Berkeley's and Lawrence Berkeley National Laboratory's continued participation in this effort. Moreover, we believe that many of the comments contained in this letter will be addressed through the development of the Specific Plan to enable the Richmond Bay Campus and surrounding development to occur in a mutually beneficial and coordinated manner. A key opportunity afforded to the City during the development of the Specific Plan is to explore the feasibility of infrastructure financing districts for the Southern Gateway Area. This approach could expedite the transformation of the Richmond Bay Campus and surrounding areas.

The City appreciates the opportunity to comment on the Notice of Preparation of a Draft Environmental Impact Report (EIR) for the Richmond Bay Campus 2013 Long Range Development Plan and Phase 1 Development proposed in Richmond, CA.

The City has the following comments:

1. The EIR should identify all proposed improvements located within the City's right of way including roadways, lighting, landscaping, etc., and confirm that proposed campus infrastructure improvements can be designed to meet or exceed City standards.
2. The EIR should confirm that the project's transportation system will complement the City's Bicycle Master Plan, Pedestrian Plan and other applicable City standards.
3. On-going project construction including site demolition, remediation, and grading, will increase truck traffic on streets maintained by the City of Richmond. The EIR should evaluate the total impact of long-term construction on City streets and identify possible mitigations.
4. The proposed project could increase demand on the City's sanitary sewage collection and treatment systems. The EIR should analyze both dry weather flows and peak wet weather flows and confirm that the City's collection and treatment system has sufficient capacity to

meet future demand. The EIR should evaluate the effects on City infrastructure due to the expansion of demand for public utilities such as water, natural gas, and telecommunications.

5. The City's municipal fiber network is currently located along Regatta Boulevard and Meade Street. The EIR should evaluate potential impact of the project and its construction on the network's operation.
6. If the project plans to discharge storm water runoff into the City drainage system, the EIR should determine whether the site will need to comply with State Water Resources Control Board requirements.
7. The EIR should evaluate the need for additional City fire apparatus or services required to support the Richmond Bay Campus development.
8. The Richmond Bay Campus site is the home of the University of California, Berkeley Richmond Field Station, and the grounds fall within the police service jurisdiction of the University of California Police Department. The Richmond Police Department stands ready to honor mutual aid agreements already in place between the agencies and anticipates expansion of those agreements as the campus evolves. The EIR should address the need to establish new or modify existing partnerships that promote public safety as part of the Richmond Bay Campus development that could include:
   - University of California and Richmond police joint substation or work stop on the project premises
   - Establishing a police substation in close proximity to the project site
9. The EIR should identify mitigation measures for potentially significant impacts that promote sustainability and conservation of resources such as the use of alternative energy systems, water conservation and recycling, complete streets, natural ventilation and other methods that take full advantage of the local climate, transportation network, and recreation facilities.

We appreciate your consideration of the comments contained herein and we look forward to meeting with you to continue our ongoing planning efforts in the Southern Gateway Area. Please feel free to contact Senior Planner/Project Manager Lina Velasco or me at (510) 620-6706.

Sincerely,

Richard Mitchell
Director of Planning and Building Services

cc: Bill Lindsay, Richmond City Manager
Shasa Curl, Richmond Administrative Chief
Michael Banks, Richmond Fire Chief
Allwyn Brown, Richmond Deputy Police Chief
Alan Wolken, Richmond City Engineer

Scoping Meeting Transcript

In The Matter Of:

RICHMOND BAY CAMPUS DEVELOPMENT SCOPING MEETING

Error getting date

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Richmond Bay Campus Long Range Development Plan and Phase One Scoping Meeting for Environmental Impact Report

Richmond City Council Chambers

403 Civic Center Plaza, Richmond, CA

January 23, 2013

7:00 p.m.

REPORTER'S TRANSCRIPT OF PROCEEDINGS
BY: JUDY LARRABEE, SHORTHAND REPORTER

CLARK REPORTING AND VIDEOCONFERENCING

2140 SHATTUCK AVENUE, SUITE 405

BERKELEY, CALIFORNIA 94704

(510) 486-0700

PROCEEDINGS

JEFF MILLER: Good evening, everyone. Thank you for coming. My name is Jeff Miller. I am head of Public Affairs at Berkeley Lab. Tonight I'm here on behalf of the University of California to introduce the Public Scoping Meeting for the Richmond Bay Campus. Now because there are rules and protocols about meetings such as this, I'm going to have to read my remarks, which is really difficult for me because people who know me know that I like to be extemporaneous. But I'm not going to do so. I'm going to read these verbatim. So I apologize if it sounds a little rote, but that's just the way it has to be.

Tonight we are here to focus on the Environmental Review under the state CEQA process of the proposed Long Range Development Plan for the Richmond Bay Campus site and the proposed first phase of development under the LRDP. LRDP meaning Long Range Development Plan.

The purpose of tonight's meeting is to gather your comments as to the scope and content of the forthcoming Environmental Impact Report. A Notice of Preparation of the Draft Environmental Impact Report was issued on January 4th, which began the public

comment period that runs through February 4th. So tonight's public meeting is an integral part of this scoping process.

At the end of the scoping period on February 4th, we will review all the comments we receive tonight, plus any we receive through e-mail or hard copy or in any other form, and we will consider them in refining the scope of the Environmental Impact Report. We will then prepare a Draft Environmental Impact Report which will be publicly circulated for review and for which we will hold a public hearing in late spring.

Now while we do not intend to directly respond to your scoping comments, we will carefully review and consider each and every one of them in preparation of the Draft EIR.

Now, we have two types of cards available. if you would like to speak tonight, please fill out a green card and pass it to Ross who is standing up right here. If you would like to give us a written comment, you can please fill out a blue card. And if you wish to send a comment by e-mail or in writing before February 4th, the addresses are on the comment card. So for example, our e-mail address is LRDP-EIR@lbl.gov, and then mail will go to Jeff Philliber at Berkeley Lab, and his address is on this

card. Is everyone with me so far?

The next public meeting in the process will be to receive comments on the Draft EIR. We don't have a date for that yet, but that should probably occur sometime in June. Okay.

We also intend to present to the community a draft of the Long Range Development Plan when it is ready for review. We expect that to be in late March or April. We will hold a public meeting at the time and present and discuss a Draft Plan with you. That meeting would not be part of this CEQA environmental review process.

So I know I've thrown a lot of dates at you. So we do have a calendar available on the RichmondBayCampus.lbl.gov Web site. If you're confused as some are -- I certainly am -- you might want to check that calendar and that should fix the problems around the dates.

The proposed LRDP is a partnership between UC Berkeley and Lawrence Berkeley National Lab. The proposed first phase of development of the LRDP is being undertaken by the Lab and UC. It will be undertaken in order to relocate and consolidate a number of Lawrence Berkeley National Laboratory programs currently located offsite from the main LBNL

site.

Tonight you will hear from Cathy Koshland from University of California Berkeley who will describe the proposed LRDP and Horst Simon from Berkeley Lab who will describe the proposed first phase of development. You will then hear from Jeff Philliber from Berkeley Lab who will describe in more detail the CEQA process. Then we will begin the official public comment period.

Please note that we have a legal reporter present who is transcribing tonight's proceedings for an official record which we've made available to the public. We also have an interpreter here for those who might need such a service. To give as many people as possible a chance to speak, we ask that speakers hold their comments to three minutes each.

When you came in, you may have seen also these posters that are now taken down. But they provided an overview of the proposed site and also described steps in the NEPA, which is the National Environmental Policy Act process, for the first phase of the Richmond Bay Campus development.

The federal environmental review process, NEPA, for the first phase of the development at the proposed Richmond Bay Campus, is being conducted simultaneously

with the state California Environmental Policy Act, the CEQA process. Two things going on simultaneously. If you would like to comment on the federal review, you can send an e-mail to Kim Abbott at Kim.abbott@bso.science.doe.gov. You will never remember that, so I'm sure Ross and others here can help you if you would like to comment via that process.

Finally I would like to emphasize that we're here tonight to conduct the process prescribed by the California Environmental Quality Act and state law. We welcome your comments on the scope of the environmental review for these projects.

And now I would like to introduce Cathy Koshland, Vice Provost for Teaching, Learning, Academic Planning & Facilities at UC Berkeley. She will then be followed by Horst Simon, who is Deputy Director at Berkeley Lab. Thank you.

CATHY KOSHLAND: Welcome to this meeting this evening. I'm going to talk briefly about our long-range plans for the Richmond Bay Campus, especially to brief those of you who haven't been able to participate in our three public meetings that we have held over the last year.

It's a pleasure to be here again in the city of

Richmond and to know that our project has reached this important milestone.

The UC Berkeley campus has long wanted its Richmond properties to contribute more to the University's core mission, and we want to contribute and be part of a vital, healthy city of Richmond. And I appreciate your support and partnership in this process.

The Richmond Bay Campus is part of a broader network of innovation centers that are part of the University of California. In this case, you see the center of the core campus of Berkeley as well as the main campus of the Berkeley Lab. And then the Richmond Bay Campus, and we also note UCSF's Mission Bay Campus where we also have ties on for both the Berkeley Campus and LBNL. So three centers of innovation. It's particularly important that the Richmond campus is part of the Green Corridor, and we see that as a critical investment in the future of our region, building economic vitality, leadership and innovation for the East Bay.

More specifically, here is the site. It includes the Richmond Field Station. The Field Station has been owned by the University of California and managed by UC Berkeley since 1950. More recently we acquired

the Regatta property next door which currently has warehouses, part of which are occupied by third parties and part of which are occupied by several of our collections, the Hearst Museum, the Berkeley Art Museum. Many of the others have critical storage facilities in that building. And then the College of Engineering has active research on the site at the present time.

The site we're discussing is the site marked "uplands" as well as the bottom portion to the north. The outboard site is submerged, and although we own it we obviously can't develop it.

The whole site that we're talking about for development that is surrounded by the yellow portion that is designated "uplands" is 133 acres. And just to give you a sense of proportionality of that, here's an overlay of that 133 acres on top of the core Berkeley campus which is about 180 acres, and you see that they are really relatively comparable.

And then we're also not so incomparable from the LBNL site. Though it's 202 acres, much of that is on a slope and therefore one can't build on. And then you can see the relationship between the Richmond Bay Campus site and the scale of the UCSF Mission Bay Project.

There's an interesting article in the Chronicle today about the ten-year anniversary of the development of the Mission Bay site and its success over this ten-year period. And we certainly aspire to something along those lines.

We've been in conversation with LBNL about a vision for this campus. We've narrowed it down to this, a state of the art, inspirational and sustainable place for this world-class, collaborative science for healthy living and sustainable communities.

At a meeting last year, some of you heard from a panel of scientists affiliated with LBNL and UC Berkeley talking about the research and the research we hope to pursue at the Richmond Bay Campus. We want to discover 21st-century solutions to 2lst-century challenges in the areas of energy, the environment, human health, and the global economy. And already research in Richmond includes research under sustainable transportation with commercial applications. And in a moment, my colleague Horst Simon will discuss the first phase of research at the Richmond Bay Campus focused on the biosciences. But you can see the additional things that we're dreaming of at the moment.

Getting back down to earth, we've completed a number of studies for this site, and we think it can comfortably house about five million square feet of development. We expect that site to be a place for research labs, obviously offices and conference space, dining and cafés to support a population that we hope will grow to about 10,000, and other support space.

The expectation is that we will have active basic research there, but we also very much want to engage in translational research that would allow the ideas that are developed in the basic research enterprise to move into being spun off in companies and in ways that enrich the economic development of the East Bay and of California.

And finally, here is a view of how one might lay out the buildings and infrastructure, roadways, connecting pathways on this site. This is strictly a concept. This is not a Master Plan; it is not a design. But it's to give you a sense of how we might do it. You'll note the wide open green spaces. That's the native prairie grasses that we seek to preserve. But we wanted to give you a sense of how we're developing, how we're thinking about this site, how we want it to interact with its neighbors in the city of Richmond, that there will be access and entry

points into the campus. We anticipate, of course, that this site will be developed in phases over 30 or 40 years, and eventually reach that total infrastructure and total population that I mentioned earlier.

This is just a general overview of the project. We'll host a community meeting on the actual Long-Range Development Plan itself this spring where we can also discuss the research programs, partnerships and economic development that can emerge with this plan. But information gathered today will help inform our study on the possible environmental impacts of that plan.

So now I want to introduce Horst Simon who will describe the actual Phase One Development that we anticipate.

HORST SIMON: Thank you, Cathy. It is again a pleasure to be back in Richmond and to talk to the city neighbors -- future neighbors -- about our plans for a Second Campus, the Richmond Bay Campus. It's always a pleasure to work with Cathy and the team at UC Berkeley on this joint development. So as you've noticed, we have developed a very strong partnership over the last year also with UC Berkeley and look at this great project jointly with great enthusiasm.

So what I would like to talk about is what is called the Phase One Development. That is the first set of new buildings that Lawrence Berkeley National Labs would like to place on the Richmond Field Station.

And just to bring you back to the beginning of this process that is now more than two years ago is that we started out with the challenge of having about 25 percent of our Lab facilities and almost 25 percent of our staff scattered over seven different sites in the East Bay that are marked here with these little yellow dots, ranging from JJI in Walnut Creek to NERSC in Oakland and then several sites in West Berkeley and in Emeryville. And it is obvious to you and it was obvious to us that this is very suboptimal. There's a lot of scientific synergy that is lost by having people in separate sites in addition to being, or course, very inefficient in terms of commuting between so many different places.

We were looking for a Second Campus and went through an RFQ process, and the City of Richmond emerged as the leading site with the Richmond Field Station. And so our vision for the future is to consolidate down to two sites -- and you saw how these dots are moving -- some of the dots are moving back to

the hill, but a large number of dots consolidate on the Richmond Bay Campus site that we're discussing today.

So specifically what we're trying to accomplish is to consolidate some of the existing facilities that are listed on this slide on the left here, the Joint Genome Institute, the Joint BioEnergy Institute, Advanced Biofuels, KBASE, and elements of the Life Science and Earth Sciences division in this Phase One Development which would be in the southeast corner of this conceptual plan that Cathy has shown you.

We expect that this first phase would be about 16 acres, and we hope to find about 800 gross square of development capability there, which over the first couple of years would be the target for building out hopefully the Richmond Bay Campus site.

I want to describe the three first buildings that we envision to happen there. The very first building there is the so-called BioIntegration facility. The notion behind this building is to take biological facilities, that as I said are currently scattered across the East Bay -- you see them listed here on this slide -- and bring them together in a building. It makes perfect sense to consolidate these facilities because they serve the scientist and the users, not

just at the Lab but in the nation. And by bringing them together in one building -- we have already done the analysis -- we will save space; we will get out of leased buildings, and we will produce a more productive facility that will serve the researchers that will not only join us on the Richmond Bay Campus site but, as I said, come from UC Berkeley, from the Bay Area, from the state of California, and from all over the world.

Just to explain -- and you will hear this in Jeff Philliber's presentation -- why we have also a NEPA process. This is going to be, as we hope, a federal building that will be financed by the Department of Energy. We are also engaging you in parallel with the CEQA process here with the NEPA process, specifically on this building.

We envisioned to have as a second building a building that is dedicated to the energy sciences. Just as a background, you are all aware of the environmental challenges that we face, not just as a community here but as a nation and the world in terms of the Increased carbon in the atmosphere. And our Lab is engaging in a number of research projects that look at the future of energy in the world and finding technologies that reduce carbon or are carbon neutral.

One of those technologies is the production of biofuels. The Joint BioEnergy Institute that's about five years old was started in a leased facility in Emeryville. That would be the anchor tenant for the second building, the energy building. Activities there would be augmented by other projects that are currently funded by DOE under the Biological Environmental Research Program.

Our third building would be our health building, health sciences. There's a large number of activities currently happening at the Lab that are currently mostly in a facility in West Berkeley on Potter Street that focus on health sciences. The notion here is that LBNL -- and you have probably heard some of the research stories when we had our young researchers here, but just to remind you -- we have a very active program which looks at physical technologies such as imaging, for example, and applies these technologies to the problems related to health.

We have a large core, for example, in breast cancer research. And so out of this combination of physically-based technology that we have developed at the Lab and the application of the health sciences, we have found a lot of important applications really benefiting the health of the population, in particular

as we consider environmental impacts on health. That's the big focus for this third building.

Here's a very short highlight, a little overview of what will happen next. Of course, we've just started the CEQA and NEPA process, and we will engage you, as you've heard, about the Long-Range Development Plan.

These are the activities that will happen throughout 2013. If the LRDP and the project funding is approved, we envision to start the project in 2014, and then expect design construction happening from 14, 15 onward through 17. And hopefully we'll be able to move into the new buildings, that's our goal, in late 17 and early 18. And then, of course, start thinking about other phases -- perhaps you've seen our long-term vision for the Richmond Bay Campus for future phases.

So with that, I would like to turn it over to Jeff Philliber, who will tell you the details of the CEQA process.

JEFF PHILLIBER: Thank you very much. Hi. My name is Jeff Philliber. I'm the Berkeley Lab environmental planner. I'll be speaking today on behalf of the University of California to present to you the CEQA process for the Richmond Bay Campus

Project.

So CEQA has a couple of main purposes. The foremost purpose is to inform governmental decision makers as to the environmental consequences of their actions or their decisions. It also allows them to choose between alternatives. It provides mitigation and ways to avoid impacts.

Another thing that CEQA allows for is public information. It informs the public. Not only does it inform the public, but it allows the public to participate in the process. The public can help inform decision makers as to what the public thinks are issues of concern. And so all of you who are here tonight are participating in our process, and we thank you for showing up.

The University's CEQA process is outlined here for an Environmental impact Report. The Environmental Impact Report is the most extensive process that CEQA provides for analyzing impacts. It starts with a scoping, typically 30 days. We're in that period right now. The scoping period is initiated by the distribution or the public circulation of a Notice of Preparation. If you haven't received that, and you want one, please contact Ross. We have them here as well. There will also be typically a public scoping

meeting which is what we're engaged in tonight.

The comments that the University receives during a scoping period are then used to help inform the report preparers as they prepare a Draft Environmental Impact Report. The Draft EIR, when its ready, is publicly circulated, typically for 45 days. The public and agencies and any interested parties may then review the report and provide comments back to the University. There will also be, as Jeff Miller pointed out, a similar meeting to this one where we would listen to your comments as to the adequacy of that Draft EIR.

At the close of that period, all of the comments received would then be responded to in a Response to Comments document that would be part of a Final Environmental Impact Report. That report would also include any refinements to the EIR as well as any mitigation plan that needs to be put together and other items that are required by the Regents or by CEQA. That would be then submitted to the Regents or the University's decision-making body, and they would then decide whether to approve or certify the EIR or not. Only after certification of an EIR can the Regents then approve the project that's the subject of the EIR.

Our process we're projecting is we'll follow this rough timeline. We open the scoping period on January 4th. It closes February 4th. The Draft EIR we're hoping will come out in the May/June timeframe of this year. The Final EIR we're projecting for sometime around October, and we are projecting or shooting for the Regents meeting in November. The Regents meet approximately once every other month.

There are different kinds of EIRs. This particular EIR comes as two different types. Program EIRs analyze general programs and master plans and proposals that are general and wide and broad in scope. Project-specific EIRs look at specific projects. This project as it's been described has both components. The LRDP will be analyzed programmatically in the EIR, and the Phase One portion of the project will be analyzed at a specific level of detail in the EIR.

Currently the University is considering a range of alternatives that would include what you see here: A reduced growth alternative on the site; an alternative development arrangement on the Richmond site that would allow for more flexibility in siting scientific facilities in the future; an off-site alternative that considers moving the entire campus to a different site

-- Alameda in particular has been looked at, but we were looking at all of the major sites that were considered in the planning process -- and a No Project Alternative which is required under CEQA which would have us analyze what would happen in the future if this project did not happen at all.

This includes most of the areas that would be analyzed in the Environmental Impact Report. You can see here -- if you want any details on any of these, just grab the NOP. We go into quite a bit of detail on our current assessment, our preliminary assessment of these areas.

As Jeff Miller mentioned, you probably noticed that the Department of Energy was answering some questions and had an informal poster session out here earlier this evening. And as Jeff pointed out, and Horst, both processes are occurring simultaneously, the CEQA process and the NEPA process.

One thing that's really important to note about these two processes, despite their many similarities, is that they're both independent of each other. That is, the University of California is conducting the CEQA process independently from the Department of Energy which is conducting the NEPA process. Therefore, if you have comments that are pertinent to

one or the other, you should make it as clear as you can when you communicate with us who you want these comments to go to. We'll definitely try to accommodate you every way we can. But if I receive comments, I'll typically assume they're for the CEQA document. And Mr. Kim Abbott, who is in the back, he's the document manager for the NEPA document, and he will be receiving all the NEPA comments. If I receive comments that reference the NEPA document, I'll make sure Kim gets those, and he will do the same for me for CEQA.

So finally as we enter into the public comment portion of this meeting, I just want to say one thing. Folks who have done this before know this already, but one frustrating thing to some folks about a public scoping meeting under CEQA, and a bit frustrating to us too, is how we have to conduct the meeting.

Those of us who work at the University are very excited about this project, and we actually love to talk about it. But we won't be able to talk about it with you tonight. That would be at odds with the purpose of the CEQA scoping meeting which is for us, the University, to be good listeners.

So we will sit quietly, and we will record everything that you say or ask or comment upon. We're

going to particularly focus on anything you have to say that's pertinent to the scope or content of the forthcoming Environmental Impact Report. But we will certainly not turn off the microphone if you talk about the project or something else.

So with that, again, I want to thank you for coming. I'm going to turn this back to Jeff. Or we can just dive right in?

JEFF MILLER: Dive right in.

JENNIFER McDOUGALL: I'm Jennifer McDougall. I'm a planner with UC Berkeley, and Jeff and I will jointly facilitate the speaker comment portion of the meeting. We will start with Carole Schemmerlinig and then after that will be Patricia Jones.

Start with three minutes. Please come to the microphone there, and give your comments. We'll do three minutes. At two minutes I'll show the fact that there's one minute left, and then we'll do 30 seconds and then we'll ask you to wrap up your comments.

CAROLE SCHEMMERLINIG: My name is Carole Schemmerlinig. I'm a member of the LBNL CAG. I have pointed out to some of the people at the Lab that this is one of the better NOPs that I've seen and had to read. I'm pleased to say that it was more comprehensive in its answers and fewer boxes checked

saying no problem. We don't have to look any further.

I am, as a member of the LBNL CAG, concerned about several issues that will be part of this project too. Water -- and there is water on the site, although the NOP says it's not a natural stream -- it was a natural stream until it was put into a concrete ditch. And so the water, and the way it's treated in the Plan, is questionable. I would like to see it restored in a natural fashion.

I'm concerned also about, in general, contamination. The present site on the hill is heavily contaminated. I know that the one in Richmond has suffered great contamination because of the Seneca buildings -- or rather properties -- and it continues to be contaminated. I need to be reassured as much as possible that the contamination will not be increased by whatever goes on at the Richmond Field Station, although I'm not sure that I can be easily reassured. But I would like to be.

The contamination of the water and the air are two things that Richmond doesn't need more of. With Chevron and the Seneca site and several other sites in Richmond, I think Richmond deserves to have everything as clean as can be.

So that's my major concern. I think it could be a

very good site for some of the expansion of the Lab. But I think in the long run, the benefits to the citizens of Richmond are more important.

JENNIFER McDOUGALL: Thank you. Our next speaker is Patricia Jones.

PATRICIA JONES: Good evening. My name is Patricia Jones. I'm the Executive Director of Citizens for East Shore Parks. So thank you for giving me an opportunity to speak this evening.

CESP, Citizens for East Shore Parks, is an environmental nonprofit group that was instrumental in creating what is now called McLaughlin East Shore State Park. And the northern tip of this park is adjacent to your project.

Our mission is to create parks and open space along the East Bay shoreline. And so to that end, we're very interested to confirm that this shoreline property along Richmond's beautiful 32-mile shoreline, is respected in terms of habitat conservation and restoration and public access.

I see that you do have appropriated boxes checked for biological resources. I just urge you to evaluate these impacts completely. There is less -- and somebody else will speak more to this; I'm not the expert -- but I understand there's less than one

percent of coastal prairie left in California, and you have a large chunk of it on your property. And I would say that having an open lawn surrounded by buildings may not make for a healthy coastal prairie.

Also, as mentioned by Carole, there is a creek running through the property that we hope restoration will be explored on that creek.

So we look forward to seeing a compete EIR and EIS, and that this project can become a community asset to the region. And CESP will be submitting comments in writing. Thank you.

JENNIFER McDOUGALL: Our next speaker is John Shively, and then after John Shively is Bruce Beyaert.

JOHN SHIVELY: I'm John Shively. I got the news of this meeting wrong. I was told that it would start at 7:30, and so I just breezed in the door. Forgive me for that.

Anyhow, I am very interested in this project. Years ago, from 1976 to 1982, I was the manager of the University's Richmond Field Station, which was a misnomer. Field stations are associated with agricultural projects. At the time I was here, there were about 13 separate totally independent research activities going on at the Field Station. And it was a delightful time.

But there was a program back then that fortunately failed. They were going to quietly -- the College of Engineering was going to sell off the Field Station for commercial development. What spoiled it is I accepted the President's office desire to build a northern region library facility, and that slipped through the radar and dropped a huge anchor which spoiled the grand plan to sell off the Field Station for commercial development.

And frankly I'm delighted. I think you can use a better name. Richmond Bay Campus doesn't ring right. I prefer to see the Richmond Research Center of the University of California. Thank you.

BRUCE BEYAERT: Good evening. My name is Bruce Beyaert. I'm a Richmond resident and chair of TRAC, the Trails for Richmond Action Committee. As you know, the citizens of Richmond are very delighted to have LBNL and UCB coming to our community, becoming a part of it.

I'd just like to address one thing tonight, and that is that the Draft EIR clearly identify the role of adopted local plans. The city of Richmond last year adopted a new General Plan, a Bicycle Master Plan, and a Pedestrian Plan. The Draft -- the initial study states on page 28 that "projects on University

property are exempt from local land use planning jurisdiction."

However, CEQA apparently does apply to the project. That's why we're here tonight. And CEQA does require addressing inconsistencies with local plans and mitigating them to a less than significant level. And, of course, most of the project's impacts occur off-site, so I would assume that that would involve consistency with the local plans I mentioned. It would be very helpful to have that clarified and addressed in the Draft EIR citing appropriate legal authorities.

But aside the legal issues and the niceties of CEQA that do a great deal in cementing the emerging great relationships between LBNL and UCB, if the Draft EIR and the institutions would commit to complying with the letter and the spirit of the City's adopted plans.

Those are my only comments. TRAC has already submitted more specific written comments. Thank you.

JENNIFER McDOUGALL: Our next speaker is Mack Casterman, and after him will be Bill Pinkham.

MACK CASTERMAN: Hello. My name is Mack Casterman, and I am the conservation analyst for the East Bay Chapter of the California Native Plant

Society.

The California Native Plant Society's East Bay Chapter has published a list of 15 Botanical Priority Protection Areas in Alameda and Contra Costa County, and the Richmond Field Station is one of those areas. Our interest in the Station is in its rare remnant coastal prairie grassland, which as Patricia Jones stated, is exceedingly rare in the state. There is very little left at this point, and so we're hopeful that the EIR will make sure to plan for any impacts to that grassland community.

Obviously, avoidance is always the best mitigation, and in the case of native grassland it is often the only feasible mitigation option. So we will be looking forward to the EIR and how it addresses the potential impacts to the native grassland at the site.

Also, it's vitally important to begin floristic surveys now, not only for this Phase One of development, but for the other phases down the line here so that appropriate data is available for this and future Environmental Impact Reports.

Also in October of 2012 I recall seeing a picture of the Plan that has the drainage that is on the west side of the property put up and possibly restored to what looked like a meandering creek. The new updated

pictures don't show that. They just show the existing drainage as it is. So I would like more information on that, or maybe some updated photos.

And we will be submitting more detailed comments for the NOP, and we'll look forward to commenting on the EIR as well. Thank you.

JENNIFER McDOUGALL: Bill Pinkham.

BILL PINKHAM: Good evening. I'm Bill Pinkham. I'm on the board of the East Bay Bicycle Coalition and on the steering committee of our local' 350.org group.

Very briefly, I hope that the EIR and the Plan will account for sea level rise in the Bay. It's pretty clear that we're going to have two or three feet already. There is 50 percent less ice on the planet than there was when we had those first pictures of earthrise that John Glenn and the other astronauts took. The seas are 30 percent more acidic, and it's much harder for them to absorb carbon. If the energy companies burn the stored energy they have right now, we'll pass a rise in two degrees Centigrade by 2015. Very scary. We're already up .8 degrees Centigrade. Especially because this project is going to be developed over 30 years or so, I think it's very important that that be a consideration. Thank you.

JENNIFER McDOUGALL: Do we have any other speaker cards tonight? Pamela Sihvola.

PAMELA SIHVOLA: My name is Pamela Sihvola, and I'm the co-chair of the Committee to Minimize Toxic Waste in Berkeley.

It is curious how little the association of this project with the Department of Energy has been mentioned. The Lawrence Berkeley National Laboratory, the Lawrence Livermore National Laboratory, the Los Alamos National Laboratory and this proposed Richmond National Laboratory are and will be all owned and operated by the Department of Energy, previously known as the Atomic Energy Commission, and managed by the University of California under contracts which generally are negotiated for five year terms.

Half of the Lawrence Berkeley National Laboratory's 72-year life span was operated without any environmental laws. Even after the Clean Air Act and the Clean Water Act, radioactive pollution continued in Berkeley next to the Lawrence Hall of Science, the Children's Museum, as tritium, a radioactive isotope of hydrogen, was released into the air and waters of the Strawberry Creek Watershed.

Regarding the proposed Richmond Field Station facility, it is critical that UC, LBNL, and the

Department of Energy prepare individual EIRs on the CEQA and full-blown Environmental Impact Statements under the National Environmental Policy Act for each of the proposed individual buildings, and analyze not only the impacts from construction but also the impacts from operations for the entire projected life span of each of these buildings.

If we had had a chance in Berkeley to comment on the National Tritium Labeling Facility Project during its planning phase, we would have learned that almost 30 percent larger inventories, 30 times larger inventories for radioactive tritium were allowed at the LBNL's site, compared, for instance, to just the central campus of UC Berkeley. And there would have been a chance to prevent radioactive emissions which reached all the way to Lake Anza in Tilden Park but may have impacted the children at Lawrence Hall of Science just 110 meters downwind from the tritium stack.

This in mind, the Richmond community must be vigilant regarding, for instance, synthetic biology, the potential impacts and risks associated with UC Berkeley's Synthetic Biology Institute being considered for the Richmond site.

Since the Richmond Lab is a federal facility, the

proposed programmatic EIR under CEQA must be accompanied by a full-blown EIS under NEPA. And the documents I have received in the mail and what was presented tonight really have no reference to the comment period for the Department of Energy's portion of this project. There are no addresses where to send these comments. There's a reference to somebody in Oakridge.

So I am urging that the EIR be accompanied with a full-blown EIS, and again, each building that is constructed should have an EIR and an EIS for both operations and the construction to fully analyze the health risks and the environmental impacts for the entire projected life span of each building. Thank you.

JENNIFER McDOUGALL: Thank you very much. Are there any other speakers tonight? Thank you very much for attending tonight and for sharing your thoughts about the project with us.

(The meeting adjourned at 7:52 p.m.)

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Appendix B

Air Quality

AIR QUALITY AND HUMAN HEALTH RISK IMPACT ASSESSMENT

University of California/Lawrence Berkeley National Laboratory – Proposed Richmond Bay Campus Long Range Development Plan

REPORT

Submitted To: Tetra Tech
1999 Harrison Street, Suite 500
Oakland, California 94612

Submitted By: Golder Associates Inc.
9 Monroe Parkway, Suite 270
Lake Oswego, Oregon 97035 USA

Distribution: Tetra Tech (*electronic file*)

November 14, 2013 **Project No. 123-99773-02**

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1.0 INTRODUCTION

1.1 Purpose and Assessments Conducted

This report documents the quantitative air quality, human health, and greenhouse gas (GHG) impact assessments conducted for the proposed Long Range Development Plan (LRDP) for the University of California's proposed Richmond Bay Campus (RBC) in Richmond, California. This assessment is based on the project components of the proposed LRDP and additional information provided by The University of California, Berkeley (UCB) and the Lawrence Berkeley National Laboratory (LBNL); collectively referred to as The University in this report. These impact assessments have been conducted using approaches consistent with the California Environmental Quality Act (CEQA) in support of the development of a draft environmental impact report (DEIR) for the proposed LRDP.

The LRDP is intended to cover potential development at the RBC out to the year 2050. Therefore, this study estimates the potential air quality, human health, and GHG impacts from potential RBC development out to the year 2050. Additionally, a separate impact assessment was completed for the first phase of the potential development (Phase 1); Phase 1 development is assumed to occur over four years.[1]

In order to assess potential air quality, human health, and GHG impacts, the following quantitative assessments were performed for both the full LRDP and the Phase 1 portion:

Air Quality

- Estimate emissions of criteria pollutants (nitrogen oxides [NO_x], carbon monoxide [CO], particulate matter less than 10 microns in diameter [PM_{10}], particulate matter less than 2.5 microns in diameter [$PM_{2.5}$], sulfur dioxide [SO_2], and volatile organic compounds [VOC]/reactive organic compounds [ROG]) from activities associated with project construction/demolition and project operation.
- Summarize criteria pollutant emissions for easy comparison to emissions-based significance thresholds.

Human Health

- Estimate emissions of toxic air contaminants (TACs) from activities associated with project construction/demolition and project operation.

[1] This risk assessment includes consideration of a previously proposed project under the proposed LRDP, called "Phase 1 Development." Although that project is no longer proposed, the information on Phase 1 in this report could potentially provide preliminary information to inform a future proposal; accordingly, information on Phase 1 has been included in this report.

- Perform AERMOD dispersion modeling to generate dispersion factors for both onsite and offsite receptor locations representative of general public (for acute assessments), occupational workers (for chronic/cancer assessments), and residents (for chronic/cancer assessments).
- Use the Hotspots Assessment Reporting Program (HARP) On-Ramp and risk assessment software to estimate human health risk assessment impacts.
- Apply age sensitivity factors to lifetime excess cancer risk (LECR) estimates for residential receptors in accordance with Bay Area Air Quality Management District (BAAQMD) guidance.

Greenhouse Gases

- Estimate emissions of GHGs from direct and indirect activities associated with project construction/demolition and project operation.
- Summarize GHG emissions for easy comparison to emissions-based significance thresholds.

Assessment methodologies were based on BAAQMD guidance where available, or guidance from other agencies such as other California air quality districts or the U.S. Environmental Protection Agency (EPA) as appropriate (any non-BAAQMD guidance used will be noted). Many of the assessments performed in this report were conducted to be consistent with assessments recommended by the BAAQMD in a CEQA guidance document published in 2011 (BAAQMD 2011), even though this guidance is currently withdrawn based on legal challenge; this was deemed appropriate since the suite of assessments recommended in the BAAQMD 2011 CEQA guidance encompass assessments typically required in other California air Districts for similar CEQA projects and represent a wide range of different types of potential air quality impacts.

1.2 Proposed Project Description

The University proposes to establish a new major research campus, at properties it owns in Richmond, California, to provide opportunities to consolidate biosciences programs of LBNL and for development of additional facilities for use by both LBNL and UCB and synergistic institutional or industry counterparts for research and development focused on energy, environment, and health. The University proposes to rename the properties as the Richmond Bay Campus (or RBC, as defined previously).

The University is preparing an LRDP in support of the research and academic goals for this proposed new research campus. An LRDP is defined by statute (Public Resources Code [PRC] 21080.09) as a "physical development and land use plan to meet the academic and institutional objectives for a particular

campus or medical center of public higher education." The proposed 2014 LRDP addresses sustainability, land use, access and circulation, utilities and infrastructure, and open space and landscaping, and provides a policy and design framework to guide the development of up to 5.4 million gross square feet (gsf) of new research, development and support space at the site (this does not include square footage of parking structures). Design principles in the proposed LRDP feature preservation of the site's important natural open spaces, which include marsh and coastal grasslands. The proposed 2014 LRDP would guide the growth and development of the campus through year 2050.

The University is also preparing an initial development plan that would construct the first three new buildings on the RBC site, referred to hereafter as the Phase 1 development.[2] Two of these buildings would be approximately 110,000 to 150,000 gsf each, and the third building would be up to 300,000 gsf for a total of up to 600,000 gsf. These new buildings would house the LBNL's Joint Genome Institute (JGI), the Joint BioEnergy Institute (JBEI), the Advanced Biofuels Process Development Unit (ABPDU), Knowledge Base (KBase), Life Sciences programs, conference facility, a dining facility, and various support facilities. Construction of Phase 1 facilities would commence in 2014, and the new buildings would be occupied starting in 2018.

The analysis in this report, as reflected in the LRDP EIR, may be used by the state Department of Toxic Substances Control regarding approval of workplans for addressing historic contamination at portions of the RBC site proposed for development.

The approximately 133-acre RBC site is located at 1301 South 46th Street in the South Shoreline area of the City of Richmond, approximately 5 miles northwest of the UCB campus and the LBNL site in Berkeley (see Figure 1-1 in the Figures section at the end of this report). The RBC site is comprised of two parcels: the Richmond Field Station (RFS) and a recently acquired parcel along Regatta Boulevard.

The properties are bounded on the west by a Pacific Gas and Electric (PG&E) service station, on the northwest by Regatta Boulevard, on the northeast by Meade Street, on the east by South 46th Street, and on the south by the San Francisco Bay. Interstate 580 (I-580) runs parallel to Meade Street (separated by only about 25 feet) along the northeastern boundary of the RBC site.

Land uses surrounding the RBC site include industrial/office uses and a major interstate freeway, with low-/medium-density residential neighborhoods. Regatta Boulevard, along the northwestern boundary of the RBC site, is adjacent to a railroad spur and a business complex developed with one- to two-story

[2] This risk assessment includes consideration of a previously proposed project under the proposed LRDP, called "Phase 1 Development." Although that project is no longer proposed, the information on Phase 1 in this report could potentially provide preliminary information to inform a future proposal; accordingly, information on Phase 1 has been included in this report.

buildings. Bio-Rad Laboratories, a private research equipment manufacturing company, is located immediately west of the RBC site. The adjacent property to the east is the location of former chemical production operations previously owned by several entities, including Stauffer and Zeneca, and is currently owned by Cherokee Simeon Venture I, LLC.

The Marina Bay residential neighborhood, across Meeker Slough, and southwest of the RBC site, consists of a mix of multi- and single-family residences. Low- and medium-density residential uses are also located across I-580, north of the Meade Street boundary of the RBC site.

1.2.1 LRDP Illustrative Development Scenario

To provide greater detail and more complete public disclosure of potential project impacts, and also to provide a basis for some of the quantified modeling that is being completed for this LRDP, the University has developed an Illustrative Development Scenario, which is shown in Figure 1-2.

This Illustrative Development Scenario is a conceptual portrayal of potential development under the LRDP that would be consistent with the proposed 2014 LRDP goals and objectives, the proposed 2014 LRDP Land Use Diagram, and the LRDP's proposed development uses and square footages. The Illustrative Development Scenario is intended to provide a conservative, but reasonable and realistic, basis for the analysis of environmental impacts.

The actual locations of buildings, configurations, uses may vary as specific projects are considered for approval in the future. The University's needs and opportunities may change over time at any particular site and the Illustrative Development Scenario is not intended to be a precise representation of the actual development program that would take place over the nearly 40-year planning horizon of the 2014 LRDP (out to 2050).[3]

The Illustrative Development Scenario shows possible siting and dimensions of new buildings, parking garages, and roadway changes, and demolition of existing buildings. Consistent with the proposed 2014 LRDP Land Use Diagram, the Illustrative Development Scenario indicates that development of major new buildings would take place within the Research, Education, and Support zone of the RBC site. Parking structures would be sited to support a pedestrian-friendly, vehicle-free environment.

While actual development at the RBC site under the term of the 2014 LRDP would likely not be precisely what is presented in this Illustrative Development Scenario, at the time of additional development the University would consider how each individual project conforms to the assumptions and impact analyses presented in the 2014 LRDP environmental impact documents to determine what, if any, further CEQA

[3] It is not possible to forecast accurately the complex series of development opportunities and decisions, including future building locations, sizes, configurations, uses, construction schedules, etc., that would comprise full implementation of the LRDP program.

documentation is necessary at that time. In particular, any development in excess of a net total of 5,400,000 gsf of occupiable (research, education, and support) space would require an amendment of the LRDP and accompanying environmental review.

1.2.1.1 Demolition Activities

In addition to construction of new building space, the Illustrative Development Scenario considers for purposes of analysis the possible demolition of up to 750,000 gsf of outdated facilities at the RBC. Demolition is considered for buildings and structures that are not cost-effective to upgrade, no longer suitable for modern science, costly to maintain, and to more efficiently use the building sites at the RBC. Most of the existing buildings are more than 40 years old, beyond the effective age of a typical laboratory building, and are relatively small, averaging about 9,600 gsf.

Demolition equipment would include large vehicles, stationary equipment, and hand-held power equipment typical to that involved in construction.

Table 1-1 identifies the major phases of demolition of an average-sized project. The table compares anticipated average and peak annual average levels of demolition activity, broken out into principal demolition parameters for analysis. The annual average is derived by dividing the total demolition gsf by a 40-year planning period. The anticipated peak demolition activity is assumed to be demolition of the majority of the existing Regatta property within a 12-month period. The calculation of truck trips assumes 10-ton haul trucks.

Table 1-1: LRDP Demolition Activity Levels

Activity	Anticipated Average Individual Demolition Project (12-month peak activity)	Anticipated Site-wide Average Annual Demolition Activity (all projects)	Anticipated Peak Demolition Activity (12-month period)
Facilities Demolition	9,600 gsf	18,750 gsf	250,000 gsf
Weight (125 lbs./gsf)	600 tons	1,172 tons	15,625 tons
Truck Trips	60 truckloads	117 truckloads	1,563 truckloads

Additional quantitative components of the demolition activities associated with the LRDP build-out are discussed further in Section 2 of this report.

1.2.1.2 Construction Activities

Construction planning for large projects includes consideration of environmental and regulatory elements of each project. Construction activities usually include the need for adjacent lay-down areas for equipment, supplies, and fabrication activities, as well as construction-worker parking, typically on or near

a job site. Under the 2014 LRDP, it is expected that large construction projects would not often occur simultaneously, although such projects may have some degree of overlap in schedules.

Construction would typically begin with demolition of existing facilities at a site, if necessary, followed by site clearing and excavation work. At the RBC site, preliminary steps include determination of any special site or building conditions due to historic site contamination that should inform site work. If excavation is involved, soil that is certified clean may be shipped off site during this phase unless the project is a balanced cut-fill excavation. Foundation work, building frame erection, and building finishing are the three major phases to follow. Under optimal conditions, site work for large projects at the RBC would typically be scheduled to occur between the months of April through September for optimal weather conditions, although it may occur in any month of the year, and the remaining phases may also take place at any time during any season.

Construction equipment would typically include large vehicles, stationary equipment, and hand-held power equipment used on the building site and at nearby staging areas, and would be powered by diesel or gasoline engines or electricity. Such equipment would include cranes, scraper/dozers, spreader/compactors, loaders, drill rigs, haul trucks, cement trucks, bore drillers, rough terrain forklifts, pavers, rollers, and other rigs. All equipment would comply with applicable regulatory standards, including required noise, air emissions, safety, and energy efficiency standards.

For the purposes of this study, the term “construction,” unless specifically indicated otherwise, includes activities that involve construction of new facilities, major rehabilitation or modification of existing facilities, and demolition of existing facilities. The maximum total new construction and renovation under the Illustrative Development Scenario is 7,300,000 gsf. This includes approximately 300,000 gsf of existing space, 5,100,000 gsf of new occupiable building space construction, and 1,900,000 gsf of new parking structures. While parking structures are not considered part of the occupiable space totals identified in the 2014 LRDP, they account for potential construction-related impacts and are thus considered in this analysis. Table 1-2 identifies the construction activity level for a typical construction project, divided into the major phases of construction. A project with 175,000 gsf is used to represent the average size of new buildings at the RBC. Table 1-2 also compares anticipated average and peak annual levels of construction activity, by major phases of construction.

The annual averages are approximately equivalent to one typical construction project being underway at all times at the RBC and are derived by combining total construction elements of the projects identified in the Illustrative Development Scenario (e.g., total square footage, footprint square footages, etc.), and then dividing these aggregates evenly over the 40-year planning period. Additionally, an annual peak average is analyzed, which is equivalent to the proposed Phase 1 construction of up to 600,000 gross square feet over a 30-month period. In this way, the peak annual average construction activity level is over three

times the annual average, or the equivalent of 3.4 typical construction projects being underway simultaneously. This level is intended to represent the maximum anticipated construction activity level for analytical purposes.

Table 1-2: LRDP Construction Activity Levels

Activity	Anticipated Average Construction Project (30 months total)	Anticipated Site-wide Average Annual Construction Activity	Anticipated Peak Construction Annual Average
Construction	175,00 gsf	175,000 gsf	600,000 gsf
Excavation & Replacement Volume	15,700 cubic yards (yd^3)	15,700 yd^3	53,800 yd^3
Soil Hauling	1,570 truckloads	1,570 truckloads	5,380 truckloads
Foundation	650 truckloads	650 truckloads	2,740 truckloads
Construction	3,400 truckloads	3,400 truckloads	14,380 truckloads
Total Truckloads	***5,620 truckloads***	***5,620 truckloads***	***22,500 truckloads***
Average Daily Truckloads	***9 truckloads/day***	***9 truckloads/day***	***36 truckloads/day***
Peak Daily Truckloads	***25 truckloads***	***25 truckloads***	***100 truckloads***

The calculation of excavation-related truck trips assumes the use of 10 yd^3 haul trucks. Excavation for these projects is assumed to be five feet deep underneath, and to five feet outside of, the footprint of each building or parking structure identified in the Illustrative Development Scenario. The structures were assumed to be an average of 4.5 stories high. While this volume is likely to be exceeded with some projects, others would require less excavation or would be balanced cut-fill excavations. Foundations are assumed to be approximately the length of the building footprint perimeter identified in the Illustrative Development Scenario. Foundations are assumed to be approximately up to 10 feet in depth and the excavated soil would be hauled in trucks, each assumed to hold 10 yd^3. An average building project is estimated to require approximately 3,400 truckloads of materials, including rental equipment, concrete, structural steel, siding, building systems equipment, and interior finishing materials.

Additionally, approximately 70,000 yd^3 of soil will be brought onsite during Phase 1 of the LRDP development to increase the site elevation of the Phase 1 area. It is also anticipated that during the LRDP development some of the contaminated soil known to exist onsite would be excavated and removed via truck (in accordance with the Soil Management Plan for the site).

Additional quantitative components of the construction activities associated with the LRDP build-out are discussed further in Section 2 of this report.

1.2.1.3 Operations

At full build-out, the LRDP would result in approximately 300,000 gsf of existing space, 5,100,000 gsf of new occupiable building space construction, and 1,900,000 gsf of new parking structures. The RBC after full build-out is anticipated to have a daily total population of approximately 10,000 persons.

Occupiable building space will utilize natural gas boilers for heating and cooling towers for cooling. In addition, diesel-fueled generators will be installed for back-up emergency electrical power.

Full build-out of the RBC will generate additional vehicle traffic due to supply/delivery trucks, waste removal trucks, shuttle buses/vans, and vehicles for employees and visitors.

For those buildings with wet laboratory space, chemical usage will occur, resulting in the potential for chemical emissions to atmosphere through lab hood vents on building roofs.

Additional quantitative components of operations associated with the LRDP build-out are discussed further in Section 2 of this report.

1.2.2 Phase 1 Development

Upon the approval of the 2014 LRDP, the University proposes to demolish 25 existing structures in the southern portion of the RBC site totaling 106,999 gsf and construct three new buildings and parking lots in the cleared area. These three research and office buildings, parking lots, associated site preparation, and utilities development, potentially including a central utility plant, are collectively called the Phase 1 development. The Phase 1 project site is about 16 acres, and the facilities that would be developed under the Phase 1 development are shown in Figure 1-3. Phase 1 development activities are estimated to take place over four years, roughly from 2014 to 2018.

Three new research buildings totaling up to 600,000 gsf would be constructed to house a mix of laboratory, office, and interaction space. The facility to be constructed at the southernmost end of the RBC site and closest to the EPA building is referred to as the “Energy” building as shown on Figure 1-3 (also shown as Building 8 in Figure 1-2). The facility to be constructed to the north of the “Energy” building is referred to as the “BIF” building as shown on Figure 1-3 (also shown as Building 9 on Figure 1-2). The facility to be constructed to the east of these buildings is referred to as the “Health” building as shown on Figure 1-3 (also shown as Buildings 6 and 7 on Figure 1-3). The “BIF” building would house LBNL’s Joint Genome Institute, the Advanced Biofuels Process Development Unit (ABPDU), and Knowledge Base programs, an imaging center, and a conference facility. The “Energy” building would house LBNL’s Joint BioEnergy Institute and closely related programs as well as a dining facility. The “Health” building would house LBNL's Life Science Division, closely related programs, and synergistic research institutions. The “BIF” building would likely be a three-story facility totaling 110,000 to 150,000 gsf. The “Energy” building

would likely be a two-story facility totaling 110,000 to 150,000 gsf. The “Health” building would likely be a two- to three-story facility totaling up to 300,000 gsf. At full occupancy, the buildings will house approximately 1,000 new employees (in addition to the 300 employees in existing buildings at the site not demolished during Phase 1). Three new surface parking lots would be constructed to accommodate approximately 600 vehicles.

As with the remainder of the LRDP build-out, Phase 1 buildings will utilize natural gas boilers for heating and cooling towers for cooling. In addition, diesel-fueled generators will be installed for back-up emergency electrical power. Phase 1 operations will also generate a portion of the vehicle traffic and laboratory chemical usage that will be associated with the full LRDP build-out.

Additional quantitative components of construction, demolition, and operations associated with Phase 1 of the LRDP build-out are discussed further in Section 2 of this report.

2.0 EMISSIONS ESTIMATES

This section describes the methodologies and input assumptions used to estimate emissions from activities associated with project construction/demolition and project operation. These estimates were completed for both Phase 1 of the LRDP and the full LRDP build-out.

2.1 Construction and Demolition

Construction and demolition emissions are estimated utilizing the California Emissions Estimator Model (CalEEMod), version CalEEMod.2011.1.1. CalEEMod is a statewide land use emissions model designed to quantify potential criteria pollutant and GHG emissions associated with construction and operations from a variety of land use projects. CalEEMod quantifies direct emissions from construction and operations (including vehicle use), as well as indirect emissions, such as GHG emissions from energy use, solid waste disposal, vegetation planting and/or removal, and water use. CalEEMod incorporates Pavley standards and Low Carbon Fuel standards into the mobile source emission factors. Although CalEEMod is capable of estimating direct operational emissions, it was only used to estimate emissions due to construction and demolition, as well as indirect GHG emissions due to water usage and waste disposal for operations.

Although CalEEMod Version 2011.11.1 was the most current version of the model at the time this analysis was conducted, it was known to contain multiple software bugs. In order to correct the data produced using CalEEMod due to software deficiencies, some data were post-processed for each model run based on guidance from the South Coast Air Quality Management District (SCAQMD). When applicable, these post-processing operations are explained in the following sections.

Generally, input parameters needed to run CalEEMod for each construction and operation scenario were provided by The University. Where input parameters were not provided, CalEEMod defaults and engineering assumptions were used. These input parameters are described in the following sections.

2.1.1 General Project Parameters

The input parameters needed for execution of each CalEEMod scenario include gsf of structures being demolished and constructed, parking lot and parking structure gsf, site preparation and grading areas acreage disturbed, and the timeline for each phase.

2.1.1.1 Phase 1

The input parameters needed for the execution of the Phase 1 CalEEMod scenarios (years 2014 and 2015) are provided in Appendix A in Tables A-1 to A-3 and A-7 to A-8. Phase 1 activities will include:

- Demolition
- Site Preparation

- Site Grading
- Building Construction
- Paving
- Architectural Coating

Data for these project phases are individually represented in the CalEEMod output files. It was determined that the 12-month period with the highest level of activity would likely occur once demolition activities commenced. Within this 12-month period, multiple weeks of each of the first four activities listed above (demolition [17 weeks], site preparation [8 weeks], site grading [27 weeks], and building construction [18 weeks]) would occur, as well as the exportation of contaminated soils and the importation of soils needed to raise the overall ground elevation in certain locations. Activity levels and durations were provided by The University for Phase 1. The activity schedule also included an outline of construction levels and durations during the second year of construction for Phase 1. Year 2 activity consists of the remaining necessary construction activities (including architectural coating), and site improvements (including paving). To summarize, emissions during the Phase 1 development construction and demolition period were conservatively estimated based on the following CalEEMod runs:

- **Year 1** – CalEEMod run for all Phase 1 demolition, 300,000 gsf of building construction, and all soil import/export activities.
- **Year 2** – CalEEMod run for the remaining 300,000 gsf of building construction, and all site improvements.

Detailed summaries of the Phase 1 construction and demolition emissions estimates are shown in Appendix A. The model output files for the two CalEEMod runs conducted to generate the emissions associated with the Phase 1 development construction and demolition are provided in Appendix B

2.1.1.2 Full LRDP

The input parameters needed for the execution of the full LRDP CalEEMod scenario are provided in Appendix C in Tables C-1 to C-3. The Full LRDP activities will include:

- Demolition
- Site Preparation
- Site Grading
- Building Construction
- Paving
- Architectural Coating

Because the LRDP (excluding Phase 1) extends from 2018 to 2050, each of the aforementioned phases can occur during a single year. The annual average activity levels and schedules for each phase were

estimated based on the Phase 1 information provided by The University. The Phase 1 activity durations were adjusted using the ratio of annual average LRDP activity levels (gsf demolished or constructed) to the respective total Phase 1 activity levels.

The daily CalEEMod outputs shown in Appendix D are used as the basis for the annual average construction and demolition emissions estimates because the annual average emissions output values were small enough that the majority were rounded to zero. The maximum of either the winter or summer daily emissions for each phase were multiplied by their respective phase lengths to approximate the annual emissions. GHG emissions calculated using this method were verified against the annual average emissions output, and the results were within the margin of error for rounding. Detailed tables showing these calculations are provided in Appendix D.

2.1.2 Off-Road Equipment

Off-road equipment types, quantity, sizes (horsepower), and usage schedules were provided by The University. Load factors for the various equipment types were edited using updated information from Table D-7 of Appendix D from the California Air Resources Board (CARB) Off-road Simulation Model (OSM) and Summary of Off-Road Emissions Inventory, "Original OFFROAD and New Load Factors (LF) by Equipment Type".

Fugitive dust emissions resulting from the operation of off-road equipment will be mitigated to the extent recommended in the 2011 BAAQMD CEQA guidance document. Based on the Basic Construction Mitigation Measures recommended by BAAQMD[4], a twice-daily exposed surface watering frequency was applied for all CalEEMod scenarios, which represents a fugitive dust control efficiency of approximately 55%.

2.1.2.1 Phase 1

The Phase 1 off-road equipment specifications assumptions are provided in Appendix A in Table A-2.

2.1.2.2 Full LRDP

It is assumed that in general, the same equipment types, quantities, and sizes will be used for the full LRDP as for Phase 1. As stated previously, the Phase 1 activity durations were adjusted using the ratio of annual average LRDP activity levels (gsf demolished or constructed) to the respective total Phase 1 activity levels. The full LRDP off-road equipment specifications are provided in Appendix C in Table C-2.

[4] 2011 BAAQMD CEQA guidance Section 8.1.2, Table 8-1, "Basic Construction Mitigation Measures Recommended for All Proposed Projects".

2.1.3 On-Road Vehicles

Emissions resulting from on-road vehicles are derived using CalEEMod. On-road fugitive PM_{10} emissions for the haul truck vehicle category are significantly overestimated in the CalEEMod output files on both a daily and annual basis. This results from the model inappropriately using the annual vehicle miles travelled (VMT) value for daily haul truck fugitive dust calculations, and multiplying that VMT value by the number of days per phase when generating the VMT value for annual haul truck fugitive dust calculations. Because the fugitive dust emission calculation methodology is a function of VMT, the emissions in the CalEEMod output file are post-processed according to the following equation, provided by Ian MacMillan of the SCAQMD, the agency overseeing the redevelopment of CalEEMod):

$$Corrected\ Fugitive\ PM_{10}\ Haul\ Truck\ Emissions = \frac{CalEEMod\ Fugitive\ PM_{10}\ Haul\ Truck\ Emissions}{Number\ of\ Days\ per\ Phase}\ x\ 2$$

This methodology was verified by performing the fugitive dust emission calculations independently of CalEEMod, utilizing the same input parameters, which resulting in comparable emission rates on both an hourly and annual basis.

Input data for the CalEEMod runs utilizes default trip distances and number of trips per vehicle type, with few exceptions, as explained in the following subsections.

2.1.3.1 Phase 1

For Phase 1, specific vehicle parameters were input for both soil importation and soil removal. Soil importation, occurring over a 7 month period near the beginning of Phase 1 construction, was included under the site grading portion of the model. As provided by The University, 70,000 yd^3 of soil are to be imported, which includes a total of 7,000 haul truck trips (10 yd^3 haul trucks), and a total of 500 "vendor" trips over the grading phase.

Contaminated soil removal was applied to the site grading phase, which was aligned with the building demolition timeline, as soil excavations must be completed before soil importation and building construction commence. The University provided a contaminated soil removal activity level of 275 haul truck trips, with a one-way trip length of 260 miles to reach the disposal facility. These values were applied to the site preparation line item so the appropriate trip length and phase duration could be applied.

CalEEMod default values were used for all other aspects of the Phase 1 on-road vehicle emission estimates.

2.1.3.2 Full LRDP

The University provided specific vehicle trip information for haul trucks used for the LRDP construction and demolition activities. CalEEMod defaults were used for worker and vendor trip information.

2.2 Operations

Emissions from operations were conservatively evaluated based on the level of activity at the end of the build-out period (2018 for Phase 1 and 2050 for the full LRDP), but with emission factors representative of equipment installed at the beginning of the build-out period (i.e. 2014). This approach was used to ensure that the assessments were conservative; although emission rates of equipment installed in future years are not known at this time, it is reasonable to assume that they will be less than or equal to those for equipment installed in 2014.

Only emissions from activities involving non-radiological materials were estimated. Emissions of radioactive materials from project operation activities associated with Phase 1 and full LRDP build-out were determined to have a less than significant impact for the following reason. As with other hazardous materials, the most probable potential pathway for public or environmental exposure to radioactive material would be air emissions from routine project operations. Based on historical data from operations at JGI, JBEI, ABPDU, Potter Street, and KBase, exposure to airborne radionuclides at the Richmond Bay Campus would be less than 0.1% of EPA and Department of Energy regulatory limits and less than 0.001% of the threshold below which risks of health effects are either too small to be observed or are nonexistent (http://hps.org/documents/risk_ps010-2.pdf).

2.2.1 Natural Gas Usage

Natural gas-fired boilers are projected for use in providing heat energy to occupied buildings. Annual natural gas usage was based on values provided in the project description.

The NO_X emission factor for natural gas boilers was based on the BAAQMD NO_X limit of 30 parts per million (ppm) for boilers greater than 10 MMBtu/hr heat input (BAAQMD Regulation 9, Rule 7). The remaining criteria emission factors were taken from AP-42 Chapter 1.4, and GHG emissions were estimated using the data from the EPA Mandatory Greenhouse Gas Reporting Rule, 40 CFR 98, Subpart C, Table C-1 "Default CO_2 Emission Factors and High Heat Values for Various Types of Fuel", and Table C-2 "Default CH_4 and N_2O Emission Factors for Various Types of Fuel".

To estimate TAC emissions from boilers, three sources of emission factors were used in order of descending preference. The first preferred source of emission factors for the boilers was the California Air Toxics Emission Factor (CATEF) database. Next, the Ventura County Air Pollution Control District (VCAPCD) emission factor database was analyzed for TAC emission factors not found in the CATEF

database. Lastly, AP-42 was consulted for TAC emission factors not found in either the CATEF or VCAPCD databases.

Emissions estimates were based on emission factors and estimated annual natural gas usage. Average daily emissions were estimated by dividing annual emissions by 260 operating days per year (5 days per week, 52 weeks per year).

2.2.1.1 Phase 1

The number and size of boilers associated with the Phase 1 occupied buildings were provided by The University. The quantitative boiler assumptions for Phase 1 are provided in Appendix E, Table E-1. Criteria pollutant and GHG emission estimates are provided in Appendix E Table E-8 and TAC emission estimates are provided in Appendix E Table E-16.

2.2.1.2 Full LRDP

Boiler sizes for the Full LRDP are provided by The University (including the Northern Regional Library Facility [NRLF] expansion). The annual natural gas consumption for each boiler was apportioned from the total facility natural gas usage based on boiler size (MMBtu/hr). The quantitative boiler assumptions for the Full LRDP are provided in Appendix F, Table F-1. Criteria pollutant and GHG emission estimates are provided in Appendix F Table F-8 and TAC emission estimates are provided in Appendix F Table F-16.

2.2.2 Emergency Generators

Emergency generators were assumed to meet EPA Tier 4 emission standards or better, except for the generator(s) at Buildings 6 and 7, which might be purchased by entities other than The University. The generator(s) at Buildings 6 and 7 were assumed to meet at least EPA Interim Tier 4 emission standards. These are reasonable assumptions for new generators given that Tier 4 standards will be in full effect around the time that Phase 1 build-out commences.

In general, the emission factors used to estimate diesel generator emissions were taken from Appendix D of the CalEEMod user's guide. The emission factor for SO_2 was derived based on the total sulfur content in ultra-low-sulfur diesel fuel, assuming 100% of the fuel sulfur content is converted to SO_2. Similarly, carbon dioxide emission rates were based on fuel usage and the estimated carbon content of diesel fuel. Methane emissions were based on a ratio to VOC emissions taken from the EPA AP-42 document.

Consistent with guidance from the CARB, since the toxicity of TACs emitted from diesel-fueled internal combustion sources is represented by the toxicity factor for DPM, this was the only TAC emission quantified for the emergency generators (equal to total particulate matter emissions).

2.2.2.1 Phase 1

The University provided estimated emergency generator sizes and locations for Phase 1 occupiable buildings.

LBNL has most recently installed generators that meet a particulate matter emission rate of 0.01 grams per horsepower-hour (g/hp-hr), so all generators, other than those for Buildings 6 and 7, were assumed to meet this particulate matter limit.

The quantitative generator assumptions are provided in Appendix E, Table E-1. Criteria pollutant and GHG emission estimates are provided in Appendix E Table E-9 and TAC emission estimates are provided in Appendix E Table E-17.

2.2.2.2 Full LRDP

The University provided estimated emergency generator sizes and locations for the LRDP occupiable buildings (including the NRLF expansion). The quantitative generator assumptions are provided in in Appendix F, Table F-1. Criteria pollutant and GHG emission estimates are provided in Appendix F Table F-9 and TAC emission estimates are provided in Appendix F Table F-17.

Aside from Buildings 6, 7, 8, and 9 which are accounted for in the previous section, all generators installed for the full LRDP are assumed to meet EPA Tier 4 final emission rates for applicable all pollutants. Sulfur dioxide, VOC, and GHG emissions are estimated as described previously.

2.2.3 Laboratory Chemicals

A potential inventory of laboratory chemicals and associated stored quantities was compiled by The University for the laboratories that could be present at the Phase 1 buildings at the RBC. The methodology described in the steps below was used for estimating emissions of chemicals from these laboratories. Note that this methodology is similar to that used to develop emissions estimates for laboratory chemicals for the 2006 LRDP Human Health Risk Assessment (HHRA) study for LBNL (SECOR, 2004). The emissions estimated using this method were applied to laboratories included in Phase 1.

Radionuclide and other radioactive materials were not considered under this methodology for the reasons discussed at the beginning of Section 2.2.

Step 1 – Identify Regulated Chemicals and Associated Quantities

The inventory of laboratory chemicals was initially screened against a list of available toxicity factors and the physical state (i.e., solid, liquid, or gas) of the chemical at room temperature. The list of toxicity factors was compiled from the CARB and California Office of Environmental Health Hazard Assessment

(OEHHA) Consolidated Table of Approved Risk Assessment Health Values (http://www.arb.ca.gov/toxics/healthval/contable.pdf).

For purposes of the remainder of this document, any chemical listed in the CARB/OEHHA Consolidated Table cited above will be considered a TAC for this study. The human health impacts of any other chemicals could not be assessed with California-approved toxicity factors and were, therefore, not assessed further.

Remaining chemicals classified as solids were also eliminated from consideration for emissions as they would generally be non-volatile and not be expected to be emitted in any appreciable quantity in a research laboratory setting.

For each remaining chemical, the next two steps in the process were used to determine a usage rate (Step 2) and an appropriate emission factor (Step 3) that could be multiplied together to obtain an emission rate.

Step 2 – Determine Chemical Usage

Usage was conservatively assumed to be equal to the quantity determined to be present in the chemical inventory multiplied by a usage factor. The usage factor was based on existing data summarizing historical chemical turnover rates (i.e., elapsed time between the purchase of a container of a chemical and the eventual disposal of the empty container).

To determine a conservative usage factor that could be applied to all chemicals, the database of historical turnover rates for all chemicals was analyzed. A single initial usage factor was determined as the 95th percentile highest turnover rate for the database. Through this analysis it was determined that the 95th percentile highest turnover rate was 311 days (i.e. each year approximately 365/311 = 1.174 times the chemical storage container quantity would be used). The data used to determine this factor is discussed in further detail in SECOR, 2004.

Although the use of the 95th percentile turnover rate in this method is likely to overestimate the usage of many of the laboratory chemicals, it greatly simplifies the initial estimates of chemical usage, and is appropriate for the initial HHRA. If during the course of performing the HHRA specific chemicals had been identified as contributing significantly to the risk estimates, these conservative usage assumptions could have been revisited on a selected subset of chemicals; however, this did not turn out to be an issue.

Step 3 – Determine Worst-Case Emission Factors for Each Chemical

For gaseous chemicals, it was conservatively assumed that 100% of the materials used were emitted to the atmosphere (i.e., an emission factor of 1.0 gram/gram was used). This discounts any potential chemical reaction or solubilization into liquids, but provides a convenient simplification that will always be conservative.

For liquid chemicals, a hybrid evaporative model was used to estimate chemical emissions to the atmosphere. This model accounts for both surface evaporation and splash loading (pouring) components of usage. Based on the required input data for these models, conservative assumptions concerning receiving vessel configuration, quantity used per event, initial vapor pressure, vapor pressure during use, event duration (usage time), and air flow were used to compute an emission factor which could be applied to each laboratory chemical (grams emitted per liter used).

The assumed vapor pressure during pouring was the vapor pressure of the chemical at approximately room temperature (295 degrees K). The vapor pressure during the surface evaporation period (30 minutes) for this worst-case use scenario was either:

1) The lesser of twice the room temperature vapor pressure or 100 mmHg for chemicals with vapor pressures less than or equal to 100 mmHg at room temperature (to account for possible heating of the material during use), or

2) The estimated vapor pressure of the chemical at 295 degrees K if it is greater than 100 mmHg (the assumption being that such a volatile compound would not be heated significantly in a vessel that is not connected to some type of condenser system as the material would otherwise evaporate completely in a relatively short period of time).

The specific details of the evaporative models used for liquid chemicals and the associated assumptions are provided in the calculation spreadsheet printouts in Appendix G.

Therefore, the following emission factors were used to calculate emissions of laboratory chemicals:

- **Gases** – 1.0 gram per gram used.
- **Liquids** – Chemical-specific emission factor based on the sum of the pouring and surface evaporation emission factors calculated from evaporative models (in units of grams per liter used).

Step 4 – Calculate Emissions

Annual emissions for each chemical were calculated by multiplying annual chemical usage by the chemical-specific emission factor.

The emission estimation approach discussed above results in estimated total annual emissions of chemicals used in laboratories at the facility. Since realistic short-term emissions from laboratory stacks could not be estimated directly from data tracked by The University, an alternate, conservative approach was devised to estimate potential worst-case acute exposure conditions. In this approach, annual facility-wide emission estimates were reduced to average hourly emission rates, which were then multiplied by a factor of 5.18, based on studies comparing maximum to average emission rates for laboratories. The data and studies used to derive this factor are presented in a preliminary human health risk assessment prepared for the University of California at Berkeley (URS, 2000).

2.2.3.1 Phase 1

A summary of the Phase 1 estimated TAC emissions from all laboratory chemicals (both liquid and gaseous) is provided in Appendix E in Table E-19.

2.2.3.2 Full LRDP

The Phase 1 chemical inventory was extrapolated to the full LRDP build-out based on the gross square footage of each research and development building. Emissions from each of the buildings in Phase 1 were summed on a chemical-by-chemical basis to calculate total individual chemical emissions. The total individual chemical emissions were then divided by the total gross square footage of the Phase 1 buildings to calculate a chemical emission factor in pounds of chemical per gross square foot of research and development space. Total gross square footage of research and development buildings in the full LRDP build-out were provided by The University.

In addition to these emission factors, The University provided a set of laboratory emission factors used previously for air quality studies for UCB laboratories for Type II (General Biological Sciences) laboratories. These emission factors varied from those estimated using the Phase 1 chemical inventories, being sometimes higher and sometimes lower. In addition, the UCB emission factors included two chemicals not found in the Phase 1 laboratories that had toxicity factors published by the CARB/OEHHA.

The University estimated that on average about 37 percent of the laboratory square footage in the illustrative LRDP would be well represented by the emission factors derived from the Phase 1 inventory and about 63 percent of the laboratory square footage would be well represented by the emission factors used previously for UCB laboratories. Therefore, for all laboratories evaluated in the illustrative LRDP,

TAC emission factors were based on a weighted (37:63) average of the emission factors from the Phase 1 inventory and those used previously for UCB laboratories. For example, the LRDP laboratory emission factor for formaldehyde was calculated as:

$$(0.37)(2.7 \times 10^{-8} \text{ tons/gsf/yr}) + (0.63)(1.7 \times 10^{-7} \text{ tons/gsf/yr}) = 1.1 \times 10^{-7} \text{ tons/gsf/yr}$$

Emissions were then based on the weighted average emission factors times the square footage of laboratories within each building.

The building square footage assumptions are provided in Appendix F in Table F-1. A summary of the LRDP estimated TAC emissions from laboratory sources are provided in Appendix F in Tables F-19.

2.2.4 Cooling Towers

The total particulate matter drift rate from the cooling towers was based on an assumed dissolved solids content, drift rate, and recirculation rate taken from data previously provided by LBNL for air quality assessments for the Computational Research and Theory building currently being constructed at the main LBNL site. The Riesemann and Frisbie method (Reisman & Frisbie, 2001) of calculating the PM_{10} fraction of total particulate matter was used; this is a mass balance method for total dissolved solids and the effect of water evaporation on aerosol particle size distribution.

Cooling tower water additives will be used to prevent scaling and biological growth in the cooling tower units. In some cases, these additives could include chemicals that are TACs, which can be emitted to the air through either volatilization or removal as a component of aerosol drift. One of the proposed biocides assumed for the Computational Research and Theory building contained sodium bromide, which is identified as a TAC (bromine compounds). In the absence of additional data, The University indicated that the same assumption would be appropriate for the current assessment. It was assumed that this bromine salt would primarily be emitted along with the aerosol drift from the cooling towers. The biocide manufacturer (ChemTreat, Inc.) indicated that the biocide would typically be used to maintain a total bromine concentration of one ppm. Therefore, bromine emissions from the cooling towers were estimated to be proportional to particulate emissions, based on the ratio of the bromine concentration (in ppm) to the total dissolved solids concentration (in ppm).

2.2.4.1 Phase 1

The number and sizes of cooling towers associated with the Phase 1 occupied buildings were provided by The University. The quantitative cooling tower assumptions are provided Appendix E, Table E-1. Criteria pollutant emission estimates are provided in Appendix E Table E-10 and TAC emission estimates are provided in Appendix E Table E-18.

2.2.4.2 Full LRDP

The number and sizes of cooling towers associated with the LRDP occupied buildings, including the NRLF expansion, were provided by The University. The quantitative cooling tower assumptions are provided in in Appendix F, Table F-1. Criteria pollutant emission estimates are provided in Appendix F Table F-10 and TAC emission estimates are provided in Appendix F Table F-18.

2.2.5 Delivery Trucks

Emission factors for delivery trucks anticipated during operation of the RBC were taken from EMFAC 2011 for the T6 Instate Small Diesel Truck (GVWR <= 26,000 lbs) for both on-road truck travel (in pounds of pollutant per vehicle mile travelled, or lbs/VMT) and stationary truck idling (in pounds per vehicle idle hour, or lbs/idle-hr). The vehicle weight class was chosen to be representative of a large UPS delivery truck size. A T6 Instate Small Diesel Truck is considered to be a conservative “average” delivery truck class representative of all delivery trucks at the RBC as it represents the upper end of the weight range anticipated for institutional facility deliveries. The on-road truck travel emission factor was multiplied by the number of trips and the miles per trip determined for each scenario. Although delivery trucks will likely turn off their engines when reaching their destination at the RBC, onsite delivery truck idling emissions are conservatively estimated for a maximum of 5 minutes of idling per trip (consistent with California’s Air Toxic Control Measure to limit diesel-fueled commercial motor vehicle idling).

Emission calculations were separated into onsite and offsite to facilitate the use of the emission estimates for modeling. Offsite vehicle trip distance of 7.3 miles per trip for the delivery trucks was taken from CalEEMod Appendix D Table 4.2 "Mobile Trip Characteristics Dependent on Location", for the Bay Area AQMD region. Delivery truck route is based on the urban commercial-NW category.

Trip lengths in CalEEMod are one way, so the value was doubled to account for round-trips. The onsite roundtrip distances discussed in the following subsections were subtracted from the offsite vehicle trip distance, which includes the onsite distance.

2.2.5.1 Phase 1

Onsite roundtrip distances for delivery trucks were based on the assumption that the trucks would enter on Seaver Avenue, and proceed onsite along 47th Street on the east side of the RBC properties to either of the two Phase 1 parking lots. Idling emissions were assumed to occur in or near the parking lots. Criteria pollutants and GHG emission estimates are provided in Appendix E Tables E-2 to E-4 for exhaust emissions and Tables E-6 to E-7 for road dust emissions, and TAC emission estimates are also provided in Appendix E Tables E-2 to E-4.

2.2.5.2 Full LRDP

Onsite routes were chosen based on the assumption that approximately one third of the total delivery trucks would service the western portion of campus, one third of the total delivery trucks would travel along the north-south campus service access round, and one third of the total delivery trucks would travel along the east campus access road. An average onsite trip length was calculated by averaging the onsite road segment lengths travelled by delivery trucks. Criteria pollutant and GHG emission estimates are provided in Appendix F Tables F-2 to F-4 for exhaust emissions and Tables F-6 to F-7 for road dust emissions, and TAC emission estimates (PM_{10} Exhaust = DPM) are also provided in Appendix F Tables F-2 to F-4.

2.2.6 Employee/Visitor Vehicles

Criteria pollutant emissions from employee and visitor vehicles travelling to the RBC site were estimated using emission factors (emissions per vehicle mile travelled) taken from the CARB EMFAC2011 emissions model for the LDA vehicle class.

Criteria pollutant emissions associated with cold starts, diurnal evaporative, hot soak evaporative, and resting losses were estimated using emission factors (emissions per vehicle per day) were also taken from the CARB EMFAC2011 emissions model for the LDA vehicle class.

Similar to delivery trucks, emission calculations were separated into onsite and offsite to facilitate the use of the emission estimates for modeling. The employee offsite vehicle trip distance was calculated according to the methodology outlined in CalEEMod Appendix A Section 5.1, Vehicle Trips, which states "The average VMT associated with a trip is adjusted by modifying the primary trip length to account for the reductions from pass-by and diverted trips". The primary trip length of 12.4 miles was taken from CalEEMod Appendix D Table 4.2 "Mobile Trip Characteristics Dependent on Location", for the Bay Area AQMD region. Employee vehicle route is based on the Home to Work (H-W) category. The primary trip percentage, diverted trip percentage, and pass-by trip percentage values were taken from CalEEMod Appendix D Table 4.3 "Mobile Trip Rates, Trip Purpose, Trip Type by Land Use" for the Commercial Land Use Type, and Research and Development Land Use Sub Type. The calculated modified trip length is 10.6 miles.

Trip lengths in CalEEMod are one way, so the value was doubled to account for round-trips. The onsite roundtrip distances discussed in the following subsections were subtracted from the offsite vehicle trip distance, which includes the onsite distance.

2.2.6.1 Phase 1

The onsite portion of the employee vehicle trips (for assignment to onsite source representations in the dispersion modeling) for Phase 1 was based on a conservative estimate of potential trip lengths on the

RBC site (0.7 miles round-trip) coming in on 47th Street along the eastern boundary of the RBC property, then into the RBC site just north of the Phase 1 parking lots. Criteria pollutant and GHG emission estimates are provided in Appendix E Tables E-2 to E-5 for exhaust emissions and Tables E-7 to E-8 for dust emissions, and TAC emission estimates are provided in Appendix E Tables E-12 to E-13.

2.2.6.2 Full LRDP

The onsite average trip distance used to estimate onsite employee vehicle emissions for the full LRDP was calculated by apportioning traffic to each road segment based on the number of parking spaces available in the parking structures being served by the onsite roads. A detailed accounting of the allocation is provided in Table F-26. The fraction of traffic for each road segment is multiplied by the road segment length, resulting in a "length fraction" for each road segment. The sum of the individual length fractions is the average onsite distance used to estimate onsite employee vehicle emissions. This distance represents the distance travelled by 100% of the employee vehicles while onsite. Criteria pollutant and GHG emission estimates are provided in Appendix F Tables F-2 to F-5 for exhaust emissions and Tables F-6 to F-7 for road dust emissions, and TAC emission estimates are provided in Appendix F Tables F-12 to F-13.

2.2.7 Shuttles

Information on shuttle routes and schedules was provided by The University. Two shuttle routes will service the RBC. One route will travel between the main LBNL campus and the RBC. The other route will travel between the El Cerrito Plaza Bay Area Rapid Transit (BART) station and the RBC. Shuttles will be equivalent to a Ford E150 XLT 15 passenger van. Based on the vehicle specifications, the EMFAC vehicle class chosen to represent the shuttles is Medium-Duty Trucks (5,751 – 8,500 lbs, gasoline fueled), or MDV.

2.2.7.1 Phase 1

Shuttle route and schedule information for Phase 1 are provided by The University. The quantitative shuttle assumptions are provided in Appendix E, Table E-1. Criteria pollutants and GHG emission estimates are provided in Appendix E Tables E-2 to E-4 for exhaust emissions and Tables E-6 to E-7 for road dust emissions, and TAC emission estimates are provided in Appendix E Tables E-14 to E-15.

2.2.7.2 Full LRDP

The shuttle route and schedule information remains unchanged from Phase 1. Criteria pollutant and GHG emission estimates are provided in Appendix F Tables F-2 to F-4 for exhaust emissions and Tables F-6 to F-7 for road dust emissions, and TAC emission estimates are provided in Appendix F Tables F-14 to F-15.

2.2.8 Indirect Greenhouse Gas Emission Sources

Indirect GHG emissions were estimated utilizing multiple methodologies. Emissions due to the generation of electricity used by the facility were estimated by multiplying the electricity demand of the project when constructed (provided by The University) by a CO_2 intensity factor, published by PG&E, the local utility. The intensity factor is for the year 2018, which is the first year of operation for Phase 1. Indirect emissions due to water use, wastewater treatment, and solid waste disposal, were generated using CalEEMod, which estimates the emissions based on region-specific emissions data. Where available, project-specific water usages provided by The University were used as inputs into the model. The remaining indirect GHG emissions generated were estimated using CalEEMod default values. Appendix H contains the Phase 1 indirect GHG emission data. Full LRDP indirect GHG emission data is provided in Appendix I.

2.2.8.1 Phase 1

Indirect GHG emissions estimated using CalEEMod for Phase 1 are based on a RBC population of 1,000 employees and Phase 1 building space of 600,000 gsf, as outlined in the project description.

2.2.8.2 Full LRDP

Indirect GHG emissions estimated using CalEEMod for the Full LRDP are based on a RBC population of 10,000 employees and occupiable building space of 5,100,000 gsf, as outlined in the project description.

In order to compare these emissions to the BAAQMD GHG thresholds, credit was taken for the reduction in natural gas usage by the 667 employees that will transfer to the RBC from the hill campus. It is assumed that these employees will not be replaced at the hill campus, so the GHG emissions attributable to the transferring employees will "offset" their portion of the emissions occurring due to the operation of the proposed facilities at the RBC. Offsets were similarly accounted for in comparing indirect GHG emissions due to electricity usage and employee vehicle trips. Offsets are assumed for employee vehicle trips because the transferring employees would already be making their commute and trips, so these emissions are not attributable to the project. It is estimated that over 2,000 trips per day will occur at RBC at an estimated population increase of 1,000 employees, so it is assumed that there are two trips per employee. Offsets from stationary sources (direct GHG emissions) were also accounted for by multiplying the total stationary GHG emissions by the ratio of offset fuel usage to total fuel usage. A detailed accounting of the GHG offsets is shown in Appendix J.

2.3 Cumulative Sources

Emissions of $PM_{2.5}$ and TACs were also needed for the cumulative impact assessments for ambient $PM_{2.5}$, excess cancer risk, and chronic hazard. Impacts from other existing cumulative sources were provided by the BAAQMD as discussed further in Section 4.4; calculation of emission rates was not necessary for inclusion of these sources in the cumulative impact assessments.

2.3.1 Existing Richmond Field Station Sources

Data were provided by the University for existing $PM_{2.5}$ and/or TAC emission sources at the Richmond Field Station that would likely still be present after completion of the Phase 1 and/or illustrative LRDP development. These sources can be summarized as follows:

- Existing standby generator and diesel fire pump engine at Building 400
- Existing standby generator at Building 194 (not in full LRDP build-out)
- Laboratory emissions at Buildings 154, 158, 167, 450, 473, 474, 478, and 480 (not in full LRDP build-out except at Building 400)
- Natural gas boilers at Buildings 400, 451, 452, 454, 472, 477, 478, 480, and 484 (not in full LRDP build-out)
- Emissions from off-road mobile diesel vehicles used for site maintenance (level of activity doubled for full LRDP build-out)
- Gasoline dispensing from on-site storage tank (throughput doubled for full LRDP build-out)

Emissions for these sources were estimated using the same methods discussed in Section 2.2 above. The only new source type was gasoline dispensing; emissions for this source were estimated using methods developed by the South Coast Air Quality Management District.[5]

The emission calculations for these sources are provided in Appendix K (non-laboratory emission sources) and Appendix L (laboratory emissions).

2.3.2 Next-Phase Sources

In order to include potential cumulative impacts from all reasonably foreseeable emission sources, The University also provided information on potential development beyond Phase 1 (i.e. additional development under the Illustrative Development Scenario). This development included:

- Adding two additional office/research and development buildings in the Illustrative Development Scenario (Buildings 10 and 11).
- Adding one parking garage in the Illustrative Development Scenario (P1).
- Increasing the assumed onsite population from 1,300 to 1,700.

[5] Currently published at http://www.aqmd.gov/aer/Updates/GuideExManuallyRptTankEmis.pdf.

Since Phase 1 construction/demolition represents the highest level of such activity in the LRDP, construction/demolition was not considered for the development of the next-phase sources (called Phase 2 development for purposes of this report).

Phase 2 source emissions were most easily estimated by adding to the Phase 1 emissions inventory. Additionally, dispersion modeling of Phase 2 sources was accomplished by adding them to the cumulative models for Phase 1. As a result, the emissions estimates for Phase 2 sources are included in the emissions inventory tables provided in Appendix M, which includes both Phase 1 and Phase 2 emission sources for operations.

3.0 DISPERSION MODELING METHODOLOGY

3.1 General

Dispersion modeling was performed as part of the air quality impact analysis for the Project in order to perform HHRA estimates. The dispersion modeling was used along with TAC emission estimates in the CARB HotSpots Analysis and Reporting Program (HARP) On-Ramp software to produce annual and hourly TAC concentrations at specified model receptor locations as input to the HARP risk assessment model.

3.1.1 Dispersion Model Used

The EPA AERMOD dispersion model (version 12345) was used for this analysis using the regulatory default options. The model was executed using source representations, meteorological data, terrain data, and building dimensions as described in following sections.

3.1.2 Source Representations

Numerical source representations were used to model the release of TACs from one or more emission points. These source representations are summarized for Phase 1 in Table 3-1 (construction and demolition) and Table 3-2 (operations), for the LRDP in Table 3-3 (construction and demolition) and Table 3-4 (operations), and for cumulative sources in Table 3-5 ("Phase 2" operations) and Table 3-6 (existing Richmond Field Station operations), and are discussed in the following sections.

3.1.2.1 Construction and Demolition

Source locations for modeling emissions from construction and demolition activities in Phase 1 are presented in Figure 3-1. Source locations for modeling emissions from construction and demolition activities in the LRDP are presented in Figure 3-2 (for annual maximum impacts) and Figure 3-3 (for lifetime cancer risk impacts). The following subsections describe the parameters used to represent sources of emissions in the dispersion modeling for construction and demolition activities.

3.1.2.1.1 Onsite Off-Road Mobile Sources

Emissions from off-road mobile equipment associated with construction and demolition activities (e.g. excavators, graders, loaders, dozers, etc.) will consist of both $PM_{2.5}$ emissions associated with fugitive dust and DPM emissions from engine tailpipes. For purposes of dispersion modeling, consistent with 2011 BAAQMD CEQA guidance, only engine tailpipe emissions were modeled.

Because emissions from mobile equipment would occur over a given area travelled by the equipment over the averaging period being assessed, an area polygon source representation was used in the model. The area polygon source was set with a release height of 1.5 meters and an initial vertical dispersion of one meter to account for the initial velocity and turbulence associated with the release.

For Phase 1, the area polygon source representing exhaust emissions from construction and demolition activities (source ID P1_EXHST) was placed on the southern edge of the developed area at the site (see Figure 3-1). The area polygon source included areas of demolished buildings, newly constructed buildings, and newly constructed roads.

Three different source representations were used to represent construction and demolition activities in the full LRDP scenario. Dispersion modeling conducted for resident chronic hazard and annual $PM_{2.5}$ assessments assumed a single area source (source ID AREA7). The area source represents the construction and demolition activities that could possibly occur in one year since these assessments are based on a "worst case" annual simulation. This size of the area source was based on the total area of construction and demolition activities over the entire LRDP period, divided by the number of years that construction and demolition would occur. Several different locations within the facility property were assessed in order to determine the worst-case location of the area source. Of the 11 locations assessed, AREA7 was determined to result in the highest offsite concentrations at resident receptor locations. The locations of sources used for resident chronic hazard assessments are presented in Figure 3-2.

Similarly, for worker chronic hazard assessments, a different area source was used to represent emissions form construction and demolition activities (source ID AREA3). Of the 11 locations assessed, AREA3 resulted in the highest offsite concentrations at worker receptor locations. The locations of sources used for offsite worker chronic hazard assessments are presented in Figure 3-3.

To assess excess cancer risk, the entire area over which construction and demolition activities would occur during the full LRDP were modeled using three area sources. The roads included in this model were all the perimeter roads in the full LRDP as it was assumed that all of the roads would be used to access areas of construction and demolition at some point within the full LRDP period. The locations of the area sources are presented in Figure 3-4.

3.1.2.1.2 Offsite/Onsite On-Road Mobile Sources

Emissions from offsite and onsite on-road vehicles will consist of both $PM_{2.5}$ emissions associated with fugitive dust and DPM emissions from engine tailpipes. For purposes of dispersion modeling, consistent with 2011 BAAQMD CEQA guidance, only engine tailpipe emissions were modeled. Emissions will occur along both on-site and off-site roads.

To represent emissions occurring during vehicle travel along roads, line sources consisting of a series of volume sources placed along the road were used. Line sources were defined consistent with the methodology presented in the EPA memo dated March 2, 2012, titled "Haul Road Workgroup Final Report Submission to EPA-OAQPS" (Haul Road Memo), a conservative approach to representing tailpipe emissions. An assumed average vehicle height of 2 meters was used in defining the line sources. Roads

were either defined as being 7 meters wide (narrow roads) or 15 meters wide (wide roads). All roads were assumed to be two lane roads.

Lines source lengths were consistent with the methodology used to estimate emissions from haul truck travel over roads (see Section 2.1.3).

For Phase 1 and the full LRDP, wide road line sources were placed along Meade Street from both the north and south approach to Seaver Avenue. Narrow road line sources were then used along all other roads (see Figure 3-1 for Phase 1 source locations, and Figures 3-2, 3-3, and 3-4 for full LRDP source locations).

Source parameters for the volume line sources used to represent emissions from on-road mobile sources are presented in Table 3-1 (Phase 1 source parameters) and Table 3-3 (full LRDP source parameters).

3.1.2.2 Operations

Source locations for modeling emissions from operation of Phase 1 sources are presented in Figure 3-5 Source locations for modeling emissions from operation of sources in the full build-out of the LRDP are presented in Figure 3-6. The following subsections describe the parameters used to represent sources of emissions in the air dispersion model.

3.1.2.2.1 Boilers

Natural gas boiler emissions were simulated as point sources. Boiler emissions are described above in Section 2.2.1 and were associated with individual buildings. Conservative stack parameters were compiled based on previous studies conducted by Golder as follows:

Parameter	Value
Height	3.05 meters (10 feet) above building height
Diameter	Adjusted to maintain exit velocity at 4.95 meters per second
Velocity	4.95 meters per second (16.2 feet per second)
Temperature	366.5 °K (200 °F)

The diameter adjustment made to each boiler was based on data acquired for a 12 MMBtu per hour natural gas boiler with a 0.46 meter stack diameter achieving a 4.95 meter per second exhaust velocity. The adjusted diameter for other boilers assumed that the exhaust stack cross-sectional area was proportional to maximum boiler heat input.

3.1.2.2.2 Emergency Generators

Emergency generator exhaust emissions were simulated as point sources. Emergency generator emissions are described above in Section 2.2.2 and were associated with individual buildings. Each building was assigned one or two emergency generators. Since actual emergency generator stack parameters were not available, conservative stack parameters were used for all emergency generators, and were based on the projected size of the emergency generator

The release parameters for all emergency generators are included in Table 3-2 for Phase 1 and Table 3-4 for the LRDP. Emergency generator source locations are shown in Figure 3-5 for Phase 1 and in Figure 3-6 for the LRDP.

3.1.2.2.3 Laboratory Fume Hood Exhausts

Laboratory fume hood exhaust emissions were simulated as point sources. Laboratory emissions are described above in Section 2.2.3 and were associated with individual buildings. Each building was assigned one laboratory stack, and all TAC emissions for that building were allocated to the associated stack. Since actual laboratory stack parameters were not available, conservative parameters were used for all laboratory stacks as follows:

Parameter	Value
Height	3.05 meters (10 feet) above building height
Diameter	1.0 meters (3.28 feet)
Velocity	10 meters per second (32.8 feet per second)
Temperature	293.15 °K (68 °F)

The release parameters for all laboratory stacks are included in Table 3-2 for Phase 1 and Table 3-4 for the LRDP. Laboratory stack source representation locations are shown in Figure 3-5 for Phase 1 and in Figure 3-6 for the LRDP.

3.1.2.2.4 Cooling Towers

Cooling tower exhaust emissions were simulated as point sources. Cooling tower emissions are described above in Section 2.2.4 and were associated with individual buildings. Each building was assigned a number of cooling tower sources depending on the size of the building. All TAC and $PM_{2.5}$ emissions for that building were divided equally among the associated cooling tower stacks. Since actual cooling tower stack parameters were not available, conservative parameters were used for all cooling tower stacks as follows:

Parameter	Value
Height	6.10 meters (20 feet) above building height
Diameter	2.5 meters (8.2 feet)
Velocity	10 meters per second (32.8 feet per second)
Temperature	10 °C (18 °F) above ambient

The release parameters for all cooling tower stacks are included in Table 3-2 for Phase 1 and Table 3-4 for the LRDP. Cooling tower source locations are shown in Figure 3-5 for Phase 1 and in Figure 3-6 for the LRDP.

3.1.2.2.5 Offsite/Onsite On-Road Mobile Sources

Emissions from offsite and onsite on-road mobile sources were represented using a series of volume sources along the road. The source representations were developed using the same methodology discussed previously in Section 3.1.2.1.2.

Source parameters for the volume line sources used to represent emissions from on-road mobile sources are presented in Table 3-2 (Phase 1 source parameters) and Table 3-4 (full LRDP source parameters). Source locations are presented in Figure 3-5 for Phase 1 and Figure 3-6 for full LRDP.

3.1.2.3 Cumulative Source Operations

Dispersion model source representations for existing emission sources at the Richmond Field Station described in Section 2.3.1 above are provided in Table 3-5.

Dispersion model source representations for emission sources included in the “Phase 2” development described in Section 2.3.2 above are provided in Table 3-6.

3.1.3 Meteorological Data

Meteorological data for use in the AERMOD dispersion model were obtained by processing data provided by the BAAQMD, which include on-site, surface, and upper air meteorological data as well as surface characterization data from the EPA AERSURFACE model. The meteorological data provided by BAAQMD covered the period beginning on January 1, 2003 through December 31, 2006 and all of the 2008 calendar year (meteorological period). Data were not provided for the 2007 calendar year due to low data quality.

The latest version of AERMET (version 12345) was used to process the data provided by the BAAQMD and generate AERMOD-ready meteorological files (both *.SFC and *.PFL files). The meteorological data processing was conducted in accordance with the guidance provided by the BAAQMD[6].

A wind rose for the meteorological period is provided in Figure 3-7.

3.1.3.1 On-site Meteorological Data

On-site data were collected at the "UC Richmond" meteorological station operated by the BAAQMD. These data were provided in space-delimited text files for the meteorological period. The BAAQMD provided the necessary FORTRAN "read" and "format" statements required by AERMET to process on-site data. The on-site data included the following:

- Station atmospheric pressure,
- Solar radiation (insolation),
- Temperature,
- Wind speed,
- Wind direction,
- Relative humidity,
- Dew point temperature, and
- Standard deviation of the horizontal wind direction (sigma theta).

3.1.3.2 Surface Meteorological Data

Surface meteorological data from the Oakland International Airport were provided by the BAAQMD for the meteorological period. Data were provided in the Integrated Surface Hourly Data (ISHD) format. Additional surface data were needed since the on-site data did not include cloud cover readings, required by AERMET to process the parameters in the on-site data set.

Consistent with BAAQMD guidance, missing on-site data (other than cloud cover) were not substituted with surface data from Oakland.

3.1.3.3 Upper Air Meteorological Data

Upper air meteorological data from the Oakland International Airport were provided by the BAAQMD for the meteorological period. Upper air data are used to determine temperature gradients and wind data governing plume dispersion in the AERMOD model at higher elevations above ground level. Data were provided in the Forecast Systems Laboratory (FSL) format. Consistent with BAAQMD guidance, the "MODIFY" keyword was not used when processing upper air data; this use of this keyword would otherwise have AERMET make certain modifications to the upper air data related to soundings at specific

[6] BAAQMD Guidance for meteorological data processing provided by James Cordova via email on January 28, 2013.

heights, wind directions during hours with zero wind speed, and interpolation of missing ambient and dew point temperatures as the data are read in.

3.1.3.4 AERSURFACE

The land use characteristics surrounding the UC Richmond meteorological station were provided by the BAAQMD. The BAAQMD executed the EPA AERSURFACE program (version 08009) for each year of the meteorological period. AERSURFACE was used to generate monthly values for albedo, Bowen ratio, and surface roughness heights. The BAAQMD provided AERSURFACE output files which were used by AERMET directly. There were no changes to the AERSURFACE output files provided by the BAAQMD.

3.1.4 Modeling Domain Terrain Data

Terrain elevation data was taken from Digital Elevation Model (DEM) data produced by the U.S. Geological Survey. DEM files with a 7.5 minute (30 meters) resolution were used to determine elevations of receptors and base elevations of downwash structures and sources.

3.1.5 Building Downwash

Building downwash affecting point source emissions was accounted for using the EPA Building Profile Input Program (BPIP) software (version 04274). Building structures within 5L of any point source representation in the model (where L is the lesser of the building height or maximum projected width) were included in the BPIP analysis. The BPIP program generates direction-specific downwash parameters for each point source that are then input to the AERMOD model (AERMOD only accounts for building downwash for point source representations).

Dispersion modeling of construction and demolition emissions for both the Phase 1 and LRDP scenarios did not include any point sources. Since AERMOD only accounts for building downwash for point sources, downwash was not assumed in construction and demolition dispersion modeling.

Downwash structures defined for the dispersion modeling of the Phase 1 operations scenario are presented in Figure 3-8, with the height of each structure detailed in Table 3-5. Downwash structures defined for the dispersion modeling of the LRDP Operations scenario are presented in Figure 3-9, with the height of each structure detailed in Table 3-6.

3.2 Human Health Risk Assessment Modeling

Potential human health risk assessment impacts were evaluated for the construction and operation phases of the Phase 1 and full LRDP build-out using the methodologies detailed below.

3.2.1 Assessments Performed

The following receptor-based human health impact assessments were performed based on exposure point concentrations determined by air pollutant dispersion modeling:

Construction/Demolition Activities

- LECR (for offsite residential receptors)
- LECR (for offsite occupational worker receptors)
- LECR (for onsite occupational worker receptors [Phase 1 only[7]])
- Chronic hazard (for offsite residential receptors)
- Chronic hazard (for offsite occupational worker receptors)
- Chronic hazard (for onsite occupational worker receptors [Phase 1 only[8]])
- $PM_{2.5}$ annual average (offsite residential receptors)

Acute impacts were not assessed for construction/demolition activities since the primary TAC emitted is DPM, and CARB has indicated that the majority of the potential toxicity from DPM is captured in the chronic assessments (CARB 2003).

These assessments included all TAC emission sources discussed in this section.

Operation Activities

- LECR (for offsite residential receptors)
- LECR (for offsite occupational worker receptors)
- LECR (for onsite occupational worker receptors)
- Chronic hazard (for offsite residential receptors)
- Chronic hazard (for offsite occupational worker receptors)
- Chronic hazard (for onsite occupational worker receptors)
- Acute hazard (for offsite receptors)
- Acute hazard (for onsite receptors)
- $PM_{2.5}$ annual average (offsite residential receptors)

These assessments were conducted for the site configuration evaluated after completion of either the Phase 1 or full LRDP build-out.

[7] For the full LRDP build-out, it was not possible to represent the full range of locations where construction might be occurring overlaid with the range of locations where occupational workers in onsite buildings might be present. Onsite source-receptor geometries will change during every year of development in ways not currently known with any certainty.

[8] Ibid.

These assessments included all TAC emission sources discussed in this section.

3.2.2 Receptor Grids

The receptors in the AERMOD model were placed in locations representing the types of human receptors identified in the previous section. The locations of these receptors were determined as follows:

3.2.2.1 Offsite Residential Receptors

Offsite residential receptors were located based on data purchased from the Contra Costa County Assessor's Office. Parcel Point data were extracted by County staff, and included X-Y data elements with associated land use codes. The land use codes were used to define each element. Based on the land use codes, school parcels that were play areas or open spaces, and vacant lots were removed from the data array. An example of the offsite residential is presented in Figure 3-10.

3.2.2.2 Offsite Occupational Worker Receptors

The offsite occupation receptor grid was generated by first constructing a tiered Cartesian grid, centered on the facility, with the following dimensions:

- 1,800 by 1,800 meters with receptors spaced 25 meters apart,
- 3,000 by 3,000 meters with receptors spaced 150 meters apart, and
- 5,000 by 5,000 meters with receptors spaced 250 meters apart.

Receptors were removed from within the RBC property line, including the area extending out to the opposite side of adjacent roads to the facility property. Where sources were used to simulate emissions from vehicles traveling on roadways extending out from the property, receptors were removed from the roadways and adjacent areas that did not include structures (parking lots, freeway medians, sidewalks, tidal marshlands, etc…). Based on the difference in modeled roadways between the Phase 1 and LRDP scenarios, two different offsite occupational worker receptors grids were generated using the same methodology as just described. An example offsite occupational worker receptor grid is presented in Figure 3-11.

3.2.2.3 Onsite Occupational Worker Receptors

The onsite occupation receptor grid was generated by first constructing a Cartesian grid of discrete receptors spaced 10 meters apart. Receptors were removed from areas that would not be occupied by occupational workers.

For Phase 1, receptors were left on buildings immediately adjacent to the Phase 1 area. These buildings are existing, would not be part of the Phase 1 development, and would be occupied during both the construction/demolition and operation scenarios for Phase 1. The onsite occupational receptor grid used for Phase 1 modeling scenarios is presented in Figure 3-12

For the full LRDP operations scenario, receptors were placed on occupied downwash structures (buildings) that will be constructed in the future. Receptors were not placed on downwash structures that will not be occupied, such as parking garages. Figure 3-13 presents the onsite occupational receptor grid used for LRDP modeling. The blue outlines define the downwash structures.

Onsite occupational worker receptors were not evaluated for construction/demolition activities for the post-Phase 1 portion of the LRDP because the exact timing of building construction and demolition is unknown, so it's not possible to know what buildings might be present near construction/demolition activities after the completion of Phase 1.

3.2.2.4 Offsite Acute Receptors

The offsite acute receptor grid was generated using the same general methodology used to generate the offsite occupational worker receptor girds, previously discussed in Section 3.2.2.2. First a tiered Cartesian grid was constructed, centered on the facility, with the following dimensions:

- 1,800 by 1,800 meters with receptors spaced 25 meters apart,
- 3,000 by 3,000 meters with receptors spaced 150 meters apart, and
- 5,000 by 5,000 meters with receptors spaced 250 meters apart.

Receptors were removed from within the facility property line. Receptors were not removed from areas that the public could be reasonably expected to access. In Phase 1, a public road bisected the facility property. Rectors were retained along this roadway since the public could be reasonably expected to access it. The offsite acute receptor grid used in the Phase 1 modeling is presented in Figure 3-14.

In the full LRDP scenario, the road bisecting the facility property will be removed as part of the site development plan. The receptors used in the Phase 1 modeling along this road have been removed from the receptor grid used in the LRDP modeling. This acute offsite receptor grid used in the full LRDP modeling is presented in Figure 3-15.

3.2.2.5 Onsite Acute Receptors

The onsite acute receptor grid was generated using the same general methodology used to generate the onsite occupational worker receptor girds, previously discussed in Section 3.2.2.3. A Cartesian grid of discrete receptors spaced 10 meters apart was constructed. Receptors were removed from areas outside of the facility property boundary and areas where the public could reasonably access. The onsite acute receptor grid used in Phase 1 modeling is presented in Figure 3-16. The onsite acute receptor grid used in the full LRDP modeling is presented in Figure 3-17.

3.2.2.6 $PM_{2.5}$ Sensitive Receptors

The receptor grid used in dispersion modeling of $PM_{2.5}$ emissions was the same grid previously discussed in Section 3.2.2.1 for offsite residential receptors.

3.2.3 HARP Model

AERMOD dispersion modeling was conducted using unit emission rates for each source adjusted consistent with guidance provided with the CARB HARP On-Ramp software. The HARP On-Ramp program generated a matrix of unit emission rate ground level concentrations for each emission source included in the AERMOD model.

The CARB HARP software (Version 1.4f) then multiplied actual estimated annual or hourly emission rates for each source and TAC by the unit emission rate value in the HARP On-Ramp matrix to produce source- and TAC-specific modeled concentrations (exposure point concentrations) for use in the risk assessment calculations. The HARP software accessed the most recent HARP health database (database of dose-response factors provided by CARB) to convert TAC concentrations to estimated LECR or chronic/acute health hazard.

3.2.3.1 Breathing Rate

For LECR calculations for residential receptors, the "*Derived (Adjusted)*" method based on the 80th percentile breathing rate was used as recommended by CARB and OEHHA.[9] All other assessments used the default HARP assessment methodology for breathing rate.

3.2.3.2 GLC Adjustment Factor

For chronic assessments, the HARP model by default will assume that the receptors are exposed to the annual average concentration resulting from source emissions, even if those emissions are periodic throughout the day. As discussed in the HARP user's guide, a ground level concentration (GLC) adjustment factor should be used for chronic assessments of occupational worker exposure when the source emissions are not constant during each hour of each day of the year. Since construction/demolition and operation activities are not expected to occur 24 hours per day or 7 days per week, such an adjustment factor should be used.

A conservative factor was based on an assumption of 12 hours of operation per day and 5 days per week (note that for activities occurring over more than 12 hours per day or 5 days per week, the GLC adjustment factor would actually be lower). If exposed occupational workers are conservatively estimated to work only 8 hours per day and 5 days per week (overlapping with the 5 days that the Project could be operating), a worst-case GLC adjustment factor can be estimated as follows:

[9] Interim Policy: http://www.arb.ca.gov/toxics/harp/rmpolicyfaq.htm.

(24 hrs/day)/(12 hrs/day) x (7 days/week)/(5 days/week) = 2.8

This GLC adjustment factor was used for all chronic HARP assessments for occupational worker exposure.

3.2.3.3 Exposure Pathways

In all HARP model runs, the inhalation exposure pathway was assessed. In addition, the following non-inhalation exposure pathways were allowed with default parameters:

- Ingestion of home-grown produce (residents only)
- Dermal absorption from soil
- Ingestion of soil
- Ingestion of mother's milk

These were estimated to be the only significant non-inhalation exposure pathways that might be influenced by the maximum ambient air impacts from Project TAC emissions, and would only be applicable to those TACs considered by the HARP model to be multipathway pollutants.

3.2.4 Application of Age Sensitivity Factors

Consistent with BAAQMD risk assessment guidance (BAAQMD 2012), age sensitivity factors were considered when estimating LECR for residential receptors. These factors represent multiplicative coefficients to the carcinogenic effect due to exposure to TACs assumed to be human carcinogens. These factors are applied as follows:

- Factor of 10 for exposure during the third trimester of pregnancy to two years of age.
- Factor of 3 for exposure occurring from age two through age 15.

All subsequent years of exposure have presumed cancer risk effects that are unmodified from that suggested by the unit risk factor associated with the carcinogen.

For the assumed 70 year exposure duration used for estimating LECR for project operations, this simply results in applying a weighted age sensitivity factor of 1.7 to the LECR value determined by the HARP model.

In the case of construction/demolition activities, the age sensitivity factors were applied year-by-year to the weighted contributions to LECR predicted by the HARP model based on emissions for that year. For example, Phase 1 construction/demolition activities were estimated to occur over a period of two years; emissions for each of these years were estimated separately. However, the HARP model output for each

of these two years' emissions assumes 70 years of exposure, so LECR is over-predicted by a factor of 70 for each year. Therefore, the contribution to LECR from each year of exposure is calculated as:

[Age Sensitivity Factor (Year i)] x [HARP LECR (Year i]) / 70

The calculated values from each year of exposure were then summed to obtain the total LECR.

For each of the two years of Phase 1 construction/demolition, the age sensitivity factor was 10. For purposes of the LECR estimates, it was estimated that full implementation of Phase 1 would take four years.

In the case of construction/demolition activities for the full LRDP build-out, it was estimated that there would be an additional 32 years of construction/demolition emissions (years 5 through 36). This results in a total age sensitivity factor of (56.5/70) = 0.81 applied to the HARP LECR value (which is based on 70 years of exposure to the LRDP emission level and includes no age sensitivity factors). Unlike Phase 1, emissions from construction/demolition activities for the remainder of the LRDP build-out were assumed to be the same for each year.

Because Phase 1 is part of the full LRDP build-out, the LECR for the full LRDP was calculated as the sum of the LECR from Phase 1 and the LECR for the remainder of the LRDP.

4.0 ASSESSMENT RESULTS

This section presents the results of the assessments performed for this report. Although this section does not compare the results to any specific thresholds of significance that might be applicable under CEQA (leaving these comparisons to the overall impact reports prepared for this program), the results are presented in formats that are likely to be comparable to such thresholds that might be used. In particular, an effort has been made to present results in formats that would be comparable to CEQA significance thresholds published by the BAAQMD in 2011, which may be used for this project.

4.1 Criteria Pollutant Impacts

Criteria pollutant emissions from the construction and operation phases of the Phase 1 and full LRDP build-out were estimated as described in Section 2.0 above. These emissions are summarized in this section for ease of comparison to potential thresholds of significance.

4.1.1 Phase 1 Construction

Criteria pollutant emissions from Phase 1 construction activities are summarized in Table 4-1 by source category for the single year estimated to have the highest emissions. Emissions are provided on an annual total tonnage and average pound per day basis. PM_{10} and $PM_{2.5}$ average pounds per day include only exhaust emissions, consistent with thresholds of significance provided by the BAAQMD in 2011.

Emissions in this table are associated with tailpipe emissions from on-road vehicles and off-road equipment.

4.1.2 Phase 1 Operations

Criteria pollutant emissions from Phase 1 operations are summarized in Table 4-2 by source category for operations anticipated after completion of Phase 1. Emissions are provided on an annual total tonnage and average pound per day basis.

The majority of the criteria pollutant emissions in this table are from onsite boilers, onsite/offsite on-road vehicle tailpipe emissions, and onsite/offsite fugitive road dust.

4.1.3 LRDP Construction

Criteria pollutant emissions from full LRDP build-out construction activities are summarized in Table 4-3 by source category for a typical year. Emissions are provided on an annual total tonnage and average pound per day basis. PM_{10} and $PM_{2.5}$ average pounds per day include only exhaust emissions, consistent with thresholds of significance provided by the BAAQMD in 2011.

Emissions in this table are associated with tailpipe emissions from on-road vehicles and off-road equipment.

4.1.4 LRDP Operations

Criteria pollutant emissions from full LRDP build-out operations are summarized in Table 4-4 by source category for operations anticipated after completion of the LRDP. Emissions are provided on an annual total tonnage and average pound per day basis.

The majority of the criteria pollutant emissions in this table are from onsite boilers, onsite/offsite on-road vehicle tailpipe emissions, and onsite/offsite fugitive road dust.

4.2 Human Health Impacts

TAC and maximum annual average $PM_{2.5}$ emissions from the construction and operation phases of the Phase 1 and full LRDP build-out were estimated as described in Section 2.0 above. These emissions were used to complete air quality dispersion modeling assessments as described in Section 2.0 above to estimate maximum potential ambient concentrations at appropriate sensitive receptor sites. In the case of TACs, these concentrations were used in the CARB HARP model to estimate maximum LECR, chronic hazard, and acute hazard where appropriate.

4.2.1 Phase 1 Construction

Modeled maximum annual $PM_{2.5}$ concentrations, LECR, and chronic hazard from Phase 1 construction activities are summarized in Table 4-5 for the single year estimated to have the highest emissions (except for LECR, which was based on total exposures over the multi-year Phase 1 construction period). Acute hazard impacts were not estimated, as the primary source of TAC emissions for this scenario come from diesel engines, the toxicity of which is adequately represented through the LECR and chronic hazard assessments (CARB, 2003).

The primary contributor to LECR, chronic hazard, and $PM_{2.5}$ results in this table is from DPM from onsite off-road diesel equipment tailpipe emissions.

4.2.2 Phase 1 Operations

Modeled maximum annual $PM_{2.5}$ concentrations, LECR, chronic hazard, and acute hazard from operations anticipated after completion of Phase 1 are summarized in Table 4-5.

The primary contributors to LECR in this table are from small quantities of 7,12-dimethylbenz[a]anthracene and hexavalent chromium emissions from natural gas boilers, and DPM emissions from diesel generators and on-road delivery trucks.

The primary contributors to chronic hazard in this table are from small quantities of arsenic and nickel from onsite boilers and on-road vehicle exhaust.

The primary contributor to acute hazard in this table is from nitrogen dioxide emissions from onsite boilers.

The primary contributor to $PM_{2.5}$ concentrations in this table are from onsite/offsite on-road vehicle travel.

4.2.3 LRDP Construction

Modeled maximum annual $PM_{2.5}$ concentrations, LECR, and chronic hazard from full LRDP build-out construction activities are summarized in Table 4-7 for a typical year (except for LECR, which was based on total exposures over the multi-year LRDP construction period, including Phase 1. Acute hazard impacts were not estimated, as the primary source of TAC emissions for this scenario come from diesel engines, the toxicity of which is adequately represented through the LECR and chronic hazard assessments (CARB, 2003).

The primary contributor to LECR, chronic hazard, and $PM_{2.5}$ results in this table is from DPM emissions from onsite off-road diesel equipment tailpipe emissions.

4.2.4 LRDP Operations

Modeled maximum annual $PM_{2.5}$ concentrations, LECR, chronic hazard, and acute hazard from operations anticipated after completion of Phase 1 are summarized in Table 4-8. Because some of these assessments were predicted to have relatively high ambient impacts, the locations of a few of these impacts are shown in Figure 4-1 as described below.

The primary contributors to LECR in this table are from small quantities of 7,12-dimethylbenz[a]anthracene and hexavalent chromium emissions from natural gas boilers, and DPM emissions from diesel generators and on-road delivery trucks. For reference, the maximum modeled LRDP LECR for an offsite resident occurred at Offsite Location 1 in Figure 4-1.

The primary contributors to chronic hazard in this table are from gluteraldehyde and hydrogen chloride emissions from laboratory fume hood stacks.

The primary contributors to acute hazard in this table are from formaldehyde and chloroform emissions from laboratory fume hoods and nitrogen dioxide emissions from onsite boilers. For reference, the maximum modeled onsite acute hazard occurred at Onsite Location 1 and the maximum modeled offsite acute hazard occurred at Offsite Location 2 in Figure 4-1.

The primary contributors to $PM_{2.5}$ concentrations in this table are from road dust in onsite parking garages and onsite/offsite on-road vehicle travel. For reference, the maximum modeled $PM_{2.5}$ for an offsite resident occurred at Offsite Location 1 in Figure 4-1.

4.3 Greenhouse Gas Impacts

GHG impacts are provided in Table 4-9 in units of metric tons (MT) of carbon dioxide (CO_2) equivalent (CO_2e) per year (MT CO_2e/yr). Maximum annual emission rates are provided for both the construction and operation phases of the Phase 1 and full LRDP build-out scenarios. CO_2e emissions are based on the following formula:

$$MT\ CO_2e/yr = (MT\ CO_2/yr) + (21 \times MT\ Methane/yr) + (310 \times MT\ Nitrous\ Oxide/yr)$$

The factors of 21 and 310 in the formula above are the global warming potentials associated with methane and nitrous oxide, respectively, and are published as part of the EPA GHG reporting program codified in 40 CFR Part 98.

Emissions are provided in Table 4-9 for subsets of emission sources consistent with those provided in the BAAQMD 2011 CEQA guidance document. For example, sources classified as Stationary include only those on-site emission sources that are stationary; this would include natural gas boilers (by far the largest GHG contributor in this category) and diesel generators. Sources classified as Not Stationary cover all other sources associated with the project emitting GHGs; this would include direct emission sources (i.e. on-site and off-site mobile sources) and indirect emission sources associated with on-site utility usage such as electricity, potable water, and wastewater.

GHG emissions on a per-employee basis assume the addition of up to 1,000 new employees to the RBC site by the end of Phase 1 and up to 10,000 new employees to the RBC site by the end of the full LRDP build-out.

4.4 Cumulative Impacts

Under CEQA, a cumulative impact is described as an impact which is created as a result of the combination of the project together with other projects causing related impacts. This typically includes potential impacts from known past, present, and probable future projects.

For this project, cumulative impacts were assessed for LECR, chronic hazard, and annual $PM_{2.5}$ concentrations consistent with the approach provided in 2011 BAAQMD CEQA guidance (BAAQMD 2011). In general, this guidance provides that emissions from known existing or probable future emission sources which are within 1,000 feet of the project boundary be included in an assessment of combined impacts at the maximally exposed individual (MEI) identified in the equivalent assessment for the project only.

The BAAQMD provides tools to aid with the assessment of cumulative impacts.[10] In particular, the Stationary Source Screening Analysis Tool provides estimated maximum LECR, chronic hazard, and annual $PM_{2.5}$ impacts from permitted stationary sources. This tool provides facility locations based on mailing addresses, so facility locations were confirmed and adjusted as necessary to reflect the actual locations of cumulative emission sources.

Additionally, the Highway Screening Analysis Tool provides similar impact data from freeways and highways (which is important in this case as the I-580 freeway is just north of the project area).

In this case, a very conservative approach to estimating the cumulative impacts at the MEI receptor is to simply add the maximum estimated impact at the MEI receptor from the project assessments contained in this report to 1) the maximum impacts at any location reported in the Stationary Source Screening Analysis Tool for sources within 1,000 feet of the project boundary (for Phase 1 or the full LRDP build-out) and 2) the maximum impact reported by the Highway Screening Analysis Tool for the distance from the highway/freeway being included (I-580 in this case) and the MEI receptor.

One adjustment to the maximum impacts from existing stationary sources provided by the BAAQMD is for diesel generators. Appropriate multiplicative coefficients are provided in the Diesel Internal Combustion (IC) Distance Multiplier Tool. Applicable to this project, the maximum cancer risk from two sources in the cumulative assessments are from diesel generators which are more than 918 feet from the MEI receptor, leading to a multiplier of 0.04 applicable to the maximum cancer risk value.

Although adding the maximum impacts from each individual cumulative stationary source at any location to the project impact at the MEI receptor is extremely conservative, if the combined impact is less than a significant impact, this approach is simple and sufficient.

4.4.1 Phase 1

Using the approach described above, the conservatively-estimated maximum cumulative impacts to LECR, chronic hazard, and annual $PM_{2.5}$ for Phase 1 of the project are presented in Table 4-10. The project team has indicated that these results are sufficient for demonstrating less-than-significant cumulative impacts, so no further refinement of the results was performed.

4.4.2 Full LRDP

Similarly, the conservatively-estimated maximum cumulative impacts to LECR, chronic hazard, and annual $PM_{2.5}$ for the full LRDP build-out are presented in Table 4-11. The project team has indicated that these results are sufficient for demonstrating less-than-significant cumulative impacts for LECR and chronic hazard, so no further refinement of these results was performed. However, Golder was asked to

[10] See http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES/Tools-and-Methodology.aspx.

perform a more refined dispersion modeling assessment for the cumulative $PM_{2.5}$ impacts for construction/demolition activities associated with the full LRDP build-out as explained further in Section 4.4.2.1 below.

Additionally, Golder was asked to re-assess the cumulative cancer risk for LRDP operations by applying the attenuation factor for diesel engines provided by BAAQMD to other existing sources within 1,000 feet of the project boundary to provide some means to reflect their actual distances from the MEI receptor being evaluated. This is detailed further in Section 4.4.2.2 below.

4.4.2.1 $PM_{2.5}$ Modeling for LRDP Construction/Demolition

Refined cumulative $PM_{2.5}$ modeling was performed in order to account for the various distances between the existing stationary sources and the MEI receptor for the assessment of $PM_{2.5}$ impacts for the construction/demolition activities associated with the full LRDP build-out. This provides a more realistic assessment of potential cumulative impacts as it accounts for the fact that maximum impacts from different sources will occur at different locations (not accounted for in the screening assessment discussed in Section 4.4.2 above).

The approach used was to explicitly model the existing stationary source $PM_{2.5}$ emissions along with the $PM_{2.5}$ emissions associated with the construction/demolition activities for the full LRDP build-out. Once the $PM_{2.5}$ concentration at the MEI receptor was determined for these sources, the maximum impact from the nearby I-580 freeway obtained from the Highway Screening Analysis Tool was added to calculate the total cumulative $PM_{2.5}$ concentration.

Conducting this assessment required that $PM_{2.5}$ emission rates and source representations for existing stationary sources be obtained from BAAQMD. Although BAAQMD was able to provide source-specific emission rates, associated release parameters were not available. Instead, BAAQMD provided conservative general release parameters for generators, generic stack sources, and generic volume sources. Therefore, each existing source to be modeled was assigned to one of these three source types. Only total particulate matter emission rates were available, so it was conservatively assumed that $PM_{2.5}$ emissions were equal to total particulate matter emissions.

The parameters and $PM_{2.5}$ emission rates associated with the existing stationary sources included in the cumulative source modeling are provided in Table 4-12.

The results of the cumulative dispersion modeling assessment, and the total annual $PM_{2.5}$ concentration with the inclusion of impacts from the I-580 freeway, are provided in Table 4-13. As can be seen by this result, the inclusion of the existing stationary sources in the LRDP construction/demolition modeling assessment increased the predicted $PM_{2.5}$ concentration at the MEI receptor only slightly (from 0.018

micrograms per cubic meter to 0.019 micrograms per cubic meter); this is a result of the existing sources being located well away from the MEI receptor location. The maximum impact from the I-580 freeway was then added to the modeled result for all other sources included in the cumulative impact assessment.

4.4.2.2 Re-Assessment of LRDP Cumulative Cancer Risk

The LRDP cumulative cancer risk result presented in Table 4-11 was re-assessed by applying the distance-dependent impact attenuation factor provided by BAAQMD for diesel generators. Although the actual attenuation of ambient pollutant concentrations from emission sources other than diesel generators might be expected to differ from that for diesel generators, the application of these factors to non-diesel generator sources in the manner used is still expected to be conservative.

Table 4-14 presents the revised assessment, which includes the distance from the existing sources within 1,000 feet of the project boundary to the cancer risk MEI being evaluated (located at Universal Transverse Mercator [UTM] coordinates of 558831, 4197161; zone 10). The diesel generator attenuation factors are constants less than 1.00 that are multiplied by the maximum predicted cancer risk for the source provided by BAAQMD, with lower factors being used as the distance between the existing source and the receptor being evaluated increases. The minimum attenuation factor provided by BAAQMD is 0.04, which can be used for distances of 280 meters and beyond. Since the distance between most of the existing sources and the MEI receptor are much greater than 280 meters, the use of an attenuation factor of 0.04 is expected to be very conservative.

When using this approach, the predicted cumulative LECR at the MEI receptor is reduced significantly compared to the results in Table 4-11 (64.4 vs. 102.4 in a million); i.e. when not accounting for the distance between the existing source and the MEI receptor.

5.0 CLOSING

This report provides the maximum predicted impacts due to estimated emissions of criteria pollutants, TACs, and GHGs for both construction/demolition and operational activities associated with the initial Phase 1 development and the full LRDP build-out. These assessments are based on a single hypothetical configuration for Phase 1 and the Illustrative Development configuration for the full LRDP build-out; the actual configuration of these projects could vary somewhat from what was assessed. However, it is believed that the air quality and human health risk assessments provided in this report conservatively represent the maximum impacts from any alternative configurations as long as they don't deviate significantly from the assumed building square footage and assumed site populations.

The results from this report will be used to support CEQA documents for the proposed project. Because these documents will determine the appropriate thresholds of significance to be used, evaluations of the potential significance of the impacts reported are not made here. As such, no conclusions are being drawn from the magnitude of the results.

Any questions on this report can be directed to Dr. Brian Patterson by phone at 503-607-1820 or by email at bpatterson@golder.com.

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6.0 REFERENCES

BAAQMD 2011, *California Environmental Quality Act Air Quality Guidelines, updated May 2011*, Bay Area Air Quality Management District, May 2011.

BAAQMD 2012, *Recommended Methods for Screening and Modeling Local Risks and Hazards*, Bay Area Air Quality Management District, May 2012.

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Reisman & Frisbie 2001, *Joel Reisman and Gordon Frisbie, Calculating Realistic PM10 Emissions from Cooling Towers, Abstract No. 216, Session No. AM-1b, Air & Waste Management Association 94th Annual Conference and Exhibition in Orlando, Florida, June 25-28, 2001.*

SECOR 2004. *Baseline Air Emissions Inventory Toxic Compound Emissions – Lawrence Berkeley National Laboratory*, SECOR International Incorporated, January 16.

URS 2000. *Central Campus Human Health Risk Assessment*, prepared by URS Corporation, June 28, 2000.

Tables

Table 3-1
Model Source Representations - Phase 1 Construction/Demolition

Area_Poly Sources						
Model ID	**Source Description**	**Base Height (m)**	**Release Height (m)**	**Initial Vert. Dimension (σZ, m)**	**Area of Source (m^2)**	**Number of Sides**
P1_EXHST	Phase 1 Construction and Demolition Area Source - Exhaust	4	1.5	1	61516.6	6

Line Source - Adjacent Volume Sources						
Source ID	**Source Description**	**Initial Lateral Dimension (m)**	**Initial Vertical Dimension (m)**	**Release Height (m)**	**Total Road Length (m)**	**Adjacent Vol. Sources**
OFS_R1	Off Site (OFS) Road Segment 1	6.05	1.58	1.7	245.9	19
OFS_R2	Off Site (OFS) Road Segment 2	9.77	1.58	0	109.7	5
OFS_R3	Off Site (OFS) Road Segment 3	9.77	1.58	1.7	532.6	25
ONS_R1	Onsite Road Segment 1	6.05	1.58	0	284.7	22

Table 3-2
Model Source Representations - Phase 1 Operations

Point Sources						
Model ID	**Source Description**	**Base Height (m)**	**Release Height (m)**	**Stack Diameter (m)**	**Exit Velocity (m/s)**	**Exit Temperature (K)**
DG_B6	Diesel Generator - Buliding 6	3	3.05	0.1524	94.56	760.85
DG_B7	Diesel Generator - Buliding 7	3.32	3.05	0.1524	94.56	760.85
DG_B8	Diesel Generator - Building 8	3	3.05	0.152	94.56	760.85
DG_B9	Diesel Generator - Building 9	3.54	3.05	0.152	94.56	760.85
NGB_B6_7	Natural Gas Boiler - Buildings 6 and 7	3	25.60	0.65	4.95	366.5
NGB_B9	Natural Gas Boiler - Building 9	3	20.12	0.46	4.95	366.5
NGB_B8	Natural Gas Boiler - Building 8	3	14.63	0.46	4.95	366.5
CTB6_7C1	Cooling Tower - Buildings 6 and 7, Cell 1	3	28.65	2.5	10	-10
CTB6_7C2	Cooling Tower - Buildings 6 and 7, Cell 2	3	28.65	2.5	10	-10
CTB6_7C3	Cooling Tower - Buildings 6 and 7, Cell 3	3	28.65	2.5	10	-10
CTB6_7C4	Cooling Tower - Buildings 6 and 7, Cell 4	3	28.65	2.5	10	-10
CTB6_7C5	Cooling Tower - Buildings 6 and 7, Cell 5	3	28.65	2.5	10	-10
CTB6_7C6	Cooling Tower - Buildings 6 and 7, Cell 6	3	28.65	2.5	10	-10
CTB8C1	Cooling Tower - Building 8, Cell 1	3	17.68	2.5	10	-10
CTB8C2	Cooling Tower - Building 8, Cell 2	3	17.68	2.5	10	-10
CTB8C3	Cooling Tower - Building 8, Cell 3	3	17.68	2.5	10	-10
CTB9C1	Cooling Tower - Building 9, Cell 1	3	23.17	2.5	10	-10
CTB9C2	Cooling Tower - Building 9, Cell 2	3	23.17	2.5	10	-10
CTB9C3	Cooling Tower - Building 9, Cell 3	3	23.17	2.5	10	-10
LAB_B6_7	Lab Hood Exhaust Stack - Building 6 and 7	3	25.60	1	10	293.15
LAB_B8	Lab Hood Exhaust Stack - Building 8	3	14.63	1	10	293.15
LAB_B9	Lab Hood Exhuast Stack - Building 9	3	20.12	1	10	293.15

Area_Poly Sources						
Model ID	**Source Description**	**Base Height (m)**	**Effective Height (m)**	**Initial Vert. Dimension (σZ, m)**	**Area of Source (m^2)**	**Number of Sides**
ONROAD1	West Onsite Onroad Vehicle Area Source	3.78	0	1	10837.9	15
ONROAD2	East Onsite Onroad Vehicle Area Source	3	0	1	13533.7	8

Line Source - Adjacent Volume Sources						
Source ID	**Source Description**	**Initial Lateral Dimension (m)**	**Initial Vertical Dimension (m)**	**Release Height (m)**	**Total Road Length (m)**	**Adjacent Vol. Sources**
ONS_R1	Onsite Road Segment 1	6.05	1.58	0	284.6	22
ONS_R2	Onsite Road Segment 2	6.05	1.58	1.7	277.4	21
OFS_R1	Off Site (OFS) Road Segment 1	6.05	1.58	1.7	245.9	19
OFS_R2	Off Site (OFS) Road Segment 2	9.77	1.58	0	109.7	5
OFS_R3	Off Site (OFS) Road Segment 3	9.77	1.58	1.7	532.6	25

Table 3-3
Model Source Representations - Full LRDP Construction/Demolition

Area Sources							
Model ID	**Source Description**	**Base Height (m)**	**Release Height (m)**	**Initial Vert. Dimension (σZ, m)**	**Area of Source (m^2)**	**Rotation (deg)**	**Assessment [1]**
AREA1	Western Construction/Demolition Activity Area	2	1.5	1	72000	0	C
AREA3	Worker Hazard Assessment Activity Area	3.73	1.5	1	8100	0	WH
AREA7	Resident Hazard Assessment Activity Area	7	1.5	1	8100	0	RH

Area_Poly Sources							
Model ID	**Source Description**	**Base Height (m)**	**Release Height (m)**	**Initial Vert. Dimension (σZ, m)**	**Area of Source (m^2)**	**Number of Sides**	**Assessment [1]**
AREA2	North-east Construction/Demolition Activity Area	9	1.5	1	96570.4	6	C
AREA3	Eastern Construction/Demolition Activity Area	6	1.5	1	48637.9	7	C
AREA4	Southern Construction/Demolition Activity Area	5	1.5	1	37054.3	6	C

Line Source - Adjacent Volume Sources							
Source ID	**Source Description**	**Initial Lateral Dimension (m)**	**Initial Vertical Dimension (m)**	**Release Height (m)**	**Total Road Length (m)**	**Adjacent Vol. Sources**	**Assessment [1]**
T2_R2	T2 to R2	6.05	1.58	1.7	164.5	13	C
R2_R3	R2 to R3	6.05	1.58	1.7	112.1	9	C
R3_R6	R3 to R6	6.05	1.58	1.7	524.9	40	C
T1_R1	T1 to R1	6.05	1.58	1.7	127.1	10	C
R1_T2	R1 to T2	6.05	1.58	1.7	98.6	8	C
R8_T3	R8 to T3	6.05	1.58	1.7	110.9	9	C
R7_R8	R7 to R8	6.05	1.58	1.7	55.3	4	C
R6_R7	R6 to R7	6.05	1.58	1.7	71.5	5	C
R14_R15	R14 to R15	9.77	1.58	1.7	180.7	9	C, RH
R15_T1	R15 to T1	9.77	1.58	1.7	153.5	7	C, RH
T1_EH	T1 to East Highway	9.77	1.58	1.7	191.5	9	C, RH
R14_NH	R14 to North Highway	9.77	1.58	1.7	99.8	5	C, RH, WH
T3_WH	T3 to West Highway	6.05	1.58	1.7	220.9	17	C, WH
T3_R11	T3 to R11	6.05	1.58	1.7	445.2	34	C, WH
R11_R12	R11 to R12	6.05	1.58	1.7	59.7	5	C, WH
R12_R13	R12 to R13	6.05	1.58	1.7	427	33	C, WH
R13_R14	R13 to R14	6.05	1.58	1.7	207.4	16	C, WH
T1_R1C	T1 to R1(C?)	6.05	1.58	1.7	99.1	8	RH

References:

(1) C = Cancer Risk Assessment, RH = Resident Hazard Assessment, WH = Worker Hazard Assessment.
Cancer Risk Assessment sources are shown in Figure 3-4, Resident Hazard Assessment sources are shown in Figure 3-2, and Worker Hazard Assessment sources are shown in Figure 3-3.

Table 3-4
Model Source Representations - Full LRDP Operations

Point Sources						
Model ID	**Source Description**	**Base Height (m)**	**Release Height (m)**	**Stack Diameter (m)**	**Exit Velocity (m/s)**	**Exit Temperature (K)**
CT_NRLF1	Cooling Tower - NRLF Expansion, Cell 1	6	10.7	2.5	10	-10
CT_NRLF2	Cooling Tower - NRLF Expansion, Cell 2	6	10.7	2.5	10	-10
CT_NRLF3	Cooling Tower - NRLF Expansion, Cell 3	6	10.7	2.5	10	-10
CT_NRLF4	Cooling Tower - NRLF Expansion, Cell 4	6	10.7	2.5	10	-10
CT_NRLF5	Cooling Tower - NRLF Expansion, Cell 5	6	10.7	2.5	10	-10
CT_NRLF6	Cooling Tower - NRLF Expansion, Cell 6	6	10.7	2.5	10	-10
CT_NRLF7	Cooling Tower - NRLF Expansion, Cell 7	6	10.7	2.5	10	-10
CT_NRLF8	Cooling Tower - NRLF Expansion, Cell 8	6	10.7	2.5	10	-10
CTB10C1	Cooling Tower - Building 10, Cell 1	4	28.7	2.5	10	-10
CTB10C2	Cooling Tower - Building 10, Cell 2	4	28.7	2.5	10	-10
CTB10C3	Cooling Tower - Building 10, Cell 3	4	28.7	2.5	10	-10
CTB11C1	Cooling Tower - Building 11, Cell 1	4.12	28.7	2.5	10	-10
CTB11C2	Cooling Tower - Building 11, Cell 2	4.1	28.7	2.5	10	-10
CTB12C1	Cooling Tower - Building 12, Cell 1	4.33	28.7	2.5	10	-10
CTB12C2	Cooling Tower - Building 12, Cell 2	4.2	28.7	2.5	10	-10
CTB12C3	Cooling Tower - Building 12, Cell 3	4.09	28.7	2.5	10	-10
CTB13C1	Cooling Tower - Building 13, Cell 1	5	23.2	2.5	10	-10
CTB13C2	Cooling Tower - Building 13, Cell 2	5	23.2	2.5	10	-10
CTB14C1	Cooling Tower - Building 14, Cell 1	5	28.7	2.5	10	-10
CTB14C2	Cooling Tower - Building 14, Cell 2	5	28.7	2.5	10	-10
CTB15C1	Cooling Tower - Building 15, Cell 1	5	28.7	2.5	10	-10
CTB15C2	Cooling Tower - Building 15, Cell 2	5	28.7	2.5	10	-10
CTB15C3	Cooling Tower - Building 15, Cell 3	5	28.7	2.5	10	-10
CTB16C1	Cooling Tower - Building 16, Cell 1	5	28.7	2.5	10	-10
CTB16C2	Cooling Tower - Building 16, Cell 2	5	28.7	2.5	10	-10
CTB16C3	Cooling Tower - Building 16, Cell 3	5	28.7	2.5	10	-10
CTB16C4	Cooling Tower - Building 16, Cell 4	5	28.7	2.5	10	-10
CTB17C1	Cooling Tower - Building 17, Cell 1	5	34.1	2.5	10	-10
CTB17C2	Cooling Tower - Building 17, Cell 2	5	34.1	2.5	10	-10
CTB17C3	Cooling Tower - Building 17, Cell 3	5	34.1	2.5	10	-10
CTB17C4	Cooling Tower - Building 17, Cell 4	5	34.1	2.5	10	-10
CTB18C1	Cooling Tower - Building 18, Cell 1	6	34.1	2.5	10	-10
CTB18C2	Cooling Tower - Building 18, Cell 2	6	34.1	2.5	10	-10
CTB18C3	Cooling Tower - Building 18, Cell 3	6	34.1	2.5	10	-10
CTB19C1	Cooling Tower - Building 19, Cell 1	6	34.1	2.5	10	-10
CTB19C2	Cooling Tower - Building 19, Cell 2	6	34.1	2.5	10	-10
CTB19C3	Cooling Tower - Building 19, Cell 3	6	34.1	2.5	10	-10
CTB20C1	Cooling Tower - Building 20, Cell 1	6	34.1	2.5	10	-10
CTB20C2	Cooling Tower - Building 20, Cell 2	6	34.1	2.5	10	-10
CTB20C3	Cooling Tower - Building 20, Cell 3	6	34.1	2.5	10	-10
CTB21C1	Cooling Tower - Building 21, Cell 1	6.05	34.1	2.5	10	-10
CTB21C2	Cooling Tower - Building 21, Cell 2	6.04	34.1	2.5	10	-10
CTB21C3	Cooling Tower - Building 21, Cell 3	6.03	34.1	2.5	10	-10
CTB21C4	Cooling Tower - Building 21, Cell 4	6.23	34.1	2.5	10	-10
CTB21C5	Cooling Tower - Building 21, Cell 5	6.19	34.1	2.5	10	-10
CTB21C6	Cooling Tower - Building 21, Cell 6	6.14	34.1	2.5	10	-10
CTB21C7	Cooling Tower - Building 21, Cell 7	6.06	34.1	2.5	10	-10
CTB22C1	Cooling Tower - Building 22, Cell 1	6	34.1	2.5	10	-10
CTB22C2	Cooling Tower - Building 22, Cell 2	6	34.1	2.5	10	-10
CTB22C3	Cooling Tower - Building 22, Cell 3	6	34.1	2.5	10	-10
CTB22C4	Cooling Tower - Building 22, Cell 4	6	34.1	2.5	10	-10
CTB22C5	Cooling Tower - Building 22, Cell 5	6	34.1	2.5	10	-10

Table 3-4 Continued
Model Source Representations - Full LRDP Operations

Point Sources (continued)						
Model ID	**Source Description**	**Base Height (m)**	**Release Height (m)**	**Stack Diameter (m)**	**Exit Velocity (m/s)**	**Exit Temperature (K)**
CTB23C1	Cooling Tower - Building 23, Cell 1	7	34.1	2.5	10	-10
CTB23C2	Cooling Tower - Building 23, Cell 2	6.93	34.1	2.5	10	-10
CTB23C3	Cooling Tower - Building 23, Cell 3	7	34.1	2.5	10	-10
CTB23C4	Cooling Tower - Building 23, Cell 4	6.96	34.1	2.5	10	-10
CTB24C1	Cooling Tower - Building 24, Cell 1	7	34.1	2.5	10	-10
CTB24C2	Cooling Tower - Building 24, Cell 2	7	34.1	2.5	10	-10
CTB24C3	Cooling Tower - Building 24, Cell 3	7	34.1	2.5	10	-10
CTB25C1	Cooling Tower - Building 25, Cell 1	6.14	34.1	2.5	10	-10
CTB25C2	Cooling Tower - Building 25, Cell 2	6.1	34.1	2.5	10	-10
CTB25C3	Cooling Tower - Building 25, Cell 3	6.26	34.1	2.5	10	-10
CTB25C4	Cooling Tower - Building 25, Cell 4	6.18	34.1	2.5	10	-10
CTB26C1	Cooling Tower - Building 26, Cell 1	7	34.1	2.5	10	-10
CTB26C2	Cooling Tower - Building 26, Cell 2	7	34.1	2.5	10	-10
CTB26C3	Cooling Tower - Building 26, Cell 3	7	34.1	2.5	10	-10
CTB26C4	Cooling Tower - Building 26, Cell 4	7	34.1	2.5	10	-10
CTB27C1	Cooling Tower - Building 27, Cell 1	7.31	28.7	2.5	10	-10
CTB27C2	Cooling Tower - Building 27, Cell 2	7.13	28.7	2.5	10	-10
CTB27C3	Cooling Tower - Building 27, Cell 3	7.44	28.7	2.5	10	-10
CTB27C4	Cooling Tower - Building 27, Cell 4	7.3	28.7	2.5	10	-10
CTB28C1	Cooling Tower - Building 28, Cell 1	7	28.7	2.5	10	-10
CTB28C2	Cooling Tower - Building 28, Cell 2	7.02	28.7	2.5	10	-10
CTB29C1	Cooling Tower - Building 29, Cell 1	7	23.2	2.5	10	-10
CTB29C2	Cooling Tower - Building 29, Cell 2	6.94	23.2	2.5	10	-10
CTB30C1	Cooling Tower - Building 30, Cell 1	7.8	28.7	2.5	10	-10
CTB30C2	Cooling Tower - Building 30, Cell 2	7.62	28.7	2.5	10	-10
CTB30C3	Cooling Tower - Building 30, Cell 3	7.84	28.7	2.5	10	-10
CTB30C4	Cooling Tower - Building 30, Cell 4	7.69	28.7	2.5	10	-10
CTB31C1	Cooling Tower - Building 31, Cell 1	4	23.2	2.5	10	-10
CTB31C2	Cooling Tower - Building 31, Cell 2	3.81	23.2	2.5	10	-10
CTB32C1	Cooling Tower - Building 32, Cell 1	3.04	34.1	2.5	10	-10
CTB32C2	Cooling Tower - Building 32, Cell 2	3.01	34.1	2.5	10	-10
CTB32C3	Cooling Tower - Building 32, Cell 3	3	34.1	2.5	10	-10
CTB33C1	Cooling Tower - Building 33, Cell 1	3.8	34.1	2.5	10	-10
CTB33C2	Cooling Tower - Building 33, Cell 2	3.75	34.1	2.5	10	-10
CTB33C3	Cooling Tower - Building 33, Cell 3	3.94	34.1	2.5	10	-10
CTB33C4	Cooling Tower - Building 33, Cell 4	3.94	34.1	2.5	10	-10
CTB34C1	Cooling Tower - Building 34, Cell 1	3	34.1	2.5	10	-10
CTB34C2	Cooling Tower - Building 34, Cell 2	3	34.1	2.5	10	-10
CTB34C3	Cooling Tower - Building 34, Cell 3	3	34.1	2.5	10	-10
CTB34C4	Cooling Tower - Building 34, Cell 4	3	34.1	2.5	10	-10
CTB35C1	Cooling Tower - Building 35, Cell 1	3	34.1	2.5	10	-10
CTB35C2	Cooling Tower - Building 35, Cell 2	3	34.1	2.5	10	-10
CTB35C3	Cooling Tower - Building 35, Cell 3	3	34.1	2.5	10	-10
CTB35C4	Cooling Tower - Building 35, Cell 4	3	34.1	2.5	10	-10
CTB35C5	Cooling Tower - Building 35, Cell 5	3	34.1	2.5	10	-10
CTB36C1	Cooling Tower - Building 36, Cell 1	2.52	34.1	2.5	10	-10
CTB36C2	Cooling Tower - Building 36, Cell 2	2.52	34.1	2.5	10	-10
CTB36C3	Cooling Tower - Building 36, Cell 3	2.71	34.1	2.5	10	-10
CTB36C4	Cooling Tower - Building 36, Cell 4	2.71	34.1	2.5	10	-10
CTB36C5	Cooling Tower - Building 36, Cell 5	2.62	34.1	2.5	10	-10
CTB37C1	Cooling Tower - Building 37, Cell 1	3	34.1	2.5	10	-10
CTB37C2	Cooling Tower - Building 37, Cell 2	3	34.1	2.5	10	-10
CTB37C3	Cooling Tower - Building 37, Cell 3	3	34.1	2.5	10	-10
CTB37C4	Cooling Tower - Building 37, Cell 4	3	34.1	2.5	10	-10
CTB37C5	Cooling Tower - Building 37, Cell 5	3	34.1	2.5	10	-10
CTB38C1	Cooling Tower - Building 38, Cell 1	2.72	23.2	2.5	10	-10

Table 3-4 Continued
Model Source Representations - Full LRDP Operations

Point Sources (continued)						
Model ID	**Source Description**	**Base Height (m)**	**Release Height (m)**	**Stack Diameter (m)**	**Exit Velocity (m/s)**	**Exit Temperature (K)**
CTB38C2	Cooling Tower - Building 38, Cell 2	2.72	23.2	2.5	10	-10
CTB6_7C1	Cooling Tower - Buildings 6 and 7, Cell 1	3	28.7	2.5	10	-10
CTB6_7C2	Cooling Tower - Buildings 6 and 7, Cell 2	3	28.7	2.5	10	-10
CTB6_7C3	Cooling Tower - Buildings 6 and 7, Cell 3	3	28.7	2.5	10	-10
CTB6_7C4	Cooling Tower - Buildings 6 and 7, Cell 4	3	28.7	2.5	10	-10
CTB6_7C5	Cooling Tower - Buildings 6 and 7, Cell 5	3	28.7	2.5	10	-10
CTB6_7C6	Cooling Tower - Buildings 6 and 7, Cell 6	3	28.7	2.5	10	-10
CTB8C1	Cooling Tower - Building 8, Cell 1	3	17.7	2.5	10	-10
CTB8C2	Cooling Tower - Building 8, Cell 2	3	17.7	2.5	10	-10
CTB8C3	Cooling Tower - Building 8, Cell 3	3	17.7	2.5	10	-10
CTB9C1	Cooling Tower - Building 9, Cell 1	3	23.2	2.5	10	-10
CTB9C2	Cooling Tower - Building 9, Cell 2	3	23.2	2.5	10	-10
CTB9C3	Cooling Tower - Building 9, Cell 3	3	23.2	2.5	10	-10
DG_B10	Diesel Generator - Buliding 10	4	3.0	0.1524	94.56	760.85
DG_B11	Diesel Generator - Buliding 11	4.82	3.0	0.1524	94.56	760.85
DG_B12	Diesel Generator - Buliding 12	4	3.0	0.1524	94.56	760.85
DG_B13	Diesel Generator - Buliding 13	5	3.0	0.1524	94.56	760.85
DG_B14	Diesel Generator - Buliding 14	5	3.0	0.1524	94.56	760.85
DG_B15	Diesel Generator - Buliding 15	5	3.0	0.1524	94.56	760.85
DG_B16	Diesel Generator - Buliding 16	5	3.0	0.1524	94.56	760.85
DG_B17	Diesel Generator - Buliding 17	5	3.0	0.1524	94.56	760.85
DG_B18	Diesel Generator - Buliding 18	6	3.0	0.1524	94.56	760.85
DG_B19	Diesel Generator - Buliding 19	6	3.0	0.1524	94.56	760.85
DG_B20	Diesel Generator - Buliding 20	6	3.0	0.1524	94.56	760.85
DG_B21A	Diesel Generator A - Building 21	6	3.0	0.1524	94.56	760.85
DG_B21B	Diesel Generator B - Building 21	6	3.0	0.1524	94.56	760.85
DG_B22	Diesel Generator - Buliding 22	6	3.0	0.203	71.01	738.15
DG_B23	Diesel Generator - Buliding 23	7	3.0	0.1524	94.56	760.85
DG_B24	Diesel Generator - Buliding 24	7	3.0	0.1524	94.56	760.85
DG_B25	Diesel Generator - Buliding 25	6	3.0	0.203	71.01	738.15
DG_B26	Diesel Generator - Buliding 26	7	3.0	0.203	71.01	738.15
DG_B27	Diesel Generator - Buliding 27	8	3.0	0.1524	94.56	760.85
DG_B28	Diesel Generator - Buliding 28	7	3.0	0.1524	94.56	760.85
DG_B29	Diesel Generator - Buliding 29	7	3.0	0.1524	94.56	760.85
DG_B30	Diesel Generator - Buliding 30	7.22	3.0	0.1524	94.56	760.85
DG_B31	Diesel Generator - Buliding 31	4	3.0	0.1524	94.56	760.85
DG_B32	Diesel Generator - Buliding 32	3	3.0	0.1524	94.56	760.85
DG_B33	Diesel Generator - Buliding 33	3.11	3.0	0.1524	94.56	760.85
DG_B34	Diesel Generator - Buliding 34	3	3.0	0.203	71.01	738.15
DG_B35	Diesel Generator - Buliding 35	3	3.0	0.203	71.01	738.15
DG_B36	Diesel Generator - Buliding 36	3	3.0	0.203	71.01	738.15
DG_B37	Diesel Generator - Buliding 27	3	3.0	0.203	71.01	738.15
DG_B38	Diesel Generator - Buliding 38	3	3.0	0.1524	94.56	760.85
DG_B6	Diesel Generator - Bulidings 6	3.32	3.0	0.1524	94.56	760.85
DG_B7	Diesel Generator - Bulidings 7	3.32	3.0	0.1524	94.56	760.85
DG_B8	Diesel Generator - Building 8	3	3.0	0.1524	94.56	760.85
DG_B9	Diesel Generator - Building 9	3.54	3.0	0.1524	94.56	760.85
DG_NRLF	Diesel Generator - NRLF Expansion	5.85	3.0	0.203	71.01	738.15
LAB_B10	Lab Stack - Building 10	4	25.6	1	10	293.15
LAB_B11	Lab Stack - Building 11	4	25.6	1	10	293.15
LAB_B12	Lab Stack - Building 12	4.16	25.6	1	10	293.15
LAB_B14	Lab Stack - Building 14	5	25.6	1	10	293.15
LAB_B15	Lab Stack - Building 15	5	25.6	1	10	293.15
LAB_B16	Lab Stack - Building 16	5	25.6	1	10	293.15
LAB_B17	Lab Stack - Building 17	5	31.1	1	10	293.15
LAB_B18	Lab Stack - Building 18	6	31.1	1	10	293.15

Table 3-4 Continued
Model Source Representations - Full LRDP Operations

Point Sources (continued)						
Model ID	**Source Description**	**Base Height (m)**	**Release Height (m)**	**Stack Diameter (m)**	**Exit Velocity (m/s)**	**Exit Temperature (K)**
LAB_B19	Lab Stack - Building 19	6	31.1	1	10	293.15
LAB_B20	Lab Stack - Building 20	6	31.1	1	10	293.15
LAB_B21	Lab Stack - Building 21	6	31.1	1	10	293.15
LAB_B22	Lab Stack - Building 22	6	31.1	1	10	293.15
LAB_B23	Lab Stack - Building 23	6.92	31.1	1	10	293.15
LAB_B24	Lab Stack - Building 24	7	31.1	1	10	293.15
LAB_B25	Lab Stack - Building 25	6.48	31.1	1	10	293.15
LAB_B26	Lab Stack - Building 26	7	31.1	1	10	293.15
LAB_B27	Lab Stack - Building 27	7	25.6	1	10	293.15
LAB_B28	Lab Stack - Building 28	7.19	25.6	1	10	293.15
LAB_B30	Lab Stack - Building 30	7.05	25.6	1	10	293.15
LAB_B32	Lab Stack - Building 32	3	31.1	1	10	293.15
LAB_B33	Lab Stack - Building 33	4	31.1	1	10	293.15
LAB_B34	Lab Stack - Building 34	2.82	31.1	1	10	293.15
LAB_B35	Lab Stack - Building 35	3.21	31.1	1	10	293.15
LAB_B36	Lab Stack - Building 36	2	31.1	1	10	293.15
LAB_B37	Lab Stack - Building 37	3	31.1	1	10	293.15
LAB_B6_7	Lab Hood Exhaust Stack - Building 6 and 7	3	25.6	1	10	293.15
LAB_B8	Lab Hood Exhaust Stack - Building 8	3	14.6	1	10	293.15
LAB_B9	Lab Hood Exhuast Stack - Building 9	3	20.1	1	10	293.15
NGB_B10	Natural Gas Boiler - Building 10	4	25.6	0.44	4.95	366.5
NGB_B11	Natural Gas Boiler - Building 11	4.58	25.6	0.33	4.95	366.5
NGB_B12	Natural Gas Boiler - Building 12	4.06	25.6	0.44	4.95	366.5
NGB_B13	Natural Gas Boiler - Building 13	4.97	20.1	0.33	4.95	366.5
NGB_B14	Natural Gas Boiler - Building 14	5	25.6	0.38	4.95	366.5
NGB_B15	Natural Gas Boiler - Building 15	5	25.6	0.48	4.95	366.5
NGB_B16	Natural Gas Boiler - Building 16	5	25.6	0.51	4.95	366.5
NGB_B17	Natural Gas Boiler - Building 17	5	31.1	0.53	4.95	366.5
NGB_B18	Natural Gas Boiler - Building 18	6	31.1	0.5	4.95	366.5
NGB_B19	Natural Gas Boiler - Building 19	6	31.1	0.46	4.95	366.5
NGB_B20	Natural Gas Boiler - Building 20	6	31.1	0.46	4.95	366.5
NGB_B21	Natural Gas Boiler - Building 21	6	31.1	0.7	4.95	366.5
NGB_B22	Natural Gas Boiler - Building 22	6	31.1	0.58	4.95	366.5
NGB_B23	Natural Gas Boiler - Building 23	7	31.1	0.5	4.95	366.5
NGB_B24	Natural Gas Boiler - Building 24	7	31.1	0.46	4.95	366.5
NGB_B25	Natural Gas Boiler - Building 25	6	31.1	0.55	4.95	366.5
NGB_B26	Natural Gas Boiler - Building 26	7	31.1	0.55	4.95	366.5
NGB_B27	Natural Gas Boiler - Building 27	7.8	25.6	0.53	4.95	366.5
NGB_B28	Natural Gas Boiler - Building 28	7	25.6	0.33	4.95	366.5
NGB_B29	Natural Gas Boiler - Building 29	6.96	20.1	0.33	4.95	366.5
NGB_B30	Natural Gas Boiler - Building 30	7.35	25.6	0.53	4.95	366.5
NGB_B31	Natural Gas Boiler - Building 31	3.95	20.1	0.33	4.95	366.5
NGB_B32	Natural Gas Boiler - Building 32	3.04	31.1	0.48	4.95	366.5
NGB_B33	Natural Gas Boiler - Building 33	3.26	31.1	0.53	4.95	366.5
NGB_B34	Natural Gas Boiler - Building 34	3	31.1	0.55	4.95	366.5
NGB_B35	Natural Gas Boiler - Building 35	3	31.1	0.58	4.95	366.5
NGB_B36	Natural Gas Boiler - Building 36	2.61	31.1	0.56	4.95	366.5
NGB_B37	Natural Gas Boiler - Building 37	3	31.1	0.59	4.95	366.5
NGB_B38	Natural Gas Boiler - Building 38	2.74	20.1	0.38	4.95	366.5
NGB_B6_7	Natural Gas Boiler - Buildings 6 and 7	3	25.6	0.65	4.95	366.5
NGB_B8	Natural Gas Boiler - Building 8	3	14.6	0.46	4.95	366.5
NGB_B9	Natural Gas Boiler - Building 9	3	20.1	0.46	4.95	366.5
NGB_NRLF	Natural Gas Boiler - NRLF Expansion	5.99	7.6	0.64	4.95	366.5

Table 3-4 Continued
Model Source Representations - Full LRDP Operations

Volume Sources						
Source ID	**Source Description**	**Base Height (m)**	**Release Height (meters)**	**Length of Side (meters)**	**Initial Lateral Dimension (σY, meters)**	**Initial Vert. Dimension (σZ, meters)**
IDLE_B30	Idle emissions at Building 30	8	1	2	0.465	0.930
IDLE_B28	Idle emissions at Building 28	7	1	2	0.465	0.930
IDLE_B26	Idle emissions at Building 26	7	1	2	0.465	0.930
IDLE_B29	Idle emissions at Building 29	6.97	1	2	0.465	0.930
IDLE_B25	Idle emissions at Building 25	6	1	2	0.465	0.930
IDLE_B18	Idle emissions at Building 18	6	1	2	0.465	0.930
IDLE_B19	Idle emissions at Building 19	6	1	2	0.465	0.930
IDLE_B17	Idle emissions at Building 17	5	1	2	0.465	0.930
IDLE_B7	Idle emissions at Building 7	3.33	1	2	0.465	0.930
IDLE_B9	Idle emissions at Building 9	3	1	2	0.465	0.930
IDLE_B34	Idle emissions at Building 34	3	1	2	0.465	0.930
IDLE_B36	Idle emissions at Building 36	3	1	2	0.465	0.930
P1	Parking Structure Volume Source P1	3.98	11.7	38.94	9.06	10.92
P2	Parking Structure Volume Source P2	5.17	11.7	51.76	12.04	5.46
P3	Parking Structure Volume Source P3	7	13.4	65.84	15.31	12.48
P4	Parking Structure Volume Source - P4	8	11.7	53.93	12.54	10.92
P5	Parking Structure Volume Source P5	4	10.1	36.99	8.60	4.68
P6	Parking Structure Volume Source P6	3	8.4	53.77	12.50	3.90

Line Source - Adjacent Volume Sources						
Source ID	**Source Description**	**Initial Lateral Dimension (m)**	**Initial Vertical Dimension (m)**	**Release Height (m)**	**Total Road Length (m)**	**Adjacent Vol. Sources**
T2_R2	T2 to R2	6.05	1.58	1.7	164.5	13
R2_R3	R2 to R3	6.05	1.58	1.7	112.1	9
R3_R4	R3 to R4	6.05	1.58	1.7	80.6	6
R3_R6	R3 to R6	6.05	1.58	1.7	524.9	40
R13_R5	R13 to R5	6.05	1.58	1.7	630.1	48
R8_R9	R8 to R9	6.05	1.58	1.7	117.4	9
R11_R10	R11 to R10	6.05	1.58	1.7	142.4	11
R15_R16	R15 to R16	6.05	1.58	1.7	186.7	14
T1_EH	T1 to East Highway	9.77	1.58	1.7	191.5	9
T1_R1	T1 to R1	6.05	1.58	1.7	127.1	10
R1_T2	R1 to T2	6.05	1.58	1.7	98.6	8
R14_NH	R14 to North Highway	9.77	1.58	1.7	99.8	5
R14_R15	R14 to R15	9.77	1.58	1.7	180.7	9
R15_T1	R15 to T1	9.77	1.58	1.7	153.5	7
T3_WH	T3 to West Highway	6.05	1.58	1.7	220.9	17
R8_T3	R8 to T3	6.05	1.58	1.7	110.9	9
R7_R8	R7 to R8	6.05	1.58	1.7	55.3	4
R6_R7	R6 to R7	6.05	1.58	1.7	71.5	5
T3_R11	T3 to R11	6.05	1.58	1.7	445.2	34
R11_R12	R11 to R12	6.05	1.58	1.7	59.7	5
R12_R13	R12 to R13	6.05	1.58	1.7	427	33
R13_R14	R13 to R14	6.05	1.58	1.7	207.4	16

Table 3-5
Model Source Representations - Existing Richmond Field Station Operations

Phase 1 Sources

Point Sources						
Model ID	**Source Description**	**Base Height (m)**	**Release Height (m)**	**Stack Diameter (m)**	**Exit Velocity (m/s)**	**Exit Temperature (K)**
DG_B194	Existing standby generator - B194	6.7	3.0	0.1524	94.56	760.85
DG_NRLF2	Existing standby generator - NRLF	7.55	3.0	0.1524	94.56	760.85
FP_NRLF2	Existing Fire Pump - NRLF	8.07	3.0	0.1524	94.56	760.85
NGB_400a	Natural Gas Boiler - Building 400a	7.71	14.0	0.15	4.95	366.5
NGB_400b	Natural Gas Boiler - Building 400b	7.71	14.0	0.16	4.95	366.5
NGB_400c	Natural Gas Boiler - Building 400c	7.7	14.0	0.16	4.95	366.5
NGB_400d	Natural Gas Boiler - Building 400d	8.07	17.7	0.16	4.95	366.5
NGB_451	Natural Gas Boiler - Building 451	8.86	6.7	0.11	4.95	366.5
NGB_452	Natural Gas Boiler - Building 452	9.47	6.7	0.08	4.95	366.5
NGB_454	Natural Gas Boiler - Building 454	9.56	6.7	0.09	4.95	366.5
NGB_472	Natural Gas Boiler - Building 472	7.73	7.3	0.08	4.95	366.5
NGB_477	Natural Gas Boiler - Building 477	7.97	6.7	0.1	4.95	366.5
NGB_478a	Natural Gas Boiler - Building 478a	8.43	10.7	0.09	4.95	366.5
NGB_478b	Natural Gas Boiler - Building 478b	8.42	10.7	0.09	4.95	366.5
NGB_478c	Natural Gas Boiler - Building 478c	8.39	10.7	0.19	4.95	366.5
NGB_480	Natural Gas Boiler - Building 480	7.96	7.3	0.09	4.95	366.5
NGB_484	Natural Gas Boiler - Building 484	7.53	22.3	0.13	4.95	366.5
LAB_B154	Lab Hood Exhaust Stack - Building 154	5.53	9.1	1	10	293.15
LAB_B158	Lab Hood Exhaust Stack - Building 158	5.52	10.4	1	10	293.15
LAB_B167	Lab Hood Exhaust Stack - Building 167	6.36	7.3	1	10	293.15
LAB_B450	Lab Hood Exhaust Stack - Building 450	7.42	7.3	1	10	293.15
LAB_B473	Lab Hood Exhaust Stack - Building 473	7.85	7.3	1	10	293.15
LAB_B474	Lab Hood Exhaust Stack - Building 474	7.99	7.3	1	10	293.15
LAB_B478	Lab Hood Exhaust Stack - Building 478	8.4	10.7	1	10	293.15
LAB_B480	Lab Hood Exhaust Stack - Building 480	7.9	7.3	1	10	293.15

Area Sources						
Model ID	**Source Description**	**Base Height (m)**	**Release Height (m)**	**Initial Vert. Dimension (σZ, m)**	**Area of Source (m^2)**	**Rotation (deg)**
OFFMAIN	Off-road mobile diesel vehicles	6.78	0	1	1225	0

Volume Sources						
Source ID	**Source Description**	**Base Height (m)**	**Release Height (meters)**	**Length of Side (meters)**	**Initial Lateral Dimension (σY, meters)**	**Initial Vert. Dimension (σZ, meters)**
FUEL	Existing gasoline dispensing	8	1	5.0	1.163	0.500

Table 3-5 Continued
Model Source Representations - Existing Richmond Field Station Operations

LRDP Sources

Point Sources						
Model ID	**Source Description**	**Base Height (m)**	**Release Height (m)**	**Stack Diameter (m)**	**Exit Velocity (m/s)**	**Exit Temperature (K)**
DG_NRLF2	Existing standby generator - NRLF	7.55	3.0	0.1524	94.56	760.85
FP_NRLF2	Existing Fire Pump - NRLF	8.07	3.0	0.1524	94.56	760.85
NGB_400a	Natural Gas Boiler - Building 400a	7.71	14.0	0.15	4.95	366.5
NGB_400b	Natural Gas Boiler - Building 400b	7.71	14.0	0.16	4.95	366.5
NGB_400c	Natural Gas Boiler - Building 400c	7.7	14.0	0.16	4.95	366.5
NGB_400d	Natural Gas Boiler - Building 400d	8.07	17.7	0.16	4.95	366.5

Area Sources						
Model ID	**Source Description**	**Base Height (m)**	**Release Height (m)**	**Initial Vert. Dimension (σZ, m)**	**Area of Source (m^2)**	**Rotation (deg)**
OFFMAIN1	Off-road mobile diesel vehicles	3.69	0	1	1225	0
OFFMAIN2	Off-road mobile diesel vehicles	6.24	0	1	1225	0

Volume Sources						
Source ID	**Source Description**	**Base Height (m)**	**Release Height (meters)**	**Length of Side (meters)**	**Initial Lateral Dimension (σY, meters)**	**Initial Vert. Dimension (σZ, meters)**
FUEL	Existing gasoline dispensing	8	1	5.0	1.163	0.500

Table 3-6
Model Source Representations - Phase 2 Operations

Point Sources						
Model ID	**Source Description**	**Base Height (m)**	**Release Height (m)**	**Stack Diameter (m)**	**Exit Velocity (m/s)**	**Exit Temperature (K)**
CTB10C1	Cooling Tower - Building 10, Cell 1	4	28.7	2.5	10	-10
CTB10C2	Cooling Tower - Building 10, Cell 2	4	28.7	2.5	10	-10
CTB10C3	Cooling Tower - Building 10, Cell 3	4	28.7	2.5	10	-10
CTB11C1	Cooling Tower - Building 11, Cell 1	4.12	28.7	2.5	10	-10
CTB11C2	Cooling Tower - Building 11, Cell 2	4.1	28.7	2.5	10	-10
DG_B10	Diesel Generator - Buliding 10	4	3.0	0.15	94.6	760.9
DG_B11	Diesel Generator - Buliding 11	4.82	3.0	0.15	94.6	760.9
LAB_B10	Lab Stack - Building 10	4	25.6	1	10	293.2
LAB_B11	Lab Stack - Building 11	4	25.6	1	10	293.2
NGB_B10	Natural Gas Boiler - Building 10	4	25.6	0.44	4.95	366.5
NGB_B11	Natural Gas Boiler - Building 11	4.58	25.6	0.33	4.95	366.5

Volume Sources						
Source ID	**Source Description**	**Base Height (m)**	**Release Height (meters)**	**Length of Side (meters)**	**Initial Lateral Dimension (σY, meters)**	**Initial Vert. Dimension (σZ, meters)**
P1	Parking Structure Volume Source P1	3.98	11.7	38.94	9.06	10.92

Line Source - Adjacent Volume Sources						
Source ID	**Source Description**	**Initial Lateral Dimension (m)**	**Initial Vertical Dimension (m)**	**Release Height (m)**	**Total Road Length (m)**	**Adjacent Vol. Sources**
ONS_R1	Onsite main entry road	6.05	1.58	0	284.6	22
R3_R4	Onsite road to P1	6.05	1.58	1.7	80.6	6
ONS_R2	Onsite Shuttle only road	6.05	1.58	1.7	277.4	21
OFS_R2	Offsite East Highway road	9.77	1.58	0	109.7	5
OFS_R1	Offsite main entry road	6.05	1.58	1.7	245.9	19
OFS_R3	Offsite North Highway road	9.77	1.58	1.7	532.6	25

Table 3-7
Phase 1 Downwash Structure Heights

Building ID	Number of Tiers	Tier Height (m)
BLDG1	1	7.6
BLD_6	1	17.1
BLD_7	1	22.6
BLD_8	1	11.6
BLD_9	1	17.1

Table 3-8
Full LRDP Downwash Structure Heights

Building ID	Number of Tiers	Tier Height (m)
B1_EPA_EX	1	7.6
B10	1	22.6
B11	1	22.6
B12	1	22.6
B13	1	17.1
B14	1	22.6
B15	1	22.6
B16	1	22.6
B17	1	28.0
B18	1	28.0
B19	1	28.0
B20	1	28.0
B21	1	28.0
B22	1	28.0
B23	1	28.0
B24	1	28.0
B25	1	28.0
B26	1	28.0
B27	1	22.6
B28	1	22.6
B29	1	17.1
B3	1	16.8
B30	1	22.6
B31	1	17.1
B32	1	28.0
B33	1	28.0
B34	1	28.0
B35	1	28.0
B36	1	28.0
B37	1	28.0
B38	1	17.1
B6	1	17.1
B7	1	22.6
B8	1	11.6
B9	1	17.1
ES1	1	4.6
NRLF_EX_2	1	12.2
P1	1	23.5
P2	1	23.5
P3	1	26.8
P4	1	23.5
P5	1	20.1
P6	1	16.8

Table 4-1. Phase 1 Construction - Maximum Criteria Pollutant Emissions Estimates

Assessment	Annual Tons per Year					
	Onsite Stationary (Exhaust)	Onsite Mobile (Exhaust)	Onsite Fugitive Dust	Offsite Mobile (Exhaust)	Offsite Fugitive Dust	Total [(1)]
ROG/VOC Emissions	--	0.25	--	0.52	--	0.77
NO_x Emissions	--	1.97	--	4.69	--	6.65
CO Emissions	--	1.17	--	3.83	--	5.00
PM_{10} Emissions	--	0.11	N/A	0.14	N/A	0.25
$PM_{2.5}$ Emissions	--	0.11	N/A	0.13	N/A	0.24

Assessment	Average Pounds per Day					
	Onsite Stationary (Exhaust)	Onsite Mobile (Exhaust)	Onsite Fugitive Dust	Offsite Mobile (Exhaust)	Offsite Fugitive Dust	Total [(1)]
ROG/VOC Emissions	--	1.38	--	2.85	--	4.23
NO_x Emissions	--	10.77	--	25.69	--	36.46
CO Emissions	--	6.38	--	21.00	--	27.38
PM_{10} Emissions	--	0.62	N/A	0.77	N/A	1.38
$PM_{2.5}$ Emissions	--	0.62	N/A	0.69	N/A	1.31

Notes:

(1) Sum of all emission categories for ROG/VOC and NO_x; sum of Exhaust emission categories only for $PM_{10}/PM_{2.5}$.

Table 4-2. Phase 1 Operations - Maximum Criteria Pollutant Emissions Estimates

Assessment	Annual Tons per Year					
	Onsite Stationary (Exhaust)	Onsite Mobile (Exhaust)	Onsite Fugitive Dust	Offsite Mobile (Exhaust)	Offsite Fugitive Dust	Total [1]
ROG/VOC Emissions	0.77	0.31	--	1.15	--	2.23
NO_x Emissions	1.13	0.22	--	1.65	--	3.00
CO Emissions	4.98	2.56	--	14.95	--	22.48
PM_{10} Emissions	1.40	0.01	0.500	0.80	1.88	4.59
$PM_{2.5}$ Emissions	1.02	0.01	0.123	0.34	0.46	1.94

Assessment	Average Pounds per Day					
	Onsite Stationary (Exhaust)	Onsite Mobile (Exhaust)	Onsite Fugitive Dust	Offsite Mobile (Exhaust)	Offsite Fugitive Dust	Total [1]
ROG/VOC Emissions	4.23	1.72	--	6.28	--	12.23
NO_x Emissions	6.18	1.19	--	9.06	--	16.44
CO Emissions	27.30	14.00	--	81.90	--	123.20
PM_{10} Emissions	7.67	0.04	2.74	4.39	10.31	25.15
$PM_{2.5}$ Emissions	5.56	0.04	0.67	1.84	2.53	10.65

Notes:

(1) Sum of all emission categories for ROG/VOC, NO_x, PM_{10}, and $PM_{2.5}$.

Table 4-3. LRDP Construction - Maximum Criteria Pollutant Emissions Estimates [1]

Assessment	Annual Tons per Year					
	Onsite Stationary (Exhaust)	Onsite Mobile (Exhaust)	Onsite Fugitive Dust	Offsite Mobile (Exhaust)	Offsite Fugitive Dust	Total [2]
ROG/VOC Emissions	--	0.09	N/A	0.20	N/A	0.29
NO_x Emissions	--	0.62	N/A	1.68	N/A	2.30
CO Emissions	--	0.47	N/A	1.49	N/A	1.95
PM_{10} Emissions	--	0.03	N/A	0.05	N/A	0.08
$PM_{2.5}$ Emissions	--	0.03	N/A	0.05	N/A	0.08

Assessment	Average Pounds per Day					
	Onsite Stationary (Exhaust)	Onsite Mobile (Exhaust)	Onsite Fugitive Dust	Offsite Mobile (Exhaust)	Offsite Fugitive Dust	Total [2]
ROG/VOC Emissions	--	0.48	N/A	1.12	N/A	1.59
NO_x Emissions	--	3.42	N/A	9.18	N/A	12.60
CO Emissions	--	2.56	N/A	8.14	N/A	10.70
PM_{10} Emissions	--	0.16	N/A	0.29	N/A	0.45
$PM_{2.5}$ Emissions	--	0.16	N/A	0.27	N/A	0.42

Notes:

(1) Excludes Phase 1 period, which was evaluated separately.

(2) Sum of all emission categories for ROG/VOC and NO_x; sum of Exhaust emission categories only for $PM_{10}/PM_{2.5}$.

Table 4-4. LRDP Operations - Maximum Criteria Pollutant Emissions Estimates

Assessment	Annual Tons per Year					
	Onsite Stationary (Exhaust)	Onsite Mobile (Exhaust)	Onsite Fugitive Dust	Offsite Mobile (Exhaust)	Offsite Fugitive Dust	Total [1]
ROG/VOC Emissions	16.44	1.71	--	6.60	--	24.75
NO_x Emissions	8.61	1.92	--	9.65	--	20.18
CO Emissions	38.91	20.18	--	88.28	--	147.37
PM_{10} Emissions	13.00	0.16	4.764	7.89	18.45	44.27
$PM_{2.5}$ Emissions	9.16	0.15	1.168	3.32	4.53	18.33

Assessment	Average Pounds per Day					
	Onsite Stationary (Exhaust)	Onsite Mobile (Exhaust)	Onsite Fugitive Dust	Offsite Mobile (Exhaust)	Offsite Fugitive Dust	Total [1]
ROG/VOC Emissions	90.10	9.38	--	36.14	--	135.62
NO_x Emissions	47.20	10.50	--	52.90	--	110.60
CO Emissions	213.20	110.60	--	483.70	--	807.50
PM_{10} Emissions	71.21	0.90	26.102	43.24	101.10	242.56
$PM_{2.5}$ Emissions	50.20	0.83	6.400	18.21	24.82	100.46

Notes:

(1) Sum of all emission categories for ROG/VOC, NO_x, PM_{10}, and $PM_{2.5}$.

Table 4-5. Phase 1 Construction - Maximum Estimated Human Health Impacts

Assessment	Assessment Metric	Maximum Result
Cancer Risk - Offsite Resident	Lifetime Excess Cancer Risk	1.1-in-a-million
Cancer Risk - Offsite Worker	Lifetime Excess Cancer Risk	0.6-in-a-million
Cancer Risk - Onsite Worker	Lifetime Excess Cancer Risk	1.7-in-a-million
Chronic Hazard - Offsite Resident	Hazard Index	0.003
Chronic Hazard - Offsite Worker	Hazard Index	0.05
Chronic Hazard - Onsite Worker	Hazard Index	0.14
Acute Hazard - Onsite Worker	Hazard Index	(1)
Acute Hazard - Offsite Worker	Hazard Index	(1)
$PM_{2.5}$ Annual Concentration	Annual Average Concentration ($\mu g/m^3$)	0.020

Notes:

(1) Not assessed for this scenario - see report text.

Table 4-6. Phase 1 Operations - Maximum Estimated Human Health Impacts

Assessment	Assessment Metric	Maximum Result
Cancer Risk - Offsite Resident	Lifetime Excess Cancer Risk	0.9-in-a-million
Cancer Risk - Offsite Worker	Lifetime Excess Cancer Risk	2.4-in-a-million
Cancer Risk - Onsite Worker	Lifetime Excess Cancer Risk	2.9-in-a-million
Chronic Hazard - Offsite Resident	Hazard Index	0.005
Chronic Hazard - Offsite Worker	Hazard Index	0.04
Chronic Hazard - Onsite Worker	Hazard Index	0.05
Acute Hazard - Onsite Worker	Hazard Index	0.42
Acute Hazard - Offsite Worker	Hazard Index	0.36
$PM_{2.5}$ Annual Concentration	Annual Average Concentration ($\mu g/m^3$)	0.082

Table 4-7. LRDP Construction - Maximum Estimated Human Health Impacts

Assessment	Assessment Metric	Maximum Result
Cancer Risk - Offsite Resident	Lifetime Excess Cancer Risk	3.3-in-a-million
Cancer Risk - Offsite Worker	Lifetime Excess Cancer Risk	2.6-in-a-million
Cancer Risk - Onsite Worker	Lifetime Excess Cancer Risk	(1)
Chronic Hazard - Offsite Resident	Hazard Index	0.003
Chronic Hazard - Offsite Worker	Hazard Index	0.06
Chronic Hazard - Onsite Worker	Hazard Index	(1)
Acute Hazard - Onsite Worker	Hazard Index	(1)
Acute Hazard - Offsite Worker	Hazard Index	(1)
$PM_{2.5}$ Annual Concentration	Annual Average Concentration ($\mu g/m^3$)	0.018

Notes:

(1) Not assessed for this scenario - see report text.

Table 4-8. LRDP Operations - Maximum Estimated Human Health Impacts

Assessment	Assessment Metric	Maximum Result
Cancer Risk - Offsite Resident (1)	Lifetime Excess Cancer Risk	8.9-in-a-million
Cancer Risk - Offsite Worker	Lifetime Excess Cancer Risk	3.1-in-a-million
Cancer Risk - Onsite Worker	Lifetime Excess Cancer Risk	4.9-in-a-million
Chronic Hazard - Offsite Resident	Hazard Index	0.070
Chronic Hazard - Offsite Worker	Hazard Index	0.27
Chronic Hazard - Onsite Worker	Hazard Index	0.36
Acute Hazard - Onsite Worker (2)	Hazard Index	1.06
Acute Hazard - Offsite Worker (3)	Hazard Index	0.89
$PM_{2.5}$ Annual Concentration (4)	Annual Average Concentration ($\mu g/m^3$)	0.89

(1) Maximum modeled value occurred at Offsite Location 1 on Figure 4-1.
(2) Maximum modeled value occurred at Onsite Location 1 on Figure 4-1.
(3) Maximum modeled value occurred at Offsite Location 2 on Figure 4-1.
(4) Maximum modeled value occurred at Offsite Location 1 on Figure 4-1.

Table 4-9. Estimated Greenhouse Gas Emissions

Scenario	Assessment	Direct Emissions (MT CO_2e/yr)	Indirect Emissions (MT CO_2e/yr)	Total Emissions (MT CO_2e/yr)
Phase 1 - Construction	GHG Emissions (Not Stationary)	1,385	--	1,385

	Assessment	Direct Emissions (MT CO_2e/yr)	Indirect Emissions (MT CO_2e/yr)	Total Emissions (MT CO_2e/yr)	Total New Employees	Emissions per Employee (MT CO_2e/yr)
Phase 1 - Operations	GHG Emissions (Not Stationary)	1,155	373	1,528	1,000	1.53
Phase 1 - Operations	GHG Emissions (Stationary)	1,158	--	1,158		

Scenario	Assessment	Direct Emissions (MT CO_2e/yr)	Indirect Emissions (MT CO_2e/yr)	Total Emissions (MT CO_2e/yr)
LRDP - Construction	GHG Emissions (Not Stationary)	404	--	404

Scenario	Assessment	Direct Emissions (MT CO_2e/yr)	Indirect Emissions (MT CO_2e/yr)	Total Emissions (MT CO_2e/yr)	Total New Employees	Emissions per Employee (MT CO_2e/yr)
LRDP - Operations	GHG Emissions (Not Stationary)	25,202	20124	45,326	10,000	4.53
LRDP - Operations	GHG Emissions (Stationary)	31,880	--	31,880		

Notes:

Not Stationary - Includes onsite and offsite mobile sources and offsite indirect sources resulting from onsite utility usage.
Stationary - Includes only onsite stationary emission sources.

Table 4-10. Cumulative Cancer Risk, Chronic Hazard, and $PM_{2.5}$ Assessments for Phase 1 Project

ID	Name	Address	Cancer Risk (in a million)	Chronic Hazard Quotient	$PM_{2.5}$ ($\mu g/m^3$)
Existing Sources within 1,000 Feet of Project Boundary [1]					
5462	Bio-Rad Laboratories	3110 REGATTA BLVD	36.1	0.374	0.028
15508	Wareham Property Group - EPA Lab	1337 SO 46TH ST, BLDG 201	19	0.0067	0.34
	Phase 1 Project - Construction [2]		1.4	0.004	0.02
	Phase 1 Project - Operations [3]		3.0	0.009	0.15
	Cumulative - Construction [4,6]		**38.3**	**0.38**	**0.39**
	Cumulative - Operations [5,6]		**39.9**	**0.39**	**0.51**

Notes:

(1) As provided in the BAAQMD Stationary Source and Highway Screening Tools (*http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES/Tools-and-Methodology.aspx*). Maximum impacts at any location reported.

(2) Includes impacts from existing RFS sources.

(3) Includes impacts from existing RFS and Phase 2 sources.

(4) Sum of maximum impacts from existing sources and Phase 1 Project - Construction

(5) Sum of maximum impacts from existing sources and Phase 1 Project - Operation

(6) Source ID 15508 cancer risk result multiplied by minimum generator distance multiplier of 0.04 because 98% of the cancer risk is from a diesel generator and the facility is >> 280 m from MEI receptor.

Table 4-11. Cumulative Cancer Risk, Chronic Hazard, and $PM_{2.5}$ Assessments for Full LRDP Build-Out

ID	Name	Address	Cancer Risk (in a million)	Chronic Hazard Quotient	$PM_{2.5}$ ($\mu g/m^3$)
Existing Sources within 1,000 Feet of Project Boundary [1]					
5462	Bio-Rad Laboratories	3110 REGATTA BLVD	36.1	0.374	0.028
G9842	University of CA-Richmond Field Station	1301 So 46th Street	0	0	na
15755	Grace Baking	3200G REGATTA BLVD	0.0576	0.00002	0.53
G7543	Pacific Gas and Electric Company	1100 So 27th Street	1.1	0.0016	na
17029	Verizon Wireless (Richmond)	SO 27TH ST & PIERSON AVE	8.5	0.003	0.002
93	Safeway Stores Inc, Bakery Plant	905 SO 34TH STREET	0.03	0.00001	0.617
G7555	Stop & Shop	800 Carlson Boulevard	2.37	0.0034	na
15508	Wareham Property Group - EPA Lab	1337 SO 46TH ST, BLDG 201	19	0.0067	0.34
851	I-580 (East/North of Freeway)	300 ft from Max. Exposed Individual	50.384	0.041	0.279
	LRDP - Construction [3]		3.6	0.004	0.02
	LRDP - Operations [3]		11.3	0.07	0.89
	Cumulative - Construction [4, 6]		**94.7**	**0.42**	**1.49**
	Cumulative - Operations [5, 6]		**102.4**	**0.49**	**2.36**

Notes:

(1) As provided in the BAAQMD Stationary Source and Highway Screening Tools (*http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES/Tools-and-Methodology.aspx*). Maximum impacts at any location reported.

(2) BAAQMD database indicated zero impact from Richmond Field Station sources; however, these source emissions were explictly included in the Cumulative dispersion modeling, and were therefore accounted for in this manner.

(3) Includes impacts from existing RFS sources.

(4) Sum of maximum impacts from existing sources and LRDP - Construction.

(5) Sum of maximum impacts from existing sources and LRDP - Operations.

(6) Source ID 17029 is a diesel generator, so maximum impacts multiplied by generator distance multiplier of 0.04 (>> 280 m from MEI receptor).
Source ID 15508 cancer risk result multiplied by minimum generator distance multiplier of 0.04 because 98% of the cancer risk is from a diesel generator and the facility is >> 280 m from MEI receptor.

Table 4-12. Summary of Cumulative PM Sources Modeled

Facility Number	Facility Name	Facility Address	Emission Source(s)	BAAQMD Source Representation Description	BAAQMD Source Representation Type	BAAQMD Source Parameters	UTM Coordinates (m, Zone 10)	PM Emissions [1] (lb/day)
15508	Wareham Property Group - EPA Lab	1337 South 46th St, Bldg 201	Emergency Generator	Generator	Point	Stack Height = 3.66 m (12 ft) Stack Diameter = 1.83 m (0.6 ft) Stack Temperature = 739.8 C (872 F) Stack Velocity = 45.3 m/sec (8,923 ft/min)	558296, 4196431	7.67E-04
15508	Wareham Property Group - EPA Lab	1337 South 46th St, Bldg 201	Natural Gas Cogeneration Plant	Unknown Stack	Point	Stack Height = 6.1 m (20 ft) Stack Diameter = 3.05 m (1 ft) Stack Temperature = 644 C(700 F) Stack Velocity = 17.8 m/s (3,500 ft/min)	558296, 4196431	7.83E-03
5462	Bio-Rad Laboratories	3110 Regatta Blvd	Fume Hoods/Bottling Operation	Unknown Source	Volume	Release Height = 1.8 m Initial Lateral Dimension = 10 m Initial Vertical Dimension = 1 m	558077, 4196531	1.04E-06
15755	Grace Baking	3200G Regatta Blvd	Tunnel Ovens	Unknown Stack	Point	Stack Height = 6.1 m (20 ft) Stack Diameter = 3.05 m (1 ft) Stack Temperature = 644 C(700 F) Stack Velocity = 17.8 m/s (3,500 ft/min)	557986, 4196651	1.35E-02
17029	Verizon Wireless (Richmond)	South 27th ST & Pierson Ave	Emergency Generator	Generator	Point	Stack Height = 3.66 m (12 ft) Stack Diameter = 1.83 m (0.6 ft) Stack Temperature = 739.8 C (872 F) Stack Velocity = 45.3 m/sec (8,923 ft/min)	557863, 4196931	2.42E-05
93	Safeway Stores Inc, Bakery Plant	905 South 34th Street	Ovens	Unknown Stack	Point	Stack Height = 6.1 m (20 ft) Stack Diameter = 3.05 m (1 ft) Stack Temperature = 644 C(700 F) Stack Velocity = 17.8 m/s (3,500 ft/min)	558209, 4197074	1.08E-02

Notes:
(1) Provided by BAAQMD - Annual average.

Table 4-13. Modeled Cumulative $PM_{2.5}$ Assessments for Full LRDP Build-Out Construction/Demolition

ID	Name	Address	$PM_{2.5}$ ($\mu g/m^3$)
Existing Sources within 1,000 Feet of Project Boundary			
5462	Bio-Rad Laboratories	3110 REGATTA BLVD	(1)
G9842	University of CA-Richmond Field Station	1301 So 46th Street	na
15755	Grace Baking	3200G REGATTA BLVD	(1)
G7543	Pacific Gas and Electric Company	1100 So 27th Street	na
17029	Verizon Wireless (Richmond)	SO 27TH ST & PIERSON AVE	(1)
93	Safeway Stores Inc, Bakery Plant	905 SO 34TH STREET	(1)
G7555	Stop & Shop	800 Carlson Boulevard	na
15508	Wareham Property Group - EPA Lab	1337 SO 46TH ST, BLDG 201	(1)
851	I-580 (East/North of Freeway)	300 ft from Max. Exposed Individual	0.279
	LRDP - Construction (2)		0.02
	Cumulative - Construction (3)		**0.30**

Notes:

(1) Included in LRDP - Construction model result.

(2) Modeled cumulative concentration including existing stationary sources and proposed full LRDP build-out sources.

(3) Sum of maximum impacts from I-580 freeway and LRDP - Construction model result; at MEI receptor (UTM 558899.52, 4197095.70).

Table 4-14. Cumulative Cancer Risk for Full LRDP Build-Out Operations with Attenuation Factors

ID	Name	Address	Cancer Risk (in a million)	Distance to Project MEI [3] (m)	BAAQMD Attenuation Factor [4]	Adjusted Cancer Risk (in a million)
Existing Sources within 1,000 Feet of Project Boundary [1]						
5462	Bio-Rad Laboratories	3110 REGATTA BLVD	36.1	985	0.04	1.44
G9842	University of CA-Richmond Field Station [2]	1301 So 46th Street	0	na	na	0
15755	Grace Baking	3200G REGATTA BLVD	0.0576	990	0.04	0.002
G7543	Pacific Gas and Electric Company	1100 So 27th Street	1.1	1200	0.04	0.04
17029	Verizon Wireless (Richmond)	SO 27TH ST & PIERSON AVE	8.5	1000	0.04	0.34
93	Safeway Stores Inc, Bakery Plant	905 SO 34TH STREET	0.03	630	0.04	0.001
G7555	Stop & Shop	800 Carlson Boulevard	2.37	180	0.034	0.08
15508	Wareham Property Group - EPA Lab	1337 SO 46TH ST, BLDG 201	19	900	0.04	0.76
851	I-580 (East/North of Freeway)	300 ft from Max. Exposed Individual	50.384	na	na	50.384
	LRDP - Operations [5]		11.3	na	na	11.30
	Cumulative - Operations [6]		**102.4**			**64.4**

Notes:

(1) As provided in the BAAQMD Stationary Source and Highway Screening Tools (*http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES/Tools-and-Methodology.aspx*). Maximum impacts at any location reported.

(2) BAAQMD database indicated zero impact from Richmond Field Station sources; however, these source emissions were explictly included in the Cumulative dispersion modeling, and were therefore accounted for in this manner.

(3) Cancer risk Maximumally Exposed Individual (MEI) located at UTM coordinates 558831, 4197161 (zone 10).

(4) BAAQMD attenuation factors applicable to diesel generators applied to all sources except G7555, which utilized a BAAQMD attenuation factor for service stations. Note that the BAAQMD attenuation factor of 0.04 for diesel generators applies for distances of 280 meters and beyond, and is therefore very conservatively applied to the generator and non-generator sources in this table, which are all well beyond 280 meters from the MEI. Sources 17029 and 15508 reflect impacts from diesel generators.

(5) Includes impacts from existing RFS sources.

(6) Sum of maximum impacts from existing sources and LRDP - Operations.

Figures

Figure 1-1. Regional Project Site Map

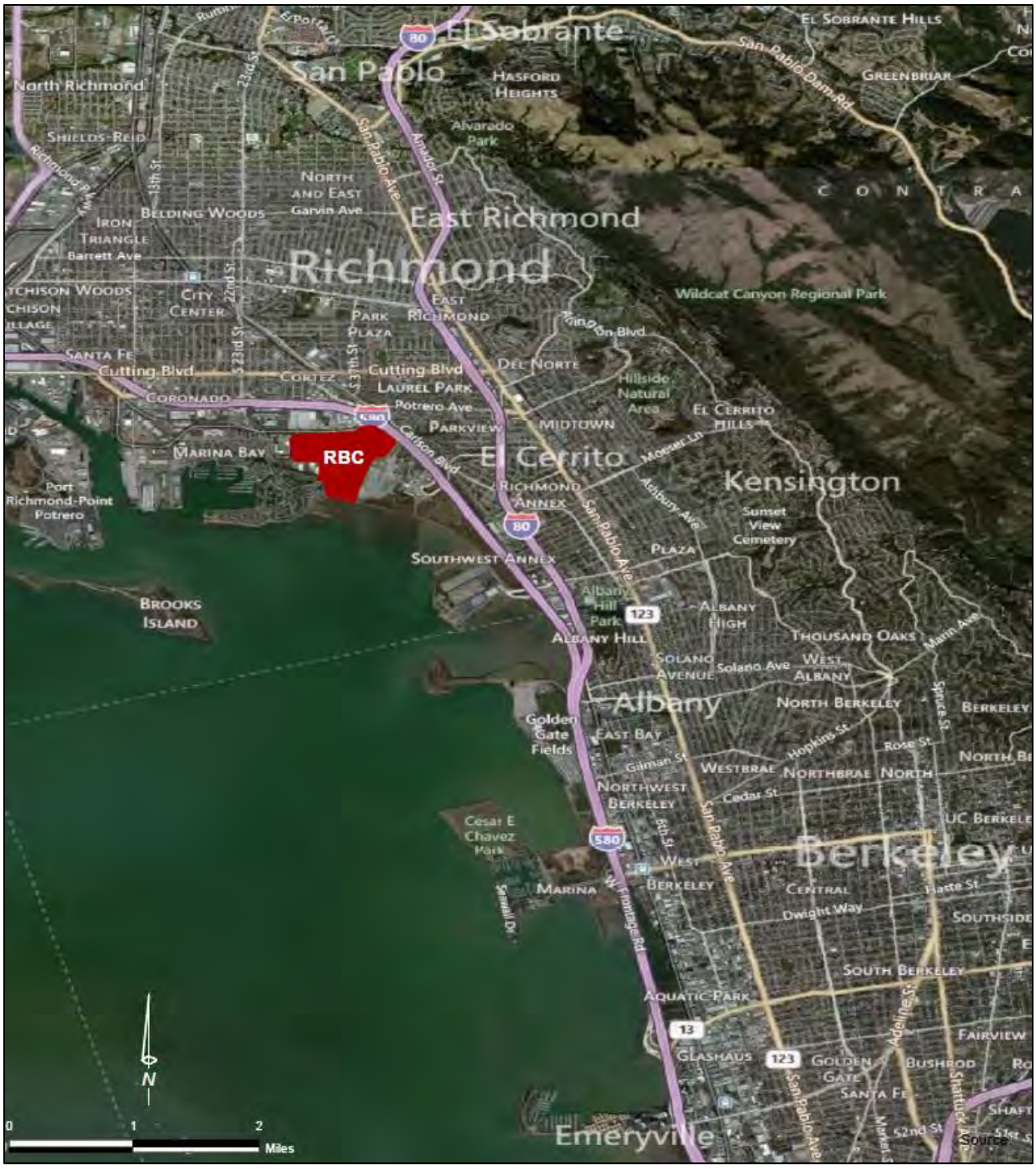


Figure provided by Tetra Tech

Figure 1-2. Long Range Development Plan Illustrative Development Scenario

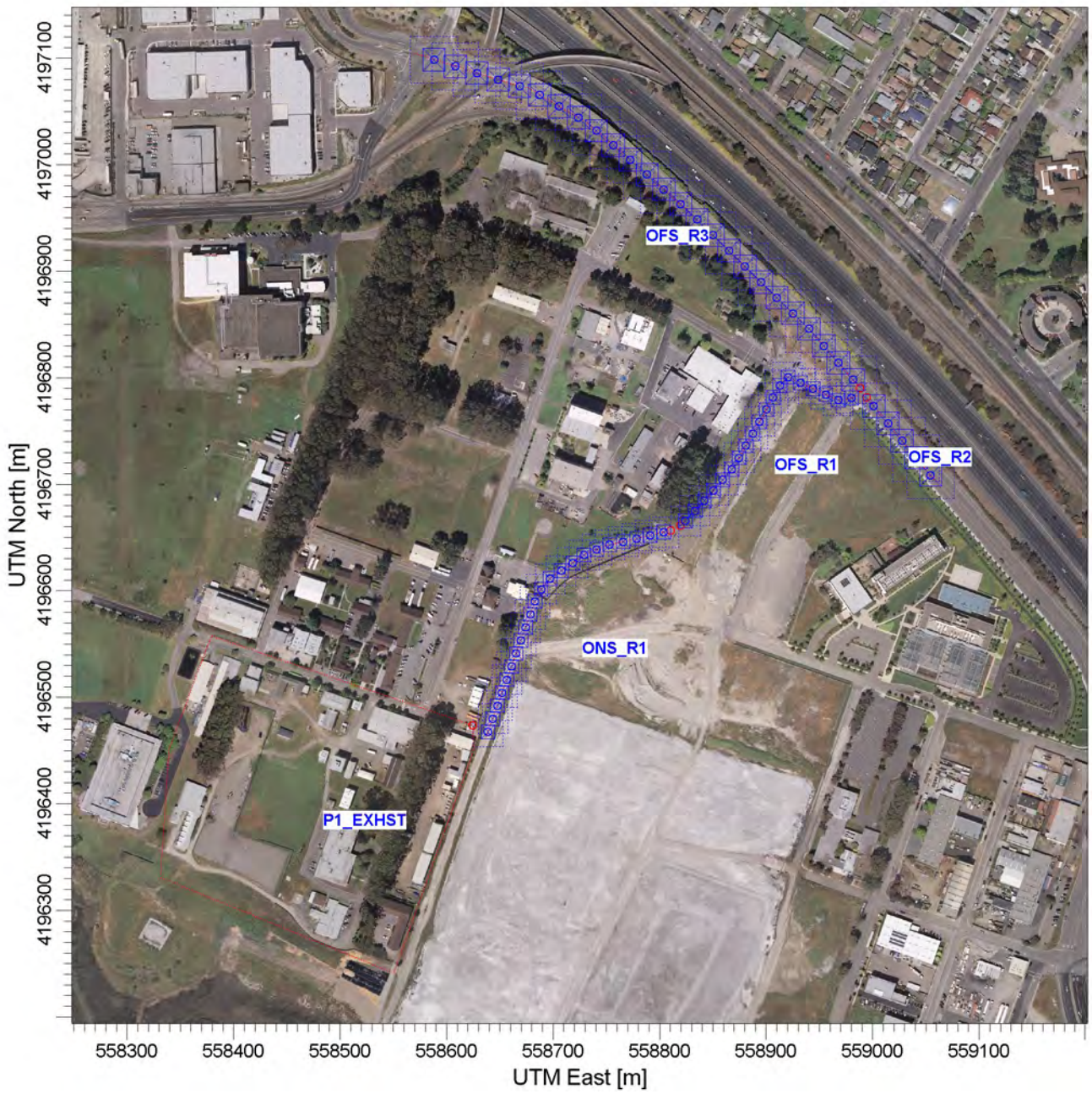
Figure provided by Tetra Tech. Represents one potential build-out scenario.

Figure 1-3. Long Range Development Plan – Phase 1

Figure provided by Tetra Tech. Represents one potential Phase 1 scenario.

PROJECT TITLE:

Figure 3-1. Source Locations - Construction/Demolition - Phase 1
Richmond Bay Campus LRDP, Richmond, California



COMMENTS:

Red dashed lines represent area source location.

Blue squares represent road line source locations.

COMPANY NAME:

Golder Associates, Inc.

MODELER:

Portland, OR

SCALE: 1:6,000

0 0.2 km

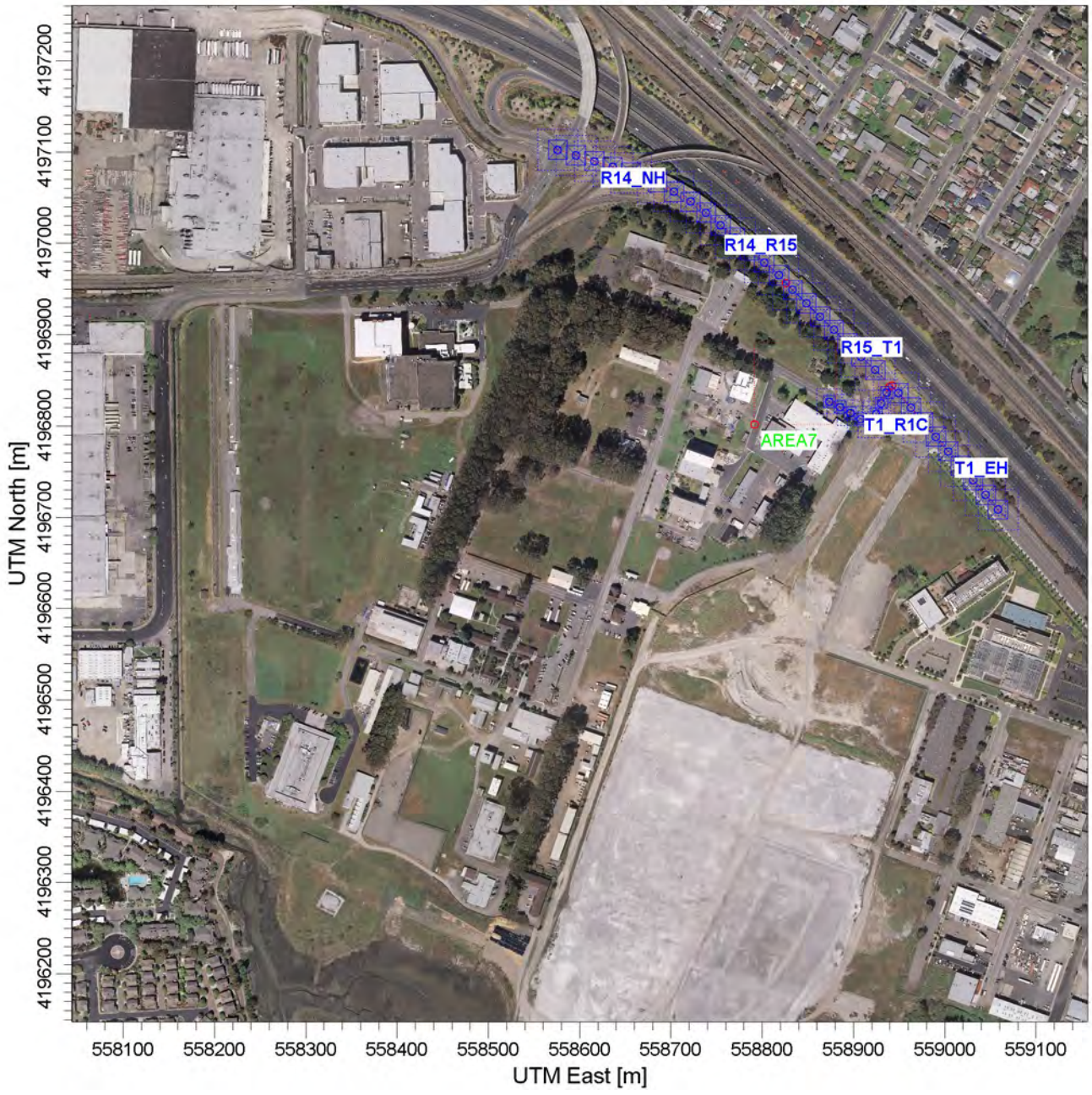
PROJECT NO.:

123-99773_02

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

Figure 3-2. Source Locations - Construction/Demolition - Maximum Annual Impacts at Resident Receptors - Full LRDP Richmond Bay Campus LRDP, Richmond, California



COMMENTS:

Red dashed lines represent area source location.

Blue squares represent road line source locations.

COMPANY NAME:

Golder Associates, Inc.

MODELER:

Portland, OR

SCALE: 1:7,000

0 0.2 km

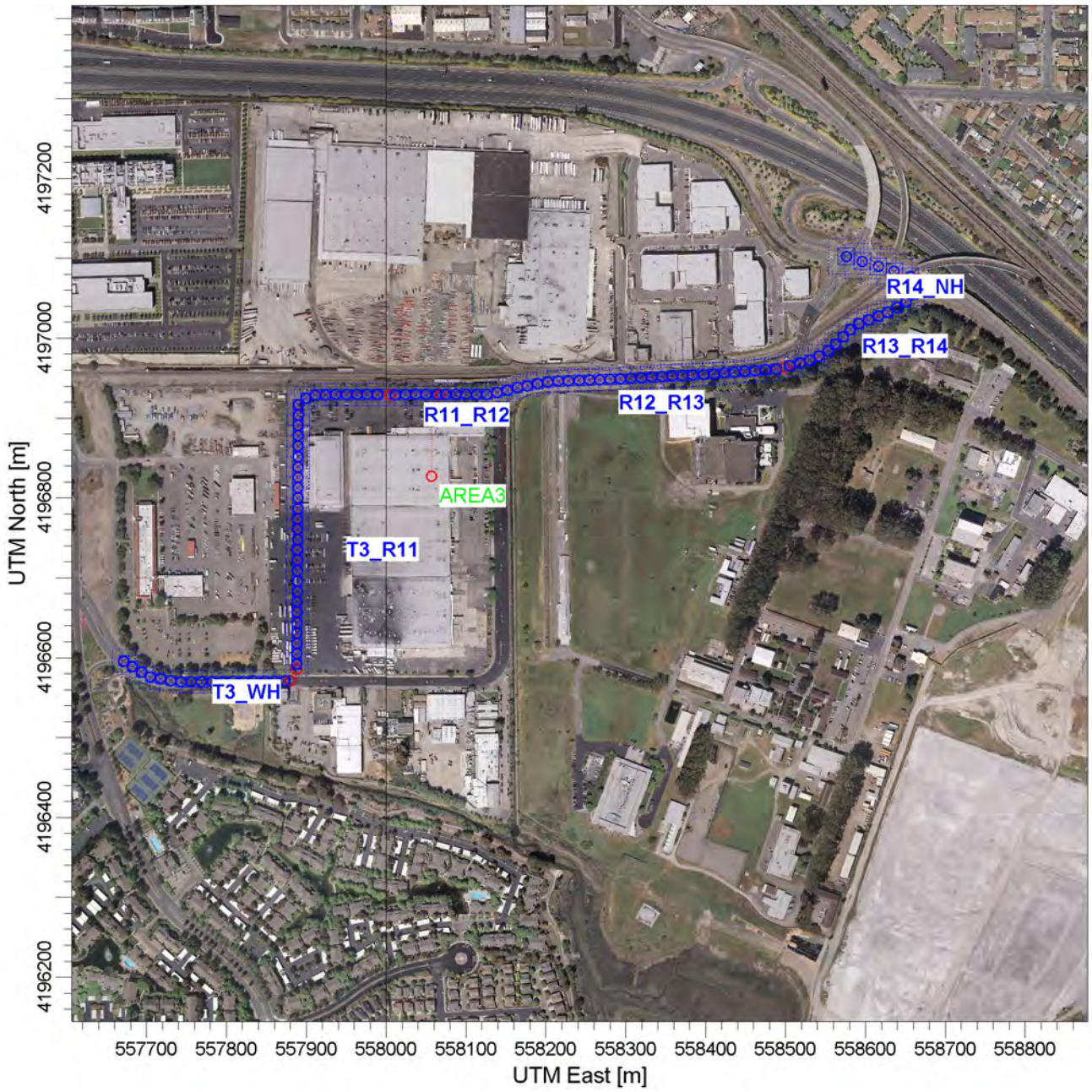
PROJECT NO.:

123-99773_02

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

Figure 3-3. Source Locations - Construction/Demolition - Maximum Annual Impacts at Offsite Worker Receptors - Full LRDP Richmond Bay Campus LRDP, Richmond, California



COMMENTS:

Red dashed lines represent area source location.

Blue squares represent road line source locations.

COMPANY NAME:

Golder Associates, Inc.

MODELER:

Portland, OR

SCALE: 1:8,000

0 0.3 km

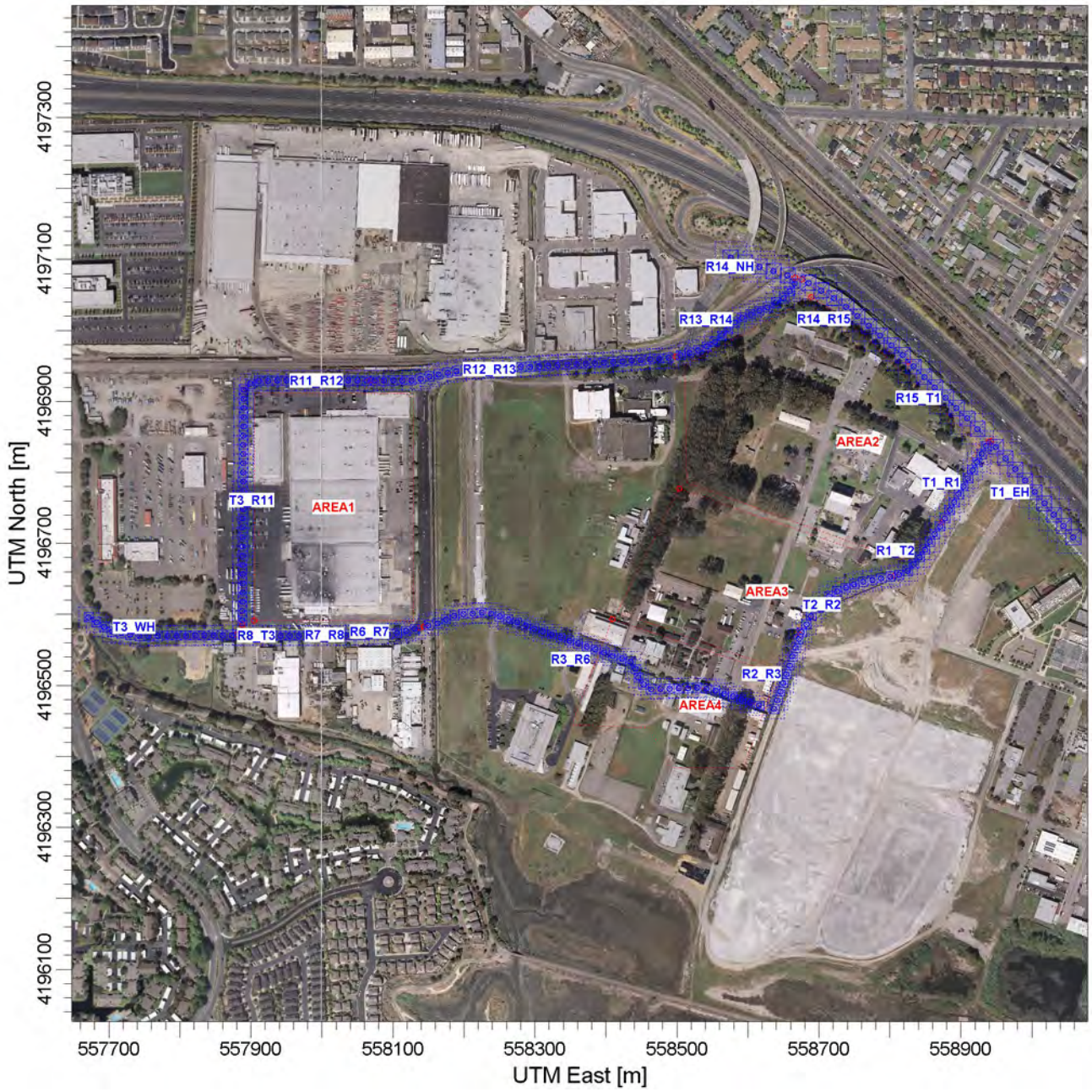
PROJECT NO.:

123-99773_02

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

Figure 3-4. Source Locations - Construction/Demolition - Lifetime Cancer Risk Impacts - Full LRDP
Richmond Bay Campus LRDP, Richmond, California



COMMENTS:

Red dashed lines represent area source locations.

Blue squares represent road line source locations.

COMPANY NAME:

Golder Associates, Inc.

MODELER:

Portland, OR

SCALE: 1:9,000

0 0.3 km

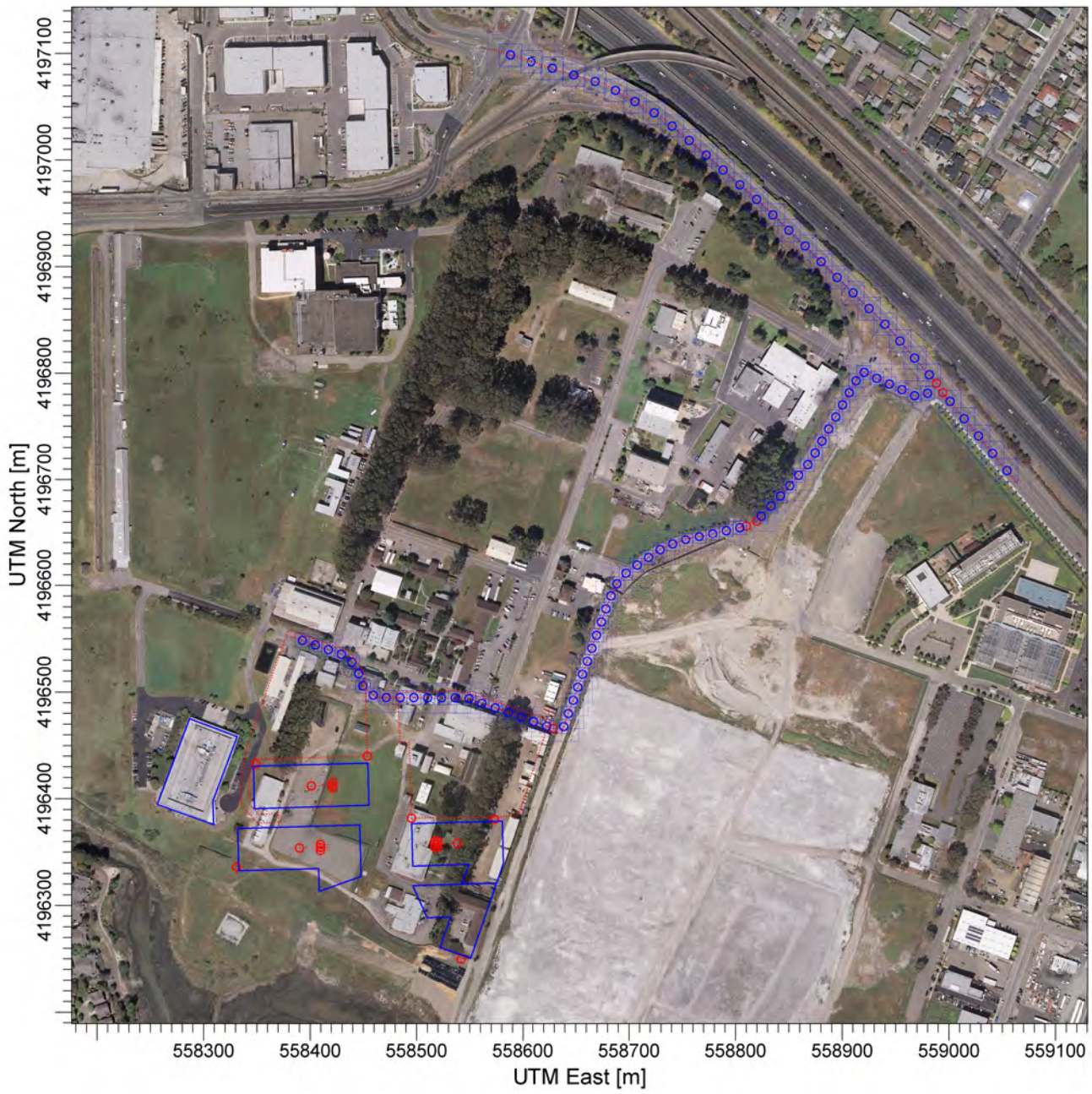
PROJECT NO.:

123-99773_02

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

Figure 3-5. Source Locations - Operations - Phase 1
Richmond Bay Campus LRDP, Richmond, California

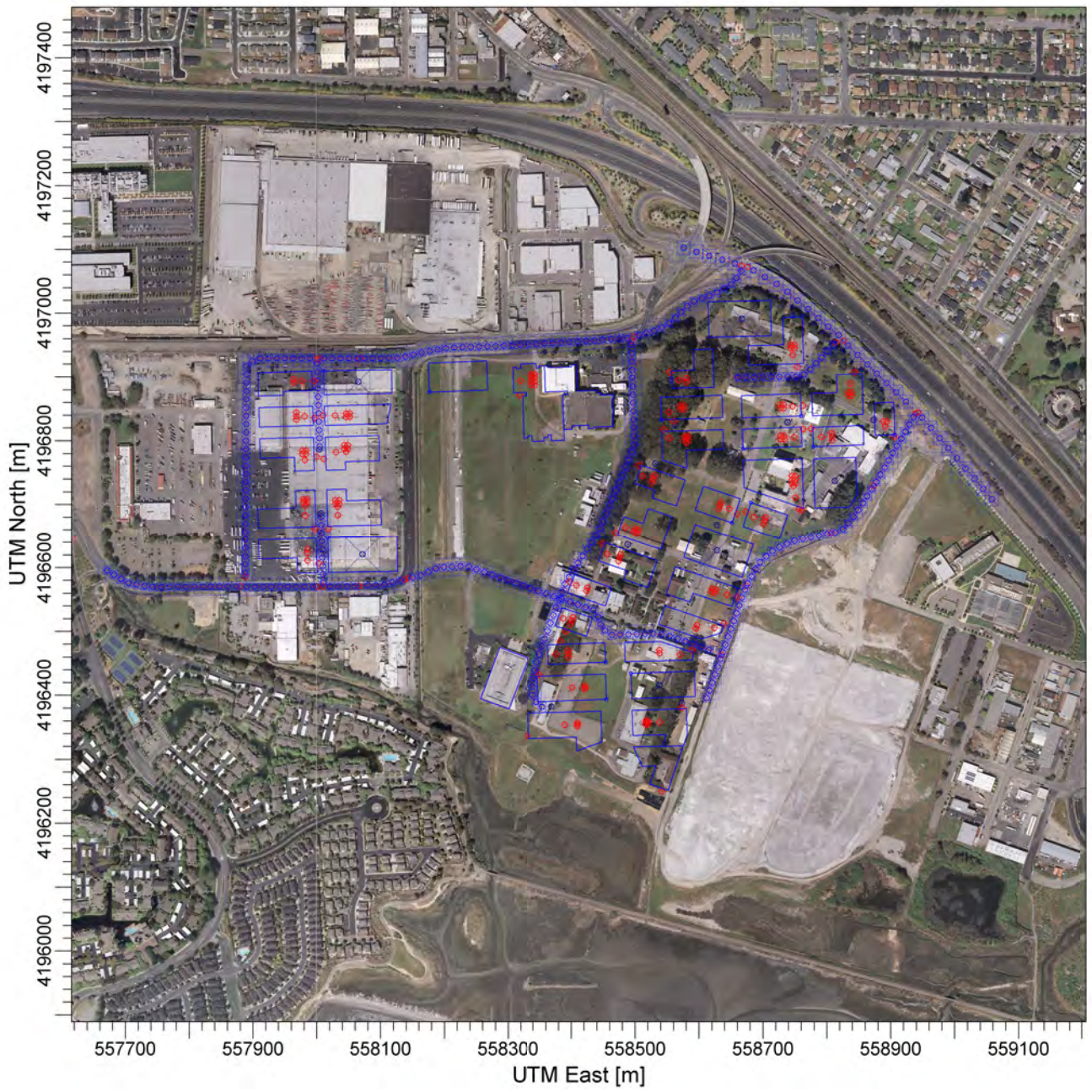


COMMENTS: Red crosshairs denote point source locations. Red dashed lines represent area source locations. Adjacent blue squares represent road line source locations. Blue outlines represent downwash structure locations.	SOURCES: **26**	COMPANY NAME: **Golder Associates, Inc.**	
		MODELER: **Portland, OR**	Golder Associates
		SCALE: 1:6,000 0 0.2 km	
			PROJECT NO.: **123-99773_02**

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

Figure 3-6. Source Locations - Operations - Full LRDP
Richmond Bay Campus LRDP, Richmond, California



COMMENTS: Red crosshairs denote point source locations. Red dashed lines represent area source locations. Adjacent blue squares represent road line source locations. Dashed blue squares represent volume source locations. Blue outlines represent downwash structure locations.	SOURCES: **229**	COMPANY NAME: **Golder Associates, Inc.**	
		MODELER: **Portland, OR**	Golder Associates
		SCALE: 1:10,000 0 0.3 km	
			PROJECT NO.: **123-99773_02**

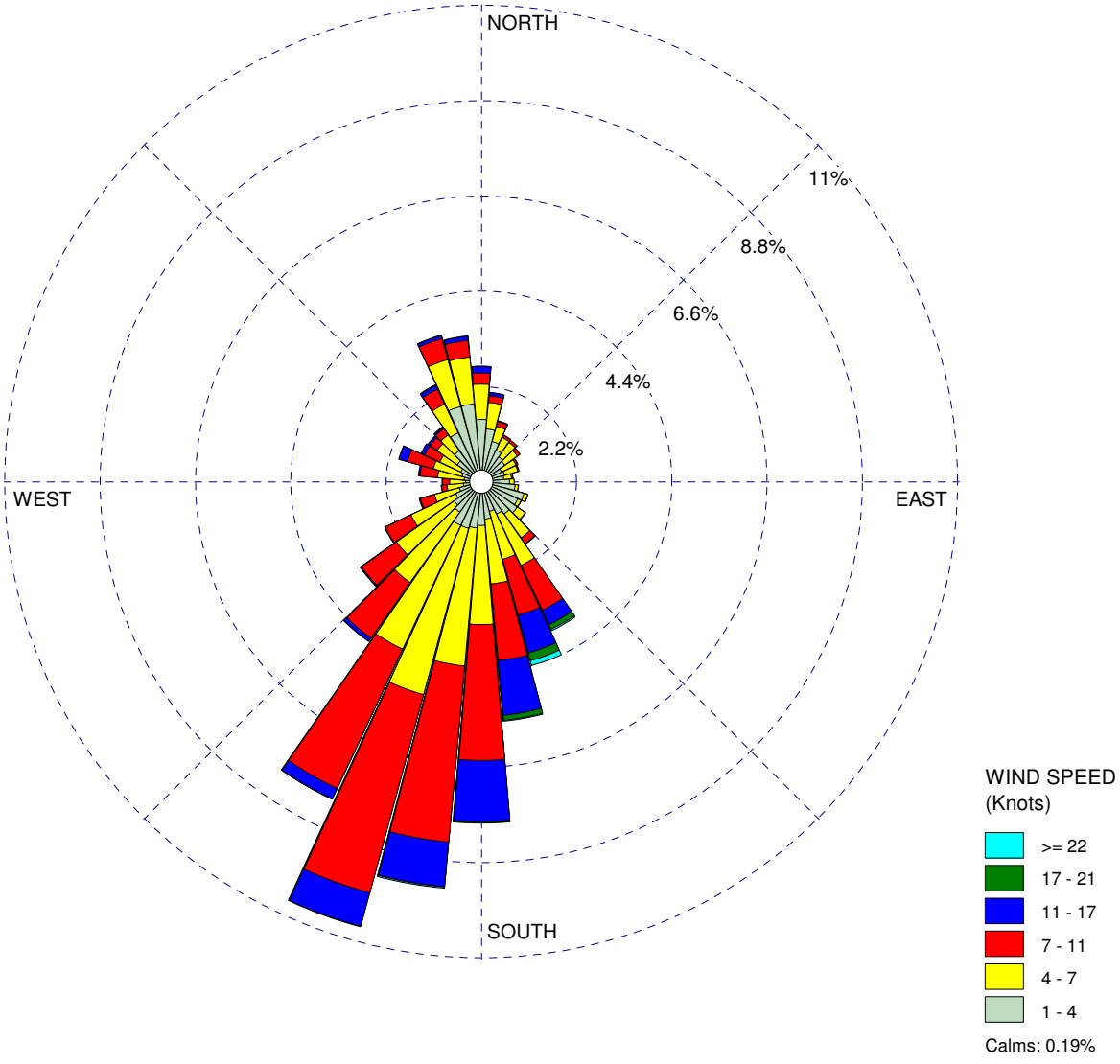
AERMOD View - Lakes Environmental Software

WIND ROSE PLOT:

Figure 3-7. Wind Rose for Modeling Period (2003-2006, and 2008)
Richmond Bay Campus LRDP, Richmond, California

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:

Surface meteorological data collected at the "UC Richmond" location operated by BAAQMD. Data provided by BAAQMD.

COMPANY NAME:

Golder Associates

MODELER:

Portland, OR

CALM WINDS:

0.19%

TOTAL COUNT:

43809 hrs.

AVG. WIND SPEED:

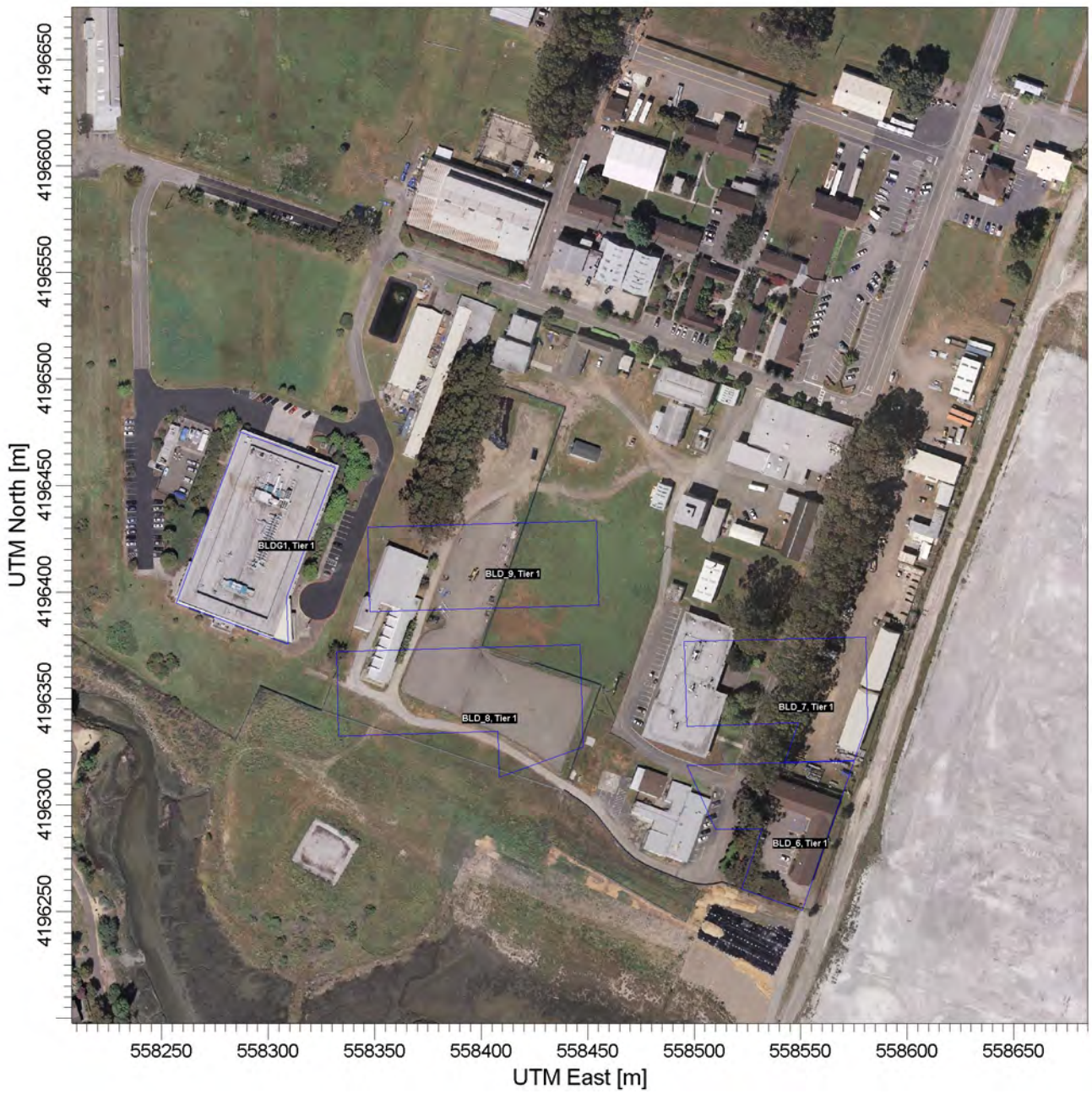
6.40 Knots

PROJECT NO.:

123-99773_02

PROJECT TITLE:

Figure 3-8. Phase 1 Downwash Structure Locations
Richmond Bay Campus LRDP, Richmond, California



COMMENTS: Blue lines denote downwash structures.		COMPANY NAME: **Golder Associates, Inc**	
		MODELER: **Portland, OR**	Golder Associates
		SCALE: 1:3,000 0 0.1 km	
			PROJECT NO.: **123-99773_02**

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

Figure 3-9. Full LRDP Downwash Structure Locations
Richmond Bay Campus LRDP, Richmond, California

COMMENTS: Blue lines denote downwash structures.		COMPANY NAME: **Golder Associates, Inc**	
		MODELER: **Portland, OR**	Golder Associates
		SCALE: 1:7,000 0 0.2 km	
			PROJECT NO.: **123-99773_02**

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

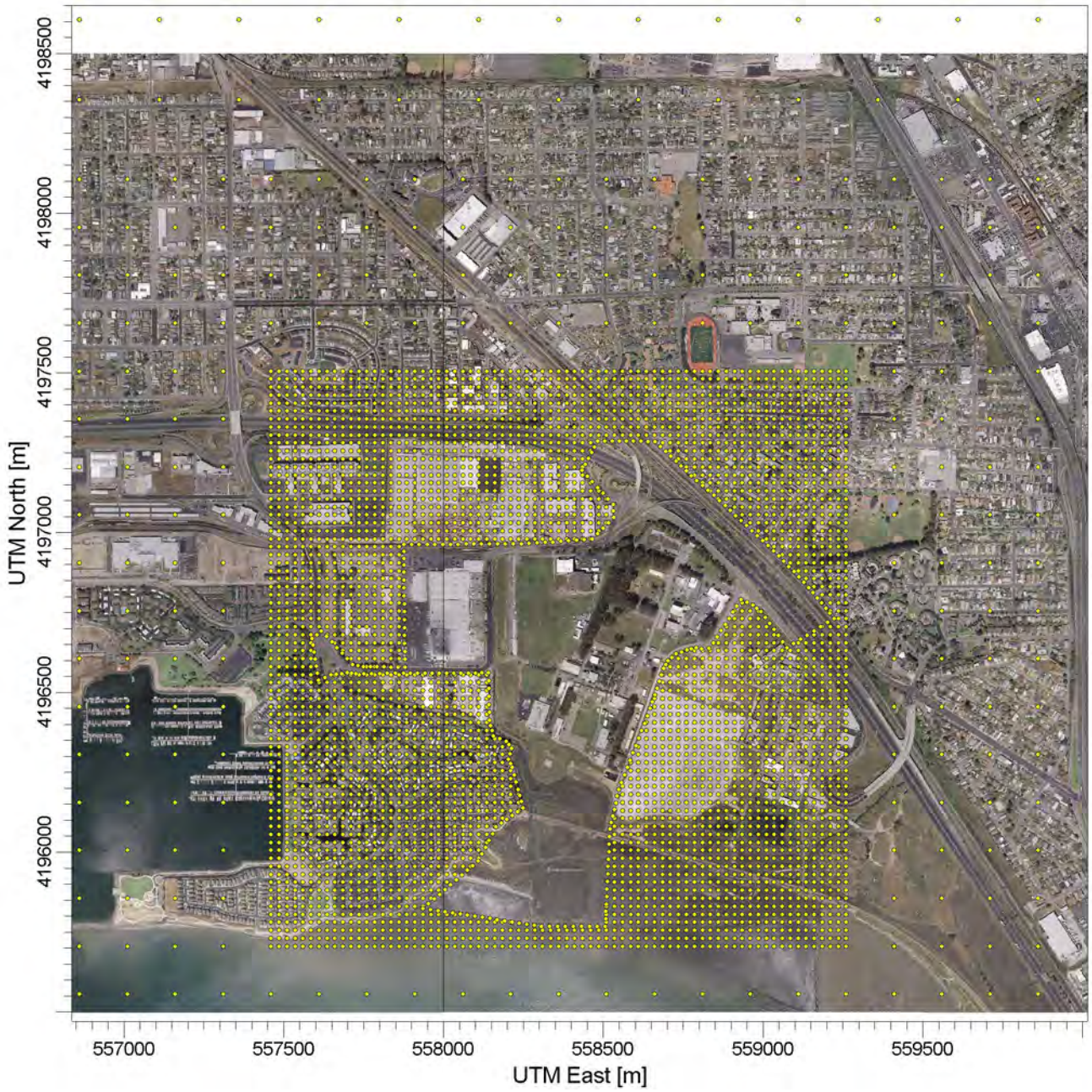
Figure 3-10. Receptor Locations - Offsite Residences
Richmond Bay Campus LRDP, Richmond, California

COMMENTS: Yellow dots represent discrete receptor locations.		COMPANY NAME: **Golder Associates, Inc**
		MODELER: **Portland, OR**
		SCALE: 1:18,000 0 0.5 km
		PROJECT NO.: **123-99773_02**

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

Figure 3-11. Receptor Locations - Offsite Occupational Workers
Richmond Bay Campus LRDP, Richmond, California



COMMENTS:

Yellow dots represent discrete receptor locations.

COMPANY NAME:

Golder Associates, Inc

MODELER:

Portland, OR

SCALE: 1:20,000

0 0.5 km

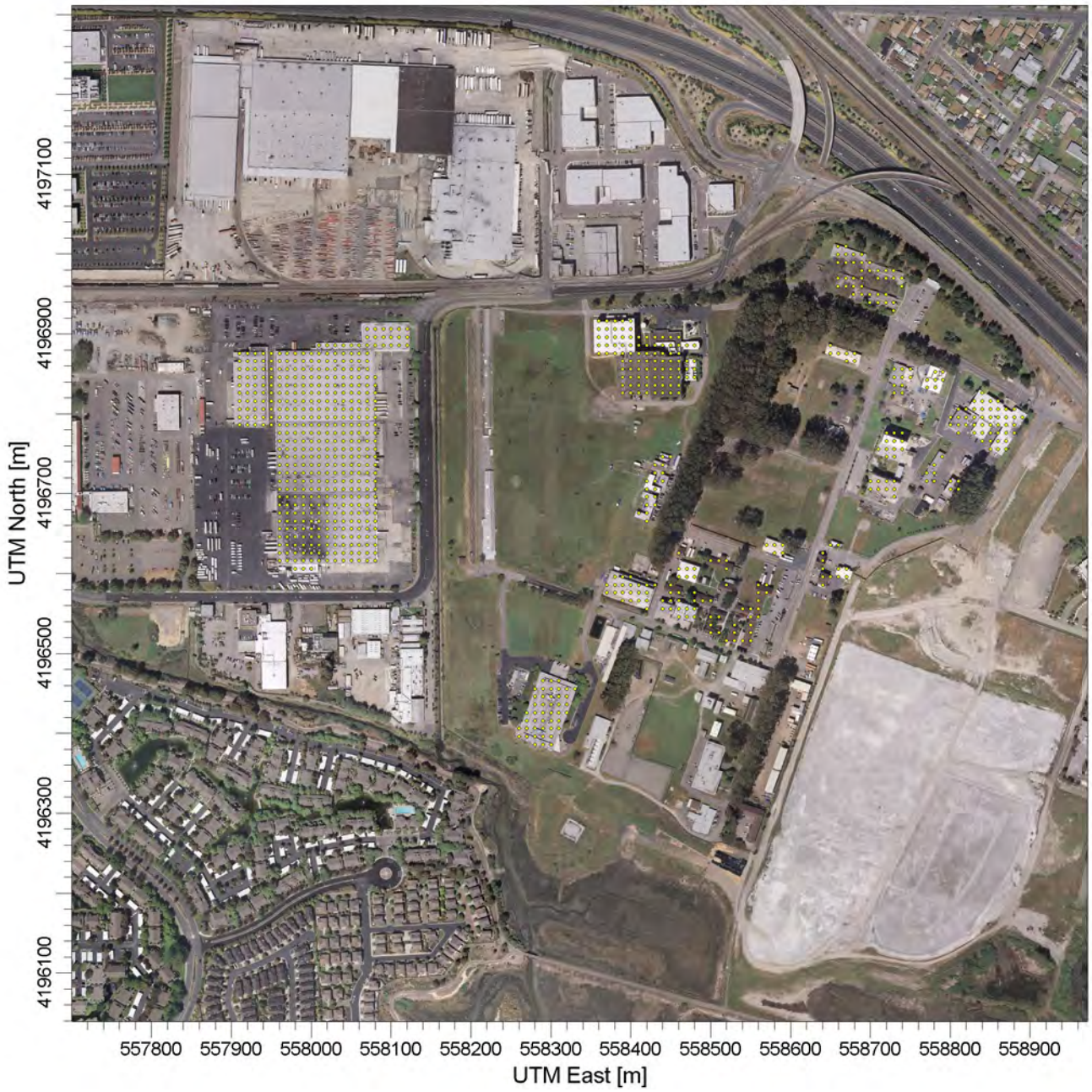
PROJECT NO.:

123-99773_02

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

Figure 3-12. Receptor Locations - Onsite Occupation Workers - Phase 1
Richmond Bay Campus LRDP, Richmond, California



COMMENTS:

Yellow dots represent discrete receptor locations.

COMPANY NAME:

Golder Associates, Inc

MODELER:

Portland, OR

SCALE: 1:8,000

0 0.3 km

PROJECT NO.:

123-99773_02

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

Figure 3-13. Receptor Locations - Onsite Occupational Workers - Full LRDP
Richmond Bay Campus LRDP, Richmond, California

COMMENTS:

Yellow dots represent discrete receptor locations.

Blue line represent downwash structures.

COMPANY NAME:

Golder Associates, Inc

MODELER:

Portland, OR

SCALE: 1:8,000

0 0.3 km

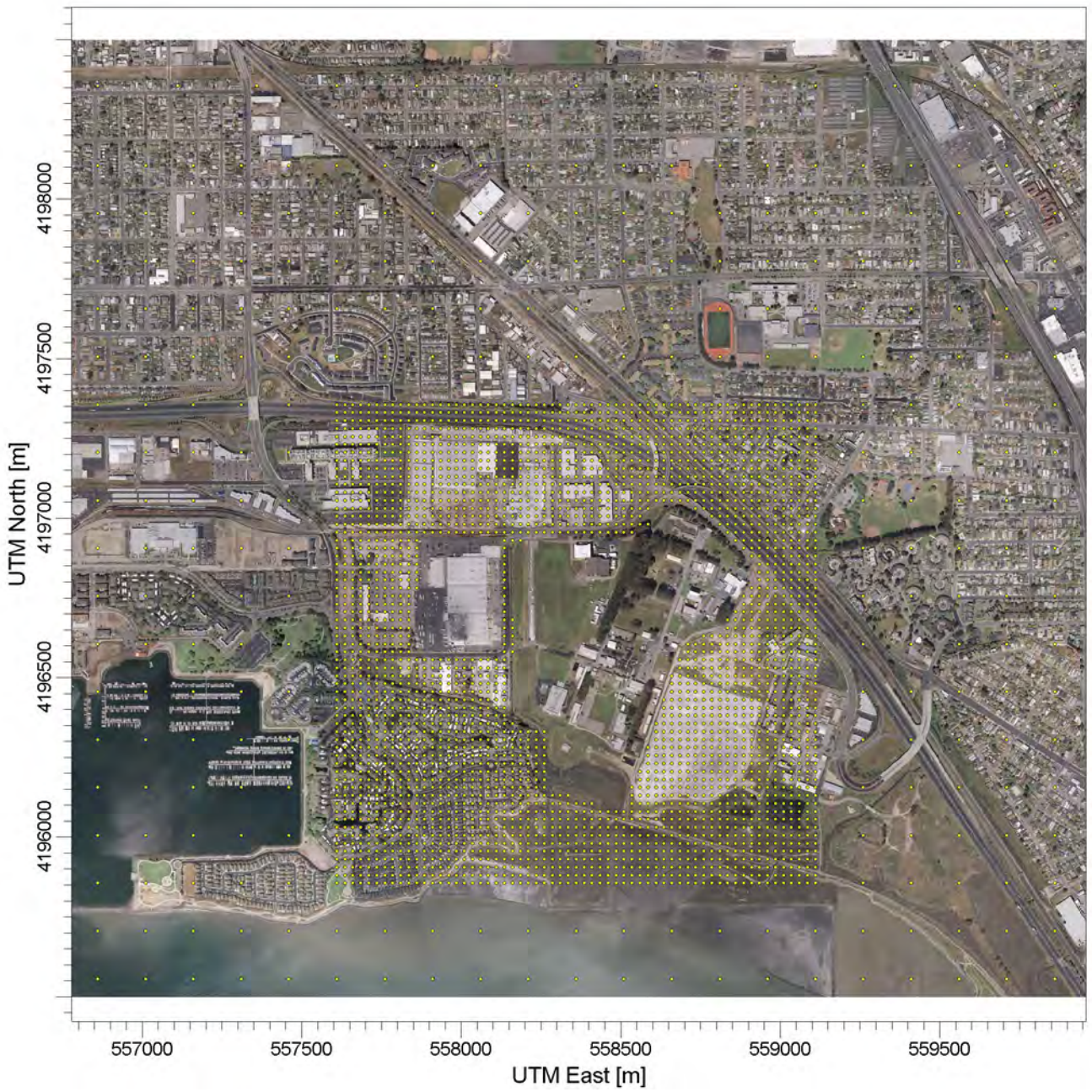
PROJECT NO.:

123-99773_02

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

Figure 3-14. Receptor Locations - Offsite Acute - Phase 1
Richmond Bay Campus LRDP, Richmond, California

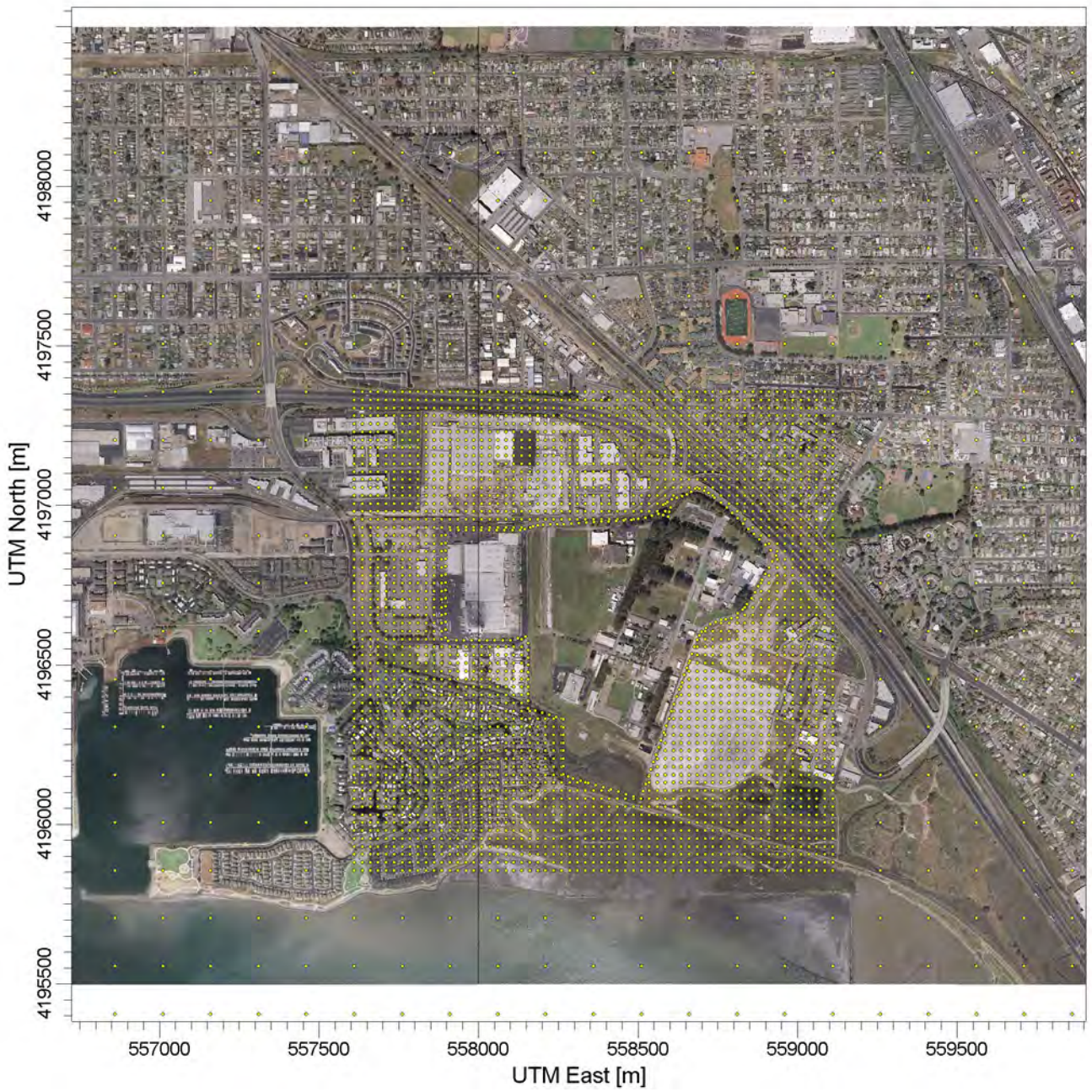


COMMENTS: Yellow dots represent discrete receptor locations.		COMPANY NAME: **Golder Associates, Inc**
		MODELER: **Portland, OR**
		SCALE: 1:20,000 0 0.5 km
		PROJECT NO.: **123-99773_02**

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

Figure 3-15. Receptor Locations - Offsite Acute - Full LRDP
Richmond Bay Campus LRDP, Richmond, California



COMMENTS:

Yellow dots represent discrete receptor locations.

COMPANY NAME:

Golder Associates, Inc

MODELER:

Portland, OR

SCALE: 1:20,000

0 0.5 km

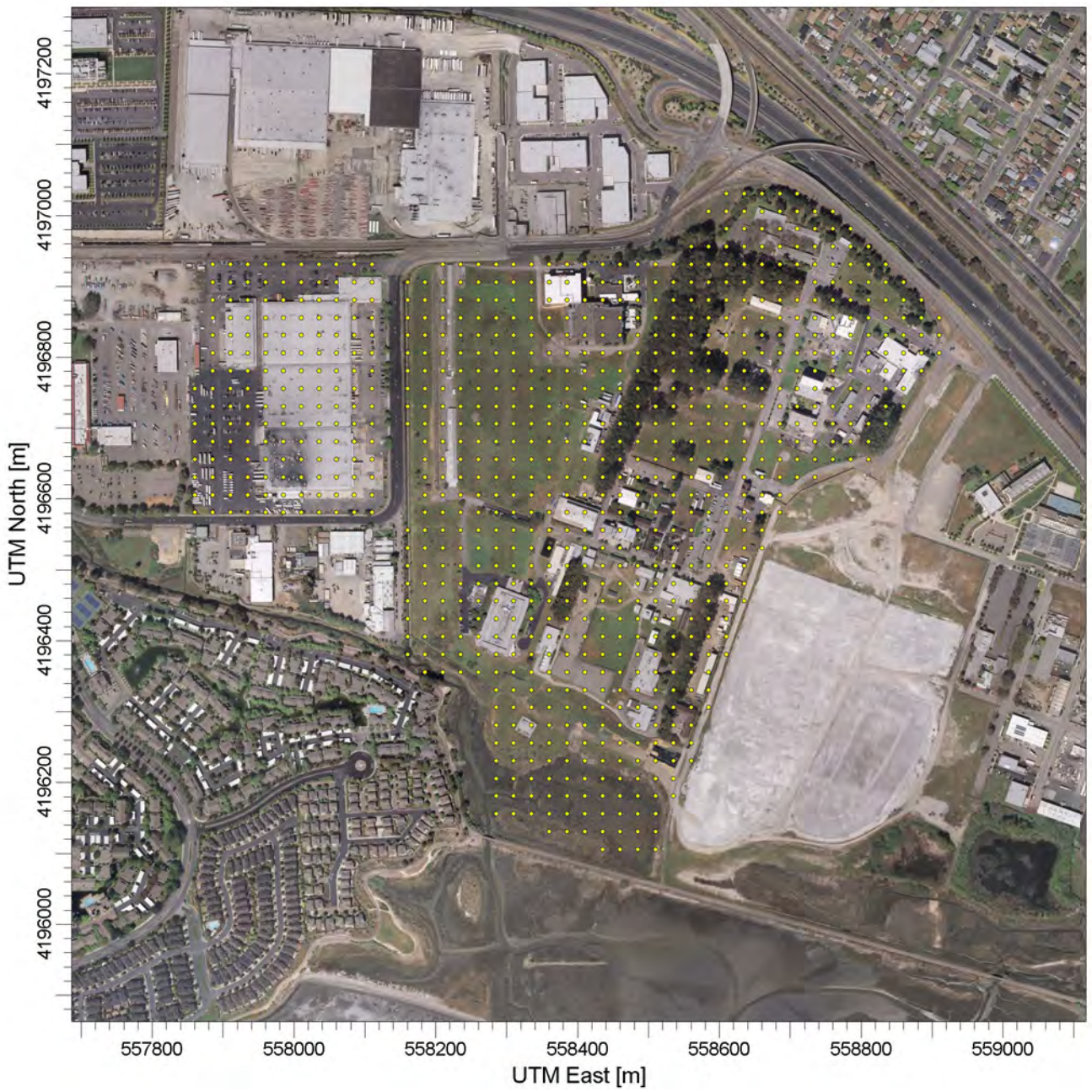
PROJECT NO.:

123-99773_02

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

Figure 3-16. Receptor Locations - Onsite Acute - Phase 1
Richmond Bay Campus LRDP, Richmond, California



COMMENTS: Yellow dots represetn discrete receptor locations.		COMPANY NAME: **Golder Associates, Inc**
		MODELER: **Portland, OR**
		SCALE: 1:9,000 0 0.3 km
		PROJECT NO.: **123-99773_02**

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

Figure 3-17. Receptor Locations - Onsite Acute - LRDP
Richmond Bay Campus LRDP, Richmond, California

COMMENTS: Yellow dots represent discrete receptor locations.		COMPANY NAME: **Golder Associates, Inc**
		MODELER: **Portland, OR**
		SCALE: 1:9,000 0 0.3 km
		PROJECT NO.: **123-99773_02**

AERMOD View - Lakes Environmental Software

Figure 4-1. Maximally Exposed Individual Reference Locations

Appendix A

Emissions Estimates – Phase 1 Construction

Table A-1
CalEEMod Input Assumptions for Phase 1 Construction and Demolition Scenario - 2014

Construction Area	Dates		Total Number of Years	Project Total	(units)	Phase Amount [a]	(units)	Truck Trips (trips/year)	Inventory Onroad Trip Length (miles/trip)	Modeling Onroad Trip Length (miles/trip)	Total Area Disturbed (acres)
Demolition - 2014											
Demolition [1]	1/20/2014	2/10/2014	1.00 [2]	106,999	gsf	106,999	gsf	Default [3]	Default [3]	0.6371 [4]	--
Site Preparation (contaminated soil removal) [1]	2/10/2014	4/7/2014	1.00 [2]	--	yd^3	--	yd^3	-- [1]	260 [1]	0.6371 [4]	-- [1]
Construction - 2014											
Grading [5]	2/10/2014	4/7/2014	1.00 [2]	70,000	yd^3	70,000	yd^3	7,500 [6]	Default [3]	0.6371 [4]	12 [1]
Grading [7]	2/10/2014	4/7/2014	1.00 [2]	2,750	yd^3	2,750	yd^3	275 [8]	Default [3]	0.6371 [4]	12 [1]
Building Construction (research & development) [1]	4/28/2014	12/7/2015	2.00 [2]	600,000	gsf	300,000	gsf	Default [3]	Default [3]	0.6371 [4]	--
Building Construction (parking lot) [1]	4/28/2014	12/7/2015	2.00 [2]	600	spaces	300	spaces	Default [3]	Default [3]	0.6371 [4]	--
Paving [1]	10/5/2015	12/14/2015	1.00 [2]	--	--	--	--	Default [3]	Default [3]	0.6371 [4]	--

Notes:

(a) Phase amount (units) = (Project total [units]) / (total number of years per phase)

References:

(1) Demolition and construction general project information provided by LBNL.
(2) Construction and demolition schedules provided by LBNL.
(3) CalEEMod default assumption. Onroad and off-road trips represent one-way trip lengths.
(4) Adjusted onroad one-way trip length derived from entrance to RBC. Used to estimate emissions for modeling purposes only.
(5) Grading phase imports 70,000 cubic yards of soil.
(6) Grading (soil import) trips include 7,000 haul truck trips per year and 500 vendor trips per year.
(7) Grading phase exports 2,750 cubic yards of soil.
(8) Phase amount divided by typical truck load capacity of 10 cubic yards per load.

Table A-2
CalEEMod Input Assumptions for Phase 1 Construction and Demolition Scenario Offroad Equipment

Phase	Type of Equipment	Units	Year	LBNL Daily Hours of Operation (hrs/phase)	LBNL Duration of Use (days/phase)	CalEEMod Phase Length (days/phase)	Total Hours of Use (hrs/phase)	CalEEMod Daily Hours of Operation [a] (hrs/day)	Approximate Size of Equipment (hp)	Load Fraction	CalEEMod Load Factor Used [1]
Demolition	Excavators	1	2014	8	20	20	160	8	153	75	0.38
	Backhoe Loader	1	2014	8	20	20	160	8	95	80	0.37
	Dozer	1	2014	8	16	20	128	6.40	99	75	0.40
	Asphalt Cutter	1	2014	4	10	20	40	2	6.5 [2]	65	0.73
	Water Truck	1	2014	8	20	20	160	8	360	75	0.42
Site Preparation	--	--	2014	--	--	44	--	--	--	--	--
Site Grading - Excavation	Excavators	1	2014	8	44	44	352	8	153	75	0.38
	Backhoe Loader	1	2014	8	44	44	352	8	95	80	0.37
	Dozer	1	2014	8	20	44	160	3.64	99	75	0.40
	Trenching Equipment	1	2014	8	20	44	160	3.64	185	80	0.50
	Compaction Equipment	2	2014	8	44	44	704	8	157	75	0.38
Building Construction - Foundations	Backhoe/Crawler Loaders	1	2014	8	40	70	320	4.57	110	75	0.37
	Forklifts	2	2014	4	65	70	520	4	110	75	0.20
	Concrete Pumps	1	2014	8	20	70	160	2.29	307 [3]	80	0.74
	Compaction Equipment	2	2014	8	20	70	320	2.29	14.0	80	0.43
	Small Tools	1	2014	8	66	70	528	7.54	15 kW/month	85	--
	Air Compressors	1	2014	2	70	70	140	2	60	70	0.48
Building Construction - Steel Erection	Mobile Crane	2	2014	6	45	85	540	3.18	279	90	0.29
	Front End Welders	2	2014	8	45	85	720	4	14	85	0.45
	Back End Welders	3	2014	8	45	85	1080	4.2	14	85	0.45
	Man Lifts	1	2014	8	45	85	360	4.24	80 kW/hr	80	--
	Boomlifts	1	2014	4	85	85	340	4	82	80	0.40
	Forklifts	1	2014	4	85	85	340	4	110	75	0.20
	Air Compressors	1	2014	2	85	85	170	2	60.0	70	0.48
	Small Tools	1	2014	8	85	85	680	8	15 kW/month	85	--
	Concrete Pumps	1	2014	8	10	85	80	0.94	307 [3]	80	0.74
Building Construction - Exterior Enclosure	Mobile Crane	1	2015	6	130	130	780	6	279	60	0.29
	Man Lifts	1	2015	8	130	130	1040	8	80 kW/hr	80	--
	Boomlifts	1	2015	2	130	130	260	2	82	75	0.40
	Forklifts	1	2015	2	130	130	260	2	110.0	75	0.20
	Water Truck	1	2015	2	130	130	260	2	360	80	0.42
	Small Tools	1	2015	8	130	130	1040	8	15 kW/month	85	--
Building Construction - Interior Finishes	Boomlifts	1	2015	2	140	140	280	2	82	75	0.40
	Forklifts	1	2015	2	140	140	280	2	110	80	0.20
	Small Tools	1	2015	8	140	140	1120	8	15 kW/month	85	--
	Water Truck	1	2015	2	140	140	280	2	360.0	80	0.42
Paving - Site Improvements	Water Truck	1	2015	2	45	45	90	2.0	360	75	0.42
	Asphalt Cutter	1	2015	8	10	45	80	2	7	65	0.73
	Paving Equipment	1	2015	8	10	45	80	1.78	142	65	0.36
	Forklifts	1	2015	2	45	45	90	2.0	50.0	65	0.40
	Compactor	2	2015	8	20	45	320	4	7	70	0.38
	Excavators	1	2015	8	20	45	160	3.56	54	70	0.38
	Skid Steered Loader	1	2015	6	20	45	120	3	50.0	80	0.37
	Small Tools	1	2015	8	45	45	360	8	15 kW/month	85	--
	Trenching Equipment	1	2015	4	20	45	80	1.78	6	80	0.50

Notes:

(a) CalEEMod daily hours of operation (hrs/day) = (Total hours of use [hrs/phase]) / (CalEEMod phase length [days/phase]) / (units)

References:

(1) Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Appendix D - OSM and Summary of Off-Road Emissions Inventory Update, California Air Resources Board, October 2010, http://www.arb.ca.gov/regact/2010/Off-Roadlsi10/Off-Roadappd.pdf.

(2) CalEEMod load factors can only input whole numbers. Thus, rounding to nearest whole number was used.

(3) Concrete pump horsepower provided by LBNL. Represents 65% usage of truck mounted pumps (450 hp) and 35% usage of the hydraulic pump (40 hp).

Table A-3

CalEEMod Input Assumptions for Phase 1 Construction and Demolition Scenario Onroad Vehicles

Source	Source Parameter	Dates [1]		Operation [2]	(units)	Worker Trips (trips/day)	Vendor Trips (trips/day)	Total Hauling Trips	Worker Trip Length [2] (miles)	Vendor Trip Length [2] (miles)	Hauling Trip Length (miles)
Onroad Vehicle Emissions											
	Demolition	1/1/2014	1/28/2014	20	days	13 [3]	0 [3]	487 [3]	12.4	7.3	20 [3]
	Site Preparation	1/1/2014	3/3/2014	44	days	0 [3]	0 [3]	275 [3]	12.4	7.3	260 [1]
	Grading	3/4/2014	5/4/2014	44	days	15 [3]	3 [1]	7,500 [1]	12.4	7.3	20 [3]
	Building Construction - Foundations	5/5/2014	8/8/2014	70	days	146 [3]	69 [3]	0 [3]	12.4	7.3	20 [3]
	Building Construction - Steel Erection	8/9/2014	12/5/2104	85	days	146 [3]	69 [3]	0 [3]	12.4	7.3	20 [3]

References:

(1) Demolition and construction general project information provided by LBNL.

(2) See Table A-2, CalEEMod Input Assumptions for Phase 1 Construction and Demolition Scenario Offroad Equipment.

(3) All off-road equipment data taken from CalEEMod defaults.

Table A-4
Phase 1 Construction and Demoltion Annual Emission Estimates - 2014

Base Year	Phase		Pollutant (tons/yr)															
			ROG	NOx	CO	SO_2	Fugitive PM_{10}	Exhaust PM_{10} (1)	PM_{10} Total	Fugitive $PM_{2.5}$	Exhaust $PM_{2.5}$	$PM_{2.5}$ Total	Bio- CO_2 (a)	NBio- CO_2 (a)	Total CO_2 (a)	CH_4 (a)	N_2O (a)	CO_2e (a)
Off-Road Vehicle Emissions																		
2014	Demolition		2.0E-02	0.15	9.0E-02	0	2.0E-02 (3)	1.0E-02	3.0E-02	0 (3)	1.0E-02	1.0E-02	0	24.5	24.5	0	0	24.5
	Site Preparation		0	0	0	0	1.0E-02 (3)	0	1.0E-02	0 (3)	0	0	0	0	0	0	0	0
	Grading		6.0E-02	0.48	0.31	0	3.0E-02 (3)	3.0E-02	6.0E-02	2.0E-02 (3)	3.0E-02	5.0E-02	0	56.0	56.0	0	0	56.1
	Building Construction - Foundations		4.0E-02	0.31	0.18	0	0 (3)	2.0E-02	2.0E-02	0 (3)	2.0E-02	2.0E-02	0	42.5	42.5	0	0	42.6
	Building Construction - Steel Erection		6.0E-02	0.46	0.25	0	0 (3)	2.0E-02	2.0E-02	0 (3)	2.0E-02	2.0E-02	0	60.5	60.5	0	0	60.6
Total Annual Off-Road Emissions			**0.12**	**0.94**	**0.58**	**0**	**6.0E-02**	**6.0E-02**	**0.12**	**2.0E-02**	**6.0E-02**	**8.0E-02**	**0**	**123**	**123**	**0**	**0**	**123**
Onroad Vehicle Emissions																		
2014	Demolition	Hauling	1.0E-02	0.11	6.0E-02	0	9.0E-03 (b)	0	9.0E-03	0	0	0	0	19.9	19.9	0	0	19.9
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	0	0	1.0E-02	0	0	0	0	0	0	0	0	1.43	1.43	0	0	1.43
	Site Preparation	Hauling	6.0E-02	0.73	0.33	0	6.6E-02 (b)	3.0E-02	9.6E-02	0	2.0E-02	2.0E-02	0	141	141	0	0	142
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	0	0	0	0	0	0	0	0	0	0	0	0.73	0.73	0	0	0.73
	Grading	Hauling	0.15	1.61	0.93	0	0.13 (b)	5.0E-02	0.18	0	5.0E-02	5.0E-02	0	286	286	1.1E-02	0	286
		Vendor	0	4.0E-02	3.0E-02	0	0	0	0	0	0	0	0	7.10	7.10	0	0	7.10
		Worker	0	0	2.0E-02	0	0	0	0	0	0	0	0	3.63	3.63	0	0	3.64
	Building Construction - Foundations	Hauling	0	0	0	0	0 (b)	0	0	0	0	0	0	0	0	0	0	0
		Vendor	3.0E-02	0.35	0.25	0	2.0E-02	1.0E-02	3.0E-02	0	1.0E-02	1.0E-02	0	64.9	64.9	0	0	64.9
		Worker	4.0E-02	4.0E-02	0.36	0	6.0E-02	0	6.0E-02	0	0	0	0	56.2	56.2	0	0	56.3
	Building Construction - Steel Erection	Hauling	0	0	0	0	0 (b)	0	0	0	0	0	0	0	0	0	0	0
		Vendor	4.0E-02	0.42	0.31	0	2.0E-02	1.0E-02	3.0E-02	0	1.0E-02	1.0E-02	0	78.8	78.8	0	0	78.8
		Worker	4.0E-02	4.0E-02	0.43	0	7.0E-02	0	8.0E-02	0	0	0	0	68.3	68.3	0	0	68.3
Total Annual Onroad Emissions			**0.37**	**3.34**	**2.73**	**0**	**0.37**	**1.0E-01**	**0.48**	**0**	**9.0E-02**	**9.0E-02**	**0**	**729**	**729**	**1.1E-02**	**0**	**729**

Notes:

(a) Pollutant (tons/yr) = (CalEEMod GHG emission [MT/yr]) x (conversion factor [short ton/metric ton])

Conversion factor [short ton/metric ton] = 1.10231 (2)

(b) Onroad hauling fugitive PM_{10} (lb/day) = (CalEEMod fugitive PM_{10} result [lb/day]) / (number of days per phase) x 2 (4)

Number of days for demolition (days) = 20 (5)

Number of days for site preparation (days) = 44 (5)

Number of days for grading (days) = 44 (5)

Number of days for building construction - foundations (days) = 70 (5)

Number of days for building construction - steel erection (days) = 85 (5)

References:

(1) Assumes 100% of Exhaust PM_{10} equals Diesel Particulate Matter (DPM).
(2) CalEEMod greenhouse gas emission result is provided in metric tons/yr.
(3) Off-road fugitive PM_{10} and $PM_{2.5}$ emissions include a two times daily watering for fugitive emissions control, resulting in a control efficiency of 55%.
(4) Email correspondance and phone conversation with AQMD regarding CalEEMod offsite emission error on January 29th, 2013 resulting in correction equation.
(5) CalEEMod defaults for number of days per phase based on timeline information from LBNL.

Table A-5
Phase 1 Construction and Demolition Annual Onroad Vehicle Emission Estimates - Modeling Offsite Trip Length - 2014

Base Year	Phase		Pollutant (tons/yr) [a]															
			ROG	NOx	CO	SO_2	Fugitive PM_{10}	Exhaust PM_{10} (2)	PM_{10} Total	Fugitive $PM_{2.5}$	Exhaust $PM_{2.5}$	$PM_{2.5}$ Total	Bio- CO_2 (b)	NBio- CO_2 (b)	Total CO_2 (b)	CH_4 (b)	N_2O (b)	CO_2e (b)
2014	Demolition	Hauling	2.7E-04	3.2E-03	1.4E-03	1.0E-05	2.9E-04 (c)	1.1E-04	3.0E-03	1.0E-05	1.1E-04	1.1E-04	0	0.61	0.61	1.1E-05	0	0.61
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	4.0E-05	4.0E-05	4.0E-04	0	8.0E-05	0	8.0E-05	0	0	0	0	7.2E-02	7.2E-02	0	0	7.2E-02
	Site Preparation	Hauling	1.5E-04	1.8E-03	8.0E-04	0	1.6E-04 (c)	6.0E-05	3.6E-03	0	6.0E-05	6.0E-05	0	0.35	0.35	1.1E-05	0	0.35
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	2.0E-05	2.0E-05	2.0E-04	0	4.0E-05	0	4.0E-05	0	0	0	0	3.7E-02	3.7E-02	0	0	3.7E-02
	Grading	Hauling	3.8E-03	4.5E-02	2.0E-02	8.0E-05	4.1E-03 (c)	1.7E-03	9.2E-02	1.0E-04	1.5E-03	1.6E-03	0	8.81	8.81	1.9E-04	0	8.81
		Vendor	2.1E-04	2.6E-03	1.3E-03	1.0E-05	1.7E-04	9.0E-05	2.6E-04	1.0E-05	9.0E-05	9.0E-05	0	0.59	0.59	1.1E-05	0	0.59
		Worker	9.0E-05	1.1E-04	1.0E-03	0	2.0E-04	1.0E-05	2.1E-04	0	1.0E-05	1.0E-05	0	0.18	0.18	1.1E-05	0	0.18
	Building Construction - Foundations	Hauling	0	0	0	0	0 (c)	0	0	0	0	0	0	0	0	0	0	0
		Vendor	1.9E-03	2.4E-02	1.1E-02	5.0E-05	1.6E-03	8.6E-04	2.4E-03	5.0E-05	7.9E-04	8.4E-04	0	5.36	5.36	8.8E-05	0	5.37
		Worker	1.4E-03	1.7E-03	1.6E-02	3.0E-05	3.1E-03	1.2E-04	3.3E-03	5.0E-05	1.1E-04	1.6E-04	0	2.85	2.85	1.7E-04	0	2.85
	Building Construction - Steel Erection	Hauling	0	0	0	0	0 (c)	0	0	0	0	0	0	0	0	0	0	0
		Vendor	2.3E-03	2.9E-02	1.4E-02	6.0E-05	1.9E-03	1.0E-03	2.9E-03	6.0E-05	9.6E-04	1.0E-03	0	6.51	6.51	1.1E-04	0	6.52
		Worker	1.8E-03	2.0E-03	1.9E-02	4.0E-05	3.8E-03	1.4E-04	4.0E-03	6.0E-05	1.3E-04	1.9E-04	0	3.45	3.45	2.0E-04	0	3.46
Total Annual Onroad Emissions			**1.2E-02**	**0.11**	**8.5E-02**	**2.8E-04**	**1.5E-02**	**4.1E-03**	**0.11**	**3.4E-04**	**3.8E-03**	**4.1E-03**	**0**	**28.8**	**28.8**	**7.9E-04**	**0**	**28.8**

Notes:

(a) Actual onroad vehicle pollutant emissions (lbs/day) = (Onroad pollutant emissions [lbs/day]) / (scaling factor)
Scaling factor = 1,000 (1)

(b) Pollutant (tons/yr) = (CalEEMod GHG emission [MT/yr]) x (conversion factor [short ton/metric ton])
Conversion factor [short ton/metric ton] = 1.10231 (3)

(c) Onroad hauling fugitive PM_{10} (lb/day) = (CalEEMod fugitive PM_{10} result [lb/day]) / (number of days per phase) x 2 (4)
Number of days for demolition (days) = 20 (5)
Number of days for site preparation (days) = 44 (5)
Number of days for grading (days) = 44 (5)
Number of days for building construction - foundations (days) = 70 (5)
Number of days for building construction - steel erection (days) = 85 (5)

References:

(1) Scaling factor applied to onroad source emissions due to CalEEMod precision inaccurarcy. Demolition and construction results obtained via CalEEMod
(2) Assumes 100% of Exhaust PM_{10} equals Diesel Particulate Matter (DPM).
(3) CalEEMod greenhouse gas emission result is provided in metric tons/yr.
(4) Email correspondance and phone conversation with AQMD regarding CalEEMod offsite emission error on January 29th, 2013 resulting in correction equation.
(5) CalEEMod defaults for number of days per phase based on timeline information from LBNL.

Table A-6
Phase 1 Construction and Demolition Criteria Pollutant Emissions Summary - 2014

Source	Annual Operation [1] (days/yr)	ROG		NO_X		CO		SO_2		Fugitive PM_{10}		Exhaust PM_{10} [2]	
		(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)
2014 Off-Road Equipment Emissions													
2014 Demolition	260	0.15	2.0E-02	1.15	0.15	0.69	9.0E-02	0	0	0.15	2.0E-02	7.7E-02	1.0E-02
2014 Site Preparation	260	0	0	0	0	0	0	0	0	7.7E-02	1.0E-02	0	0
2014 Grading	260	0.46	6.0E-02	3.69	0.48	2.38	0.31	0	0	0.23	3.0E-02	0.23	3.0E-02
2014 Building Construction - Foundations	260	0.31	4.0E-02	2.38	0.31	1.38	0.18	0	0	0	0	0.15	2.0E-02
2014 Building Construction - Steel Erection	260	0.46	6.0E-02	3.54	0.46	1.92	0.25	0	0	0	0	0.15	2.0E-02
Total 2014 Off-Road Emissions		**1.38**	**0.18**	**10.8**	**1.40**	**6.38**	**0.83**	**0**	**0**	**0.46**	**6.0E-02**	**0.62**	**8.0E-02**
2014 Onroad Vehicle Emissions													
Total 2014 Onroad Demolition Source Emissions		**7.7E-02**	**1.0E-02**	**0.85**	**0.11**	**0.54**	**7.0E-02**	**0**	**0**	**6.9E-02**	**9.0E-03**	**0**	**0**
Demolition Hauling Vehicle Onroad Emissions	260	7.7E-02	1.0E-02	0.85	0.11	0.46	6.0E-02	0	0	6.9E-02	9.0E-03	0	0
Demolition Vendor Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0
Demolition Worker Vehicle Onroad Emissions	260	0	0	0	0	7.7E-02	1.0E-02	0	0	0	0	0	0
Total 2014 Onroad Site Preparation Source Emissions		**0.46**	**6.0E-02**	**5.62**	**0.73**	**2.54**	**0.33**	**0**	**0**	**0.51**	**6.6E-02**	**0.23**	**3.0E-02**
Site Preparation Hauling Vehicle Onroad Emissions	260	0.46	6.0E-02	5.62	0.73	2.54	0.33	0	0	0.51	6.6E-02	0.23	3.0E-02
Site Preparation Vendor Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0
Site Preparation Worker Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0
Total 2014 Onroad Grading Source Emissions		**1.15**	**0.15**	**12.7**	**1.65**	**7.54**	**0.98**	**0**	**0**	**0.99**	**0.13**	**0.38**	**5.0E-02**
Grading Hauling Vehicle Onroad Emissions	260	1.15	0.15	12.4	1.61	7.15	0.93	0	0	0.99	0.13	0.38	5.0E-02
Grading Vendor Vehicle Onroad Emissions	260	0	0	0.31	4.0E-02	0.23	3.0E-02	0	0	0	0	0	0
Grading Worker Vehicle Onroad Emissions	260	0	0	0	0	0.15	2.0E-02	0	0	0	0	0	0
Total 2014 Onroad Building Construction - Foundations Source Emissions		**0.54**	**7.0E-02**	**3.00**	**0.39**	**4.69**	**0.61**	**0**	**0**	**0.62**	**8.0E-02**	**7.7E-02**	**1.0E-02**
Building Construction - Foundations Hauling Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0
Building Construction - Foundations Vendor Vehicle Onroad Emissions	260	0.23	3.0E-02	2.69	0.35	1.92	0.25	0	0	0.15	2.0E-02	7.7E-02	1.0E-02
Building Construction - Foundations Worker Vehicle Onroad Emissions	260	0.31	4.0E-02	0.31	4.0E-02	2.77	0.36	0	0	0.46	6.0E-02	0	0
Total 2014 Onroad Building Construction - Steel Erection Source Emissions		**0.62**	**8.0E-02**	**3.54**	**0.46**	**5.69**	**0.74**	**0**	**0**	**0.69**	**9.0E-02**	**7.7E-02**	**1.0E-02**
Building Construction - Steel Erection Hauling Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0
Building Construction - Steel Erection Vendor Vehicle Onroad Emissions	260	0.31	4.0E-02	3.23	0.42	2.38	0.31	0	0	0.15	2.0E-02	7.7E-02	1.0E-02
Building Construction - Steel Erection Worker Vehicle Onroad Emissions	260	0.31	4.0E-02	0.31	4.0E-02	3.31	0.43	0	0	0.54	7.0E-02	0	0
Total 2014 Onroad Emissions		**2.85**	**0.37**	**25.7**	**3.34**	**21.0**	**2.73**	**0**	**0**	**2.88**	**0.37**	**0.77**	**1.0E-01**
Total 2014 Project Emissions	**--**	**4.23**	**0.55**	**36.5**	**4.74**	**27.4**	**3.56**	**0**	**0**	**3.34**	**0.43**	**1.38**	**0.18**
Onsite Stationary Exhaust	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**
Onsite Mobile Exhaust	**--**	**1.38**	**0.18**	**10.8**	**1.40**	**6.38**	**0.83**	**0**	**0**	**--**	**--**	**0.62**	**8.0E-02**
Onsite Fugitive Dust	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**0.46**	**6.0E-02**	**--**	**--**
Offsite Mobile Exhaust	**--**	**2.85**	**0.37**	**25.7**	**3.34**	**21.0**	**2.73**	**0**	**0**	**--**	**--**	**0.77**	**1.0E-01**
Offsite Fugitive Dust	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**2.88**	**0.37**	**--**	**--**
Total 2014 Project Emissions	**--**	**4.23**	**0.55**	**36.5**	**4.74**	**27.4**	**3.56**	**0**	**0**	**3.34**	**0.43**	**1.38**	**0.18**

References:

(1) Annual operation assumes a 5-day work week and 52 weeks per year.

(2) Assumes 100% of Exhaust PM_{10} equals Diesel Particulate Matter (DPM).

Table A-6
Phase 1 Construction and Demolition Criteria Pollutant Emissions Summary - 2014

Source	Annual Operation (1) (days/yr)	PM_{10} Total		Fugitive $PM_{2.5}$		Exhaust $PM_{2.5}$		$PM_{2.5}$ Total		Total CO_2	
		(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)
2014 Off-Road Equipment Emissions											
2014 Demolition	260	0.23	3.0E-02	0	0	7.7E-02	1.0E-02	7.7E-02	1.0E-02	188	24.5
2014 Site Preparation	260	7.7E-02	1.0E-02	0	0	0	0	0	0	0	0
2014 Grading	260	0.46	6.0E-02	0.15	2.0E-02	0.23	3.0E-02	0.38	5.0E-02	431	56.0
2014 Building Construction - Foundations	260	0.15	2.0E-02	0	0	0.15	2.0E-02	0.15	2.0E-02	327	42.5
2014 Building Construction - Steel Erection	260	0.15	2.0E-02	0	0	0.15	2.0E-02	0.15	2.0E-02	466	60.5
Total 2014 Off-Road Emissions		**1.08**	**0.14**	**0.15**	**2.0E-02**	**0.62**	**8.0E-02**	**0.77**	**1.0E-01**	**1,412**	**184**
2014 Onroad Vehicle Emissions											
Total 2014 Onroad Demolition Source Emissions		**6.9E-02**	**9.0E-03**	**0**	**0**	**0**	**0**	**0**	**0**	**164**	**21.3**
Demolition Hauling Vehicle Onroad Emissions	260	6.9E-02	9.0E-03	0	0	0	0	0	0	153	19.9
Demolition Vendor Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0
Demolition Worker Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	11.0	1.43
Total 2014 Onroad Site Preparation Source Emissions		**0.74**	**9.6E-02**	**0**	**0**	**0.15**	**2.0E-02**	**0.15**	**2.0E-02**	**1,094**	**142**
Site Preparation Hauling Vehicle Onroad Emissions	260	0.74	9.6E-02	0	0	0.15	2.0E-02	0.15	2.0E-02	1,088	141
Site Preparation Vendor Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0
Site Preparation Worker Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	5.60	0.73
Total 2014 Onroad Grading Source Emissions		**1.38**	**0.18**	**0**	**0**	**0.38**	**5.0E-02**	**0.38**	**5.0E-02**	**2,283**	**297**
Grading Hauling Vehicle Onroad Emissions	260	1.38	0.18	0	0	0.38	5.0E-02	0.38	5.0E-02	2,201	286
Grading Vendor Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	54.6	7.10
Grading Worker Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	27.9	3.63
Total 2014 Onroad Building Construction - Foundations Source Emissions		**0.69**	**9.0E-02**	**0**	**0**	**7.7E-02**	**1.0E-02**	**7.7E-02**	**1.0E-02**	**932**	**121**
Building Construction - Foundations Hauling Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0
Building Construction - Foundations Vendor Vehicle Onroad Emissions	260	0.23	3.0E-02	0	0	7.7E-02	1.0E-02	7.7E-02	1.0E-02	499	64.9
Building Construction - Foundations Worker Vehicle Onroad Emissions	260	0.46	6.0E-02	0	0	0	0	0	0	432	56.2
Total 2014 Onroad Building Construction - Steel Erection Source Emissions		**0.85**	**0.11**	**0**	**0**	**7.7E-02**	**1.0E-02**	**7.7E-02**	**1.0E-02**	**1,131**	**147**
Building Construction - Steel Erection Hauling Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0
Building Construction - Steel Erection Vendor Vehicle Onroad Emissions	260	0.23	3.0E-02	0	0	7.7E-02	1.0E-02	7.7E-02	1.0E-02	606	78.8
Building Construction - Steel Erection Worker Vehicle Onroad Emissions	260	0.62	8.0E-02	0	0	0	0	0	0	525	68.3
Total 2014 Onroad Emissions		**3.72**	**0.48**	**0**	**0**	**0.69**	**9.0E-02**	**0.69**	**9.0E-02**	**5,604**	**729**
Total 2014 Project Emissions	**--**	**4.80**	**0.62**	**0.15**	**2.0E-02**	**1.31**	**0.17**	**1.46**	**0.19**	**7,016**	**912**
Onsite Stationary Exhaust	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**
Onsite Mobile Exhaust	**--**	**0.62**	**8.0E-02**	**--**	**--**	**0.62**	**8.0E-02**	**0.62**	**8.0E-02**	**1,412**	**184**
Onsite Fugitive Dust	**--**	**0.46**	**6.0E-02**	**0.15**	**2.0E-02**	**--**	**--**	**0.15**	**2.0E-02**	**--**	**--**
Offsite Mobile Exhaust	**--**	**0.77**	**1.0E-01**	**--**	**--**	**0.69**	**9.0E-02**	**0.69**	**9.0E-02**	**5,604**	**729**
Offsite Fugitive Dust	**--**	**2.88**	**0.37**	**0**	**0**	**--**	**--**	**0**	**0**	**--**	**--**
Total 2014 Project Emissions	**--**	**4.80**	**0.62**	**0.15**	**2.0E-02**	**1.31**	**0.17**	**1.46**	**0.19**	**7,016**	**912**

References:

(1) Annual operation assumes a 5-day work week and 52 weeks per year.

(2) Assumes 100% of Exhaust PM_{10} equals Diesel Particulate Matter (DPM).

Table A-6
Phase 1 Construction and Demolition Criteria Pollutant Emissions Summary - 2014

Source		Annual Operation [1] (days/yr)	CH_4		N_2O		CO_2e	
			(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)
2014 Off-Road Equipment Emissions								
2014	Demolition	260	0	0	0	0	189	24.5
2014	Site Preparation	260	0	0	0	0	0	0
2014	Grading	260	0	0	0	0	432	56.1
2014	Building Construction - Foundations	260	0	0	0	0	328	42.6
2014	Building Construction - Steel Erection	260	0	0	0	0	466	60.6
Total 2014 Off-Road Emissions			**0**	**0**	**0**	**0**	**1,414**	**184**
2014 Onroad Vehicle Emissions								
Total 2014 Onroad Demolition Source Emissions			**0**	**0**	**0**	**0**	**164**	**21.4**
	Demolition Hauling Vehicle Onroad Emissions	260	0	0	0	0	153	19.9
	Demolition Vendor Vehicle Onroad Emissions	260	0	0	0	0	0	0
	Demolition Worker Vehicle Onroad Emissions	260	0	0	0	0	11.0	1.43
Total 2014 Onroad Site Preparation Source Emissions			**0**	**0**	**0**	**0**	**1,094**	**142**
	Site Preparation Hauling Vehicle Onroad Emissions	260	0	0	0	0	1,089	142
	Site Preparation Vendor Vehicle Onroad Emissions	260	0	0	0	0	0	0
	Site Preparation Worker Vehicle Onroad Emissions	260	0	0	0	0	5.60	0.73
Total 2014 Onroad Grading Source Emissions			**8.5E-02**	**1.1E-02**	**0**	**0**	**2,284**	**297**
	Grading Hauling Vehicle Onroad Emissions	260	8.5E-02	1.1E-02	0	0	2,202	286
	Grading Vendor Vehicle Onroad Emissions	260	0	0	0	0	54.6	7.10
	Grading Worker Vehicle Onroad Emissions	260	0	0	0	0	28.0	3.64
Total 2014 Onroad Building Construction - Foundations Source Emissions			**0**	**0**	**0**	**0**	**932**	**121**
	Building Construction - Foundations Hauling Vehicle Onroad Emissions	260	0	0	0	0	0	0
	Building Construction - Foundations Vendor Vehicle Onroad Emissions	260	0	0	0	0	499	64.9
	Building Construction - Foundations Worker Vehicle Onroad Emissions	260	0	0	0	0	433	56.3
Total 2014 Onroad Building Construction - Steel Erection Source Emissions			**0**	**0**	**0**	**0**	**1,132**	**147**
	Building Construction - Steel Erection Hauling Vehicle Onroad Emissions	260	0	0	0	0	0	0
	Building Construction - Steel Erection Vendor Vehicle Onroad Emissions	260	0	0	0	0	606	78.8
	Building Construction - Steel Erection Worker Vehicle Onroad Emissions	260	0	0	0	0	526	68.3
Total 2014 Onroad Emissions			**8.5E-02**	**1.1E-02**	**0**	**0**	**5,608**	**729**
Total 2014 Project Emissions		**--**	**8.5E-02**	**1.1E-02**	**0**	**0**	**7,022**	**913**
Onsite Stationary Exhaust		**--**	**--**	**--**	**--**	**--**	**--**	**--**
Onsite Mobile Exhaust		**--**	**0**	**0**	**0**	**0**	**1,414**	**184**
Onsite Fugitive Dust		**--**	**--**	**--**	**--**	**--**	**--**	**--**
Offsite Mobile Exhaust		**--**	**8.5E-02**	**1.1E-02**	**0**	**0**	**5,608**	**729**
Offsite Fugitive Dust		**--**	**--**	**--**	**--**	**--**	**--**	**--**
Total 2014 Project Emissions		**--**	**8.5E-02**	**1.1E-02**	**0**	**0**	**7,022**	**913**

References:

(1) Annual operation assumes a 5-day work week and 52 weeks per year.

(2) Assumes 100% of Exhaust PM_{10} equals Diesel Particulate Matter (DPM).

Table A-7
CalEEMod Input Assumptions for Phase 1 Construction and Demolition Scenario - 2015

Construction Area	Dates		Total Number of Years	Project Total	(units)	Phase Amount [a]	(units)	Truck Trips (trips/year)	Inventory Onroad Trip Length (miles/trip)	Modeling Onroad Trip Length (miles/trip)	Total Area Disturbed (acres)
Construction - 2015											
Building. Construction (research & development) (1)	1/1/2015	12/31/2015	2.00 (2)	600,000	gsf	300,000	gsf	Default (3)	Default (3)	0.6371 (4)	--
Building Construction (parking lot) (1)	1/1/2015	12/31/2015	2.00 (2)	600	spaces	300	spaces	Default (3)	Default (3)	0.6371 (4)	--
Paving (1)	10/30/2015	12/31/2015	1.00 (2)	--	--	--	--	Default (3)	Default (3)	0.6371 (4)	--

Notes:

(a) Phase amount (units) = (Project total [units]) x (total number of years per phase)

References:

(1) Demolition and construction general project information provided by LBNL.
(2) Construction and demolition schedules provided by LBNL. Construction occurs over approximately 4.2 months out of a possible 20 total month period.
(3) CalEEMod default assumption. Onroad and off-road trips represent one-way trip lengths.
(4) Adjusted Onroad one-way trip length derived from entrance to RBC. Used to estimate emissions for modeling purposes only.

Table A-8

CalEEMod Input Assumptions for Phase 1 Construction and Demolition Scenario Onroad Vehicles - 2015

Source	Source Parameter	Dates [1]		Operation [2]	(units)	Worker Trips (trips/day)	Vendor Trips (trips/day)	Total Hauling Trips	Worker Trip Length (miles) [3]	Vendor Trip Length (miles) [3]	Hauling Trip Length (miles) [3]
Onroad Vehicle Emissions											
	Building Construction - Exterior Enclosure	1/1/2015	7/1/2015	130	days	146 [3]	69 [3]	0 [3]	12.4	7.3	20
	Building Construction - Interior Finishes	6/1/2015	12/11/2015	140	days	146 [3]	69 [3]	0 [3]	12.4	7.3	260
	Paving	10/30/2015	12/31/2015	45	days	23 [3]	0 [1]	0 [1]	12.4	7.3	20

References:

(1) Demolition and construction general project information provided by LBNL.

(2) See Table A-9, CalEEMod Input Assumptions for Phase 1 Construction and Demolition Scenario Offroad Equipment - 2015.

(3) All Off-Road equipment data taken from CalEEMod defaults.

Table A-9
Phase 1 Construction and Demoltion Annual Emission Estimates - 2015

Base Year	Phase		Pollutant (tons/yr)															
			ROG	NOx	CO	SO_2	Fugitive PM_{10}	Exhaust PM_{10} (1)	PM_{10} Total	Fugitive $PM_{2.5}$	Exhaust $PM_{2.5}$	$PM_{2.5}$ Total	Bio- CO_2 (a)	NBio- CO_2 (a)	Total CO_2 (a)	CH_4 (a)	N_2O (a)	CO_2e (a)
Off-Road Vehicle Emissions																		
2015	Building Construction - Exterior Enclosure		6.0E-02	0.52	0.26	0	0 (3)	2.0E-02	2.0E-02	0 (3)	2.0E-02	2.0E-02	0	88.3	88.3	1.1E-02	0	88.4
	Building Construction - Interior Finishes		3.0E-02	0.22	0.14	0	0 (3)	1.0E-02	1.0E-02	0 (3)	1.0E-02	1.0E-02	0	39.9	39.9	0	0	40.0
	Paving		2.0E-02	0.11	8.0E-02	0	0 (3)	1.0E-02	1.0E-02	0 (3)	1.0E-02	1.0E-02	0	16.6	16.6	0	0	16.6
Total Annual Off-Road Emissions			**0.11**	**0.85**	**0.48**	**0**	**0**	**4.0E-02**	**4.0E-02**	**0**	**4.0E-02**	**4.0E-02**	**0**	**145**	**145**	**1.1E-02**	**0**	**145**
Onroad Vehicle Emissions																		
2015	Building Construction - Exterior Enclosure	Hauling	0	0	0	0	0 (b)	0	0	0	0	0	0	0	0	0	0	0
		Vendor	6.0E-02	0.59	0.43	0	3.0E-02	2.0E-02	5.0E-02	0	2.0E-02	2.0E-02	0	121	121	0	0	121
		Worker	6.0E-02	6.0E-02	0.60	0	0.11	0	0.11	0	0	0	0	102	102	1.1E-02	0	102
	Building Construction - Interior Finishes	Hauling	0	0	0	0	0 (b)	0	0	0	0	0	0	0	0	0	0	0
		Vendor	6.0E-02	0.63	0.47	0	4.0E-02	2.0E-02	6.0E-02	0	2.0E-02	2.0E-02	0	130	130	0	0	130
		Worker	7.0E-02	7.0E-02	0.65	0	0.12	0	0.12	0	0	0	0	110	110	1.1E-02	0	110
	Paving	Hauling	0	0	0	0	0 (b)	0	0	0	0	0	0	0	0	0	0	0
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	0	0	3.0E-02	0	1.0E-02	0	1.0E-02	0	0	0	0	5.57	5.57	0	0	5.57
Total Annual Onroad Emissions			**0.25**	**1.35**	**2.18**	**0**	**0.31**	**4.0E-02**	**0.35**	**0**	**4.0E-02**	**4.0E-02**	**0**	**468**	**468**	**2.2E-02**	**0**	**469**

Notes:

(a) Pollutant (tons/yr) = (CalEEMod GHG emission [MT/yr]) x (conversion factor [short ton/metric ton])
Conversion factor [short ton/metric ton] = 1.10231 (2)

(b) Onroad hauling fugitive PM10 (lb/day) = (CalEEMod fugitive PM10 result [lb/day]) / (number of days per phase) x 2 (4)
Number of days for building construction - exterior enclosure (days) = 130 (5)
Number of days for building construction - interior finishes(days) = 140 (5)
Number of days for paving (days) = 45 (5)

References:

(1) Assumes 100% of exhaust PM_{10} equals diesel particulate matter (DPM).
(2) CalEEMod greenhouse gas emission result is provided in metric tons/yr.
(3) Off-road fugitive PM_{10} and $PM_{2.5}$ emissions include a two times daily watering for fugitive emissions control, resulting in a control efficiency of 55%.
(4) Email correspondance and phone conversation with AQMD regarding CalEEMod offsite emission error on January 29th, 2013 resulting in correction equation.
(5) CalEEMod defaults for number of days per phase based on timeline information from LBNL.

Table A-10
Phase 1 Construction and Demolition Annual Onroad Vehicle Emission Estimates - Modeling Offsite Trip Length - 2015

Base Year	Phase		Pollutant (tons/yr) [a]															
			ROG	NOx	CO	SO_2	Fugitive PM_{10}	Exhaust PM_{10} [2]	PM_{10} Total	Fugitive $PM_{2.5}$	Exhaust $PM_{2.5}$	$PM_{2.5}$ Total	Bio- CO_2 [b]	NBio- CO_2 [b]	Total CO_2 [b]	CH_4 [b]	N_2O [b]	CO_2e [b]
2015	Building Construction - Exterior Enclosure	Hauling	0	0	0	0	0 [c]	0	0	0	0	0	0	0	0	0	0	0
		Vendor	3.2E-03	4.0E-02	1.9E-02	1.0E-04	2.9E-03	1.5E-03	4.4E-03	9.0E-05	1.3E-03	1.4E-03	0	9.97	9.97	1.5E-04	0	9.97
		Worker	2.5E-03	2.8E-03	2.6E-02	5.0E-05	5.8E-03	2.2E-04	6.0E-03	1.0E-04	2.0E-04	3.0E-04	0	5.16	5.16	2.9E-04	0	5.17
	Building Construction - Interior Finishes	Hauling	0	0	0	0	0 [c]	0	0	0	0	0	0	0	0	0	0	0
		Vendor	3.4E-03	4.3E-02	2.1E-02	1.0E-04	3.1E-03	1.6E-03	4.7E-03	1.0E-04	1.4E-03	1.5E-03	0	10.7	10.7	1.7E-04	0	10.7
		Worker	2.7E-03	3.0E-03	2.8E-02	6.0E-05	6.3E-03	2.3E-04	6.5E-03	1.1E-04	2.2E-04	3.2E-04	0	5.56	5.56	3.1E-04	0	5.57
	Paving	Hauling	0	0	0	0	0 [c]	0	0	0	0	0	0	0	0	0	0	0
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	1.3E-04	1.5E-04	1.4E-03	0	3.2E-04	1.0E-05	3.3E-04	1.0E-05	1.0E-05	2.0E-05	0	0.28	0.28	1.1E-05	0	0.28
Total Annual Onroad Emissions			**1.2E-02**	**8.9E-02**	**9.6E-02**	**3.1E-04**	**1.8E-02**	**3.5E-03**	**2.2E-02**	**4.1E-04**	**3.2E-03**	**3.6E-03**	**0**	**31.7**	**31.7**	**9.3E-04**	**0**	**31.7**

Notes:

(a) Actual onroad vehicle pollutant emissions (lbs/day) = (Onroad pollutant emissions [lbs/day]) / (scaling factor)
Scaling factor = 1,000 (1)

(b) Pollutant (tons/yr) = (CalEEMod GHG emission [MT/yr]) x (conversion factor [short ton/metric ton])
Conversion factor [short ton/metric ton] = 1.10231 (3)

(c) Onroad hauling fugitive PM_{10} (lb/day) = (CalEEMod fugitive PM_{10} result [lb/day]) / (Number of days per phase) x 2 (4)
Number of days for building construction - exterior enclosure (days) = 130 (5)
Number of days for building construction - interior finishes (days) = 140 (5)
Number of days for paving (days) = 45 (5)

References:

(1) Scaling factor applied to Onroad source emissions due to CalEEMod precision inaccurarcy. Demolition and construction results obtained via CalEEMod
(2) Assumes 100% of Exhaust PM_{10} equals Diesel Particulate Matter (DPM).
(3) CalEEMod greenhouse gas emission result is provided in metric tons/yr.
(4) Email correspondance and phone conversation with AQMD regarding CalEEMod offsite emission error on January 29th, 2013 resulting in correction equation.
(5) CalEEMod defaults for number of days per phase based on timeline information from LBNL.

Table A-11
Phase 1 Construction and Demolition Criteria Pollutant Emissions Summary - 2015

Source	Annual Operation (days/yr)	ROG		NO_X		CO		SO_2		Fugitive PM_{10}		Exhaust PM_{10} (1)		PM_{10} Total	
		(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)
2015 Off-Road Equipment Emissions															
2015 Building Construction - Exterior Enclosure	260	0.46	6.0E-02	4.00	0.52	2.00	0.26	0	0	0	0	0.15	2.0E-02	0.15	2.0E-02
2015 Building Construction - Interior Finishes	260	0.23	3.0E-02	1.69	0.22	1.08	0.14	0	0	0	0	7.7E-02	1.0E-02	7.7E-02	1.0E-02
2015 Paving	260	0.15	2.0E-02	0.85	0.11	0.62	8.0E-02	0	0	0	0	7.7E-02	1.0E-02	7.7E-02	1.0E-02
Total 2015 Off-Road Emissions		**0.85**	**0.11**	**6.54**	**0.85**	**3.69**	**0.48**	**0**	**0**	**0**	**0**	**0.31**	**4.0E-02**	**0.31**	**4.0E-02**
2015 Onroad Vehicle Emissions															
Total 2015 Onroad Building Construction - Exterior Enclosure Source Emissions		**0.92**	**0.12**	**5.00**	**0.65**	**7.92**	**1.03**	**0**	**0**	**1.08**	**0.14**	**0.15**	**2.0E-02**	**1.23**	**0.16**
Building Construction - Exterior Enclosure Hauling Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Building Construction - Exterior Enclosure Vendor Vehicle Onroad Emissions	260	0.46	6.0E-02	4.54	0.59	3.31	0.43	0	0	0.23	3.0E-02	0.15	2.0E-02	0.38	5.0E-02
Building Construction - Exterior Enclosure Worker Vehicle Onroad Emissions	260	0.46	6.0E-02	0.46	6.0E-02	4.62	0.60	0	0	0.85	0.11	0	0	0.85	0.11
Total 2015 Onroad Building Construction - Interior Finishes Source Emissions		**1.00**	**0.13**	**5.38**	**0.70**	**8.62**	**1.12**	**0**	**0**	**1.23**	**0.16**	**0.15**	**2.0E-02**	**1.38**	**0.18**
Building Construction - Interior Finishes Hauling Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Building Construction - Interior Finishes Vendor Vehicle Onroad Emissions	260	0.46	6.0E-02	4.85	0.63	3.62	0.47	0	0	0.31	4.0E-02	0.15	2.0E-02	0.46	6.0E-02
Building Construction - Interior Finishes Worker Vehicle Onroad Emissions	260	0.54	7.0E-02	0.54	7.0E-02	5.00	0.65	0	0	0.92	0.12	0	0	0.92	0.12
Total 2015 Onroad Paving Source Emissions		**0**	**0**	**0**	**0**	**0.23**	**3.0E-02**	**0**	**0**	**7.7E-02**	**1.0E-02**	**0**	**0**	**7.7E-02**	**1.0E-02**
Paving Hauling Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paving Vendor Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paving Worker Vehicle Onroad Emissions	260	0	0	0	0	0.23	3.0E-02	0	0	7.7E-02	1.0E-02	0	0	7.7E-02	1.0E-02
Total 2015 Onroad Emissions		**1.92**	**0.25**	**10.4**	**1.35**	**16.8**	**2.18**	**0**	**0**	**2.38**	**0.31**	**0.31**	**4.0E-02**		**0.35**
Total 2015 Project Emissions	**--**	**2.77**	**0.36**	**16.9**	**2.20**	**20.5**	**2.66**	**0**	**0**	**2.38**	**0.31**	**0.62**	**8.0E-02**	**0.31**	**0.39**
Onsite Stationary Exhaust	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**
Onsite Mobile Exhaust	**--**	**0.85**	**0.11**	**6.54**	**0.85**	**3.69**	**0.48**	**0**	**0**	**--**	**--**	**0.31**	**4.0E-02**	**0.31**	**4.0E-02**
Onsite Fugitive Dust	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**0**	**0**	**--**	**--**	**0**	**0**
Offsite Mobile Exhaust	**--**	**1.92**	**0.25**	**10.4**	**1.35**	**16.8**	**2.18**	**0**	**0**	**--**	**--**	**0.31**	**4.0E-02**	**0.31**	**4.0E-02**
Offsite Fugitive Dust	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**2.38**	**0.31**	**--**	**--**	**2.38**	**0.31**
Total 2015 Project Emissions	**--**	**2.77**	**0.36**	**16.9**	**2.20**	**20.5**	**2.66**	**0**	**0**	**2.38**	**0.31**	**0.62**	**8.0E-02**	**0.31**	**0.39**

References:

(1) Assumes 100% of Exhaust PM_{10} equals Diesel Particulate Matter (DPM).

Table A-11
Phase 1 Construction and Demolition Criteria Pollutant Emissions Summary - 2015

Source	Annual Operation (days/yr)	Fugitive $PM_{2.5}$		Exhaust $PM_{2.5}$		$PM_{2.5}$ Total		Total CO_2		CH_4		N_2O		CO_2e	
		(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)
2015 Off-Road Equipment Emissions															
2015 Building Construction - Exterior Enclosure	260	0	0	0.15	2.0E-02	0.15	2.0E-02	679	88.3	8.5E-02	1.1E-02	0	0	680	88.4
2015 Building Construction - Interior Finishes	260	0	0	7.7E-02	1.0E-02	7.7E-02	1.0E-02	307	39.9	0	0	0	0	308	40.0
2015 Paving	260	0	0	7.7E-02	1.0E-02	7.7E-02	1.0E-02	127	16.6	0	0	0	0	128	16.6
Total 2015 Off-Road Emissions		**0**	**0**	**0.31**	**4.0E-02**	**0.31**	**4.0E-02**	**1,114**	**145**	**8.5E-02**	**1.1E-02**	**0**	**0**	**1,115**	**145**
2015 Onroad Vehicle Emissions															
Total 2015 Onroad Building Construction - Exterior Enclosure Source Emissions		**0**	**0**	**0.15**	**2.0E-02**	**0.15**	**2.0E-02**	**1,714**	**223**	**8.5E-02**	**1.1E-02**	**0**	**0**	**1,715**	**223**
Building Construction - Exterior Enclosure Hauling Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Building Construction - Exterior Enclosure Vendor Vehicle Onroad Emissions	260	0	0	0.15	2.0E-02	0.15	2.0E-02	929	121	0	0	0	0	929	121
Building Construction - Exterior Enclosure Worker Vehicle Onroad Emissions	260	0	0	0	0	0	0	785	102	8.5E-02	1.1E-02	0	0	786	102
Total 2015 Onroad Building Construction - Interior Finishes Source Emissions		**0**	**0**	**0.15**	**2.0E-02**	**0.15**	**2.0E-02**	**1,846**	**240**	**8.5E-02**	**1.1E-02**	**0**	**0**	**1,847**	**240**
Building Construction - Interior Finishes Hauling Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Building Construction - Interior Finishes Vendor Vehicle Onroad Emissions	260	0	0	0.15	2.0E-02	0.15	2.0E-02	1,000	130	0	0	0	0	1,001	130
Building Construction - Interior Finishes Worker Vehicle Onroad Emissions	260	0	0	0	0	0	0	845	110	8.5E-02	1.1E-02	0	0	846	110
Total 2015 Onroad Paving Source Emissions		**0**	**0**	**0**	**0**	**0**	**0**	**42.8**	**5.57**	**0**	**0**	**0**	**0**	**42.8**	**5.57**
Paving Hauling Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paving Vendor Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paving Worker Vehicle Onroad Emissions	260	0	0	0	0	0	0	42.8	5.57	0	0	0	0	42.8	5.57
Total 2015 Onroad Emissions		**0**	**0**	**0.31**	**4.0E-02**	**0.31**	**4.0E-02**	**3,602**	**468**	**0.17**	**2.2E-02**	**0**	**0**	**3,605**	**469**
Total 2015 Project Emissions	**--**	**0**	**0**	**0.62**	**8.0E-02**	**0.62**	**8.0E-02**	**4,716**	**613**	**0.25**	**3.3E-02**	**0**	**0**	**4,721**	**614**
Onsite Stationary Exhaust	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**
Onsite Mobile Exhaust	**--**	**--**	**--**	**0.31**	**4.0E-02**	**0.31**	**4.0E-02**	**1,114**	**145**	**8.5E-02**	**1.1E-02**	**0**	**0**	**1,115**	**145**
Onsite Fugitive Dust	**--**	**0**	**0**	**--**	**--**	**0**	**0**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**
Offsite Mobile Exhaust	**--**	**--**	**--**	**0.31**	**4.0E-02**	**0.31**	**4.0E-02**	**3,602**	**468**	**0.17**	**2.2E-02**	**0**	**0**	**3,605**	**469**
Offsite Fugitive Dust	**--**	**0**	**0**	**--**	**--**	**0**	**0**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**
Total 2015 Project Emissions	**--**	**0**	**0**	**0.62**	**8.0E-02**	**0.62**	**8.0E-02**	**4,716**	**613**	**0.25**	**3.3E-02**	**0**	**0**	**4,721**	**614**

References:

(1) Assumes 100% of Exhaust PM_{10} equals Diesel Particulate Matter (DPM).

Appendix B

CalEEMod Outputs – Phase 1 Construction

Phase 1 Development - Year 1 Max - 03/22/2012

Bay Area AQMD Air District, Annual

1.0 Project Characteristics

1.1 Land Usage

Land Uses	Size	Metric
Research & Development	300	1000sqft
Parking Lot	300	Space

1.2 Other Project Characteristics

Urbanization	Urban	**Wind Speed (m/s)**	2.2	**Utility Company**	Pacific Gas & Electric Company
Climate Zone	5	**Precipitation Freq (Days)**	64		

1.3 User Entered Comments

Project Characteristics -

Land Use - 300,000 gsf for R&D, 300 spaces for parking lot, and 1,300 population. Updated: 3/22/13

Construction Phase - Demolition (1/1/14 - 1/28/14); Site Prep (1/1/14 - 3/3/14); Grading (3/4/14 - 5/4/14); BC-F (5/5/14 - 8/8/14); BC-SE (8/9/14 - 12/5/14) Updated: 3/22/13

Off-road Equipment - Pumps = 307 hp. Updated: 3/22/13

Off-road Equipment - Pumps = 307 hp. Updated: 3/22/13

Off-road Equipment - Updated: 3/22/13

Off-road Equipment - Updated: 3/22/13

Off-road Equipment - Site Prep: Rubber tired dozer assigned 0 hp and 0 LF. Updated: 3/22/13

Trips and VMT - Site Prep: 275 hauling truck trips @ 260 miles
Grading: 12 vendor trips/day and 7,000 hauling truck trips
Updated: 3/22/13

Demolition - Demolition = 106,999 gsf; Updated: 3/22/13

Grading - Grading: 70,000 cyd material imported and 2,750 material exported @ 12 acres disturbed
Updated: 3/22/13

Construction Off-road Equipment Mitigation - Water Exposed Area = 2/day @ 55% reduction
Updated: 3/22/13

2.0 Emissions Summary

2.1 Overall Construction

Unmitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2014	0.56	4.75	3.56	0.01	4.70	0.19	4.88	0.06	0.18	0.24	0.00	827.37	827.37	0.03	0.00	828.11
Total	**0.56**	**4.75**	**3.56**	**0.01**	**4.70**	**0.19**	**4.88**	**0.06**	**0.18**	**0.24**	**0.00**	**827.37**	**827.37**	**0.03**	**0.00**	**828.11**

Mitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2014	0.56	4.75	3.56	0.01	4.62	0.19	4.81	0.03	0.18	0.21	0.00	827.37	827.37	0.03	0.00	828.11
Total	**0.56**	**4.75**	**3.56**	**0.01**	**4.62**	**0.19**	**4.81**	**0.03**	**0.18**	**0.21**	**0.00**	**827.37**	**827.37**	**0.03**	**0.00**	**828.11**

2.2 Overall Operational

Unmitigated Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Area	2.13	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	1,132.87	1,132.87	0.04	0.02	1,139.89
Mobile	1.34	2.52	11.76	0.02	2.24	0.11	2.36	0.04	0.10	0.14	0.00	1,939.17	1,939.17	0.08	0.00	1,940.95
Waste						0.00	0.00		0.00	0.00	4.63	0.00	4.63	0.27	0.00	10.37
Water						0.00	0.00		0.00	0.00	0.00	233.85	233.85	4.51	0.12	364.48
Total	**3.51**	**2.90**	**12.08**	**0.02**	**2.24**	**0.11**	**2.39**	**0.04**	**0.10**	**0.17**	**4.63**	**3,305.89**	**3,310.52**	**4.90**	**0.14**	**3,455.69**

2.2 Overall Operational

Mitigated Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Area	2.13	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	1,132.87	1,132.87	0.04	0.02	1,139.89
Mobile	1.34	2.52	11.76	0.02	2.24	0.11	2.36	0.04	0.10	0.14	0.00	1,939.17	1,939.17	0.08	0.00	1,940.95
Waste						0.00	0.00		0.00	0.00	4.63	0.00	4.63	0.27	0.00	10.37
Water						0.00	0.00		0.00	0.00	0.00	233.85	233.85	4.51	0.12	364.48
Total	**3.51**	**2.90**	**12.08**	**0.02**	**2.24**	**0.11**	**2.39**	**0.04**	**0.10**	**0.17**	**4.63**	**3,305.89**	**3,310.52**	**4.90**	**0.14**	**3,455.69**

3.0 Construction Detail

3.1 Mitigation Measures Construction

Water Exposed Area

3.2 Demolition - 2014

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.05	0.00	0.05	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Off-Road	0.02	0.15	0.09	0.00		0.01	0.01		0.01	0.01	0.00	22.20	22.20	0.00	0.00	22.24
Total	**0.02**	**0.15**	**0.09**	**0.00**	**0.05**	**0.01**	**0.06**	**0.01**	**0.01**	**0.02**	**0.00**	**22.20**	**22.20**	**0.00**	**0.00**	**22.24**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.01	0.11	0.06	0.00	0.09	0.00	0.09	0.00	0.00	0.00	0.00	18.06	18.06	0.00	0.00	18.07
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worker	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.30	1.30	0.00	0.00	1.30
Total	**0.01**	**0.11**	**0.07**	**0.00**	**0.09**	**0.00**	**0.09**	**0.00**	**0.00**	**0.00**	**0.00**	**19.36**	**19.36**	**0.00**	**0.00**	**19.37**

3.2 Demolition - 2014

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off-Road	0.02	0.15	0.09	0.00		0.01	0.01		0.01	0.01	0.00	22.20	22.20	0.00	0.00	22.24
Total	**0.02**	**0.15**	**0.09**	**0.00**	**0.02**	**0.01**	**0.03**	**0.00**	**0.01**	**0.01**	**0.00**	**22.20**	**22.20**	**0.00**	**0.00**	**22.24**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.01	0.11	0.06	0.00	0.09	0.00	0.09	0.00	0.00	0.00	0.00	18.06	18.06	0.00	0.00	18.07
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worker	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.30	1.30	0.00	0.00	1.30
Total	**0.01**	**0.11**	**0.07**	**0.00**	**0.09**	**0.00**	**0.09**	**0.00**	**0.00**	**0.00**	**0.00**	**19.36**	**19.36**	**0.00**	**0.00**	**19.37**

3.3 Site Preparation - 2014

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.02	0.00	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Total					**0.02**	**0.00**	**0.02**	**0.01**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.06	0.73	0.33	0.00	1.45	0.03	1.48	0.00	0.02	0.03	0.00	128.34	128.34	0.00	0.00	128.40
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.66	0.00	0.00	0.66
Total	**0.06**	**0.73**	**0.33**	**0.00**	**1.45**	**0.03**	**1.48**	**0.00**	**0.02**	**0.03**	**0.00**	**129.00**	**129.00**	**0.00**	**0.00**	**129.06**

3.3 Site Preparation - 2014

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total					**0.01**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.06	0.73	0.33	0.00	1.45	0.03	1.48	0.00	0.02	0.03	0.00	128.34	128.34	0.00	0.00	128.40
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.66	0.00	0.00	0.66
Total	**0.06**	**0.73**	**0.33**	**0.00**	**1.45**	**0.03**	**1.48**	**0.00**	**0.02**	**0.03**	**0.00**	**129.00**	**129.00**	**0.00**	**0.00**	**129.06**

3.4 Grading - 2014

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.07	0.00	0.07	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Off-Road	0.06	0.48	0.31	0.00		0.03	0.03		0.03	0.03	0.00	50.80	50.80	0.00	0.00	50.90
Total	**0.06**	**0.48**	**0.31**	**0.00**	**0.07**	**0.03**	**0.10**	**0.03**	**0.03**	**0.06**	**0.00**	**50.80**	**50.80**	**0.00**	**0.00**	**50.90**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.15	1.61	0.93	0.00	2.84	0.05	2.89	0.00	0.05	0.05	0.00	259.54	259.54	0.01	0.00	259.68
Vendor	0.00	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.44	6.44	0.00	0.00	6.44
Worker	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.29	3.29	0.00	0.00	3.30
Total	**0.15**	**1.65**	**0.98**	**0.00**	**2.84**	**0.05**	**2.89**	**0.00**	**0.05**	**0.05**	**0.00**	**269.27**	**269.27**	**0.01**	**0.00**	**269.42**

3.4 Grading - 2014

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.03	0.00	0.03	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Off-Road	0.06	0.48	0.31	0.00		0.03	0.03		0.03	0.03	0.00	50.80	50.80	0.00	0.00	50.90
Total	**0.06**	**0.48**	**0.31**	**0.00**	**0.03**	**0.03**	**0.06**	**0.02**	**0.03**	**0.05**	**0.00**	**50.80**	**50.80**	**0.00**	**0.00**	**50.90**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.15	1.61	0.93	0.00	2.84	0.05	2.89	0.00	0.05	0.05	0.00	259.54	259.54	0.01	0.00	259.68
Vendor	0.00	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.44	6.44	0.00	0.00	6.44
Worker	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.29	3.29	0.00	0.00	3.30
Total	**0.15**	**1.65**	**0.98**	**0.00**	**2.84**	**0.05**	**2.89**	**0.00**	**0.05**	**0.05**	**0.00**	**269.27**	**269.27**	**0.01**	**0.00**	**269.42**

3.5 Building Construction - Foundations - 2014

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.04	0.31	0.18	0.00		0.02	0.02		0.02	0.02	0.00	38.58	38.58	0.00	0.00	38.64
Total	**0.04**	**0.31**	**0.18**	**0.00**		**0.02**	**0.02**		**0.02**	**0.02**	**0.00**	**38.58**	**38.58**	**0.00**	**0.00**	**38.64**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.03	0.35	0.25	0.00	0.02	0.01	0.03	0.00	0.01	0.01	0.00	58.87	58.87	0.00	0.00	58.90
Worker	0.04	0.04	0.36	0.00	0.06	0.00	0.06	0.00	0.00	0.00	0.00	51.00	51.00	0.00	0.00	51.06
Total	**0.07**	**0.39**	**0.61**	**0.00**	**0.08**	**0.01**	**0.09**	**0.00**	**0.01**	**0.01**	**0.00**	**109.87**	**109.87**	**0.00**	**0.00**	**109.96**

3.5 Building Construction - Foundations - 2014

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.04	0.31	0.18	0.00		0.02	0.02		0.02	0.02	0.00	38.58	38.58	0.00	0.00	38.64
Total	**0.04**	**0.31**	**0.18**	**0.00**		**0.02**	**0.02**		**0.02**	**0.02**	**0.00**	**38.58**	**38.58**	**0.00**	**0.00**	**38.64**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.03	0.35	0.25	0.00	0.02	0.01	0.03	0.00	0.01	0.01	0.00	58.87	58.87	0.00	0.00	58.90
Worker	0.04	0.04	0.36	0.00	0.06	0.00	0.06	0.00	0.00	0.00	0.00	51.00	51.00	0.00	0.00	51.06
Total	**0.07**	**0.39**	**0.61**	**0.00**	**0.08**	**0.01**	**0.09**	**0.00**	**0.01**	**0.01**	**0.00**	**109.87**	**109.87**	**0.00**	**0.00**	**109.96**

3.6 Building Construction - Steel Erection - 2014

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.06	0.46	0.25	0.00		0.02	0.02		0.02	0.02	0.00	54.90	54.90	0.00	0.00	55.00
Total	**0.06**	**0.46**	**0.25**	**0.00**		**0.02**	**0.02**		**0.02**	**0.02**	**0.00**	**54.90**	**54.90**	**0.00**	**0.00**	**55.00**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.04	0.42	0.31	0.00	0.02	0.01	0.03	0.00	0.01	0.01	0.00	71.48	71.48	0.00	0.00	71.52
Worker	0.04	0.04	0.43	0.00	0.07	0.00	0.08	0.00	0.00	0.00	0.00	61.92	61.92	0.00	0.00	62.00
Total	**0.08**	**0.46**	**0.74**	**0.00**	**0.09**	**0.01**	**0.11**	**0.00**	**0.01**	**0.01**	**0.00**	**133.40**	**133.40**	**0.00**	**0.00**	**133.52**

3.6 Building Construction - Steel Erection - 2014

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.06	0.46	0.25	0.00		0.02	0.02		0.02	0.02	0.00	54.90	54.90	0.00	0.00	55.00
Total	**0.06**	**0.46**	**0.25**	**0.00**		**0.02**	**0.02**		**0.02**	**0.02**	**0.00**	**54.90**	**54.90**	**0.00**	**0.00**	**55.00**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.04	0.42	0.31	0.00	0.02	0.01	0.03	0.00	0.01	0.01	0.00	71.48	71.48	0.00	0.00	71.52
Worker	0.04	0.04	0.43	0.00	0.07	0.00	0.08	0.00	0.00	0.00	0.00	61.92	61.92	0.00	0.00	62.00
Total	**0.08**	**0.46**	**0.74**	**0.00**	**0.09**	**0.01**	**0.11**	**0.00**	**0.01**	**0.01**	**0.00**	**133.40**	**133.40**	**0.00**	**0.00**	**133.52**

4.0 Mobile Detail

4.1 Mitigation Measures Mobile

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Mitigated	1.34	2.52	11.76	0.02	2.24	0.11	2.36	0.04	0.10	0.14	0.00	1,939.17	1,939.17	0.08	0.00	1,940.95
Unmitigated	1.34	2.52	11.76	0.02	2.24	0.11	2.36	0.04	0.10	0.14	0.00	1,939.17	1,939.17	0.08	0.00	1,940.95
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

4.2 Trip Summary Information

	Average Daily Trip Rate			Unmitigated	Mitigated
Land Use	Weekday	Saturday	Sunday	Annual VMT	Annual VMT
Parking Lot	0.00	0.00	0.00		
Research & Development	2,433.00	570.00	333.00	4,678,806	4,678,806
Total	2,433.00	570.00	333.00	4,678,806	4,678,806

4.3 Trip Type Information

	Miles			Trip %		
Land Use	H-W or C-W	H-S or C-C	H-O or C-NW	H-W or C-W	H-S or C-C	H-O or C-NW
Parking Lot	9.50	7.30	7.30	0.00	0.00	0.00
Research & Development	9.50	7.30	7.30	33.00	48.00	19.00

5.0 Energy Detail

5.1 Mitigation Measures Energy

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Electricity Mitigated						0.00	0.00		0.00	0.00	0.00	721.75	721.75	0.03	0.01	726.27
Electricity Unmitigated						0.00	0.00		0.00	0.00	0.00	721.75	721.75	0.03	0.01	726.27
NaturalGas Mitigated	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	411.11	411.11	0.01	0.01	413.62
NaturalGas Unmitigated	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	411.11	411.11	0.01	0.01	413.62
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

5.2 Energy by Land Use - NaturalGas

Unmitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU	tons/yr										MT/yr					
Parking Lot	0	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Research & Development	7.704e+006	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	411.11	411.11	0.01	0.01	413.62
Total		**0.04**	**0.38**	**0.32**	**0.00**		**0.00**	**0.03**		**0.00**	**0.03**	**0.00**	**411.11**	**411.11**	**0.01**	**0.01**	**413.62**

5.2 Energy by Land Use - NaturalGas

Mitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU	tons/yr										MT/yr					
Parking Lot	0	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Research & Development	7.704e+006	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	411.11	411.11	0.01	0.01	413.62
Total		**0.04**	**0.38**	**0.32**	**0.00**		**0.00**	**0.03**		**0.00**	**0.03**	**0.00**	**411.11**	**411.11**	**0.01**	**0.01**	**413.62**

5.3 Energy by Land Use - Electricity

Unmitigated

	Electricity Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	kWh	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research & Development	2.481e+006					721.75	0.03	0.01	726.27
Total						**721.75**	**0.03**	**0.01**	**726.27**

5.3 Energy by Land Use - Electricity

Mitigated

	Electricity Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	kWh	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research & Development	2.481e+006					721.75	0.03	0.01	726.27
Total						**721.75**	**0.03**	**0.01**	**726.27**

6.0 Area Detail

6.1 Mitigation Measures Area

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Mitigated	2.13	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unmitigated	2.13	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

6.2 Area by SubCategory

Unmitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
SubCategory	tons/yr										MT/yr					
Architectural Coating	0.49					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumer Products	1.64					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landscaping	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**2.13**	**0.00**	**0.00**	**0.00**		**0.00**	**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Mitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
SubCategory	tons/yr										MT/yr					
Architectural Coating	0.49					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumer Products	1.64					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landscaping	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**2.13**	**0.00**	**0.00**	**0.00**		**0.00**	**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

7.0 Water Detail

7.1 Mitigation Measures Water

	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr				MT/yr			
Mitigated					233.85	4.51	0.12	364.48
Unmitigated					233.85	4.51	0.12	364.48
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

7.2 Water by Land Use

Unmitigated

	Indoor/Outdoor Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	Mgal	tons/yr				MT/yr			
Parking Lot	0 / 0					0.00	0.00	0.00	0.00
Research & Development	147.508 / 0					233.85	4.51	0.12	364.48
Total						**233.85**	**4.51**	**0.12**	**364.48**

7.2 Water by Land Use

Mitigated

	Indoor/Outdoor Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	Mgal	tons/yr				MT/yr			
Parking Lot	0 / 0					0.00	0.00	0.00	0.00
Research & Development	147.508 / 0					233.85	4.51	0.12	364.48
Total						**233.85**	**4.51**	**0.12**	**364.48**

8.0 Waste Detail

8.1 Mitigation Measures Waste

Category/Year

	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
	tons/yr				MT/yr			
Mitigated					4.63	0.27	0.00	10.37
Unmitigated					4.63	0.27	0.00	10.37
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

8.2 Waste by Land Use

Unmitigated

	Waste Disposed	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	tons	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research & Development	22.8					4.63	0.27	0.00	10.37
Total						**4.63**	**0.27**	**0.00**	**10.37**

Mitigated

	Waste Disposed	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	tons	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research & Development	22.8					4.63	0.27	0.00	10.37
Total						**4.63**	**0.27**	**0.00**	**10.37**

9.0 Vegetation

Phase 1 Development - Year 2 Max - 03/22/2012

Bay Area AQMD Air District, Annual

1.0 Project Characteristics

1.1 Land Usage

Land Uses	Size	Metric
Research & Development	300	1000sqft
Parking Lot	300	Space

1.2 Other Project Characteristics

Urbanization	Urban	**Wind Speed (m/s)**	2.2	**Utility Company**	Pacific Gas & Electric Company
Climate Zone	5	**Precipitation Freq (Days)**	64		

1.3 User Entered Comments

Construction Phase - BC-EE (1/1/15 - 7/1/15); BC-IF (6/1/15 - 12/11/15); Paving (10/30/15 - 12/31/15) Updated: 3/22/13

Off-road Equipment - Site Prep: Rubber tired dozer assigned 0 hp and 0 LF. Updated: 3/22/13

Grading - Grading: 70,000 cyd material imported and 2,750 material exported @ 12 acres disturbed Updated: 3/22/13

Demolition - Demolition = 106,999 gsf; Updated: 3/22/13

Trips and VMT -

Construction Off-road Equipment Mitigation - Water Exposed Area = 2/day @ 55% reduction
Updated: 3/22/13

Project Characteristics -

Land Use - 300,000 gsf of R&D, 300 spaces for the parking lot, and 1,300 population. Updated: 3/22/13

Off-road Equipment - Updated: 3/22/13

Off-road Equipment - Updated: 3/22/13 - 2 Forklifts and 1 Other Constr. Equip.

Off-road Equipment - Updated: 3/22/13

2.0 Emissions Summary

2.1 Overall Construction

Unmitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2015	0.36	2.20	2.66	0.01	0.31	0.08	0.40	0.01	0.08	0.09	0.00	556.21	556.21	0.03	0.00	556.75
Total	**0.36**	**2.20**	**2.66**	**0.01**	**0.31**	**0.08**	**0.40**	**0.01**	**0.08**	**0.09**	**0.00**	**556.21**	**556.21**	**0.03**	**0.00**	**556.75**

Mitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2015	0.36	2.20	2.66	0.01	0.31	0.08	0.40	0.01	0.08	0.09	0.00	556.21	556.21	0.03	0.00	556.75
Total	**0.36**	**2.20**	**2.66**	**0.01**	**0.31**	**0.08**	**0.40**	**0.01**	**0.08**	**0.09**	**0.00**	**556.21**	**556.21**	**0.03**	**0.00**	**556.75**

2.2 Overall Operational

Unmitigated Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Area	2.13	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	1,132.87	1,132.87	0.04	0.02	1,139.89
Mobile	1.34	2.52	11.76	0.02	2.24	0.11	2.36	0.04	0.10	0.14	0.00	1,939.17	1,939.17	0.08	0.00	1,940.95
Waste						0.00	0.00		0.00	0.00	4.63	0.00	4.63	0.27	0.00	10.37
Water						0.00	0.00		0.00	0.00	0.00	233.85	233.85	4.51	0.12	364.48
Total	**3.51**	**2.90**	**12.08**	**0.02**	**2.24**	**0.11**	**2.39**	**0.04**	**0.10**	**0.17**	**4.63**	**3,305.89**	**3,310.52**	**4.90**	**0.14**	**3,455.69**

2.2 Overall Operational

Mitigated Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Area	2.13	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	1,132.87	1,132.87	0.04	0.02	1,139.89
Mobile	1.34	2.52	11.76	0.02	2.24	0.11	2.36	0.04	0.10	0.14	0.00	1,939.17	1,939.17	0.08	0.00	1,940.95
Waste						0.00	0.00		0.00	0.00	4.63	0.00	4.63	0.27	0.00	10.37
Water						0.00	0.00		0.00	0.00	0.00	233.85	233.85	4.51	0.12	364.48
Total	**3.51**	**2.90**	**12.08**	**0.02**	**2.24**	**0.11**	**2.39**	**0.04**	**0.10**	**0.17**	**4.63**	**3,305.89**	**3,310.52**	**4.90**	**0.14**	**3,455.69**

3.0 Construction Detail

3.1 Mitigation Measures Construction

Water Exposed Area

3.2 Building Construction - Exterior Enclosure - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.06	0.52	0.26	0.00		0.02	0.02		0.02	0.02	0.00	80.10	80.10	0.01	0.00	80.20
Total	**0.06**	**0.52**	**0.26**	**0.00**		**0.02**	**0.02**		**0.02**	**0.02**	**0.00**	**80.10**	**80.10**	**0.01**	**0.00**	**80.20**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.06	0.59	0.43	0.00	0.03	0.02	0.05	0.00	0.02	0.02	0.00	109.55	109.55	0.00	0.00	109.60
Worker	0.06	0.06	0.60	0.00	0.11	0.00	0.12	0.00	0.00	0.01	0.00	92.58	92.58	0.01	0.00	92.69
Total	**0.12**	**0.65**	**1.03**	**0.00**	**0.14**	**0.02**	**0.17**	**0.00**	**0.02**	**0.03**	**0.00**	**202.13**	**202.13**	**0.01**	**0.00**	**202.29**

3.2 Building Construction - Exterior Enclosure - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.06	0.52	0.26	0.00		0.02	0.02		0.02	0.02	0.00	80.10	80.10	0.01	0.00	80.20
Total	**0.06**	**0.52**	**0.26**	**0.00**		**0.02**	**0.02**		**0.02**	**0.02**	**0.00**	**80.10**	**80.10**	**0.01**	**0.00**	**80.20**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.06	0.59	0.43	0.00	0.03	0.02	0.05	0.00	0.02	0.02	0.00	109.55	109.55	0.00	0.00	109.60
Worker	0.06	0.06	0.60	0.00	0.11	0.00	0.12	0.00	0.00	0.01	0.00	92.58	92.58	0.01	0.00	92.69
Total	**0.12**	**0.65**	**1.03**	**0.00**	**0.14**	**0.02**	**0.17**	**0.00**	**0.02**	**0.03**	**0.00**	**202.13**	**202.13**	**0.01**	**0.00**	**202.29**

3.3 Building Construction - Interior Finishes - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.03	0.22	0.14	0.00		0.01	0.01		0.01	0.01	0.00	36.24	36.24	0.00	0.00	36.29
Total	**0.03**	**0.22**	**0.14**	**0.00**		**0.01**	**0.01**		**0.01**	**0.01**	**0.00**	**36.24**	**36.24**	**0.00**	**0.00**	**36.29**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.06	0.63	0.47	0.00	0.04	0.02	0.05	0.00	0.02	0.02	0.00	117.97	117.97	0.00	0.00	118.03
Worker	0.07	0.07	0.65	0.00	0.12	0.00	0.13	0.00	0.00	0.01	0.00	99.70	99.70	0.01	0.00	99.82
Total	**0.13**	**0.70**	**1.12**	**0.00**	**0.16**	**0.02**	**0.18**	**0.00**	**0.02**	**0.03**	**0.00**	**217.67**	**217.67**	**0.01**	**0.00**	**217.85**

3.3 Building Construction - Interior Finishes - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.03	0.22	0.14	0.00		0.01	0.01		0.01	0.01	0.00	36.24	36.24	0.00	0.00	36.29
Total	**0.03**	**0.22**	**0.14**	**0.00**		**0.01**	**0.01**		**0.01**	**0.01**	**0.00**	**36.24**	**36.24**	**0.00**	**0.00**	**36.29**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.06	0.63	0.47	0.00	0.04	0.02	0.05	0.00	0.02	0.02	0.00	117.97	117.97	0.00	0.00	118.03
Worker	0.07	0.07	0.65	0.00	0.12	0.00	0.13	0.00	0.00	0.01	0.00	99.70	99.70	0.01	0.00	99.82
Total	**0.13**	**0.70**	**1.12**	**0.00**	**0.16**	**0.02**	**0.18**	**0.00**	**0.02**	**0.03**	**0.00**	**217.67**	**217.67**	**0.01**	**0.00**	**217.85**

3.4 Paving - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.02	0.11	0.08	0.00		0.01	0.01		0.01	0.01	0.00	15.03	15.03	0.00	0.00	15.06
Paving	0.00					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**0.02**	**0.11**	**0.08**	**0.00**		**0.01**	**0.01**		**0.01**	**0.01**	**0.00**	**15.03**	**15.03**	**0.00**	**0.00**	**15.06**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worker	0.00	0.00	0.03	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	5.05	5.05	0.00	0.00	5.05
Total	**0.00**	**0.00**	**0.03**	**0.00**	**0.01**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**5.05**	**5.05**	**0.00**	**0.00**	**5.05**

3.4 Paving - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.02	0.11	0.08	0.00		0.01	0.01		0.01	0.01	0.00	15.03	15.03	0.00	0.00	15.06
Paving	0.00					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**0.02**	**0.11**	**0.08**	**0.00**		**0.01**	**0.01**		**0.01**	**0.01**	**0.00**	**15.03**	**15.03**	**0.00**	**0.00**	**15.06**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worker	0.00	0.00	0.03	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	5.05	5.05	0.00	0.00	5.05
Total	**0.00**	**0.00**	**0.03**	**0.00**	**0.01**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**5.05**	**5.05**	**0.00**	**0.00**	**5.05**

4.0 Mobile Detail

4.1 Mitigation Measures Mobile

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Mitigated	1.34	2.52	11.76	0.02	2.24	0.11	2.36	0.04	0.10	0.14	0.00	1,939.17	1,939.17	0.08	0.00	1,940.95
Unmitigated	1.34	2.52	11.76	0.02	2.24	0.11	2.36	0.04	0.10	0.14	0.00	1,939.17	1,939.17	0.08	0.00	1,940.95
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

4.2 Trip Summary Information

	Average Daily Trip Rate			Unmitigated	Mitigated
Land Use	Weekday	Saturday	Sunday	Annual VMT	Annual VMT
Parking Lot	0.00	0.00	0.00		
Research & Development	2,433.00	570.00	333.00	4,678,806	4,678,806
Total	2,433.00	570.00	333.00	4,678,806	4,678,806

4.3 Trip Type Information

	Miles			Trip %		
Land Use	H-W or C-W	H-S or C-C	H-O or C-NW	H-W or C-W	H-S or C-C	H-O or C-NW
Parking Lot	9.50	7.30	7.30	0.00	0.00	0.00
Research & Development	9.50	7.30	7.30	33.00	48.00	19.00

5.0 Energy Detail

5.1 Mitigation Measures Energy

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Electricity Mitigated						0.00	0.00		0.00	0.00	0.00	721.75	721.75	0.03	0.01	726.27
Electricity Unmitigated						0.00	0.00		0.00	0.00	0.00	721.75	721.75	0.03	0.01	726.27
NaturalGas Mitigated	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	411.11	411.11	0.01	0.01	413.62
NaturalGas Unmitigated	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	411.11	411.11	0.01	0.01	413.62
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

5.2 Energy by Land Use - NaturalGas

Unmitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU	tons/yr										MT/yr					
Parking Lot	0	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Research & Development	7.704e+006	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	411.11	411.11	0.01	0.01	413.62
Total		**0.04**	**0.38**	**0.32**	**0.00**		**0.00**	**0.03**		**0.00**	**0.03**	**0.00**	**411.11**	**411.11**	**0.01**	**0.01**	**413.62**

Mitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU	tons/yr										MT/yr					
Parking Lot	0	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Research & Development	7.704e+006	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	411.11	411.11	0.01	0.01	413.62
Total		**0.04**	**0.38**	**0.32**	**0.00**		**0.00**	**0.03**		**0.00**	**0.03**	**0.00**	**411.11**	**411.11**	**0.01**	**0.01**	**413.62**

5.3 Energy by Land Use - Electricity

Unmitigated

	Electricity Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	kWh	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research & Development	2.481e+006					721.75	0.03	0.01	726.27
Total						**721.75**	**0.03**	**0.01**	**726.27**

Mitigated

	Electricity Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	kWh	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research & Development	2.481e+006					721.75	0.03	0.01	726.27
Total						**721.75**	**0.03**	**0.01**	**726.27**

6.0 Area Detail

6.1 Mitigation Measures Area

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Mitigated	2.13	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unmitigated	2.13	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

6.2 Area by SubCategory

Unmitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
SubCategory	tons/yr										MT/yr					
Architectural Coating	0.49					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumer Products	1.64					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landscaping	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**2.13**	**0.00**	**0.00**	**0.00**		**0.00**	**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

6.2 Area by SubCategory

Mitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
SubCategory	tons/yr										MT/yr					
Architectural Coating	0.49					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumer Products	1.64					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landscaping	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**2.13**	**0.00**	**0.00**	**0.00**		**0.00**	**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

7.0 Water Detail

7.1 Mitigation Measures Water

	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr				MT/yr			
Mitigated					233.85	4.51	0.12	364.48
Unmitigated					233.85	4.51	0.12	364.48
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

7.2 Water by Land Use

Unmitigated

	Indoor/Outdoor Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	Mgal	tons/yr				MT/yr			
Parking Lot	0 / 0					0.00	0.00	0.00	0.00
Research & Development	147.508 / 0					233.85	4.51	0.12	364.48
Total						**233.85**	**4.51**	**0.12**	**364.48**

7.2 Water by Land Use

Mitigated

	Indoor/Outdoor Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	Mgal	tons/yr				MT/yr			
Parking Lot	0 / 0					0.00	0.00	0.00	0.00
Research & Development	147.508 / 0					233.85	4.51	0.12	364.48
Total						**233.85**	**4.51**	**0.12**	**364.48**

8.0 Waste Detail

8.1 Mitigation Measures Waste

Category/Year

	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
	tons/yr				MT/yr			
Mitigated					4.63	0.27	0.00	10.37
Unmitigated					4.63	0.27	0.00	10.37
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

8.2 Waste by Land Use

Unmitigated

	Waste Disposed	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	tons	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research & Development	22.8					4.63	0.27	0.00	10.37
Total						**4.63**	**0.27**	**0.00**	**10.37**

Mitigated

	Waste Disposed	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	tons	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research & Development	22.8					4.63	0.27	0.00	10.37
Total						**4.63**	**0.27**	**0.00**	**10.37**

9.0 Vegetation

Phase 1 Development - Year 1 Max - 03/22/2012

Bay Area AQMD Air District, Annual

1.0 Project Characteristics

1.1 Land Usage

Land Uses	Size	Metric
Research & Development	300	1000sqft
Parking Lot	300	Space

1.2 Other Project Characteristics

Urbanization	Urban	**Wind Speed (m/s)**	2.2	**Utility Company**	Pacific Gas & Electric Company
Climate Zone	5	**Precipitation Freq (Days)**	64		

1.3 User Entered Comments

Project Characteristics -

Land Use - 300,000 gsf for R&D, 300 spaces for parking lot, and 1,300 population. Updated: 3/22/13

Construction Phase - Demolition (1/1/14 - 1/28/14); Site Prep (1/1/14 - 3/3/14); Grading (3/4/14 - 5/4/14); BC-F (5/5/14 - 8/8/14); BC-SE (8/9/14 - 12/5/14) Updated: 3/22/13

Off-road Equipment - Pumps = 307 hp. Updated: 3/22/13

Off-road Equipment - Pumps = 307 hp. Updated: 3/22/13

Off-road Equipment - Updated: 3/22/13

Off-road Equipment - Updated: 3/22/13

Off-road Equipment - Site Prep: Rubber tired dozer assigned 0 hp and 0 LF. Updated: 3/22/13

Trips and VMT - Site Prep: 275 hauling truck trips @ 260 miles
Grading: 12 vendor trips/day and 7,000 hauling truck trips
Modeling Length = 637.1 miles
Updated: 3/22/13

Demolition - Demolition = 106,999 gsf; Updated: 3/22/13

Grading - Grading: 70,000 cyd material imported and 2,750 material exported @ 12 acres disturbed
Updated: 3/22/13

Construction Off-road Equipment Mitigation - Water Exposed Area = 2/day @ 55% reduction
Updated: 3/22/13

2.0 Emissions Summary

2.1 Overall Construction

Unmitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2014	12.14	111.72	86.10	0.28	107.90	4.16	112.06	0.40	3.84	4.24	0.00	26,316.46	26,316.46	0.74	0.00	26,332.04
Total	**12.14**	**111.72**	**86.10**	**0.28**	**107.90**	**4.16**	**112.06**	**0.40**	**3.84**	**4.24**	**0.00**	**26,316.46**	**26,316.46**	**0.74**	**0.00**	**26,332.04**

Mitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2014	12.14	111.72	86.10	0.28	107.82	4.16	111.99	0.37	3.84	4.21	0.00	26,316.46	26,316.46	0.74	0.00	26,332.04
Total	**12.14**	**111.72**	**86.10**	**0.28**	**107.82**	**4.16**	**111.99**	**0.37**	**3.84**	**4.21**	**0.00**	**26,316.46**	**26,316.46**	**0.74**	**0.00**	**26,332.04**

2.2 Overall Operational

Unmitigated Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Area	2.13	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	1,132.87	1,132.87	0.04	0.02	1,139.89
Mobile	1.34	2.52	11.76	0.02	2.24	0.11	2.36	0.04	0.10	0.14	0.00	1,939.17	1,939.17	0.08	0.00	1,940.95
Waste						0.00	0.00		0.00	0.00	4.63	0.00	4.63	0.27	0.00	10.37
Water						0.00	0.00		0.00	0.00	0.00	233.85	233.85	4.51	0.12	364.48
Total	**3.51**	**2.90**	**12.08**	**0.02**	**2.24**	**0.11**	**2.39**	**0.04**	**0.10**	**0.17**	**4.63**	**3,305.89**	**3,310.52**	**4.90**	**0.14**	**3,455.69**

2.2 Overall Operational

Mitigated Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Area	2.13	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	1,132.87	1,132.87	0.04	0.02	1,139.89
Mobile	1.34	2.52	11.76	0.02	2.24	0.11	2.36	0.04	0.10	0.14	0.00	1,939.17	1,939.17	0.08	0.00	1,940.95
Waste						0.00	0.00		0.00	0.00	4.63	0.00	4.63	0.27	0.00	10.37
Water						0.00	0.00		0.00	0.00	0.00	233.85	233.85	4.51	0.12	364.48
Total	**3.51**	**2.90**	**12.08**	**0.02**	**2.24**	**0.11**	**2.39**	**0.04**	**0.10**	**0.17**	**4.63**	**3,305.89**	**3,310.52**	**4.90**	**0.14**	**3,455.69**

3.0 Construction Detail

3.1 Mitigation Measures Construction

Water Exposed Area

3.2 Demolition - 2014

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.05	0.00	0.05	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Off-Road	0.02	0.15	0.09	0.00		0.01	0.01		0.01	0.01	0.00	22.20	22.20	0.00	0.00	22.24
Total	**0.02**	**0.15**	**0.09**	**0.00**	**0.05**	**0.01**	**0.06**	**0.01**	**0.01**	**0.02**	**0.00**	**22.20**	**22.20**	**0.00**	**0.00**	**22.24**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.27	3.16	1.42	0.01	2.87	0.11	2.99	0.01	0.11	0.11	0.00	556.02	556.02	0.01	0.00	556.27
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worker	0.04	0.04	0.40	0.00	0.08	0.00	0.08	0.00	0.00	0.00	0.00	65.66	65.66	0.00	0.00	65.74
Total	**0.31**	**3.20**	**1.82**	**0.01**	**2.95**	**0.11**	**3.07**	**0.01**	**0.11**	**0.11**	**0.00**	**621.68**	**621.68**	**0.01**	**0.00**	**622.01**

3.2 Demolition - 2014

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off-Road	0.02	0.15	0.09	0.00		0.01	0.01		0.01	0.01	0.00	22.20	22.20	0.00	0.00	22.24
Total	**0.02**	**0.15**	**0.09**	**0.00**	**0.02**	**0.01**	**0.03**	**0.00**	**0.01**	**0.01**	**0.00**	**22.20**	**22.20**	**0.00**	**0.00**	**22.24**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.27	3.16	1.42	0.01	2.87	0.11	2.99	0.01	0.11	0.11	0.00	556.02	556.02	0.01	0.00	556.27
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worker	0.04	0.04	0.40	0.00	0.08	0.00	0.08	0.00	0.00	0.00	0.00	65.66	65.66	0.00	0.00	65.74
Total	**0.31**	**3.20**	**1.82**	**0.01**	**2.95**	**0.11**	**3.07**	**0.01**	**0.11**	**0.11**	**0.00**	**621.68**	**621.68**	**0.01**	**0.00**	**622.01**

3.3 Site Preparation - 2014

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.02	0.00	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Total					**0.02**	**0.00**	**0.02**	**0.01**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.15	1.78	0.80	0.00	3.55	0.06	3.62	0.00	0.06	0.06	0.00	313.97	313.97	0.01	0.00	314.11
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worker	0.02	0.02	0.20	0.00	0.04	0.00	0.04	0.00	0.00	0.00	0.00	33.34	33.34	0.00	0.00	33.38
Total	**0.17**	**1.80**	**1.00**	**0.00**	**3.59**	**0.06**	**3.66**	**0.00**	**0.06**	**0.06**	**0.00**	**347.31**	**347.31**	**0.01**	**0.00**	**347.49**

3.3 Site Preparation - 2014

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total					**0.01**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.15	1.78	0.80	0.00	3.55	0.06	3.62	0.00	0.06	0.06	0.00	313.97	313.97	0.01	0.00	314.11
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worker	0.02	0.02	0.20	0.00	0.04	0.00	0.04	0.00	0.00	0.00	0.00	33.34	33.34	0.00	0.00	33.38
Total	**0.17**	**1.80**	**1.00**	**0.00**	**3.59**	**0.06**	**3.66**	**0.00**	**0.06**	**0.06**	**0.00**	**347.31**	**347.31**	**0.01**	**0.00**	**347.49**

3.4 Grading - 2014

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.07	0.00	0.07	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Off-Road	0.06	0.48	0.31	0.00		0.03	0.03		0.03	0.03	0.00	50.80	50.80	0.00	0.00	50.90
Total	**0.06**	**0.48**	**0.31**	**0.00**	**0.07**	**0.03**	**0.10**	**0.03**	**0.03**	**0.06**	**0.00**	**50.80**	**50.80**	**0.00**	**0.00**	**50.90**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	3.83	45.38	20.40	0.08	90.44	1.65	92.08	0.10	1.51	1.62	0.00	7,992.08	7,992.08	0.17	0.00	7,995.62
Vendor	0.21	2.64	1.25	0.01	0.17	0.09	0.26	0.01	0.09	0.09	0.00	531.98	531.98	0.01	0.00	532.16
Worker	0.09	0.11	1.00	0.00	0.20	0.01	0.21	0.00	0.01	0.01	0.00	166.68	166.68	0.01	0.00	166.89
Total	**4.13**	**48.13**	**22.65**	**0.09**	**90.81**	**1.75**	**92.55**	**0.11**	**1.61**	**1.72**	**0.00**	**8,690.74**	**8,690.74**	**0.19**	**0.00**	**8,694.67**

3.4 Grading - 2014

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.03	0.00	0.03	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Off-Road	0.06	0.48	0.31	0.00		0.03	0.03		0.03	0.03	0.00	50.80	50.80	0.00	0.00	50.90
Total	**0.06**	**0.48**	**0.31**	**0.00**	**0.03**	**0.03**	**0.06**	**0.02**	**0.03**	**0.05**	**0.00**	**50.80**	**50.80**	**0.00**	**0.00**	**50.90**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	3.83	45.38	20.40	0.08	90.44	1.65	92.08	0.10	1.51	1.62	0.00	7,992.08	7,992.08	0.17	0.00	7,995.62
Vendor	0.21	2.64	1.25	0.01	0.17	0.09	0.26	0.01	0.09	0.09	0.00	531.98	531.98	0.01	0.00	532.16
Worker	0.09	0.11	1.00	0.00	0.20	0.01	0.21	0.00	0.01	0.01	0.00	166.68	166.68	0.01	0.00	166.89
Total	**4.13**	**48.13**	**22.65**	**0.09**	**90.81**	**1.75**	**92.55**	**0.11**	**1.61**	**1.72**	**0.00**	**8,690.74**	**8,690.74**	**0.19**	**0.00**	**8,694.67**

3.5 Building Construction - Foundations - 2014

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.04	0.31	0.18	0.00		0.02	0.02		0.02	0.02	0.00	38.58	38.58	0.00	0.00	38.64
Total	**0.04**	**0.31**	**0.18**	**0.00**		**0.02**	**0.02**		**0.02**	**0.02**	**0.00**	**38.58**	**38.58**	**0.00**	**0.00**	**38.64**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	1.88	24.16	11.45	0.05	1.56	0.86	2.42	0.05	0.79	0.84	0.00	4,866.38	4,866.38	0.08	0.00	4,868.09
Worker	1.44	1.67	15.55	0.03	3.14	0.12	3.25	0.05	0.11	0.16	0.00	2,581.03	2,581.03	0.15	0.00	2,584.22
Total	**3.32**	**25.83**	**27.00**	**0.08**	**4.70**	**0.98**	**5.67**	**0.10**	**0.90**	**1.00**	**0.00**	**7,447.41**	**7,447.41**	**0.23**	**0.00**	**7,452.31**

3.5 Building Construction - Foundations - 2014

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.04	0.31	0.18	0.00		0.02	0.02		0.02	0.02	0.00	38.58	38.58	0.00	0.00	38.64
Total	**0.04**	**0.31**	**0.18**	**0.00**		**0.02**	**0.02**		**0.02**	**0.02**	**0.00**	**38.58**	**38.58**	**0.00**	**0.00**	**38.64**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	1.88	24.16	11.45	0.05	1.56	0.86	2.42	0.05	0.79	0.84	0.00	4,866.38	4,866.38	0.08	0.00	4,868.09
Worker	1.44	1.67	15.55	0.03	3.14	0.12	3.25	0.05	0.11	0.16	0.00	2,581.03	2,581.03	0.15	0.00	2,584.22
Total	**3.32**	**25.83**	**27.00**	**0.08**	**4.70**	**0.98**	**5.67**	**0.10**	**0.90**	**1.00**	**0.00**	**7,447.41**	**7,447.41**	**0.23**	**0.00**	**7,452.31**

3.6 Building Construction - Steel Erection - 2014

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.06	0.46	0.24	0.00		0.02	0.02		0.02	0.02	0.00	54.47	54.47	0.00	0.00	54.56
Total	**0.06**	**0.46**	**0.24**	**0.00**		**0.02**	**0.02**		**0.02**	**0.02**	**0.00**	**54.47**	**54.47**	**0.00**	**0.00**	**54.56**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	2.29	29.34	13.91	0.06	1.90	1.04	2.94	0.06	0.96	1.02	0.00	5,909.17	5,909.17	0.10	0.00	5,911.25
Worker	1.75	2.03	18.88	0.04	3.81	0.14	3.95	0.06	0.13	0.19	0.00	3,134.11	3,134.11	0.18	0.00	3,137.98
Total	**4.04**	**31.37**	**32.79**	**0.10**	**5.71**	**1.18**	**6.89**	**0.12**	**1.09**	**1.21**	**0.00**	**9,043.28**	**9,043.28**	**0.28**	**0.00**	**9,049.23**

3.6 Building Construction - Steel Erection - 2014

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.06	0.46	0.24	0.00		0.02	0.02		0.02	0.02	0.00	54.47	54.47	0.00	0.00	54.56
Total	**0.06**	**0.46**	**0.24**	**0.00**		**0.02**	**0.02**		**0.02**	**0.02**	**0.00**	**54.47**	**54.47**	**0.00**	**0.00**	**54.56**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	2.29	29.34	13.91	0.06	1.90	1.04	2.94	0.06	0.96	1.02	0.00	5,909.17	5,909.17	0.10	0.00	5,911.25
Worker	1.75	2.03	18.88	0.04	3.81	0.14	3.95	0.06	0.13	0.19	0.00	3,134.11	3,134.11	0.18	0.00	3,137.98
Total	**4.04**	**31.37**	**32.79**	**0.10**	**5.71**	**1.18**	**6.89**	**0.12**	**1.09**	**1.21**	**0.00**	**9,043.28**	**9,043.28**	**0.28**	**0.00**	**9,049.23**

4.0 Mobile Detail

4.1 Mitigation Measures Mobile

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Mitigated	1.34	2.52	11.76	0.02	2.24	0.11	2.36	0.04	0.10	0.14	0.00	1,939.17	1,939.17	0.08	0.00	1,940.95
Unmitigated	1.34	2.52	11.76	0.02	2.24	0.11	2.36	0.04	0.10	0.14	0.00	1,939.17	1,939.17	0.08	0.00	1,940.95
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

4.2 Trip Summary Information

	Average Daily Trip Rate			Unmitigated	Mitigated
Land Use	Weekday	Saturday	Sunday	Annual VMT	Annual VMT
Parking Lot	0.00	0.00	0.00		
Research & Development	2,433.00	570.00	333.00	4,678,806	4,678,806
Total	2,433.00	570.00	333.00	4,678,806	4,678,806

4.3 Trip Type Information

	Miles			Trip %		
Land Use	H-W or C-W	H-S or C-C	H-O or C-NW	H-W or C-W	H-S or C-C	H-O or C-NW
Parking Lot	9.50	7.30	7.30	0.00	0.00	0.00
Research & Development	9.50	7.30	7.30	33.00	48.00	19.00

5.0 Energy Detail

5.1 Mitigation Measures Energy

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Electricity Mitigated						0.00	0.00		0.00	0.00	0.00	721.75	721.75	0.03	0.01	726.27
Electricity Unmitigated						0.00	0.00		0.00	0.00	0.00	721.75	721.75	0.03	0.01	726.27
NaturalGas Mitigated	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	411.11	411.11	0.01	0.01	413.62
NaturalGas Unmitigated	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	411.11	411.11	0.01	0.01	413.62
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

5.2 Energy by Land Use - NaturalGas

Unmitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU	tons/yr										MT/yr					
Parking Lot	0	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Research & Development	7.704e+006	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	411.11	411.11	0.01	0.01	413.62
Total		**0.04**	**0.38**	**0.32**	**0.00**		**0.00**	**0.03**		**0.00**	**0.03**	**0.00**	**411.11**	**411.11**	**0.01**	**0.01**	**413.62**

5.2 Energy by Land Use - NaturalGas

Mitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU	tons/yr										MT/yr					
Parking Lot	0	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Research & Development	7.704e+006	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	411.11	411.11	0.01	0.01	413.62
Total		**0.04**	**0.38**	**0.32**	**0.00**		**0.00**	**0.03**		**0.00**	**0.03**	**0.00**	**411.11**	**411.11**	**0.01**	**0.01**	**413.62**

5.3 Energy by Land Use - Electricity

Unmitigated

	Electricity Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	kWh	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research & Development	2.481e+006					721.75	0.03	0.01	726.27
Total						**721.75**	**0.03**	**0.01**	**726.27**

5.3 Energy by Land Use - Electricity

Mitigated

	Electricity Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	kWh	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research & Development	2.481e+006					721.75	0.03	0.01	726.27
Total						**721.75**	**0.03**	**0.01**	**726.27**

6.0 Area Detail

6.1 Mitigation Measures Area

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Mitigated	2.13	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unmitigated	2.13	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

6.2 Area by SubCategory

Unmitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
SubCategory	tons/yr										MT/yr					
Architectural Coating	0.49					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumer Products	1.64					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landscaping	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**2.13**	**0.00**	**0.00**	**0.00**		**0.00**	**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Mitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
SubCategory	tons/yr										MT/yr					
Architectural Coating	0.49					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumer Products	1.64					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landscaping	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**2.13**	**0.00**	**0.00**	**0.00**		**0.00**	**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

7.0 Water Detail

7.1 Mitigation Measures Water

	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr				MT/yr			
Mitigated					233.85	4.51	0.12	364.48
Unmitigated					233.85	4.51	0.12	364.48
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

7.2 Water by Land Use

Unmitigated

	Indoor/Outdoor Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	Mgal	tons/yr				MT/yr			
Parking Lot	0 / 0					0.00	0.00	0.00	0.00
Research & Development	147.508 / 0					233.85	4.51	0.12	364.48
Total						**233.85**	**4.51**	**0.12**	**364.48**

7.2 Water by Land Use

Mitigated

	Indoor/Outdoor Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	Mgal	tons/yr				MT/yr			
Parking Lot	0 / 0					0.00	0.00	0.00	0.00
Research & Development	147.508 / 0					233.85	4.51	0.12	364.48
Total						**233.85**	**4.51**	**0.12**	**364.48**

8.0 Waste Detail

8.1 Mitigation Measures Waste

Category/Year

	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
	tons/yr				MT/yr			
Mitigated					4.63	0.27	0.00	10.37
Unmitigated					4.63	0.27	0.00	10.37
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

8.2 Waste by Land Use

Unmitigated

	Waste Disposed	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	tons	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research & Development	22.8					4.63	0.27	0.00	10.37
Total						**4.63**	**0.27**	**0.00**	**10.37**

Mitigated

	Waste Disposed	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	tons	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research & Development	22.8					4.63	0.27	0.00	10.37
Total						**4.63**	**0.27**	**0.00**	**10.37**

9.0 Vegetation

Phase 1 Development - Year 2 Max - 03/22/2012

Bay Area AQMD Air District, Annual

1.0 Project Characteristics

1.1 Land Usage

Land Uses	Size	Metric
Research & Development	300	1000sqft
Parking Lot	300	Space

1.2 Other Project Characteristics

Urbanization	Urban	**Wind Speed (m/s)**	2.2	**Utility Company**	Pacific Gas & Electric Company
Climate Zone	5	**Precipitation Freq (Days)**	64		

1.3 User Entered Comments

Construction Phase - BC-EE (1/1/15 - 7/1/15); BC-IF (6/1/15 - 12/11/15); Paving (10/30/15 - 12/31/15)
Updated: 3/22/13

Off-road Equipment - Site Prep: Rubber tired dozer assigned 0 hp and 0 LF. Updated: 3/22/13

Grading - Grading: 70,000 cyd material imported and 2,750 material exported @ 12 acres disturbed
Updated: 3/22/13

Demolition - Demolition = 106,999 gsf; Updated: 3/22/13

Trips and VMT - Modeling Length = 637.1 miles
Updated: 3/22/13

Construction Off-road Equipment Mitigation - Water Exposed Area = 2/day @ 55% reduction
Updated: 3/22/13

Project Characteristics -

Land Use - 300,000 gsf of R&D, 300 spaces for the parking lot, and 1,300 population. Updated: 3/22/13

Off-road Equipment - Updated: 3/22/13

Off-road Equipment - Updated: 3/22/13 - 2 Forklifts and 1 Other Constr. Equip.

Off-road Equipment - Updated: 3/22/13

2.0 Emissions Summary

2.1 Overall Construction

Unmitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2015	12.00	89.79	96.49	0.32	18.44	3.51	21.96	0.40	3.24	3.64	0.00	28,904.12	28,904.12	0.85	0.00	28,921.95
Total	**12.00**	**89.79**	**96.49**	**0.32**	**18.44**	**3.51**	**21.96**	**0.40**	**3.24**	**3.64**	**0.00**	**28,904.12**	**28,904.12**	**0.85**	**0.00**	**28,921.95**

Mitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2015	12.00	89.79	96.49	0.32	18.44	3.51	21.96	0.40	3.24	3.64	0.00	28,904.12	28,904.12	0.85	0.00	28,921.95
Total	**12.00**	**89.79**	**96.49**	**0.32**	**18.44**	**3.51**	**21.96**	**0.40**	**3.24**	**3.64**	**0.00**	**28,904.12**	**28,904.12**	**0.85**	**0.00**	**28,921.95**

2.2 Overall Operational

Unmitigated Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Area	2.13	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	1,132.87	1,132.87	0.04	0.02	1,139.89
Mobile	1.34	2.52	11.76	0.02	2.24	0.11	2.36	0.04	0.10	0.14	0.00	1,939.17	1,939.17	0.08	0.00	1,940.95
Waste						0.00	0.00		0.00	0.00	4.63	0.00	4.63	0.27	0.00	10.37
Water						0.00	0.00		0.00	0.00	0.00	233.85	233.85	4.51	0.12	364.48
Total	**3.51**	**2.90**	**12.08**	**0.02**	**2.24**	**0.11**	**2.39**	**0.04**	**0.10**	**0.17**	**4.63**	**3,305.89**	**3,310.52**	**4.90**	**0.14**	**3,455.69**

2.2 Overall Operational

Mitigated Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Area	2.13	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	1,132.87	1,132.87	0.04	0.02	1,139.89
Mobile	1.34	2.52	11.76	0.02	2.24	0.11	2.36	0.04	0.10	0.14	0.00	1,939.17	1,939.17	0.08	0.00	1,940.95
Waste						0.00	0.00		0.00	0.00	4.63	0.00	4.63	0.27	0.00	10.37
Water						0.00	0.00		0.00	0.00	0.00	233.85	233.85	4.51	0.12	364.48
Total	**3.51**	**2.90**	**12.08**	**0.02**	**2.24**	**0.11**	**2.39**	**0.04**	**0.10**	**0.17**	**4.63**	**3,305.89**	**3,310.52**	**4.90**	**0.14**	**3,455.69**

3.0 Construction Detail

3.1 Mitigation Measures Construction

Water Exposed Area

3.2 Building Construction - Exterior Enclosure - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.06	0.52	0.26	0.00		0.02	0.02		0.02	0.02	0.00	80.10	80.10	0.01	0.00	80.20
Total	**0.06**	**0.52**	**0.26**	**0.00**		**0.02**	**0.02**		**0.02**	**0.02**	**0.00**	**80.10**	**80.10**	**0.01**	**0.00**	**80.20**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	3.19	39.94	19.37	0.10	2.90	1.45	4.35	0.09	1.33	1.43	0.00	9,045.14	9,045.14	0.14	0.00	9,048.03
Worker	2.47	2.81	26.17	0.05	5.83	0.22	6.04	0.10	0.20	0.30	0.00	4,685.39	4,685.39	0.26	0.00	4,690.85
Total	**5.66**	**42.75**	**45.54**	**0.15**	**8.73**	**1.67**	**10.39**	**0.19**	**1.53**	**1.73**	**0.00**	**13,730.53**	**13,730.53**	**0.40**	**0.00**	**13,738.88**

3.2 Building Construction - Exterior Enclosure - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.06	0.52	0.26	0.00		0.02	0.02		0.02	0.02	0.00	80.10	80.10	0.01	0.00	80.20
Total	**0.06**	**0.52**	**0.26**	**0.00**		**0.02**	**0.02**		**0.02**	**0.02**	**0.00**	**80.10**	**80.10**	**0.01**	**0.00**	**80.20**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	3.19	39.94	19.37	0.10	2.90	1.45	4.35	0.09	1.33	1.43	0.00	9,045.14	9,045.14	0.14	0.00	9,048.03
Worker	2.47	2.81	26.17	0.05	5.83	0.22	6.04	0.10	0.20	0.30	0.00	4,685.39	4,685.39	0.26	0.00	4,690.85
Total	**5.66**	**42.75**	**45.54**	**0.15**	**8.73**	**1.67**	**10.39**	**0.19**	**1.53**	**1.73**	**0.00**	**13,730.53**	**13,730.53**	**0.40**	**0.00**	**13,738.88**

3.3 Building Construction - Interior Finishes - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.03	0.22	0.14	0.00		0.01	0.01		0.01	0.01	0.00	36.24	36.24	0.00	0.00	36.29
Total	**0.03**	**0.22**	**0.14**	**0.00**		**0.01**	**0.01**		**0.01**	**0.01**	**0.00**	**36.24**	**36.24**	**0.00**	**0.00**	**36.29**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	3.44	43.01	20.86	0.10	3.12	1.56	4.69	0.10	1.44	1.54	0.00	9,740.92	9,740.92	0.15	0.00	9,744.03
Worker	2.66	3.02	28.18	0.06	6.28	0.23	6.51	0.11	0.22	0.32	0.00	5,045.81	5,045.81	0.28	0.00	5,051.69
Total	**6.10**	**46.03**	**49.04**	**0.16**	**9.40**	**1.79**	**11.20**	**0.21**	**1.66**	**1.86**	**0.00**	**14,786.73**	**14,786.73**	**0.43**	**0.00**	**14,795.72**

3.3 Building Construction - Interior Finishes - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.03	0.22	0.14	0.00		0.01	0.01		0.01	0.01	0.00	36.24	36.24	0.00	0.00	36.29
Total	**0.03**	**0.22**	**0.14**	**0.00**		**0.01**	**0.01**		**0.01**	**0.01**	**0.00**	**36.24**	**36.24**	**0.00**	**0.00**	**36.29**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	3.44	43.01	20.86	0.10	3.12	1.56	4.69	0.10	1.44	1.54	0.00	9,740.92	9,740.92	0.15	0.00	9,744.03
Worker	2.66	3.02	28.18	0.06	6.28	0.23	6.51	0.11	0.22	0.32	0.00	5,045.81	5,045.81	0.28	0.00	5,051.69
Total	**6.10**	**46.03**	**49.04**	**0.16**	**9.40**	**1.79**	**11.20**	**0.21**	**1.66**	**1.86**	**0.00**	**14,786.73**	**14,786.73**	**0.43**	**0.00**	**14,795.72**

3.4 Paving - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.02	0.11	0.08	0.00		0.01	0.01		0.01	0.01	0.00	15.03	15.03	0.00	0.00	15.06
Paving	0.00					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**0.02**	**0.11**	**0.08**	**0.00**		**0.01**	**0.01**		**0.01**	**0.01**	**0.00**	**15.03**	**15.03**	**0.00**	**0.00**	**15.06**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worker	0.13	0.15	1.43	0.00	0.32	0.01	0.33	0.01	0.01	0.02	0.00	255.50	255.50	0.01	0.00	255.80
Total	**0.13**	**0.15**	**1.43**	**0.00**	**0.32**	**0.01**	**0.33**	**0.01**	**0.01**	**0.02**	**0.00**	**255.50**	**255.50**	**0.01**	**0.00**	**255.80**

3.4 Paving - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.02	0.11	0.08	0.00		0.01	0.01		0.01	0.01	0.00	15.03	15.03	0.00	0.00	15.06
Paving	0.00					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**0.02**	**0.11**	**0.08**	**0.00**		**0.01**	**0.01**		**0.01**	**0.01**	**0.00**	**15.03**	**15.03**	**0.00**	**0.00**	**15.06**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worker	0.13	0.15	1.43	0.00	0.32	0.01	0.33	0.01	0.01	0.02	0.00	255.50	255.50	0.01	0.00	255.80
Total	**0.13**	**0.15**	**1.43**	**0.00**	**0.32**	**0.01**	**0.33**	**0.01**	**0.01**	**0.02**	**0.00**	**255.50**	**255.50**	**0.01**	**0.00**	**255.80**

4.0 Mobile Detail

4.1 Mitigation Measures Mobile

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Mitigated	1.34	2.52	11.76	0.02	2.24	0.11	2.36	0.04	0.10	0.14	0.00	1,939.17	1,939.17	0.08	0.00	1,940.95
Unmitigated	1.34	2.52	11.76	0.02	2.24	0.11	2.36	0.04	0.10	0.14	0.00	1,939.17	1,939.17	0.08	0.00	1,940.95
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

4.2 Trip Summary Information

	Average Daily Trip Rate			Unmitigated	Mitigated
Land Use	Weekday	Saturday	Sunday	Annual VMT	Annual VMT
Parking Lot	0.00	0.00	0.00		
Research & Development	2,433.00	570.00	333.00	4,678,806	4,678,806
Total	2,433.00	570.00	333.00	4,678,806	4,678,806

4.3 Trip Type Information

	Miles			Trip %		
Land Use	H-W or C-W	H-S or C-C	H-O or C-NW	H-W or C-W	H-S or C-C	H-O or C-NW
Parking Lot	9.50	7.30	7.30	0.00	0.00	0.00
Research & Development	9.50	7.30	7.30	33.00	48.00	19.00

5.0 Energy Detail

5.1 Mitigation Measures Energy

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Electricity Mitigated						0.00	0.00		0.00	0.00	0.00	721.75	721.75	0.03	0.01	726.27
Electricity Unmitigated						0.00	0.00		0.00	0.00	0.00	721.75	721.75	0.03	0.01	726.27
NaturalGas Mitigated	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	411.11	411.11	0.01	0.01	413.62
NaturalGas Unmitigated	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	411.11	411.11	0.01	0.01	413.62
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

5.2 Energy by Land Use - NaturalGas

Unmitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU	tons/yr										MT/yr					
Parking Lot	0	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Research & Development	7.704e+006	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	411.11	411.11	0.01	0.01	413.62
Total		**0.04**	**0.38**	**0.32**	**0.00**		**0.00**	**0.03**		**0.00**	**0.03**	**0.00**	**411.11**	**411.11**	**0.01**	**0.01**	**413.62**

Mitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU	tons/yr										MT/yr					
Parking Lot	0	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Research & Development	7.704e+006	0.04	0.38	0.32	0.00		0.00	0.03		0.00	0.03	0.00	411.11	411.11	0.01	0.01	413.62
Total		**0.04**	**0.38**	**0.32**	**0.00**		**0.00**	**0.03**		**0.00**	**0.03**	**0.00**	**411.11**	**411.11**	**0.01**	**0.01**	**413.62**

5.3 Energy by Land Use - Electricity

Unmitigated

	Electricity Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	kWh	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research & Development	2.481e+006					721.75	0.03	0.01	726.27
Total						**721.75**	**0.03**	**0.01**	**726.27**

Mitigated

	Electricity Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	kWh	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research & Development	2.481e+006					721.75	0.03	0.01	726.27
Total						**721.75**	**0.03**	**0.01**	**726.27**

6.0 Area Detail

6.1 Mitigation Measures Area

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Mitigated	2.13	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unmitigated	2.13	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

6.2 Area by SubCategory

Unmitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
SubCategory	tons/yr										MT/yr					
Architectural Coating	0.49					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumer Products	1.64					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landscaping	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**2.13**	**0.00**	**0.00**	**0.00**		**0.00**	**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

6.2 Area by SubCategory

Mitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
SubCategory	tons/yr										MT/yr					
Architectural Coating	0.49					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumer Products	1.64					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landscaping	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**2.13**	**0.00**	**0.00**	**0.00**		**0.00**	**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

7.0 Water Detail

7.1 Mitigation Measures Water

	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr				MT/yr			
Mitigated					233.85	4.51	0.12	364.48
Unmitigated					233.85	4.51	0.12	364.48
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

7.2 Water by Land Use

Unmitigated

	Indoor/Outdoor Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	Mgal	tons/yr				MT/yr			
Parking Lot	0 / 0					0.00	0.00	0.00	0.00
Research & Development	147.508 / 0					233.85	4.51	0.12	364.48
Total						**233.85**	**4.51**	**0.12**	**364.48**

7.2 Water by Land Use

Mitigated

	Indoor/Outdoor Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	Mgal	tons/yr				MT/yr			
Parking Lot	0 / 0					0.00	0.00	0.00	0.00
Research & Development	147.508 / 0					233.85	4.51	0.12	364.48
Total						**233.85**	**4.51**	**0.12**	**364.48**

8.0 Waste Detail

8.1 Mitigation Measures Waste

Category/Year

	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
	tons/yr				MT/yr			
Mitigated					4.63	0.27	0.00	10.37
Unmitigated					4.63	0.27	0.00	10.37
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

8.2 Waste by Land Use

Unmitigated

	Waste Disposed	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	tons	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research & Development	22.8					4.63	0.27	0.00	10.37
Total						**4.63**	**0.27**	**0.00**	**10.37**

Mitigated

	Waste Disposed	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	tons	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research & Development	22.8					4.63	0.27	0.00	10.37
Total						**4.63**	**0.27**	**0.00**	**10.37**

9.0 Vegetation

Appendix C

Emissions Estimates – Full LRDP Construction

Table C-1
CalEEMod Input Assumptions for LRDP Construction and Demolition Scenario

Construction Area	Dates		Total Number of Years	Project Total	(units)	Phase Amount	(units)	Truck Trips (trips/year)	Inventory Onroad Trip Length (miles/trip)	Modeling Onroad Trip Length (miles/trip)	Total Area Disturbed (acres)
Demolition											
Demolition (1)	1/1/2018	12/31/2050	32.00 (2)	643,001	gsf (3)	20,094	gsf (a)	125 (b)	Default (5)	0.6371 (6)	--
Construction											
Grading (soil import and export) (1)	1/1/2018	12/31/2050	32.00 (2)	502,400	yd^3 (c)	15,700	yd^3 (1)	1,570 (1)	Default (5)	0.6371 (6)	2.00 (8)
Building Construction (total) (1)	1/1/2018	12/31/2050	32.00 (2)	6,400,000	gsf (9)	200,000	gsf (a)	4,050 (1)	Default (5)	0.6371 (6)	--
Post Construction											
Paving (1)	1/1/2018	12/31/2050	32.00 (2)	--	--	--	--	Default (5)	Default (5)	0.6371 (6)	--

Notes:

(a) Phase amount (units) = (Project total [units]) / (total number of years per phase)

(b) Demolition truck trips (trips/yr) = (Average demolition truck trips [trips/yr]) / (average demolition activity [gsf]) x (phase amount [gsf])

Average demolition truck trips (trips/yr) = 117 (4)

Average demolition activity (gsf) = 18,750 (4)

(c) Project total (units) = (Phase amount [units]) x (total number of years per phase)

References:

(1) Demolition and construction general project information provided by LBNL.
(2) Construction and demolition schedules provided by LBNL. Construction occurs from the year 2018 to 2050.
(3) Total project demolition (750,000 gsf) minus Phase 1 demolition (106,999 gsf).
(4) Demolition trip informaiton provided by LBNL.
(5) CalEEMod default assumption. Onroad and off-road trips represent one-way trip lengths.
(6) Adjusted onroad trip length derived from entrance to RBC used for modeling purposes only.
(7) Assumes an additional 20% area disturbed above the average building footprint.
(8) Total area disturbed is based on the average square footage of the modeling footprint areas.
(9) Total building construction (7,000,000 gsf) minus Phase 1 building construction (600,000 gsf).

Table C-2
CalEEMod Input Assumptions for LRDP Construction and Demolition Offroad Equipment

Phase	Type of Equipment	Units	LBNL Daily Hours of Operation (hrs/phase)	Phase 1 LBNL Duration of Use (days/phase)	Phase 1 CalEEMod Phase Length (days/phase)	LRDP CalEEMod Phase Length (days/phase)	Phase 1 LBNL Phase Length (hrs/phase)	CalEEMod Daily Hours of Operation (hrs/day) [a]	Approximate Size of Equipment (hp)	Load Factor	CalEEMod Load Factor Used [1]
Demolition	Excavators	1	8	20	20	4 [b]	160	8	153	75	0.38
	Backhoe Loader	1	8	20	20	4 [b]	160	8	95	80	0.37
	Dozer	1	8	16	20	4 [b]	128	6.40	99	75	0.40
	Asphalt Cutter	1	4	10	20	4 [b]	40	2	6.5 [4]	65	0.73
	Water Truck	1	8	20	20	4 [b]	160	8	360	75	0.42
Site Grading - Excavation	Excavators	1	8	44	44	15 [c]	352	8	153	75	0.38
	Backhoe Loader	1	8	44	44	15 [c]	352	8	95	80	0.37
	Dozer	1	8	20	44	15 [c]	160	3.64	99	75	0.40
	Trenching Equipment	1	8	20	44	15 [c]	160	3.64	185	80	0.50
	Compaction Equipment	2	8	44	44	15 [c]	704	8	157	75	0.38
Building Construction - Foundations	Backhoe/Crawler Loaders	1	8	40	70	24 [c]	320	4.57	110	75	0.37
	Forklifts	2	4	65	70	24 [c]	520	4	110	75	0.20
	Concrete Pumps	1	8	20	70	24 [c]	160	2.29	307 [5]	80	0.74
	Compaction Equipment	2	8	20	70	24 [c]	320	2.29	14.0	80	0.43
	Small Tools	1	8	66	70	24 [c]	528	7.54	15 kW/month	85	--
	Air Compressors	1	2	70	70	24 [c]	140	2	60	70	0.48
Building Construction - Steel Erection	Mobile Crane	2	6	45	85	29 [c]	540	3.18	279	90	0.29
	Front End Welders	2	8	45	85	29 [c]	720	4	14	85	0.45
	Back End Welders	3	8	45	85	29 [c]	1080	4.2	14	85	0.45
	Man Lifts	1	8	45	85	29 [c]	360	4.24	80 kW/hr	80	--
	Boomlifts	1	4	85	85	29 [c]	340	4	82	80	0.40
	Forklifts	1	4	85	85	29 [c]	340	4	110	75	0.20
	Air Compressors	1	2	85	85	29 [c]	170	2	60.0	70	0.48
	Small Tools	1	8	85	85	29 [c]	680	8	15 kW/month	85	--
	Concrete Pumps	1	8	10	85	29 [c]	80	0.94	307 [5]	80	0.74
Building Construction - Exterior Enclosure	Mobile Crane	1	6	130	130	44 [c]	780	6	279	60	0.29
	Man Lifts	1	8	130	130	44 [c]	1040	8	80 kW/hr	80	--
	Boomlifts	1	2	130	130	44 [c]	260	2	82	75	0.40
	Forklifts	1	2	130	130	44 [c]	260	2	110.0	75	0.20
	Water Truck	1	2	130	130	44 [c]	260	2	360	80	0.42
	Small Tools	1	8	130	130	44 [c]	1040	8	15 kW/month	85	--
Building Construction - Interior Finishes	Boomlifts	1	2	140	140	47 [c]	280	2	82	75	0.40
	Forklifts	1	2	140	140	47 [c]	280	2	110	80	0.20
	Small Tools	1	8	140	140	47 [c]	1120	8	15 kW/month	85	--
	Water Truck	1	2	140	140	47 [c]	280	2	360.0	80	0.42
Paving - Site Improvements	Water Truck	1	2	45	45	15 [c]	90	2.0	360	75	0.42
	Asphalt Cutter	1	8	10	45	15 [c]	80	2	7	65	0.73
	Paving Equipment	1	8	10	45	15 [c]	80	1.78	142	65	0.36
	Forklifts	1	2	45	45	15 [c]	90	2.0	50.0	65	0.40
	Compactor	2	8	20	45	15 [c]	320	4	7	70	0.38
	Excavators	1	8	20	45	15 [c]	160	3.56	54	70	0.38
	Skid Steered Loader	1	6	20	45	15 [c]	120	3	50.0	80	0.37
	Small Tools	1	8	45	45	15 [c]	360	8	15 kW/month	85	--
	Trenching Equipment	1	4	20	45	15 [c]	80	1.78	6	80	0.50

Notes:

(a) CalEEMod daily hours of operation (hrs/day) = (Phase 1 LBNL phase length [hrs/phase]) / (Phase 1 CalEEMod phase length [days/phase]) / (units)

(b) LRDP demolition phase length (days/phase) = (LRDP demolition [gsf]) / (Phase 1 demolition [gsf]) x (Phase 1 CalEEMod phase length [days/phase])

LRDP demolition gross square footage (gsf) = 20,094 (2)

Phase 1 demolition gross square footage (gsf) = 106,999 (3)

(c) LRDP phase length (days/phase) = (LRDP total gross square footage [gsf]) / (Phase 1 total gross square footage [gsf]) x (Phase 1 CalEEMod phase length [days/phase])

LRDP total building construction (gsf) = 200,000 (2)

Phase 1 total building construction (gsf) = 600,000 (3)

References:

(1) Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Appendix D - OSM and Summary of Off-Road Emissions Inventory Update, California Air Resources Board, October 2010, http://www.arb.ca.gov/regact/2010/Off-Roadlsi10/Off-Roadappd.pdf.

(2) See Table C-1, CalEEMod Input Assumptions for LRDP Construction and Demolition Scenario.

(3) See Phase 1 Development input assumptions provided by LBNL.

(4) CalEEMod only allows load factor input as whole numbers. Thus, rounding to nearest whole number was used.

(5) Concrete pump horsepower provided by LBNL. Represents 65% usage of truck mounted pumps (450 hp) and 35% usage of the hydraulic pump (40 hp).

Table C-3

CalEEMod Assumptions for LRDP Construction and Demolition Onroad Vehicles

Source	Phase Operation [1] (days/phase)	Worker Trips (trips/day)	Vendor Trips (trips/day)	Total Hauling Trips (trips/yr)	Worker Trip Distance [2] (miles)	Vendor Trip Distance [2] (miles)	Hauling Trip Distance [2] (miles)
Onroad Vehicle Emissions							
Demolition	4	13 [2]	0 [2]	125 [3]	12.4	7.3	20
Site Grading - Excavation	15	15 [2]	0 [2]	1,570 [3]	12.4	7.3	20
Building Construction - Foundations	24	64 [2]	33 [2]	650 [3]	12.4	7.3	20
Building Construction - Steel Erection	29	64 [2]	33 [4]	3,400 [3]	12.4	7.3	20
Building Construction - Exterior Enclosure	44	64 [2]	33 [4]	0 [2]	12.4	7.3	20
Building Construction - Interior Finishes	47	64 [2]	33 [2]	0 [2]	12.4	7.3	20
Paving - Site Improvements	15	23 [2]	0 [2]	0 [2]	12.4	7.3	20

References:

(1) See Table C-2, CalEEMod Input Assumptions for LRDP Construction and Demolition Offroad Equipment .

(2) CalEEMod default vehicle trip assumption.

(3) Demolition and construction general project information provided by LBNL.

(4) CalEEMod default assumption set vendor trips for exterior enclosure and steel erection (building construction) to zero. Value is conservatively set to 33 vendor trips per day within CalEEMod model for consistency.

Table C-4
LRDP Construction and Demolition Maximum Daily Emission Estimates

Base Year	Phase		Pollutant (lbs/day) [1]															
			ROG	NOx	CO	SO_2	Fugitive PM_{10}	Exhaust PM_{10} [2]	PM_{10} Total	Fugitive $PM_{2.5}$	Exhaust $PM_{2.5}$	$PM_{2.5}$ Total	Bio- CO_2	NBio- CO_2	Total CO_2	CH_4	N_2O	CO_2e
	Off-Road Vehicle Emissions																	
2018	Demolition		1.39	9.39	8.60	2.0E-02	2.23 [3]	0.42	2.65	0 [3]	0.42	0.42	0	2,448	2,448	0.12	0	2,451
	Site Grading - Excavation		1.06	7.52	6.86	1.0E-02	1.34 [3]	0.37	1.71	0.68 [3]	0.37	1.05	0	1,351	1,351	9.0E-02	0	1,353
	Building Construction - Foundations		0.76	6.01	4.93	1.0E-02	0 [3]	0.29	0.29	0 [3]	0.29	0.29	0	1,215	1,215	7.0E-02	0	1,217
	Building Construction - Steel Erection		1.08	7.73	5.28	1.0E-02	0 [3]	0.37	0.37	0 [3]	0.37	0.37	0	1,413	1,413	1.0E-01	0	1,415
	Building Construction - Exterior Enclosure		0.70	4.97	3.01	1.0E-02	0 [3]	0.20	0.20	0 [3]	0.20	0.20	0	1,123	1,123	6.0E-02	0	1,125
	Building Construction - Interior Finishes		0.29	2.02	1.63	0	0 [3]	1.0E-01	1.0E-01	0 [3]	1.0E-01	1.0E-01	0	516	516	3.0E-02	0	516
	Paving - Site Improvements		0.56	3.74	3.26	1.0E-02	0 [3]	0.17	0.17	0 [3]	0.17	0.17	0	739	739	5.0E-02	0	740
Total Daily Off-Road Emissions			**5.84**	**41.4**	**33.6**	**7.0E-02**	**3.57**	**1.92**	**5.49**	**0.68**	**1.92**	**2.60**	**0**	**8,806**	**8,806**	**0.52**	**0**	**8,817**
	Onroad Vehicle Emissions																	
2018	Demolition	Hauling	0.99	9.99	6.45	2.0E-02	1.50 [a]	0.30	1.80	3.0E-02	0.28	0.31	0	2,588	2,588	5.0E-02	0	2,589
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	8.0E-02	7.0E-02	0.69	0	0.19	1.0E-02	0.20	0	1.0E-02	1.0E-02	0	146	146	1.0E-02	0	146
	Site Grading - Excavation	Hauling	3.31	33.5	21.6	8.0E-02	4.91 [a]	1.02	5.93	1.0E-01	0.93	1.03	0	8,668	8,668	0.16	0	8,671
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	9.0E-02	8.0E-02	0.80	0	0.22	1.0E-02	0.23	0	1.0E-02	1.0E-02	0	168	168	1.0E-02	0	169
	Building Construction - Foundations	Hauling	0.86	8.66	5.59	2.0E-02	1.27 [a]	0.26	1.53	3.0E-02	0.24	0.27	0	2,243	2,243	4.0E-02	0	2,244
		Vendor	0.35	3.47	2.82	1.0E-02	0.30	1.0E-01	0.40	1.0E-02	9.0E-02	1.0E-01	0	897	897	2.0E-02	0	897
		Worker	0.38	0.33	3.41	1.0E-02	0.96	3.0E-02	0.99	1.0E-02	3.0E-02	4.0E-02	0	719	719	3.0E-02	0	719
	Building Construction - Steel Erection	Hauling	3.70	37.5	24.2	9.0E-02	5.48 [a]	1.14	6.62	0.11	1.05	1.16	0	9,709	9,709	0.18	0	9,712
		Vendor	0.35	3.47	2.82	1.0E-02	0.30	1.0E-01	0.40	1.0E-02	9.0E-02	1.0E-01	0	897	897	2.0E-02	0	897
		Worker	0.38	0.33	3.41	1.0E-02	0.96	3.0E-02	0.99	1.0E-02	3.0E-02	4.0E-02	0	719	719	3.0E-02	0	719
	Building Construction - Exterior Enclosure	Hauling	0	0	0	0	0 [a]	0	0	0	0	0	0	0	0	0	0	0
		Vendor	0.35	3.47	2.82	1.0E-02	0.30	1.0E-01	0.40	1.0E-02	9.0E-02	1.0E-01	0	897	897	2.0E-02	0	897
		Worker	0.38	0.33	3.41	1.0E-02	0.96	3.0E-02	0.99	1.0E-02	3.0E-02	4.0E-02	0	719	719	3.0E-02	0	719
	Building Construction - Interior Finishes	Hauling	0	0	0	0	0 [a]	0	0	0	0	0	0	0	0	0	0	0
		Vendor	0.35	3.47	2.82	1.0E-02	0.30	1.0E-01	0.40	1.0E-02	9.0E-02	1.0E-01	0	897	897	2.0E-02	0	897
		Worker	0.38	0.33	3.41	1.0E-02	0.96	3.0E-02	0.99	1.0E-02	3.0E-02	4.0E-02	0	719	719	3.0E-02	0	719
	Paving - Site Improvements	Hauling	0	0	0	0	0 [a]	0	0	0	0	0	0	0	0	0	0	0
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	0.14	0.12	1.23	0	0.34	1.0E-02	0.35	0	1.0E-02	1.0E-02	0	258	258	1.0E-02	0	259
Total Daily Onroad Emissions			**12.1**	**105**	**85.5**	**0.29**	**18.9**	**3.27**	**22.2**	**0.35**	**3.01**	**3.36**	**0**	**30,242**	**30,242**	**0.66**	**0**	**30,256**

Notes:

(a) Onroad vehicle fugitive PM_{10} (lb/day) = (CalEEMod fugitive PM_{10} result [lb/day]) / (number of days per phase) x 2 (4)

Number of days for Demolition (days/phase) =	4	(5)
Number of days for Site Grading - Excavation (days/phase) =	15	(5)
Number of days for Building Construction - Foundations (days/phase) =	24	(5)
Number of days for Building Construction - Steel Erection (days/phase) =	29	(5)
Number of days for Building Construction - Exterior Enclosure (days/phase) =	44	(5)
Number of days for Building Construction - Interior Finishes (days/phase) =	47	(5)

References:

(1) Demolition and construction daily emissions obtained via CalEEMod results.
(2) Assumes 100% of exhaust PM_{10} equals diesel particulate matter (DPM).
(3) Off-road fugitive PM_{10} and $PM_{2.5}$ emissions include a control efficiency due to watering 2 times daily.
(4) Email correspondance and phone conversation with AQMD regarding CalEEMod offsite emission error on January 29th, 2013 resulting in correction equation.
(5) See Table C-2, CalEEMod Input Assumptions for LRDP Construction and Demolition Offroad Equipment .

Table C-5
LRDP Construction and Demolition Annual Emission Estimates

Base Year	Phase		Annual Emissions (tons/yr) [a]														
			ROG	NOx	CO	SO_2	Fugitive PM_{10}	Exhaust PM_{10} [3]	PM_{10} Total	Fugitive $PM_{2.5}$	Exhaust $PM_{2.5}$	$PM_{2.5}$ Total	Bio- CO_2	NBio- CO_2	Total CO_2	CH_4	N_2O	CO_2e
Off-Road Vehicle Emissions																		
2018	Demolition		2.8E-03	1.9E-02	1.7E-02	4.0E-05	4.5E-03 [4]	8.4E-04	5.3E-03	0 [4]	8.4E-04	8.4E-04	0	4.90	4.90	2.4E-04	0	4.90
	Site Grading - Excavation		8.0E-03	5.6E-02	5.1E-02	7.5E-05	1.0E-02 [4]	2.8E-03	1.3E-02	5.1E-03 [4]	2.8E-03	7.9E-03	0	10.1	10.1	6.8E-04	0	10.1
	Building Construction - Foundations		9.1E-03	7.2E-02	5.9E-02	1.2E-04	0 [4]	3.5E-03	3.5E-03	0 [4]	3.5E-03	3.5E-03	0	14.6	14.6	8.4E-04	0	14.6
	Building Construction - Steel Erection		1.6E-02	0.11	7.7E-02	1.5E-04	0 [4]	5.4E-03	5.4E-03	0 [4]	5.4E-03	5.4E-03	0	20.5	20.5	1.5E-03	0	20.5
	Building Construction - Exterior Enclosure		1.5E-02	0.11	6.6E-02	2.2E-04	0 [4]	4.4E-03	4.4E-03	0 [4]	4.4E-03	4.4E-03	0	24.7	24.7	1.3E-03	0	24.7
	Building Construction - Interior Finishes		6.8E-03	4.7E-02	3.8E-02	0	0 [4]	2.4E-03	2.4E-03	0 [4]	2.4E-03	2.4E-03	0	12.1	12.1	7.1E-04	0	12.1
	Paving - Site Improvements		4.2E-03	2.8E-02	2.4E-02	7.5E-05	0 [4]	1.3E-03	1.3E-03	0 [4]	1.3E-03	1.3E-03	0	5.54	5.54	3.8E-04	0	5.55
Total Annual Off-Road Emissions			**6.2E-02**	**0.44**	**0.33**	**6.8E-04**	**1.5E-02**	**2.0E-02**	**3.5E-02**	**5.1E-03**	**2.0E-02**	**2.6E-02**	**0**	**92.5**	**92.5**	**5.6E-03**	**0**	**92.6**
Onroad Vehicle Emissions																		
2018	Demolition	Hauling	2.0E-03	2.0E-02	1.3E-02	4.0E-05	3.0E-03	6.0E-04	3.6E-03	6.0E-05	5.6E-04	6.2E-04	0	5.18	5.18	1.0E-04	0	5.18
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	1.6E-04	1.4E-04	1.4E-03	0	3.8E-04	2.0E-05	4.0E-04	0	2.0E-05	2.0E-05	0	0.29	0.29	2.0E-05	0	0.29
	Site Grading - Excavation	Hauling	2.5E-02	0.25	0.16	6.0E-04	3.7E-02	7.7E-03	4.4E-02	7.5E-04	7.0E-03	7.7E-03	0	65.0	65.0	1.2E-03	0	65.0
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	6.8E-04	6.0E-04	6.0E-03	0	1.7E-03	7.5E-05	1.7E-03	0	7.5E-05	7.5E-05	0	1.26	1.26	7.5E-05	0	1.26
	Building Construction - Foundations	Hauling	1.0E-02	0.10	6.7E-02	2.4E-04	1.5E-02	3.1E-03	1.8E-02	3.6E-04	2.9E-03	3.2E-03	0	26.9	26.9	4.8E-04	0	26.9
		Vendor	4.2E-03	4.2E-02	3.4E-02	1.2E-04	3.6E-03	1.2E-03	4.8E-03	1.2E-04	1.1E-03	1.2E-03	0	10.8	10.8	2.4E-04	0	10.8
		Worker	4.6E-03	4.0E-03	4.1E-02	1.2E-04	1.2E-02	3.6E-04	1.2E-02	1.2E-04	3.6E-04	4.8E-04	0	8.62	8.62	3.6E-04	0	8.63
	Building Construction - Steel Erection	Hauling	5.4E-02	0.54	0.35	1.3E-03	7.9E-02	1.7E-02	9.6E-02	1.6E-03	1.5E-02	1.7E-02	0	141	141	2.6E-03	0	141
		Vendor	5.1E-03	5.0E-02	4.1E-02	1.5E-04	4.4E-03	1.5E-03	5.8E-03	1.5E-04	1.3E-03	1.5E-03	0	13.0	13.0	2.9E-04	0	13.0
		Worker	5.5E-03	4.8E-03	4.9E-02	1.5E-04	1.4E-02	4.4E-04	1.4E-02	1.5E-04	4.4E-04	5.8E-04	0	10.4	10.4	4.4E-04	0	10.4
	Building Construction - Exterior Enclosure	Hauling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Vendor	7.7E-03	7.6E-02	6.2E-02	2.2E-04	6.6E-03	2.2E-03	8.8E-03	2.2E-04	2.0E-03	2.2E-03	0	19.7	19.7	4.4E-04	0	19.7
		Worker	8.4E-03	7.3E-03	7.5E-02	2.2E-04	2.1E-02	6.6E-04	2.2E-02	2.2E-04	6.6E-04	8.8E-04	0	15.8	15.8	6.6E-04	0	15.8
	Building Construction - Interior Finishes	Hauling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Vendor	8.2E-03	8.2E-02	6.6E-02	2.4E-04	7.1E-03	2.4E-03	9.4E-03	2.4E-04	2.1E-03	2.4E-03	0	21.1	21.1	4.7E-04	0	21.1
		Worker	8.9E-03	7.8E-03	8.0E-02	2.4E-04	2.3E-02	7.1E-04	2.3E-02	2.4E-04	7.1E-04	9.4E-04	0	16.9	16.9	7.1E-04	0	16.9
	Paving - Site Improvements	Hauling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	1.1E-03	9.0E-04	9.2E-03	0	2.6E-03	7.5E-05	2.6E-03	0	7.5E-05	7.5E-05	0	1.94	1.94	7.5E-05	0	1.94
Total Annual Onroad Emissions			**0.15**	**1.19**	**1.06**	**3.6E-03**	**0.23**	**3.7E-02**	**0.27**	**4.2E-03**	**3.4E-02**	**3.9E-02**	**0**	**358**	**358**	**8.2E-03**	**0**	**358**

Notes:

(a) Annual emissions (tons/yr) = (Daily emissions [lbs/day]) x (number of days per phase) x (ton/2,000 lbs) (1)

Number of days for Demolition (days/phase) =	4	(2)
Number of days for Site Grading - Excavation (days/phase) =	15	(2)
Number of days for Building Construction - Foundations (days/phase) =	24	(2)
Number of days for Building Construction - Steel Erection (days/phase) =	29	(2)
Number of days for Building Construction - Exterior Enclosure (days/phase) =	44	(2)
Number of days for Building Construction - Interior Finishes (days/phase) =	47	(2)
Number of days for Paving - Site Improvements (days/phase) =	15	(2)

References:

(1) Email correspondance and phone conversation with AQMD regarding CalEEMod offsite emission error on January 29th, 2013 resulting in correction equation.
(2) See Table C-2, CalEEMod Input Assumptions for LRDP Construction and Demolition Offroad Equipment .
(3) Assumes 100% of Exhaust PM_{10} equals Diesel Particulate Matter (DPM).
(4) Off-road fugitive PM_{10} and $PM_{2.5}$ emissions include a 55% control efficiency due to watering.

Table C-6
LRDP Construction and Demolition Annual Emission Estimates For Residential Hazard Modeling

Base Year	Phase		Annual Emissions (tons/yr)															
			ROG	NOx	CO	SO_2	Fugitive PM_{10}	Exhaust PM_{10} (1)	PM_{10} Total	Fugitive $PM_{2.5}$	Exhaust $PM_{2.5}$	$PM_{2.5}$ Total	Bio- CO_2	NBio- CO_2	Total CO_2	CH_4	N_2O	CO_2e
Onroad Vehicle Emissions (a)																		
2018	Demolition	Hauling	3.1E-05	3.1E-04	2.0E-04	6.2E-07	4.7E-05	9.4E-06	5.6E-05	9.4E-07	8.7E-06	9.7E-06	0	8.1E-02	8.1E-02	1.6E-06	0	8.1E-02
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	4.0E-06	3.5E-06	3.5E-05	0	9.6E-06	5.0E-07	1.0E-05	0	5.0E-07	5.0E-07	0	7.3E-03	7.3E-03	5.0E-07	0	7.3E-03
	Site Grading - Excavation	Hauling	3.9E-04	3.9E-03	2.5E-03	9.4E-06	5.7E-04	1.2E-04	6.9E-04	1.2E-05	1.1E-04	1.2E-04	0	1.01	1.01	1.9E-05	0	1.01
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	1.7E-05	1.5E-05	1.5E-04	0	4.1E-05	1.9E-06	4.3E-05	0	1.9E-06	1.9E-06	0	3.2E-02	3.2E-02	1.9E-06	0	3.2E-02
	Building Construction - Foundations	Hauling	1.6E-04	1.6E-03	1.0E-03	3.7E-06	2.4E-04	4.9E-05	2.9E-04	5.6E-06	4.5E-05	5.1E-05	0	0.42	0.42	7.5E-06	0	0.42
		Vendor	1.8E-04	1.8E-03	1.4E-03	5.1E-06	1.5E-04	5.1E-05	2.1E-04	5.1E-06	4.6E-05	5.1E-05	0	0.46	0.46	1.0E-05	0	0.46
		Worker	1.1E-04	1.0E-04	1.0E-03	3.0E-06	2.9E-04	9.1E-06	3.0E-04	3.0E-06	9.1E-06	1.2E-05	0	0.22	0.22	9.1E-06	0	0.22
	Building Construction - Steel Erection	Hauling	8.4E-04	8.5E-03	5.5E-03	2.0E-05	1.2E-03	2.6E-04	1.5E-03	2.5E-05	2.4E-04	2.6E-04	0	2.19	2.19	4.1E-05	0	2.20
		Vendor	2.2E-04	2.1E-03	1.7E-03	6.2E-06	1.9E-04	6.2E-05	2.5E-04	6.2E-06	5.6E-05	6.2E-05	0	0.56	0.56	1.2E-05	0	0.56
		Worker	1.4E-04	1.2E-04	1.2E-03	3.6E-06	3.5E-04	1.1E-05	3.6E-04	3.6E-06	1.1E-05	1.5E-05	0	0.26	0.26	1.1E-05	0	0.26
	Building Construction - Exterior Enclosure	Hauling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Vendor	3.3E-04	3.3E-03	2.7E-03	9.4E-06	2.8E-04	9.4E-05	3.8E-04	9.4E-06	8.5E-05	9.4E-05	0	0.84	0.84	1.9E-05	0	0.84
		Worker	2.1E-04	1.8E-04	1.9E-03	5.5E-06	5.3E-04	1.7E-05	5.5E-04	5.5E-06	1.7E-05	2.2E-05	0	0.40	0.40	1.7E-05	0	0.40
	Building Construction - Interior Finishes	Hauling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Vendor	3.5E-04	3.5E-03	2.8E-03	1.0E-05	3.0E-04	1.0E-04	4.0E-04	1.0E-05	9.0E-05	1.0E-04	0	0.90	0.90	2.0E-05	0	0.90
		Worker	2.2E-04	2.0E-04	2.0E-03	5.9E-06	5.7E-04	1.8E-05	5.9E-04	5.9E-06	1.8E-05	2.4E-05	0	0.42	0.42	1.8E-05	0	0.43
	Paving - Site Improvements	Hauling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	2.6E-05	2.3E-05	2.3E-04	0	6.4E-05	1.9E-06	6.6E-05	0	1.9E-06	1.9E-06	0	4.9E-02	4.9E-02	1.9E-06	0	4.9E-02
Total Annual Onroad Emissions			**3.2E-03**	**2.6E-02**	**2.5E-02**	**8.3E-05**	**4.9E-03**	**8.0E-04**	**5.7E-03**	**9.2E-05**	**7.4E-04**	**8.3E-04**	**0**	**7.86**	**7.86**	**1.9E-04**	**0**	**7.86**

Notes:

(a) Annual emissions (tons/yr) = (Daily emissions [lbs/day]) x (number of days per phase) x (ton/2,000 lbs) x (modeling road length [mi]) / (hauling, vendor, or worker CalEEMod default road length [mi]) (2)

Number of days for Demolition (days/phase) =	4	(3)
Number of days for Site Grading - Excavation (days/phase) =	15	(3)
Number of days for Building Construction - Foundations (days/phase) =	24	(3)
Number of days for Building Construction - Steel Erection (days/phase) =	29	(3)
Number of days for Building Construction - Exterior Enclosure (days/phase) =	44	(3)
Number of days for Building Construction - Interior Finishes (days/phase) =	47	(3)
Number of days for Paving - Site Improvements (days/phase) =	15	(3)
Residential modeling road length (mi) =	0.31	(4)
Hauling road length (mi) =	20	(5)
Vendor road length (mi) =	7.3	(5)
Worker road length (mi) =	12.4	(5)

References:

(1) Assumes 100% of Exhaust PM_{10} equals Diesel Particulate Matter (DPM).
(2) Email correspondance and phone conversation with AQMD regarding CalEEMod offsite emission error on January 29th, 2013 resulting in correction equation.
(3) See Table C-2, CalEEMod Input Assumptions for LRDP Construction and Demolition Offroad Equipment .
(4) Engineering judgement based on an analysis of road length data provided by LBNL.
(5) See Table C-3, CalEEMod Assumptions for LRDP Construction and Demolition Onroad Vehicles.

Table C-7
LRDP Construction and Demolition Annual Emission Estimates For Worker Hazard Modeling

Base Year	Phase		Annual Emissions (tons/yr)														
			ROG	NOx	CO	SO_2	Fugitive PM_{10}	Exhaust PM_{10} (1)	PM_{10} Total	Fugitive $PM_{2.5}$	Exhaust $PM_{2.5}$	$PM_{2.5}$ Total	Bio- CO_2	NBio- CO_2	Total CO_2	CH_4	N_2O	CO_2e
Onroad Vehicle Emissions (a)																	
2018	Demolition	Hauling	5.0E-05	5.1E-04	3.3E-04	1.0E-06	7.6E-05	1.5E-05	9.2E-05	1.5E-06	1.4E-05	1.6E-05	0	0.13	0.13	2.5E-06	0	0.13
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	6.6E-06	5.8E-06	5.7E-05	0	1.6E-05	8.2E-07	1.6E-05	0	8.2E-07	8.2E-07	0	1.2E-02	1.2E-02	8.2E-07	0	1.2E-02
	Site Grading - Excavation	Hauling	6.3E-04	6.4E-03	4.1E-03	1.5E-05	9.4E-04	1.9E-04	1.1E-03	1.9E-05	1.8E-04	2.0E-04	0	1.66	1.66	3.1E-05	0	1.66
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	2.8E-05	2.5E-05	2.5E-04	0	6.8E-05	3.1E-06	7.1E-05	0	3.1E-06	3.1E-06	0	5.2E-02	5.2E-02	3.1E-06	0	5.2E-02
	Building Construction - Foundations	Hauling	2.6E-04	2.6E-03	1.7E-03	6.1E-06	3.9E-04	7.9E-05	4.7E-04	9.2E-06	7.3E-05	8.3E-05	0	0.69	0.69	1.2E-05	0	0.69
		Vendor	2.9E-04	2.9E-03	2.4E-03	8.4E-06	2.5E-04	8.4E-05	3.4E-04	8.4E-06	7.5E-05	8.4E-05	0	0.75	0.75	1.7E-05	0	0.75
		Worker	1.9E-04	1.6E-04	1.7E-03	4.9E-06	4.7E-04	1.5E-05	4.9E-04	4.9E-06	1.5E-05	2.0E-05	0	0.35	0.35	1.5E-05	0	0.35
	Building Construction - Steel Erection	Hauling	1.4E-03	1.4E-02	8.9E-03	3.3E-05	2.0E-03	4.2E-04	2.4E-03	4.1E-05	3.9E-04	4.3E-04	0	3.59	3.59	6.6E-05	0	3.59
		Vendor	3.5E-04	3.5E-03	2.9E-03	1.0E-05	3.0E-04	1.0E-04	4.0E-04	1.0E-05	9.1E-05	1.0E-04	0	0.91	0.91	2.0E-05	0	0.91
		Worker	2.3E-04	2.0E-04	2.0E-03	6.0E-06	5.7E-04	1.8E-05	5.9E-04	6.0E-06	1.8E-05	2.4E-05	0	0.43	0.43	1.8E-05	0	0.43
	Building Construction - Exterior Enclosure	Hauling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Vendor	5.4E-04	5.3E-03	4.3E-03	1.5E-05	4.6E-04	1.5E-04	6.1E-04	1.5E-05	1.4E-04	1.5E-04	0	1.38	1.38	3.1E-05	0	1.38
		Worker	3.4E-04	3.0E-04	3.1E-03	9.0E-06	8.7E-04	2.7E-05	8.9E-04	9.0E-06	2.7E-05	3.6E-05	0	0.65	0.65	2.7E-05	0	0.65
	Building Construction - Interior Finishes	Hauling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Vendor	5.7E-04	5.7E-03	4.6E-03	1.6E-05	4.9E-04	1.6E-04	6.6E-04	1.6E-05	1.5E-04	1.6E-04	0	1.47	1.47	3.3E-05	0	1.47
		Worker	3.7E-04	3.2E-04	3.3E-03	9.7E-06	9.3E-04	2.9E-05	9.6E-04	9.7E-06	2.9E-05	3.9E-05	0	0.69	0.69	2.9E-05	0	0.69
	Paving - Site Improvements	Hauling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	4.3E-05	3.7E-05	3.8E-04	0	1.0E-04	3.1E-06	1.1E-04	0	3.1E-06	3.1E-06	0	8.0E-02	8.0E-02	3.1E-06	0	8.0E-02
Total Annual Onroad Emissions			**5.3E-03**	**4.2E-02**	**4.0E-02**	**1.4E-04**	**8.0E-03**	**1.3E-03**	**9.3E-03**	**1.5E-04**	**1.2E-03**	**1.4E-03**	**0**	**12.8**	**12.8**	**3.1E-04**	**0**	**12.8**

Notes:

(a) Annual emissions (tons/yr) = (Daily emissions [lbs/day]) x (number of days per phase) x (ton/2,000 lbs) x (modeling road length [mi]) / (Hauling, Vendor, or Worker CalEEMod default road length [mi]) (2)

Number of days for Demolition (days/phase) =	4	(3)
Number of days for Site Grading - Excavation (days/phase) =	15	(3)
Number of days for Building Construction - Foundations (days/phase) =	24	(3)
Number of days for Building Construction - Steel Erection (days/phase) =	29	(3)
Number of days for Building Construction - Exterior Enclosure (days/phase) =	44	(3)
Number of days for Building Construction - Interior Finishes (days/phase) =	47	(3)
Number of days for Paving - Site Improvements (days/phase) =	15	(3)
Worker modeling road length (mi) =	0.51	(4)
Hauling road length (mi) =	20	(5)
Vendor road length (mi) =	7.3	(5)
Worker road length (mi) =	12.4	(5)

References:

(1) Assumes 100% of Exhaust PM_{10} equals Diesel Particulate Matter (DPM).
(2) Email correspondance and phone conversation with AQMD regarding CalEEMod offsite emission error on January 29th, 2013 resulting in correction equation.
(3) See Table C-2, CalEEMod Input Assumptions for LRDP Construction and Demolition Offroad Equipment .
(4) Engineering judgement based on an analysis of road length data provided by LBNL.
(5) See Table C-3, CalEEMod Assumptions for LRDP Construction and Demolition Onroad Vehicles.

Table C-8
LRDP Construction and Demolition Annual Emission Estimates For Cancer Risk Modeling

Base Year	Phase		Annual Emissions (tons/yr)															
			ROG	NOx	CO	SO_2	Fugitive PM_{10}	Exhaust PM_{10} (1)	PM_{10} Total	Fugitive $PM_{2.5}$	Exhaust $PM_{2.5}$	$PM_{2.5}$ Total	Bio- CO_2	NBio- CO_2	Total CO_2	CH_4	N_2O	CO_2e
Onroad Vehicle Emissions (a)																		
2018	Demolition	Hauling	7.2E-05	7.3E-04	4.7E-04	1.5E-06	1.1E-04	2.2E-05	1.3E-04	2.2E-06	2.0E-05	2.3E-05	0	0.19	0.19	3.6E-06	0	0.19
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	9.4E-06	8.2E-06	8.1E-05	0	2.2E-05	1.2E-06	2.4E-05	0	1.2E-06	1.2E-06	0	1.7E-02	1.7E-02	1.2E-06	0	1.7E-02
	Site Grading - Excavation	Hauling	9.1E-04	9.1E-03	5.9E-03	2.2E-05	1.3E-03	2.8E-04	1.6E-03	2.7E-05	2.5E-04	2.8E-04	0	2.37	2.37	4.4E-05	0	2.37
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	4.0E-05	3.5E-05	3.5E-04	0	9.7E-05	4.4E-06	1.0E-04	0	4.4E-06	4.4E-06	0	7.4E-02	7.4E-02	4.4E-06	0	7.4E-02
	Building Construction - Foundations	Hauling	3.8E-04	3.8E-03	2.4E-03	8.8E-06	5.5E-04	1.1E-04	6.7E-04	1.3E-05	1.1E-04	1.2E-04	0	0.98	0.98	1.8E-05	0	0.98
		Vendor	4.2E-04	4.2E-03	3.4E-03	1.2E-05	3.6E-04	1.2E-04	4.8E-04	1.2E-05	1.1E-04	1.2E-04	0	1.08	1.08	2.4E-05	0	1.08
		Worker	2.7E-04	2.3E-04	2.4E-03	7.1E-06	6.8E-04	2.1E-05	7.0E-04	7.1E-06	2.1E-05	2.8E-05	0	0.51	0.51	2.1E-05	0	0.51
	Building Construction - Steel Erection	Hauling	2.0E-03	2.0E-02	1.3E-02	4.8E-05	2.9E-03	6.0E-04	3.5E-03	5.8E-05	5.6E-04	6.1E-04	0	5.13	5.13	9.5E-05	0	5.13
		Vendor	5.1E-04	5.0E-03	4.1E-03	1.4E-05	4.3E-04	1.4E-04	5.8E-04	1.4E-05	1.3E-04	1.4E-04	0	1.30	1.30	2.9E-05	0	1.30
		Worker	3.2E-04	2.8E-04	2.9E-03	8.5E-06	8.2E-04	2.6E-05	8.4E-04	8.5E-06	2.6E-05	3.4E-05	0	0.61	0.61	2.6E-05	0	0.61
	Building Construction - Exterior Enclosure	Hauling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Vendor	7.7E-04	7.6E-03	6.2E-03	2.2E-05	6.6E-04	2.2E-04	8.8E-04	2.2E-05	2.0E-04	2.2E-04	0	1.97	1.97	4.4E-05	0	1.97
		Worker	4.9E-04	4.3E-04	4.4E-03	1.3E-05	1.2E-03	3.9E-05	1.3E-03	1.3E-05	3.9E-05	5.2E-05	0	0.93	0.93	3.9E-05	0	0.93
	Building Construction - Interior Finishes	Hauling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Vendor	8.2E-04	8.1E-03	6.6E-03	2.3E-05	7.0E-04	2.3E-04	9.4E-04	2.3E-05	2.1E-04	2.3E-04	0	2.11	2.11	4.7E-05	0	2.11
		Worker	5.3E-04	4.6E-04	4.7E-03	1.4E-05	1.3E-03	4.1E-05	1.4E-03	1.4E-05	4.1E-05	5.5E-05	0	0.99	0.99	4.1E-05	0	0.99
	Paving - Site Improvements	Hauling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Vendor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Worker	6.2E-05	5.3E-05	5.4E-04	0	1.5E-04	4.4E-06	1.5E-04	0	4.4E-06	4.4E-06	0	0.11	0.11	4.4E-06	0	0.11
Total Annual Onroad Emissions			**7.5E-03**	**6.0E-02**	**5.7E-02**	**1.9E-04**	**1.1E-02**	**1.9E-03**	**1.3E-02**	**2.2E-04**	**1.7E-03**	**1.9E-03**	**0**	**18.4**	**18.4**	**4.4E-04**	**0**	**18.4**

Notes:

(a) Annual emissions (tons/yr) = (Daily emissions [lbs/day]) x (number of days per phase) x (ton/2,000 lbs) x (modeling road length [mi]) / (Hauling, Vendor, or Worker CalEEMod default road length [mi]) (2)

Number of days for Demolition (days/phase) =	4	(3)
Number of days for Site Grading - Excavation (days/phase) =	15	(3)
Number of days for Building Construction - Foundations (days/phase) =	24	(3)
Number of days for Building Construction - Steel Erection (days/phase) =	29	(3)
Number of days for Building Construction - Exterior Enclosure (days/phase) =	44	(3)
Number of days for Building Construction - Interior Finishes (days/phase) =	47	(3)
Number of days for Paving - Site Improvements (days/phase) =	15	(3)
Cancer risk modeling road length (mi) =	0.73	(4)
Hauling road length (mi) =	20	(5)
Vendor road length (mi) =	7.3	(5)
Worker road length (mi) =	12.4	(5)

References:

(1) Assumes 100% of Exhaust PM_{10} equals Diesel Particulate Matter (DPM).
(2) Email correspondance and phone conversation with AQMD regarding CalEEMod offsite emission error on January 29th, 2013 resulting in correction equation.
(3) See Table C-2, CalEEMod Input Assumptions for LRDP Construction and Demolition Offroad Equipment .
(4) Engineering judgement based on an analysis of road length data provided by LBNL.
(5) See Table C-3, CalEEMod Assumptions for LRDP Construction and Demolition Onroad Vehicles.

Table C-9
LRDP Construction and Demolition Criteria Pollutant Emissions Summary

Source	Annual Operation (days/yr)	ROG		NO_X		CO		SO_2		Fugitive PM_{10}		Exhaust PM_{10} (1)		PM_{10} Total		Fugitive $PM_{2.5}$		Exhaust $PM_{2.5}$		$PM_{2.5}$ Total	
		(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)
2018 Off-Road Equipment Emissions																					
Demolition	260	2.1E-02	2.8E-03	0.14	1.9E-02	0.13	1.7E-02	3.1E-04	4.0E-05	3.4E-02	4.5E-03	6.5E-03	8.4E-04	4.1E-02	5.3E-03	0	0	6.5E-03	8.4E-04	6.5E-03	8.4E-04
Site Grading - Excavation	260	6.1E-02	8.0E-03	0.43	5.6E-02	0.40	5.1E-02	5.8E-04	7.5E-05	7.7E-02	1.0E-02	2.1E-02	2.8E-03	9.9E-02	1.3E-02	3.9E-02	5.1E-03	2.1E-02	2.8E-03	6.1E-02	7.9E-03
Building Construction - Foundations	260	7.0E-02	9.1E-03	0.55	7.2E-02	0.46	5.9E-02	9.2E-04	1.2E-04	0	0	2.7E-02	3.5E-03	2.7E-02	3.5E-03	0	0	2.7E-02	3.5E-03	2.7E-02	3.5E-03
Building Construction - Steel Erection	260	0.12	1.6E-02	0.86	0.11	0.59	7.7E-02	1.1E-03	1.5E-04	0	0	4.1E-02	5.4E-03	4.1E-02	5.4E-03	0	0	4.1E-02	5.4E-03	4.1E-02	5.4E-03
Building Construction - Exterior Enclosure	260	0.12	1.5E-02	0.84	0.11	0.51	6.6E-02	1.7E-03	2.2E-04	0	0	3.4E-02	4.4E-03	3.4E-02	4.4E-03	0	0	3.4E-02	4.4E-03	3.4E-02	4.4E-03
Building Construction - Interior Finishes	260	5.2E-02	6.8E-03	0.37	4.7E-02	0.29	3.8E-02	0	0	0	0	1.8E-02	2.4E-03	1.8E-02	2.4E-03	0	0	1.8E-02	2.4E-03	1.8E-02	2.4E-03
Paving - Site Improvements	260	3.2E-02	4.2E-03	0.22	2.8E-02	0.19	2.4E-02	5.8E-04	7.5E-05	0	0	9.8E-03	1.3E-03	9.8E-03	1.3E-03	0	0	9.8E-03	1.3E-03	9.8E-03	1.3E-03
Total 2018 Off-Road Emissions		**0.48**	**5.8E-02**	**3.42**	**0.42**	**2.56**	**0.31**	**5.2E-03**	**6.0E-04**	**0.11**	**1.5E-02**	**0.16**	**1.9E-02**	**0.27**	**3.4E-02**	**3.9E-02**	**5.1E-03**	**0.16**	**1.9E-02**	**0.20**	**2.4E-02**
2018 Onroad Vehicle Emissions																					
Total Demolition		**1.6E-02**	**2.1E-03**	**0.15**	**2.0E-02**	**0.11**	**1.4E-02**	**3.1E-04**	**4.0E-05**	**2.6E-02**	**3.4E-03**	**4.8E-03**	**6.2E-04**	**3.1E-02**	**4.0E-03**	**4.6E-04**	**6.0E-05**	**4.5E-03**	**5.8E-04**	**4.9E-03**	**6.4E-04**
Hauling Vehicle Onroad Emissions	260	1.5E-02	2.0E-03	0.15	2.0E-02	9.9E-02	1.3E-02	3.1E-04	4.0E-05	2.3E-02	3.0E-03	4.6E-03	6.0E-04	2.8E-02	3.6E-03	4.6E-04	6.0E-05	4.3E-03	5.6E-04	4.8E-03	6.2E-04
Vendor Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Worker Vehicle Onroad Emissions	260	1.2E-03	1.6E-04	1.1E-03	1.4E-04	1.1E-02	1.4E-03	0	0	2.9E-03	3.8E-04	1.5E-04	2.0E-05	3.1E-03	4.0E-04	0	0	1.5E-04	2.0E-05	1.5E-04	2.0E-05
Total Site Grading - Excavation		**0.20**	**2.6E-02**	**1.94**	**0.25**	**1.29**	**0.17**	**4.6E-03**	**6.0E-04**	**0.30**	**3.8E-02**	**5.9E-02**	**7.7E-03**	**0.36**	**4.6E-02**	**5.8E-03**	**7.5E-04**	**5.4E-02**	**7.1E-03**	**6.0E-02**	**7.8E-03**
Hauling Vehicle Onroad Emissions	260	0.19	2.5E-02	1.93	0.25	1.25	0.16	4.6E-03	6.0E-04	0.28	3.7E-02	5.9E-02	7.7E-03	0.34	4.4E-02	5.8E-03	7.5E-04	5.4E-02	7.0E-03	5.9E-02	7.7E-03
Vendor Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Worker Vehicle Onroad Emissions	260	5.2E-03	6.8E-04	4.6E-03	6.0E-04	4.6E-02	6.0E-03	0	0	1.3E-02	1.7E-03	5.8E-04	7.5E-05	1.3E-02	1.7E-03	0	0	5.8E-04	7.5E-05	5.8E-04	7.5E-05
Total Building Construction - Foundations		**0.15**	**1.9E-02**	**1.15**	**0.15**	**1.09**	**0.14**	**3.7E-03**	**4.8E-04**	**0.23**	**3.0E-02**	**3.6E-02**	**4.7E-03**	**0.27**	**3.5E-02**	**4.6E-03**	**6.0E-04**	**3.3E-02**	**4.3E-03**	**3.8E-02**	**4.9E-03**
Hauling Vehicle Onroad Emissions	260	7.9E-02	1.0E-02	0.80	0.10	0.52	6.7E-02	1.8E-03	2.4E-04	0.12	1.5E-02	2.4E-02	3.1E-03	0.14	1.8E-02	2.8E-03	3.6E-04	2.2E-02	2.9E-03	2.5E-02	3.2E-03
Vendor Vehicle Onroad Emissions	260	3.2E-02	4.2E-03	0.32	4.2E-02	0.26	3.4E-02	9.2E-04	1.2E-04	2.8E-02	3.6E-03	9.2E-03	1.2E-03	3.7E-02	4.8E-03	9.2E-04	1.2E-04	8.3E-03	1.1E-03	9.2E-03	1.2E-03
Worker Vehicle Onroad Emissions	260	3.5E-02	4.6E-03	3.0E-02	4.0E-03	0.31	4.1E-02	9.2E-04	1.2E-04	8.9E-02	1.2E-02	2.8E-03	3.6E-04	9.1E-02	1.2E-02	9.2E-04	1.2E-04	2.8E-03	3.6E-04	3.7E-03	4.8E-04
Total Building Construction - Steel Erection		**0.49**	**6.4E-02**	**4.60**	**0.60**	**3.40**	**0.44**	**1.2E-02**	**1.6E-03**	**0.75**	**9.8E-02**	**0.14**	**1.8E-02**	**0.89**	**0.12**	**1.5E-02**	**1.9E-03**	**0.13**	**1.7E-02**	**0.15**	**1.9E-02**
Hauling Vehicle Onroad Emissions	260	0.41	5.4E-02	4.18	0.54	2.70	0.35	1.0E-02	1.3E-03	0.61	7.9E-02	0.13	1.7E-02	0.74	9.6E-02	1.2E-02	1.6E-03	0.12	1.5E-02	0.13	1.7E-02
Vendor Vehicle Onroad Emissions	260	3.9E-02	5.1E-03	0.39	5.0E-02	0.31	4.1E-02	1.1E-03	1.5E-04	3.3E-02	4.4E-03	1.1E-02	1.5E-03	4.5E-02	5.8E-03	1.1E-03	1.5E-04	1.0E-02	1.3E-03	1.1E-02	1.5E-03
Worker Vehicle Onroad Emissions	260	4.2E-02	5.5E-03	3.7E-02	4.8E-03	0.38	4.9E-02	1.1E-03	1.5E-04	0.11	1.4E-02	3.3E-03	4.4E-04	0.11	1.4E-02	1.1E-03	1.5E-04	3.3E-03	4.4E-04	4.5E-03	5.8E-04
Total Building Construction - Exterior Enclosure		**0.12**	**1.6E-02**	**0.64**	**8.4E-02**	**1.05**	**0.14**	**3.4E-03**	**4.4E-04**	**0.21**	**2.8E-02**	**2.2E-02**	**2.9E-03**	**0.24**	**3.1E-02**	**3.4E-03**	**4.4E-04**	**2.0E-02**	**2.6E-03**	**2.4E-02**	**3.1E-03**
Hauling Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vendor Vehicle Onroad Emissions	260	5.9E-02	7.7E-03	0.59	7.6E-02	0.48	6.2E-02	1.7E-03	2.2E-04	5.1E-02	6.6E-03	1.7E-02	2.2E-03	6.8E-02	8.8E-03	1.7E-03	2.2E-04	1.5E-02	2.0E-03	1.7E-02	2.2E-03
Worker Vehicle Onroad Emissions	260	6.4E-02	8.4E-03	5.6E-02	7.3E-03	0.58	7.5E-02	1.7E-03	2.2E-04	0.16	2.1E-02	5.1E-03	6.6E-04	0.17	2.2E-02	1.7E-03	2.2E-04	5.1E-03	6.6E-04	6.8E-03	8.8E-04
Total Building Construction - Interior Finishes		**0.13**	**1.7E-02**	**0.69**	**8.9E-02**	**1.13**	**0.15**	**3.6E-03**	**4.7E-04**	**0.23**	**3.0E-02**	**2.4E-02**	**3.1E-03**	**0.25**	**3.3E-02**	**3.6E-03**	**4.7E-04**	**2.2E-02**	**2.8E-03**	**2.5E-02**	**3.3E-03**
Hauling Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vendor Vehicle Onroad Emissions	260	6.3E-02	8.2E-03	0.63	8.2E-02	0.51	6.6E-02	1.8E-03	2.4E-04	5.4E-02	7.1E-03	1.8E-02	2.4E-03	7.2E-02	9.4E-03	1.8E-03	2.4E-04	1.6E-02	2.1E-03	1.8E-02	2.4E-03
Worker Vehicle Onroad Emissions	260	6.9E-02	8.9E-03	6.0E-02	7.8E-03	0.62	8.0E-02	1.8E-03	2.4E-04	0.17	2.3E-02	5.4E-03	7.1E-04	0.18	2.3E-02	1.8E-03	2.4E-04	5.4E-03	7.1E-04	7.2E-03	9.4E-04
Total Paving - Site Improvements		**8.1E-03**	**1.1E-03**	**6.9E-03**	**9.0E-04**	**7.1E-02**	**9.2E-03**	**0**	**0**	**2.0E-02**	**2.6E-03**	**5.8E-04**	**7.5E-05**	**2.0E-02**	**2.6E-03**	**0**	**0**	**5.8E-04**	**7.5E-05**	**5.8E-04**	**7.5E-05**
Hauling Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vendor Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Worker Vehicle Onroad Emissions	260	8.1E-03	1.1E-03	6.9E-03	9.0E-04	7.1E-02	9.2E-03	0	0	2.0E-02	2.6E-03	5.8E-04	7.5E-05	2.0E-02	2.6E-03	0	0	5.8E-04	7.5E-05	5.8E-04	7.5E-05
Total 2018 Onroad Emissions	**--**	**1.12**	**0.15**	**9.18**	**1.19**	**8.14**	**1.06**	**2.8E-02**	**3.6E-03**	**1.77**	**0.23**	**0.29**	**3.7E-02**	**2.06**	**0.27**	**3.2E-02**	**4.2E-03**	**0.27**	**3.4E-02**	**0.30**	**3.9E-02**
Total 2018 Project Emissions	**--**	**1.59**	**0.20**	**12.6**	**1.61**	**10.7**	**1.37**	**3.3E-02**	**4.2E-03**	**1.88**	**0.24**	**0.45**	**5.7E-02**	**2.32**	**0.30**	**7.2E-02**	**9.3E-03**	**0.42**	**5.4E-02**	**0.49**	**6.3E-02**
Onsite Stationary Exhaust	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**
Onsite Mobile Exhaust	**--**	**0.48**	**5.8E-02**	**3.42**	**0.42**	**2.56**	**0.31**	**5.2E-03**	**6.0E-04**	**--**	**--**	**0.16**	**1.9E-02**	**--**	**--**	**--**	**--**	**0.16**	**1.9E-02**	**--**	**--**
Onsite Fugitive Dust	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**0.11**	**1.5E-02**	**--**	**--**	**--**	**--**	**3.9E-02**	**5.1E-03**	**--**	**--**	**--**	**--**
Offsite Mobile Exhaust	**--**	**1.12**	**0.15**	**9.18**	**1.19**	**8.14**	**1.06**	**2.8E-02**	**3.6E-03**	**--**	**--**	**0.29**	**3.7E-02**	**--**	**--**	**--**	**--**	**0.27**	**3.4E-02**	**--**	**--**
Offsite Fugitive Dust	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**1.77**	**0.23**	**--**	**--**	**--**	**--**	**3.2E-02**	**4.2E-03**	**--**	**--**	**--**	**--**
Total 2018 Project Emissions	**--**	**1.59**	**0.20**	**12.6**	**1.61**	**10.7**	**1.37**	**3.3E-02**	**4.2E-03**	**1.88**	**0.24**	**0.45**	**5.7E-02**	**2.32**	**0.30**	**7.2E-02**	**9.3E-03**	**0.42**	**5.4E-02**	**0.49**	**6.3E-02**

References:

(1) Assumes 100% of Exhaust PM_{10} equals Diesel Particulate Matter (DPM).

Table C-9
LRDP Construction and Demolition Criteria Pollutant Emissions Summary

Source	Annual Operation (days/yr)	Total CO_2		CH_4		N_2O		CO_2e	
		(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)
2018 Off-Road Equipment Emissions									
Demolition	260	37.7	4.90	1.8E-03	2.4E-04	0	0	37.7	4.90
Site Grading - Excavation	260	77.9	10.1	5.2E-03	6.8E-04	0	0	78.1	10.1
Building Construction - Foundations	260	112	14.6	6.5E-03	8.4E-04	0	0	112	14.6
Building Construction - Steel Erection	260	158	20.5	1.1E-02	1.5E-03	0	0	158	20.5
Building Construction - Exterior Enclosure	260	190	24.7	1.0E-02	1.3E-03	0	0	190	24.7
Building Construction - Interior Finishes	260	93.2	12.1	5.4E-03	7.1E-04	0	0	93.3	12.1
Paving - Site Improvements	260	42.6	5.54	2.9E-03	3.8E-04	0	0	42.7	5.55
Total 2018 Off-Road Emissions		**711**	**86.9**	**4.3E-02**	**5.2E-03**	**0**	**0**	**712**	**87.0**
2018 Onroad Vehicle Emissions									
Total Demolition		**42.1**	**5.47**	**9.2E-04**	**1.2E-04**	**0**	**0**	**42.1**	**5.47**
Hauling Vehicle Onroad Emissions	260	39.8	5.18	7.7E-04	1.0E-04	0	0	39.8	5.18
Vendor Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0
Worker Vehicle Onroad Emissions	260	2.25	0.29	1.5E-04	2.0E-05	0	0	2.25	0.29
Total Site Grading - Excavation		**510**	**66.3**	**9.8E-03**	**1.3E-03**	**0**	**0**	**510**	**66.3**
Hauling Vehicle Onroad Emissions	260	500	65.0	9.2E-03	1.2E-03	0	0	500	65.0
Vendor Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0
Worker Vehicle Onroad Emissions	260	9.72	1.26	5.8E-04	7.5E-05	0	0	9.73	1.26
Total Building Construction - Foundations		**356**	**46.3**	**8.3E-03**	**1.1E-03**	**0**	**0**	**356**	**46.3**
Hauling Vehicle Onroad Emissions	260	207	26.9	3.7E-03	4.8E-04	0	0	207	26.9
Vendor Vehicle Onroad Emissions	260	82.8	10.8	1.8E-03	2.4E-04	0	0	82.8	10.8
Worker Vehicle Onroad Emissions	260	66.3	8.62	2.8E-03	3.6E-04	0	0	66.4	8.63
Total Building Construction - Steel Erection		**1,263**	**164**	**2.6E-02**	**3.3E-03**	**0**	**0**	**1,264**	**164**
Hauling Vehicle Onroad Emissions	260	1,083	141	2.0E-02	2.6E-03	0	0	1,083	141
Vendor Vehicle Onroad Emissions	260	100	13.0	2.2E-03	2.9E-04	0	0	100	13.0
Worker Vehicle Onroad Emissions	260	80.2	10.4	3.3E-03	4.4E-04	0	0	80.2	10.4
Total Building Construction - Exterior Enclosure		**273**	**35.5**	**8.5E-03**	**1.1E-03**	**0**	**0**	**274**	**35.6**
Hauling Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0
Vendor Vehicle Onroad Emissions	260	152	19.7	3.4E-03	4.4E-04	0	0	152	19.7
Worker Vehicle Onroad Emissions	260	122	15.8	5.1E-03	6.6E-04	0	0	122	15.8
Total Building Construction - Interior Finishes		**292**	**38.0**	**9.0E-03**	**1.2E-03**	**0**	**0**	**292**	**38.0**
Hauling Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0
Vendor Vehicle Onroad Emissions	260	162	21.1	3.6E-03	4.7E-04	0	0	162	21.1
Worker Vehicle Onroad Emissions	260	130	16.9	5.4E-03	7.1E-04	0	0	130	16.9
Total Paving - Site Improvements		**14.9**	**1.94**	**5.8E-04**	**7.5E-05**	**0**	**0**	**14.9**	**1.94**
Hauling Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0
Vendor Vehicle Onroad Emissions	260	0	0	0	0	0	0	0	0
Worker Vehicle Onroad Emissions	260	14.9	1.94	5.8E-04	7.5E-05	0	0	14.9	1.94
Total 2018 Onroad Emissions	**--**	**2,751**	**358**	**6.3E-02**	**8.2E-03**	**0**	**0**	**2,753**	**358**
Total 2018 Project Emissions	**--**	**3,463**	**445**	**0.11**	**1.3E-02**	**0**	**0**	**3,465**	**445**
Onsite Stationary Exhaust	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**
Onsite Mobile Exhaust	**--**	**711**	**86.9**	**4.3E-02**	**5.2E-03**	**0**	**0**	**712**	**87.0**
Onsite Fugitive Dust	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**
Offsite Mobile Exhaust	**--**	**2,751**	**358**	**6.3E-02**	**8.2E-03**	**0**	**0**	**2,753**	**358**
Offsite Fugitive Dust	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**
Total 2018 Project Emissions	**--**	**3,463**	**445**	**0.11**	**1.3E-02**	**0**	**0**	**3,465**	**445**

References:

(1) Assumes 100% of Exhaust PM_{10} equals Diesel Particulate Matter (DPM).

Table C-10
LRDP Construction and Demolition Onsite and Offsite Vehicle Traffic Assumptions for Modeling

Road Segment	Offsite Road Length (m)	Onsite Road Length (m)	Area Source Length of Side (m)	Fraction of Traffic [(1)]	Length Fraction	Fraction of Emissions
Resident Construction/Demolition - Offsite						
R14_NH	99.8	--	--	0.50	49.9	0.099
R14_R15	181	--	--	0.50	90.4	0.18
R15_T1	154	--	--	0.50	76.8	0.15
T1_EH	192	--	--	0.50	95.8	0.19
Total Offsite Resident Length				1.00	313	0.62
Resident Construction/Demolition - Onsite						
T1_R1C	--	99.1	--	1.00	99.1	0.20
AREA7	--	--	90.0	1.00	90.0	0.18
Total Onsite Resident Length				1.00	189	0.38
Total Resident Road Length					**502**	
Worker Construction/Demolition						
R14_NH	99.8	--	--	0.50	49.9	0.061
R13_R14	207	--	--	0.50	104	0.13
R12_R13	427	--	--	0.50	214	0.26
R11_R12	59.7	--	--	0.50	29.9	0.036
T3_R11	445	--	--	0.50	223	0.27
T3_WH	221	--	--	0.50	110	0.13
Total Offsite Worker Length				1.00	730	0.89
Worker Construction/Demolition - Onsite						
AREA3	--	--	90.0	1.00	90.0	0.11
Total Onsite Worker Length				1.00	90.0	0.11
Total Worker Road Length					**820**	
Cancer Risk Construction/Demolition - Offsite						
R14_NH	99.8	--	--	0.33	33.3	0.028
R14_R15	181	--	--	0.33	60.2	0.051
R15_T1	154	--	--	0.33	51.2	0.044
T1_EH	192	--	--	0.33	63.8	0.054
T1_R1	127	--	--	0.33	42.4	0.036
R1_T2	98.6	--	--	0.33	32.9	0.028
T3_WH	221	--	--	0.33	73.6	0.063
T3_R11	445	--	--	0.33	148	0.13
R11_R12	59.7	--	--	0.33	19.9	0.017
R12_R13	427	--	--	0.33	142	0.12
R13_R14	207	--	--	0.33	69.1	0.059
R8_T3	111	--	--	0.33	37.0	0.032
R7_R8	55.3	--	--	0.33	18.4	0.016
R6_R7	71.5	--	--	0.33	23.8	0.020
Total Offsite Cancer Risk Road Length					816	0.70
Cancer Risk Construction/Demolition - Onsite						
T2_R2	--	165	--	0.33	54.8	0.047
R2_R3	--	112	--	0.33	37.4	0.032
R3_R6	--	525	--	0.33	175	0.15
AREA1	--	--	90.0	0.28	25.5	0.022
AREA2	--	--	90.0	0.38	34.2	0.029
AREA3	--	--	90.0	0.19	17.2	0.015
AREA4	--	--	90.0	0.15	13.1	0.011
Total Onsite Cancer Risk Road Length					357	0.30
Total Cancer Risk Road Length					**1,174**	

References:

(1) Vehicle traffic provided by LBNL.

Appendix D

CalEEMod Output – Full LRDP Construction

LRDP - Average Demolition - 04/04/2013

Bay Area AQMD Air District, Summer

1.0 Project Characteristics

1.1 Land Usage

Land Uses	Size	Metric
Research & Development	200	1000sqft

1.2 Other Project Characteristics

Urbanization	Urban	**Wind Speed (m/s)**	2.2	**Utility Company**	Pacific Gas & Electric Company
Climate Zone	5	**Precipitation Freq (Days)**	64		

1.3 User Entered Comments

Project Characteristics -

Land Use - Average construction of 200,000 gsf for R&D and 10,000 population. - Updated: 3/27/13

Construction Phase - Dem (1/1/18 - 1/4/18); Grading (1/5/18 - 1/25/18); BC-F (1/26/18 - 2/28/18); BC-SE (3/01/18 - 4/10/18); BC-EE (4/11/18 - 6/11/18); BC-IF (6/12/18 - 8/15/18); Paving (8/16/18 - 9/05/18)
- Updated: 4/4/18

Off-road Equipment - Cranes, Forklifts, Other construction equip., and Rough terrain forklifts. - Updated: 4/4/13

Off-road Equipment - Tractors/loaders/backhoes, Forklifts, Pumps. Plate compactors, and Air compressors. - Updated: 4/4/18

Off-road Equipment - Forklifts, Other construction equip., and Rough terrain forklifts. Updated; 4/4/13

Off-road Equipment - Air Compressors, Cranes, Forklifts, Pumps, Rough terrain forklifts, Welders, and Welders. Updated: 4/4/13

Off-road Equipment - Excavators, Tractors/Loaders/Backhoes, Rubber Tired Dozers, Concrete/Industrial Saws, and Other Construction Equipment - Updated: 4/4/18

Off-road Equipment - Concrete/Industrial saws, Excavators. Forklifts, Other construction equip., Paving equip., Plate compactors, Skid steer loaders, and Trenchers. - Updated: 4/4/13

Off-road Equipment - Excavators, Tractors/loaders/backhoes, Rubber tired dozers, Trenchers, and Plate compactors. - Updated: 4/4/13

Trips and VMT - Demolition (125 hauling trips); Site Grading (1,570 hauling trips); BC-F (650 hauling trips); BC-SE (3,400 hauling trips). - Updated: 4/4/13

Demolition - Avg demolition = 20,094 gsf - Updated: 4/4/13

Grading - Grading soil export = 15,700 CYD @ 2.00 acres disturbed. - Updated: 4/4/13

Energy Use -

Water And Wastewater - - 340,000,000 gallons/yr of potable water - Updated: 4/4/13

Construction Off-road Equipment Mitigation - Watering 2 times per day @ 55% reduction. - Updated: 4/4/13

2.0 Emissions Summary

2.1 Overall Construction (Maximum Daily Emission)

Unmitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Year	lb/day										lb/day					
2018	5.29	48.97	31.22	0.12	80.70	1.62	82.32	1.61	1.52	2.91	0.00	12,737.51	0.00	0.32	0.00	12,744.22
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Mitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Year	lb/day										lb/day					
2018	5.29	48.97	31.22	0.12	80.70	1.62	82.32	0.78	1.52	2.08	0.00	12,737.51	0.00	0.32	0.00	12,744.22
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

2.2 Overall Operational

Unmitigated Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Area	5.55	0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00		0.00		0.00
Energy	0.15	1.38	1.16	0.01		0.00	0.10		0.00	0.10		1,655.44		0.03	0.03	1,665.51
Mobile	6.81	11.97	57.07	0.13	13.45	0.53	13.98	0.19	0.49	0.68		11,047.02		0.44		11,056.16
Total	**12.51**	**13.35**	**58.23**	**0.14**	**13.45**	**0.53**	**14.08**	**0.19**	**0.49**	**0.78**		**12,702.46**		**0.47**	**0.03**	**12,721.67**

Mitigated Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Area	5.55	0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00		0.00		0.00
Energy	0.15	1.38	1.16	0.01		0.00	0.10		0.00	0.10		1,655.44		0.03	0.03	1,665.51
Mobile	6.81	11.97	57.07	0.13	13.45	0.53	13.98	0.19	0.49	0.68		11,047.02		0.44		11,056.16
Total	**12.51**	**13.35**	**58.23**	**0.14**	**13.45**	**0.53**	**14.08**	**0.19**	**0.49**	**0.78**		**12,702.46**		**0.47**	**0.03**	**12,721.67**

3.0 Construction Detail

3.1 Mitigation Measures Construction

Water Exposed Area

3.2 Demolition - 2018

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Fugitive Dust					4.94	0.00	4.94	0.00	0.00	0.00						0.00
Off-Road	1.39	9.39	8.60	0.02		0.42	0.42		0.42	0.42		2,448.30		0.12		2,450.88
Total	**1.39**	**9.39**	**8.60**	**0.02**	**4.94**	**0.42**	**5.36**	**0.00**	**0.42**	**0.42**		**2,448.30**		**0.12**		**2,450.88**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.94	9.99	5.42	0.02	3.00	0.30	3.30	0.03	0.28	0.30		2,587.84		0.05		2,588.81
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Worker	0.07	0.06	0.69	0.00	0.19	0.01	0.20	0.00	0.01	0.01		145.98		0.01		146.13
Total	**1.01**	**10.05**	**6.11**	**0.02**	**3.19**	**0.31**	**3.50**	**0.03**	**0.29**	**0.31**		**2,733.82**		**0.06**		**2,734.94**

3.2 Demolition - 2018

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Fugitive Dust					2.23	0.00	2.23	0.00	0.00	0.00						0.00
Off-Road	1.39	9.39	8.60	0.02		0.42	0.42		0.42	0.42	0.00	2,448.30		0.12		2,450.88
Total	**1.39**	**9.39**	**8.60**	**0.02**	**2.23**	**0.42**	**2.65**	**0.00**	**0.42**	**0.42**	**0.00**	**2,448.30**		**0.12**		**2,450.88**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.94	9.99	5.42	0.02	3.00	0.30	3.30	0.03	0.28	0.30		2,587.84		0.05		2,588.81
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Worker	0.07	0.06	0.69	0.00	0.19	0.01	0.20	0.00	0.01	0.01		145.98		0.01		146.13
Total	**1.01**	**10.05**	**6.11**	**0.02**	**3.19**	**0.31**	**3.50**	**0.03**	**0.29**	**0.31**		**2,733.82**		**0.06**		**2,734.94**

3.3 Site Grading - Excavation - 2018

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Fugitive Dust					2.97	0.00	2.97	1.51	0.00	1.51						0.00
Off-Road	1.06	7.52	6.86	0.01		0.37	0.37		0.37	0.37		1,351.02		0.09		1,353.01
Total	**1.06**	**7.52**	**6.86**	**0.01**	**2.97**	**0.37**	**3.34**	**1.51**	**0.37**	**1.88**		**1,351.02**		**0.09**		**1,353.01**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	3.15	33.45	18.16	0.08	36.82	1.00	37.83	0.10	0.92	1.02		8,667.54		0.15		8,670.77
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Worker	0.08	0.07	0.80	0.00	0.22	0.01	0.23	0.00	0.01	0.01		168.44		0.01		168.61
Total	**3.23**	**33.52**	**18.96**	**0.08**	**37.04**	**1.01**	**38.06**	**0.10**	**0.93**	**1.03**		**8,835.98**		**0.16**		**8,839.38**

3.3 Site Grading - Excavation - 2018

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Fugitive Dust					1.34	0.00	1.34	0.68	0.00	0.68						0.00
Off-Road	1.06	7.52	6.86	0.01		0.37	0.37		0.37	0.37	0.00	1,351.02		0.09		1,353.01
Total	**1.06**	**7.52**	**6.86**	**0.01**	**1.34**	**0.37**	**1.71**	**0.68**	**0.37**	**1.05**	**0.00**	**1,351.02**		**0.09**		**1,353.01**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	3.15	33.45	18.16	0.08	36.82	1.00	37.83	0.10	0.92	1.02		8,667.54		0.15		8,670.77
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Worker	0.08	0.07	0.80	0.00	0.22	0.01	0.23	0.00	0.01	0.01		168.44		0.01		168.61
Total	**3.23**	**33.52**	**18.96**	**0.08**	**37.04**	**1.01**	**38.06**	**0.10**	**0.93**	**1.03**		**8,835.98**		**0.16**		**8,839.38**

3.4 Building Construction - Foundations - 2018

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	0.76	6.01	4.93	0.01		0.29	0.29		0.29	0.29		1,215.47		0.07		1,216.89
Total	**0.76**	**6.01**	**4.93**	**0.01**		**0.29**	**0.29**		**0.29**	**0.29**		**1,215.47**		**0.07**		**1,216.89**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.82	8.66	4.70	0.02	15.20	0.26	15.46	0.03	0.24	0.26		2,242.80		0.04		2,243.63
Vendor	0.32	3.47	2.19	0.01	0.30	0.10	0.40	0.01	0.09	0.10		896.92		0.02		897.25
Worker	0.36	0.30	3.41	0.01	0.96	0.03	0.99	0.01	0.03	0.04		718.68		0.03		719.41
Total	**1.50**	**12.43**	**10.30**	**0.04**	**16.46**	**0.39**	**16.85**	**0.05**	**0.36**	**0.40**		**3,858.40**		**0.09**		**3,860.29**

3.4 Building Construction - Foundations - 2018

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	0.76	6.01	4.93	0.01		0.29	0.29		0.29	0.29	0.00	1,215.47		0.07		1,216.89
Total	**0.76**	**6.01**	**4.93**	**0.01**		**0.29**	**0.29**		**0.29**	**0.29**	**0.00**	**1,215.47**		**0.07**		**1,216.89**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.82	8.66	4.70	0.02	15.20	0.26	15.46	0.03	0.24	0.26		2,242.80		0.04		2,243.63
Vendor	0.32	3.47	2.19	0.01	0.30	0.10	0.40	0.01	0.09	0.10		896.92		0.02		897.25
Worker	0.36	0.30	3.41	0.01	0.96	0.03	0.99	0.01	0.03	0.04		718.68		0.03		719.41
Total	**1.50**	**12.43**	**10.30**	**0.04**	**16.46**	**0.39**	**16.85**	**0.05**	**0.36**	**0.40**		**3,858.40**		**0.09**		**3,860.29**

3.5 Building Construction - Steel Erection - 2018

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	1.08	7.73	5.28	0.01		0.37	0.37		0.37	0.37		1,413.04		0.10		1,415.07
Total	**1.08**	**7.73**	**5.28**	**0.01**		**0.37**	**0.37**		**0.37**	**0.37**		**1,413.04**		**0.10**		**1,415.07**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	3.53	37.47	20.34	0.09	79.44	1.12	80.56	0.11	1.03	1.14		9,708.87		0.17		9,712.49
Vendor	0.32	3.47	2.19	0.01	0.30	0.10	0.40	0.01	0.09	0.10		896.92		0.02		897.25
Worker	0.36	0.30	3.41	0.01	0.96	0.03	0.99	0.01	0.03	0.04		718.68		0.03		719.41
Total	**4.21**	**41.24**	**25.94**	**0.11**	**80.70**	**1.25**	**81.95**	**0.13**	**1.15**	**1.28**		**11,324.47**		**0.22**		**11,329.15**

3.5 Building Construction - Steel Erection - 2018

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	1.08	7.73	5.28	0.01		0.37	0.37		0.37	0.37	0.00	1,413.04		0.10		1,415.07
Total	**1.08**	**7.73**	**5.28**	**0.01**		**0.37**	**0.37**		**0.37**	**0.37**	**0.00**	**1,413.04**		**0.10**		**1,415.07**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	3.53	37.47	20.34	0.09	79.44	1.12	80.56	0.11	1.03	1.14		9,708.87		0.17		9,712.49
Vendor	0.32	3.47	2.19	0.01	0.30	0.10	0.40	0.01	0.09	0.10		896.92		0.02		897.25
Worker	0.36	0.30	3.41	0.01	0.96	0.03	0.99	0.01	0.03	0.04		718.68		0.03		719.41
Total	**4.21**	**41.24**	**25.94**	**0.11**	**80.70**	**1.25**	**81.95**	**0.13**	**1.15**	**1.28**		**11,324.47**		**0.22**		**11,329.15**

3.6 Building Construction - Exterior Enclosure - 2018

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	0.70	4.97	3.01	0.01		0.20	0.20		0.20	0.20		1,123.38		0.06		1,124.69
Total	**0.70**	**4.97**	**3.01**	**0.01**		**0.20**	**0.20**		**0.20**	**0.20**		**1,123.38**		**0.06**		**1,124.69**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Vendor	0.32	3.47	2.19	0.01	0.30	0.10	0.40	0.01	0.09	0.10		896.92		0.02		897.25
Worker	0.36	0.30	3.41	0.01	0.96	0.03	0.99	0.01	0.03	0.04		718.68		0.03		719.41
Total	**0.68**	**3.77**	**5.60**	**0.02**	**1.26**	**0.13**	**1.39**	**0.02**	**0.12**	**0.14**		**1,615.60**		**0.05**		**1,616.66**

3.6 Building Construction - Exterior Enclosure - 2018

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	0.70	4.97	3.01	0.01		0.20	0.20		0.20	0.20	0.00	1,123.38		0.06		1,124.69
Total	**0.70**	**4.97**	**3.01**	**0.01**		**0.20**	**0.20**		**0.20**	**0.20**	**0.00**	**1,123.38**		**0.06**		**1,124.69**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Vendor	0.32	3.47	2.19	0.01	0.30	0.10	0.40	0.01	0.09	0.10		896.92		0.02		897.25
Worker	0.36	0.30	3.41	0.01	0.96	0.03	0.99	0.01	0.03	0.04		718.68		0.03		719.41
Total	**0.68**	**3.77**	**5.60**	**0.02**	**1.26**	**0.13**	**1.39**	**0.02**	**0.12**	**0.14**		**1,615.60**		**0.05**		**1,616.66**

3.7 Building Construction - Interior Finishes - 2018

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	0.29	2.02	1.63	0.00		0.10	0.10		0.10	0.10		515.71		0.03		516.26
Total	**0.29**	**2.02**	**1.63**	**0.00**		**0.10**	**0.10**		**0.10**	**0.10**		**515.71**		**0.03**		**516.26**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Vendor	0.32	3.47	2.19	0.01	0.30	0.10	0.40	0.01	0.09	0.10		896.92		0.02		897.25
Worker	0.36	0.30	3.41	0.01	0.96	0.03	0.99	0.01	0.03	0.04		718.68		0.03		719.41
Total	**0.68**	**3.77**	**5.60**	**0.02**	**1.26**	**0.13**	**1.39**	**0.02**	**0.12**	**0.14**		**1,615.60**		**0.05**		**1,616.66**

3.7 Building Construction - Interior Finishes - 2018

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	0.29	2.02	1.63	0.00		0.10	0.10		0.10	0.10	0.00	515.71		0.03		516.26
Total	**0.29**	**2.02**	**1.63**	**0.00**		**0.10**	**0.10**		**0.10**	**0.10**	**0.00**	**515.71**		**0.03**		**516.26**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Vendor	0.32	3.47	2.19	0.01	0.30	0.10	0.40	0.01	0.09	0.10		896.92		0.02		897.25
Worker	0.36	0.30	3.41	0.01	0.96	0.03	0.99	0.01	0.03	0.04		718.68		0.03		719.41
Total	**0.68**	**3.77**	**5.60**	**0.02**	**1.26**	**0.13**	**1.39**	**0.02**	**0.12**	**0.14**		**1,615.60**		**0.05**		**1,616.66**

3.8 Paving - Site Improvements - 2018

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	0.56	3.74	3.26	0.01		0.17	0.17		0.17	0.17		739.11		0.05		740.16
Paving	0.00					0.00	0.00		0.00	0.00						0.00
Total	**0.56**	**3.74**	**3.26**	**0.01**		**0.17**	**0.17**		**0.17**	**0.17**		**739.11**		**0.05**		**740.16**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Worker	0.13	0.11	1.23	0.00	0.34	0.01	0.36	0.00	0.01	0.01		258.28		0.01		258.54
Total	**0.13**	**0.11**	**1.23**	**0.00**	**0.34**	**0.01**	**0.36**	**0.00**	**0.01**	**0.01**		**258.28**		**0.01**		**258.54**

3.8 Paving - Site Improvements - 2018

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	0.56	3.74	3.26	0.01		0.17	0.17		0.17	0.17	0.00	739.11		0.05		740.16
Paving	0.00					0.00	0.00		0.00	0.00						0.00
Total	**0.56**	**3.74**	**3.26**	**0.01**		**0.17**	**0.17**		**0.17**	**0.17**	**0.00**	**739.11**		**0.05**		**740.16**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Worker	0.13	0.11	1.23	0.00	0.34	0.01	0.36	0.00	0.01	0.01		258.28		0.01		258.54
Total	**0.13**	**0.11**	**1.23**	**0.00**	**0.34**	**0.01**	**0.36**	**0.00**	**0.01**	**0.01**		**258.28**		**0.01**		**258.54**

4.0 Mobile Detail

4.1 Mitigation Measures Mobile

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Mitigated	6.81	11.97	57.07	0.13	13.45	0.53	13.98	0.19	0.49	0.68		11,047.02		0.44		11,056.16
Unmitigated	6.81	11.97	57.07	0.13	13.45	0.53	13.98	0.19	0.49	0.68		11,047.02		0.44		11,056.16
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

4.2 Trip Summary Information

	Average Daily Trip Rate			Unmitigated	Mitigated
Land Use	Weekday	Saturday	Sunday	Annual VMT	Annual VMT
Research & Development	1,622.00	380.00	222.00	3,119,204	3,119,204
Total	1,622.00	380.00	222.00	3,119,204	3,119,204

4.3 Trip Type Information

	Miles			Trip %		
Land Use	H-W or C-W	H-S or C-C	H-O or C-NW	H-W or C-W	H-S or C-C	H-O or C-NW
Research & Development	9.50	7.30	7.30	33.00	48.00	19.00

5.0 Energy Detail

5.1 Mitigation Measures Energy

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
NaturalGas Mitigated	0.15	1.38	1.16	0.01		0.00	0.10		0.00	0.10		1,655.44		0.03	0.03	1,665.51
NaturalGas Unmitigated	0.15	1.38	1.16	0.01		0.00	0.10		0.00	0.10		1,655.44		0.03	0.03	1,665.51
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

5.2 Energy by Land Use - NaturalGas

Unmitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU	lb/day										lb/day					
Research & Development	14071.2	0.15	1.38	1.16	0.01		0.00	0.10		0.00	0.10		1,655.44		0.03	0.03	1,665.51
Total		**0.15**	**1.38**	**1.16**	**0.01**		**0.00**	**0.10**		**0.00**	**0.10**		**1,655.44**		**0.03**	**0.03**	**1,665.51**

5.2 Energy by Land Use - NaturalGas

Mitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU	lb/day										lb/day					
Research & Development	14.0712	0.15	1.38	1.16	0.01		0.00	0.10		0.00	0.10		1,655.44		0.03	0.03	1,665.51
Total		**0.15**	**1.38**	**1.16**	**0.01**		**0.00**	**0.10**		**0.00**	**0.10**		**1,655.44**		**0.03**	**0.03**	**1,665.51**

6.0 Area Detail

6.1 Mitigation Measures Area

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Mitigated	5.55	0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00		0.00		0.00
Unmitigated	5.55	0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00		0.00		0.00
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

6.2 Area by SubCategory

Unmitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
SubCategory	lb/day										lb/day					
Architectural Coating	1.27					0.00	0.00		0.00	0.00						0.00
Consumer Products	4.28					0.00	0.00		0.00	0.00						0.00
Landscaping	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00		0.00		0.00
Total	**5.55**	**0.00**	**0.00**	**0.00**		**0.00**	**0.00**		**0.00**	**0.00**		**0.00**		**0.00**		**0.00**

Mitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
SubCategory	lb/day										lb/day					
Architectural Coating	1.27					0.00	0.00		0.00	0.00						0.00
Consumer Products	4.28					0.00	0.00		0.00	0.00						0.00
Landscaping	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00		0.00		0.00
Total	**5.55**	**0.00**	**0.00**	**0.00**		**0.00**	**0.00**		**0.00**	**0.00**		**0.00**		**0.00**		**0.00**

7.0 Water Detail

7.1 Mitigation Measures Water

8.0 Waste Detail

8.1 Mitigation Measures Waste

9.0 Vegetation

LRDP - Average Demolition - 04/04/2013

Bay Area AQMD Air District, Winter

1.0 Project Characteristics

1.1 Land Usage

Land Uses	Size	Metric
Research & Development	200	1000sqft

1.2 Other Project Characteristics

Urbanization	Urban	**Wind Speed (m/s)**	2.2	**Utility Company**	Pacific Gas & Electric Company
Climate Zone	5	**Precipitation Freq (Days)**	64		

1.3 User Entered Comments

Project Characteristics -

Land Use - Average construction of 200,000 gsf for R&D and 10,000 population. - Updated: 3/27/13

Construction Phase - Dem (1/1/18 - 1/4/18); Grading (1/5/18 - 1/25/18); BC-F (1/26/18 - 2/28/18); BC-SE (3/01/18 - 4/10/18); BC-EE (4/11/18 - 6/11/18); BC-IF (6/12/18 - 8/15/18); Paving (8/16/18 - 9/05/18)
- Updated: 4/4/18

Off-road Equipment - Cranes, Forklifts, Other construction equip., and Rough terrain forklifts. - Updated: 4/4/13

Off-road Equipment - Tractors/loaders/backhoes, Forklifts, Pumps. Plate compactors, and Air compressors. - Updated: 4/4/18

Off-road Equipment - Forklifts, Other construction equip., and Rough terrain forklifts. Updated; 4/4/13

Off-road Equipment - Air Compressors, Cranes, Forklifts, Pumps, Rough terrain forklifts, Welders, and Welders. Updated: 4/4/13

Off-road Equipment - Excavators, Tractors/Loaders/Backhoes, Rubber Tired Dozers, Concrete/Industrial Saws, and Other Construction Equipment - Updated: 4/4/18

Off-road Equipment - Concrete/Industrial saws, Excavators. Forklifts, Other construction equip., Paving equip., Plate compactors, Skid steer loaders, and Trenchers. - Updated: 4/4/13

Off-road Equipment - Excavators, Tractors/loaders/backhoes, Rubber tired dozers, Trenchers, and Plate compactors. - Updated: 4/4/13

Trips and VMT - Demolition (125 hauling trips); Site Grading (1,570 hauling trips); BC-F (650 hauling trips); BC-SE (3,400 hauling trips). - Updated: 4/4/13

Demolition - Avg demolition = 20,094 gsf - Updated: 4/4/13

Grading - Grading soil export = 15,700 CYD @ 2.00 acres disturbed. - Updated: 4/4/13

Energy Use -

Water And Wastewater - - 340,000,000 gallons/yr of potable water - Updated: 4/4/13

Construction Off-road Equipment Mitigation - Watering 2 times per day @ 55% reduction. - Updated: 4/4/13

2.0 Emissions Summary

2.1 Overall Construction (Maximum Daily Emission)

Unmitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Year	lb/day										lb/day					
2018	5.52	48.99	35.45	0.12	80.70	1.64	82.34	1.61	1.53	2.92	0.00	12,604.85	0.00	0.33	0.00	12,611.73
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Mitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Year	lb/day										lb/day					
2018	5.52	48.99	35.45	0.12	80.70	1.64	82.34	0.78	1.53	2.09	0.00	12,604.85	0.00	0.33	0.00	12,611.73
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

2.2 Overall Operational

Unmitigated Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Area	5.55	0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00		0.00		0.00
Energy	0.15	1.38	1.16	0.01		0.00	0.10		0.00	0.10		1,655.44		0.03	0.03	1,665.51
Mobile	6.99	12.50	57.57	0.11	13.45	0.53	13.98	0.19	0.50	0.68		10,079.71		0.45		10,089.08
Total	**12.69**	**13.88**	**58.73**	**0.12**	**13.45**	**0.53**	**14.08**	**0.19**	**0.50**	**0.78**		**11,735.15**		**0.48**	**0.03**	**11,754.59**

Mitigated Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Area	5.55	0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00		0.00		0.00
Energy	0.15	1.38	1.16	0.01		0.00	0.10		0.00	0.10		1,655.44		0.03	0.03	1,665.51
Mobile	6.99	12.50	57.57	0.11	13.45	0.53	13.98	0.19	0.50	0.68		10,079.71		0.45		10,089.08
Total	**12.69**	**13.88**	**58.73**	**0.12**	**13.45**	**0.53**	**14.08**	**0.19**	**0.50**	**0.78**		**11,735.15**		**0.48**	**0.03**	**11,754.59**

3.0 Construction Detail

3.1 Mitigation Measures Construction

Water Exposed Area

3.2 Demolition - 2018

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Fugitive Dust					4.94	0.00	4.94	0.00	0.00	0.00						0.00
Off-Road	1.39	9.39	8.60	0.02		0.42	0.42		0.42	0.42		2,448.30		0.12		2,450.88
Total	**1.39**	**9.39**	**8.60**	**0.02**	**4.94**	**0.42**	**5.36**	**0.00**	**0.42**	**0.42**		**2,448.30**		**0.12**		**2,450.88**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.99	9.99	6.45	0.02	3.00	0.30	3.30	0.03	0.28	0.31		2,574.61		0.05		2,575.62
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Worker	0.08	0.07	0.64	0.00	0.19	0.01	0.20	0.00	0.01	0.01		130.54		0.01		130.68
Total	**1.07**	**10.06**	**7.09**	**0.02**	**3.19**	**0.31**	**3.50**	**0.03**	**0.29**	**0.32**		**2,705.15**		**0.06**		**2,706.30**

3.2 Demolition - 2018

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Fugitive Dust					2.23	0.00	2.23	0.00	0.00	0.00						0.00
Off-Road	1.39	9.39	8.60	0.02		0.42	0.42		0.42	0.42	0.00	2,448.30		0.12		2,450.88
Total	**1.39**	**9.39**	**8.60**	**0.02**	**2.23**	**0.42**	**2.65**	**0.00**	**0.42**	**0.42**	**0.00**	**2,448.30**		**0.12**		**2,450.88**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.99	9.99	6.45	0.02	3.00	0.30	3.30	0.03	0.28	0.31		2,574.61		0.05		2,575.62
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Worker	0.08	0.07	0.64	0.00	0.19	0.01	0.20	0.00	0.01	0.01		130.54		0.01		130.68
Total	**1.07**	**10.06**	**7.09**	**0.02**	**3.19**	**0.31**	**3.50**	**0.03**	**0.29**	**0.32**		**2,705.15**		**0.06**		**2,706.30**

3.3 Site Grading - Excavation - 2018

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Fugitive Dust					2.97	0.00	2.97	1.51	0.00	1.51						0.00
Off-Road	1.06	7.52	6.86	0.01		0.37	0.37		0.37	0.37		1,351.02		0.09		1,353.01
Total	**1.06**	**7.52**	**6.86**	**0.01**	**2.97**	**0.37**	**3.34**	**1.51**	**0.37**	**1.88**		**1,351.02**		**0.09**		**1,353.01**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	3.31	33.46	21.61	0.08	36.82	1.02	37.84	0.10	0.93	1.03		8,623.22		0.16		8,626.62
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Worker	0.09	0.08	0.74	0.00	0.22	0.01	0.23	0.00	0.01	0.01		150.62		0.01		150.78
Total	**3.40**	**33.54**	**22.35**	**0.08**	**37.04**	**1.03**	**38.07**	**0.10**	**0.94**	**1.04**		**8,773.84**		**0.17**		**8,777.40**

3.3 Site Grading - Excavation - 2018

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Fugitive Dust					1.34	0.00	1.34	0.68	0.00	0.68						0.00
Off-Road	1.06	7.52	6.86	0.01		0.37	0.37		0.37	0.37	0.00	1,351.02		0.09		1,353.01
Total	**1.06**	**7.52**	**6.86**	**0.01**	**1.34**	**0.37**	**1.71**	**0.68**	**0.37**	**1.05**	**0.00**	**1,351.02**		**0.09**		**1,353.01**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	3.31	33.46	21.61	0.08	36.82	1.02	37.84	0.10	0.93	1.03		8,623.22		0.16		8,626.62
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Worker	0.09	0.08	0.74	0.00	0.22	0.01	0.23	0.00	0.01	0.01		150.62		0.01		150.78
Total	**3.40**	**33.54**	**22.35**	**0.08**	**37.04**	**1.03**	**38.07**	**0.10**	**0.94**	**1.04**		**8,773.84**		**0.17**		**8,777.40**

3.4 Building Construction - Foundations - 2018

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	0.76	6.01	4.93	0.01		0.29	0.29		0.29	0.29		1,215.47		0.07		1,216.89
Total	**0.76**	**6.01**	**4.93**	**0.01**		**0.29**	**0.29**		**0.29**	**0.29**		**1,215.47**		**0.07**		**1,216.89**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.86	8.66	5.59	0.02	15.20	0.26	15.46	0.03	0.24	0.27		2,231.33		0.04		2,232.21
Vendor	0.35	3.44	2.82	0.01	0.30	0.10	0.40	0.01	0.09	0.10		889.93		0.02		890.29
Worker	0.38	0.33	3.14	0.01	0.96	0.03	0.99	0.01	0.03	0.04		642.66		0.03		643.34
Total	**1.59**	**12.43**	**11.55**	**0.04**	**16.46**	**0.39**	**16.85**	**0.05**	**0.36**	**0.41**		**3,763.92**		**0.09**		**3,765.84**

3.4 Building Construction - Foundations - 2018

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	0.76	6.01	4.93	0.01		0.29	0.29		0.29	0.29	0.00	1,215.47		0.07		1,216.89
Total	**0.76**	**6.01**	**4.93**	**0.01**		**0.29**	**0.29**		**0.29**	**0.29**	**0.00**	**1,215.47**		**0.07**		**1,216.89**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.86	8.66	5.59	0.02	15.20	0.26	15.46	0.03	0.24	0.27		2,231.33		0.04		2,232.21
Vendor	0.35	3.44	2.82	0.01	0.30	0.10	0.40	0.01	0.09	0.10		889.93		0.02		890.29
Worker	0.38	0.33	3.14	0.01	0.96	0.03	0.99	0.01	0.03	0.04		642.66		0.03		643.34
Total	**1.59**	**12.43**	**11.55**	**0.04**	**16.46**	**0.39**	**16.85**	**0.05**	**0.36**	**0.41**		**3,763.92**		**0.09**		**3,765.84**

3.5 Building Construction - Steel Erection - 2018

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	1.08	7.73	5.28	0.01		0.37	0.37		0.37	0.37		1,413.04		0.10		1,415.07
Total	**1.08**	**7.73**	**5.28**	**0.01**		**0.37**	**0.37**		**0.37**	**0.37**		**1,413.04**		**0.10**		**1,415.07**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	3.70	37.48	24.21	0.09	79.44	1.14	80.58	0.11	1.05	1.16		9,659.22		0.18		9,663.03
Vendor	0.35	3.44	2.82	0.01	0.30	0.10	0.40	0.01	0.09	0.10		889.93		0.02		890.29
Worker	0.38	0.33	3.14	0.01	0.96	0.03	0.99	0.01	0.03	0.04		642.66		0.03		643.34
Total	**4.43**	**41.25**	**30.17**	**0.11**	**80.70**	**1.27**	**81.97**	**0.13**	**1.17**	**1.30**		**11,191.81**		**0.23**		**11,196.66**

3.5 Building Construction - Steel Erection - 2018

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	1.08	7.73	5.28	0.01		0.37	0.37		0.37	0.37	0.00	1,413.04		0.10		1,415.07
Total	**1.08**	**7.73**	**5.28**	**0.01**		**0.37**	**0.37**		**0.37**	**0.37**	**0.00**	**1,413.04**		**0.10**		**1,415.07**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	3.70	37.48	24.21	0.09	79.44	1.14	80.58	0.11	1.05	1.16		9,659.22		0.18		9,663.03
Vendor	0.35	3.44	2.82	0.01	0.30	0.10	0.40	0.01	0.09	0.10		889.93		0.02		890.29
Worker	0.38	0.33	3.14	0.01	0.96	0.03	0.99	0.01	0.03	0.04		642.66		0.03		643.34
Total	**4.43**	**41.25**	**30.17**	**0.11**	**80.70**	**1.27**	**81.97**	**0.13**	**1.17**	**1.30**		**11,191.81**		**0.23**		**11,196.66**

3.6 Building Construction - Exterior Enclosure - 2018

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	0.70	4.97	3.01	0.01		0.20	0.20		0.20	0.20		1,123.38		0.06		1,124.69
Total	**0.70**	**4.97**	**3.01**	**0.01**		**0.20**	**0.20**		**0.20**	**0.20**		**1,123.38**		**0.06**		**1,124.69**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Vendor	0.35	3.44	2.82	0.01	0.30	0.10	0.40	0.01	0.09	0.10		889.93		0.02		890.29
Worker	0.38	0.33	3.14	0.01	0.96	0.03	0.99	0.01	0.03	0.04		642.66		0.03		643.34
Total	**0.73**	**3.77**	**5.96**	**0.02**	**1.26**	**0.13**	**1.39**	**0.02**	**0.12**	**0.14**		**1,532.59**		**0.05**		**1,533.63**

3.6 Building Construction - Exterior Enclosure - 2018

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	0.70	4.97	3.01	0.01		0.20	0.20		0.20	0.20	0.00	1,123.38		0.06		1,124.69
Total	**0.70**	**4.97**	**3.01**	**0.01**		**0.20**	**0.20**		**0.20**	**0.20**	**0.00**	**1,123.38**		**0.06**		**1,124.69**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Vendor	0.35	3.44	2.82	0.01	0.30	0.10	0.40	0.01	0.09	0.10		889.93		0.02		890.29
Worker	0.38	0.33	3.14	0.01	0.96	0.03	0.99	0.01	0.03	0.04		642.66		0.03		643.34
Total	**0.73**	**3.77**	**5.96**	**0.02**	**1.26**	**0.13**	**1.39**	**0.02**	**0.12**	**0.14**		**1,532.59**		**0.05**		**1,533.63**

3.7 Building Construction - Interior Finishes - 2018

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	0.29	2.02	1.63	0.00		0.10	0.10		0.10	0.10		515.71		0.03		516.26
Total	**0.29**	**2.02**	**1.63**	**0.00**		**0.10**	**0.10**		**0.10**	**0.10**		**515.71**		**0.03**		**516.26**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Vendor	0.35	3.44	2.82	0.01	0.30	0.10	0.40	0.01	0.09	0.10		889.93		0.02		890.29
Worker	0.38	0.33	3.14	0.01	0.96	0.03	0.99	0.01	0.03	0.04		642.66		0.03		643.34
Total	**0.73**	**3.77**	**5.96**	**0.02**	**1.26**	**0.13**	**1.39**	**0.02**	**0.12**	**0.14**		**1,532.59**		**0.05**		**1,533.63**

3.7 Building Construction - Interior Finishes - 2018

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	0.29	2.02	1.63	0.00		0.10	0.10		0.10	0.10	0.00	515.71		0.03		516.26
Total	**0.29**	**2.02**	**1.63**	**0.00**		**0.10**	**0.10**		**0.10**	**0.10**	**0.00**	**515.71**		**0.03**		**516.26**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Vendor	0.35	3.44	2.82	0.01	0.30	0.10	0.40	0.01	0.09	0.10		889.93		0.02		890.29
Worker	0.38	0.33	3.14	0.01	0.96	0.03	0.99	0.01	0.03	0.04		642.66		0.03		643.34
Total	**0.73**	**3.77**	**5.96**	**0.02**	**1.26**	**0.13**	**1.39**	**0.02**	**0.12**	**0.14**		**1,532.59**		**0.05**		**1,533.63**

3.8 Paving - Site Improvements - 2018

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	0.56	3.74	3.26	0.01		0.17	0.17		0.17	0.17		739.11		0.05		740.16
Paving	0.00					0.00	0.00		0.00	0.00						0.00
Total	**0.56**	**3.74**	**3.26**	**0.01**		**0.17**	**0.17**		**0.17**	**0.17**		**739.11**		**0.05**		**740.16**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Worker	0.14	0.12	1.13	0.00	0.34	0.01	0.36	0.00	0.01	0.01		230.96		0.01		231.20
Total	**0.14**	**0.12**	**1.13**	**0.00**	**0.34**	**0.01**	**0.36**	**0.00**	**0.01**	**0.01**		**230.96**		**0.01**		**231.20**

3.8 Paving - Site Improvements - 2018

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Off-Road	0.56	3.74	3.26	0.01		0.17	0.17		0.17	0.17	0.00	739.11		0.05		740.16
Paving	0.00					0.00	0.00		0.00	0.00						0.00
Total	**0.56**	**3.74**	**3.26**	**0.01**		**0.17**	**0.17**		**0.17**	**0.17**	**0.00**	**739.11**		**0.05**		**740.16**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00		0.00
Worker	0.14	0.12	1.13	0.00	0.34	0.01	0.36	0.00	0.01	0.01		230.96		0.01		231.20
Total	**0.14**	**0.12**	**1.13**	**0.00**	**0.34**	**0.01**	**0.36**	**0.00**	**0.01**	**0.01**		**230.96**		**0.01**		**231.20**

4.0 Mobile Detail

4.1 Mitigation Measures Mobile

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Mitigated	6.99	12.50	57.57	0.11	13.45	0.53	13.98	0.19	0.50	0.68		10,079.71		0.45		10,089.08
Unmitigated	6.99	12.50	57.57	0.11	13.45	0.53	13.98	0.19	0.50	0.68		10,079.71		0.45		10,089.08
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

4.2 Trip Summary Information

	Average Daily Trip Rate			Unmitigated	Mitigated
Land Use	Weekday	Saturday	Sunday	Annual VMT	Annual VMT
Research & Development	1,622.00	380.00	222.00	3,119,204	3,119,204
Total	1,622.00	380.00	222.00	3,119,204	3,119,204

4.3 Trip Type Information

	Miles			Trip %		
Land Use	H-W or C-W	H-S or C-C	H-O or C-NW	H-W or C-W	H-S or C-C	H-O or C-NW
Research & Development	9.50	7.30	7.30	33.00	48.00	19.00

5.0 Energy Detail

5.1 Mitigation Measures Energy

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
NaturalGas Mitigated	0.15	1.38	1.16	0.01		0.00	0.10		0.00	0.10		1,655.44		0.03	0.03	1,665.51
NaturalGas Unmitigated	0.15	1.38	1.16	0.01		0.00	0.10		0.00	0.10		1,655.44		0.03	0.03	1,665.51
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

5.2 Energy by Land Use - NaturalGas

Unmitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU	lb/day										lb/day					
Research & Development	14071.2	0.15	1.38	1.16	0.01		0.00	0.10		0.00	0.10		1,655.44		0.03	0.03	1,665.51
Total		**0.15**	**1.38**	**1.16**	**0.01**		**0.00**	**0.10**		**0.00**	**0.10**		**1,655.44**		**0.03**	**0.03**	**1,665.51**

5.2 Energy by Land Use - NaturalGas

Mitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU	lb/day										lb/day					
Research & Development	14.0712	0.15	1.38	1.16	0.01		0.00	0.10		0.00	0.10		1,655.44		0.03	0.03	1,665.51
Total		**0.15**	**1.38**	**1.16**	**0.01**		**0.00**	**0.10**		**0.00**	**0.10**		**1,655.44**		**0.03**	**0.03**	**1,665.51**

6.0 Area Detail

6.1 Mitigation Measures Area

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
Category	lb/day										lb/day					
Mitigated	5.55	0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00		0.00		0.00
Unmitigated	5.55	0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00		0.00		0.00
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

6.2 Area by SubCategory

Unmitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
SubCategory	lb/day										lb/day					
Architectural Coating	1.27					0.00	0.00		0.00	0.00						0.00
Consumer Products	4.28					0.00	0.00		0.00	0.00						0.00
Landscaping	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00		0.00		0.00
Total	**5.55**	**0.00**	**0.00**	**0.00**		**0.00**	**0.00**		**0.00**	**0.00**		**0.00**		**0.00**		**0.00**

Mitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
SubCategory	lb/day										lb/day					
Architectural Coating	1.27					0.00	0.00		0.00	0.00						0.00
Consumer Products	4.28					0.00	0.00		0.00	0.00						0.00
Landscaping	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00		0.00		0.00
Total	**5.55**	**0.00**	**0.00**	**0.00**		**0.00**	**0.00**		**0.00**	**0.00**		**0.00**		**0.00**		**0.00**

7.0 Water Detail

7.1 Mitigation Measures Water

8.0 Waste Detail

8.1 Mitigation Measures Waste

9.0 Vegetation

Appendix E

Emissions Estimates – Phase 1 Operations

Table E-1
Phase 1 Operations Input Assumptions for Emission Rate Calculations

Source	Source Parameter	Unit Size (units)	Short Term Input (units)	Annual Input (units)
Employee and Facility Data				
	Number of Employees	--	1,300 (1)	--
	Average Occupancy (for vehicle trip calculation)	--	16 (hrs/day)	260 (days/yr) (2)
Diesel Emergency Generators				
	Emergency Generator Usage	--	2 (hrs/day) (3)	25.15 (hrs/yr) (3)
	Building 9 Emergency Generator	440 (BHP) (4)	22.3 (gal/hr) (a)	--
	Building 8 Emergency Generator	440 (BHP) (4)	22.3 (gal/hr) (a)	--
	Building 6 Emergency Generator	440 (BHP) (4)	22.3 (gal/hr) (a)	--
	Building 7 Emergency Generator	440 (BHP) (4)	22.3 (gal/hr) (a)	--
Natural Gas Boilers				
	Building 9 Natural Gas Boiler	12 (MMBtu/hr) (4)	24 (hrs/day)	21,000 (MMBtu/yr) (4)
	Building 8 Natural Gas Boiler	12 (MMBtu/hr) (4)	24 (hrs/day)	21,000 (MMBtu/yr) (4)
	Building 6 & 7 Natural Gas Boiler	24 (MMBtu/hr) (4)	24 (hrs/day)	42,000 (MMBtu/yr) (4)
Cooling Towers				
	Cooling Tower Usage		24 (hrs/day)	6,360 (hrs/yr) (7)
	Cooling Tower Design	**Number of Cells**	**Cell Size**	**Total Recirculation Rate**
	Building 9 Cooling Tower	3 (cells) (4)	500 (tons/cell) (4)	4,500 (gpm) (b)
	Building 8 Cooling Tower	3 (cells) (4)	500 (tons/cell) (4)	4,500 (gpm) (b)
	Building 6 & 7 Cooling Tower	6 (cells) (4)	500 (tons/cell) (4)	9,000 (gpm) (b)
Laboratory Chemicals				
	Lab Hood Exhaust Stack - Building 9	--	10 (hrs/day) (8)	260 (days/yr) (2)
	Lab Hood Exhaust Stack - Building 8	--	10 (hrs/day) (8)	260 (days/yr) (2)
	Lab Hood Exhaust Stack - Buildings 6 & 7	--	10 (hrs/day) (8)	260 (days/yr) (2)
Vehicle Data				
	Vehicle Trips		**Maximum Daily (trips/day)**	**Average Annual (trips/yr)**
	Employee Trips		2,031 (9)	528,060 (10)
	Delivery Truck Trips		10 (11)	2,600 (11)
	LBNL - RBC Shuttle Trips		13 (12)	3,380 (12)
	BART - RBC Shuttle Trips		25 (12)	6,500 (12)
	Total trips		2,079	540,540
	Vehicle Idling Times and Round Trip Distances	**Onsite Idling Time (min/trip)**	**Onsite Round Trip Distance (mi/trip)**	**Offsite Round Trip Distance (mi/trip)**
	Employee Vehicles	0 (13)	0.697 (14)	20.6 (c)
	Delivery Trucks	0.08 (18)	0.697 (14)	13.9 (19)
	LBNL - RBC Shuttle	0.08 (20)	0.695 (14)	15.5 (21)
	BART - RBC Shuttle	0.08 (20)	0.695 (14)	8 (21)
	Employee Offsite Round Trip Distance - Modeling (mi/trip)			0.706 (14)
	Delivery Truck Offsite Round Trip Distance - Modeling (mi/trip)			0.706 (14)
	LBNL - RBC Shuttle Round Trip Distance - Modeling (mi/trip)			0.706 (14)
	BART - RBC Shuttle Round Trip Distance (mi/trip)			0.706 (14)
	Average Vehicle Weights			**Average Weight (tons)**
	Employee Vehicles			2.4 (22)
	Delivery Trucks			13 (23)
	LBNL - RBC Shuttle			4.2 (24)
	BART - RBC Shuttle			4.2 (24)
	Mean Vehicle Weight Calculation		**Daily Basis (tons)**	**Annual Basis (tons)**
	Employee Mean Vehicle Weight portion (ton)		2.34 (d)	2.34 (d)
	Delivery Truck Mean Vehicle Weight Portion (ton)		0.06 (d)	0.063 (d)
	LBNL - RBC Shuttle Mean Vehicle Weight Portion (ton)		0.026 (d)	0.026 (d)
	BART - RBC Shuttle Mean Vehicle Weight Portion (ton)		0.051 (d)	0.051 (d)
	Mean Vehicle Weight - sum of weight portions (ton)		2.48	2.48
Additional Site-Specific Data and Constants Used for Emission Calculations				
	Cooling Towers - Equivalent Ton Water Usage (gpm/ton)		3	(e)
	Cooling Towers - Total Dissolved Solids Concentration (ppm)		536	(25)
	Roads - P = No. of Days with Precip. > 0.01 in. (days/yr)		62	(26)

Notes:

(a) Engine fuel consumption (gal/hr) = (Engine size [hp]) x (average brake-specific fuel consumption [Btu/hp-hr]) / (liquid fuel higher heating value [Btu/gal])

Average brake-specific fuel consumption (Btu/hp-hr) =	7,000	(5)
Liquid fuel higher heating value (Btu/gal) =	138,000	(6)

(b) Recirculation rate (gpm) = (Number of cooling tower cells) x (heat removal equivalent tons per cell [tons/cell]) x (equivalent ton water usage [gpm/ton])

(c) Offsite round trip distance (mi/trip) = {(Primary trip length [mi]) x (primary trip percentage [%]) + (primary trip length [mi]) x (diverted trip percentage [%]) x (diverted trip percentage of primary trip length [%]) + (pass-by trip percentage [%]) x (pass-by trip length [mi])} x 2 - (onsite round trip distance [mi/trip])

Primary trip length (mi) =	12.4	(15)
Primary trip percentage (%) =	82	(16)
Diverted trip percentage of primary trip length (%) =	25	(17)
Diverted trip percentage (%) =	15	(16)
Pass-by trip length (mi) =	0.1	(17)
Pass-by trip percentage (%) =	3	(16)

(d) Mean vehicle weight portions (tons) = (Individual vehicle trips [trips/day or trips/yr]) / (total vehicle trips [trips/day or trips/yr]) x (individual vehicle average weight [tons])

(e) Equivalent ton water usage (gpm/ton) = (15,000 Btu/hr/ton) x (hr/60 min) x (gal/8.337 lbs) / (1 Btu/lb-°F) / (10 °F temperature differential)

References:

(1) January 17, 2013 LBNL response - population increase by approx. 1,000 over the current 300. Assume 1,300 trips per day.
(2) Assumes employees will generally be visiting the site 5 days per week, 52 weeks per year. This provides a conservative value to calculate the annual employee vehicle trips.
(3) Hourly value conservatively assumes a maximum of 2 hours per day of operation for maintenance and testing. Annual value is based on the average historical emergency engine usage from the LBNL LRDP.
(4) January 17, 2013 LBNL responses.
(5) AP-42 Chapter 3.3 (October 1996), Footnote to Table 3.3-1, "Emission Factors for Uncontrolled Gasoline and Diesel Industrial Engines".
(6) ULSD higher heating value.
(7) January 31, 2013 I.R. responses. Assumes cooling tower fans are off 2,400 hours per year, and only operate at full speed 260 hours per year.
(8) Assumes laboratory work is conducted over 10 hours per day. This conservatively estimates hourly emissions .
(9) Updated traffic information provided by LBNL (RBC LRDP TIA 20130301.pdf)
(10) Assumes daily worker trips will occur 5 days per week, 52 weeks per year.
(11) January 31, 2013 I.R. responses. Assumes that the 10 weekly trips will occur over 5 days per week, 52 weeks per year.
(12) Shuttle schedule provided by LBNL. Assumes shuttle trips occur 5 days per week, 52 weeks per year.
(13) It is assumed that employee vehicles will have negligible idling time.
(14) Onsite and offsite modeling trip distances approximated using the AERMOD modeling software.
(15) CalEEMod Appendix D Table 4.2 "Mobile Trip Characteristics Dependent on Location", Bay Area AQMD. Light duty employee vehicle route is based on the urban home to work (H-W) trip length. Trip lengths in CalEEMod are one way.
(16) CalEEMod Appendix D Table 4.3 "Mobile Trip Rates, Trip Purpose, Trip Type by Land Use", Commercial Land Use Type, Research and Development Land Use Sub Type.
(17) CalEEMod Appendix A Section 5.1, Vehicle Trips. "For pass-by trip links the trip length will be 0.1 miles and diverted trip links the trip length will be 25% of the primary trip length".
(18) Assumes 5 minutes of idle time consistent with California Code of Regulations Section 2485, Airborne Toxic Control Measure to Limit Diesel-Fueled Commercial Motor Vehicle Idling.
(19) CalEEMod Appendix D Table 4.2 "Mobile Trip Characteristics Dependent on Location", Bay Area AQMD. Delivery truck route is based on the urban commercial-NW route. Trip lengths in CalEEMod are one way.
(20) Conservative estimate of idling time for each shuttle drop-off event.
(21) Shuttle bus routes and schedules provided by LBNL.
(22) CalEEMod Appendix D Table 4.1 "Road Characteristics". Average vehicle weight for Bay Area AQMD.
(23) Based on the EMFAC vehicle class used for estimating emissions: T6 instate small, which has the higher VMT of all comparable categories, and is representative of delivery trucks. Max GVWR = 26,000 lbs. Also assumes that LBNL would not be the final destination for deliveries, so only a nominal difference between loaded and unloaded weights is used.
(24) Ford E150 XLT - 5,700 lb curb weight, plus 15 passengers at ~180 lbs/person.
(25) From CRT project emissions calculations, provided by Impact Sciences.
(26) Comparative Climatic Data, National Climatic Data Center, NOAA, 2011. 84 year average for San Francisco AP, CA.

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Table E-2
Summary of Offsite On-Road Exhaust Criteria Pollutant Emission Estimates

Pollutant	Vehicle Type	EMFAC Vehicle Class	Maximum Daily Round-Trips [1] (trips/day)	Total Annual Round-Trips [1] (trips/yr)	Round-Trip Distance [1] (miles)	Emission Factors [2] (lbs/VMT)	Maximum Daily Emissions Estimate [a] (lbs/day)	Annual Average Emissions Estimate [b] (tons/yr)
ROG	Delivery Trucks	T6 Instate Small	10.0	2,600	14	3.9E-04	5.4E-02	7.1E-03
	LBNL - RBC Shuttle	MDV	13	3,380	16	3.7E-04	7.5E-02	9.8E-03
	BART - RBC Shuttle	MDV	25	6,500	8.0	3.7E-04	7.5E-02	9.7E-03
	Employees	LDA	2,031	528,060	21	1.5E-04	6.1	0.79
	Total ROG Emissions						**6.3**	**0.82**
NO_X	Delivery Trucks	T6 Instate Small	10	2,600	14	5.1E-03	0.71	9.2E-02
	LBNL - RBC Shuttle	MDV	13	3,380	16	6.6E-04	0.13	1.7E-02
	BART - RBC Shuttle	MDV	25	6,500	8.0	6.6E-04	0.13	1.7E-02
	Employees	LDA	2,031	528,060	21	1.9E-04	8.1	1.1
	Total NO_X Emissions						**9.1**	**1.2**
CO	Delivery Trucks	T6 Instate Small	10.0	2,600	14	1.3E-03	0.19	2.4E-02
	LBNL - RBC Shuttle	MDV	13	3,380	16	4.6E-03	0.92	0.12
	BART - RBC Shuttle	MDV	25	6,500	8.0	4.6E-03	0.92	0.12
	Employees	LDA	2,031	528,060	21	1.9E-03	80	10
	Total CO Emissions						**82**	**11**
SO_2	Delivery Trucks	T6 Instate Small	10.0	2,600	14	2.5E-05	3.4E-03	4.5E-04
	LBNL - RBC Shuttle	MDV	13	3,380	16	1.3E-05	2.6E-03	3.4E-04
	BART - RBC Shuttle	MDV	25	6,500	8.0	1.3E-05	2.6E-03	3.4E-04
	Employees	LDA	2,031	528,060	21	7.5E-06	0.31	4.1E-02
	Total SO_2 Emissions						**0.32**	**4.2E-02**
PM_{10} Exhaust	Delivery Trucks	T6 Instate Small	10.0	2,600	14	1.9E-04	2.7E-02	3.5E-03
	LBNL - RBC Shuttle	MDV	13	3,380	16	4.7E-06	9.4E-04	1.2E-04
	BART - RBC Shuttle	MDV	25	6,500	8.0	4.7E-06	9.3E-04	1.2E-04
	Employees	LDA	2,031	528,060	21	3.8E-06	0.16	2.1E-02
	Total PM_{10} Emissions						**0.19**	**2.4E-02**
PM_{10} Tire/Brake	Delivery Trucks	T6 Instate Small	10.0	2,600	14	3.1E-04	4.4E-02	5.7E-03
	LBNL - RBC Shuttle	MDV	13	3,380	16	9.9E-05	2.0E-02	2.6E-03
	BART - RBC Shuttle	MDV	25	6,500	8.0	9.9E-05	2.0E-02	2.6E-03
	Employees	LDA	2,031	528,060	21	9.9E-05	4.1	0.54
	Total PM_{10} Emissions						**4.2**	**0.55**
$PM_{2.5}$ Exhaust	Delivery Trucks	T6 Instate Small	10.0	2,600	14	1.8E-04	2.5E-02	3.2E-03
	LBNL - RBC Shuttle	MDV	13	3,380	16	4.3E-06	8.7E-04	1.1E-04
	BART - RBC Shuttle	MDV	25	6,500	8.0	4.3E-06	8.6E-04	1.1E-04
	Employees	LDA	2,031	528,060	21	3.5E-06	0.15	1.9E-02
	Total $PM_{2.5}$ Emissions						**0.17**	**2.3E-02**
$PM_{2.5}$ Tire/Brake	Delivery Trucks	T6 Instate Small	10.0	2,600	14	1.3E-04	1.8E-02	2.3E-03
	LBNL - RBC Shuttle	MDV	13	3,380	16	3.9E-05	7.9E-03	1.0E-03
	BART - RBC Shuttle	MDV	25	6,500	8.0	3.9E-05	7.8E-03	1.0E-03
	Employees	LDA	2,031	528,060	21	3.9E-05	1.6	0.21
	Total $PM_{2.5}$ Emissions						**1.7**	**0.22**
CO_2	Delivery Trucks	T6 Instate Small	10.0	2,600	14	2.4	337	44
	LBNL - RBC Shuttle	MDV	13	3,380	16	1.1	221	29
	BART - RBC Shuttle	MDV	25	6,500	8.0	1.1	219	28
	Employees	LDA	2,031	528,060	21	0.56	23,569	3,064
	Total CO_2 Emissions						**24,345**	**3,165**

Notes:
(a) Maximum daily emissions estimate (lbs/day) = (Maximum daily round-trips [trips/day]) x (round-trip distance [miles]) x (emission factor [lbs/VMT])
(b) Annual average emissions estimate (tons/yr) = (Annual round-trips [trips/yr]) x (round-trip distance [miles]) x (emission factor [lbs/VMT]) x (ton/2,000 lbs)

References:
(1) See Table E-1, Phase 1 Operations Input Assumptions for Emission Rate Calculations.
(2) Emission Factors source: Emfac 2011 (Model Years to 2018), typical speed distribution. Carbon dioxide emission factors are representative of post-Low Carbon Fuel Standard implementation.

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Table E-3
Summary of Onsite On-Road Exhaust Criteria Pollutant Emission Estimates

Pollutant	Vehicle Type	EMFAC Vehicle Class	Maximum Daily Round-Trips [1] (trips/day)	Total Annual Round-Trips [1] (trips/yr)	Round-Trip Distance [1] (miles)	Emission Factor [2] (lbs/VMT)	Maximum Daily Emissions Estimate [a] (lbs/day)	Annual Average Emissions Estimate [b] (tons/yr)
ROG	Delivery Trucks	T6 Instate Small	10.0	2,600	0.70	2.1E-03	1.5E-02	1.9E-03
	LBNL - RBC Shuttle	MDV	13	3,380	0.70	4.7E-04	4.2E-03	5.5E-04
	BART - RBC Shuttle	MDV	25	6,500	0.70	4.7E-04	8.1E-03	1.1E-03
	Employees	LDA	2,031	528,060	0.70	1.6E-04	0.23	2.9E-02
	Total ROG Emissions						**0.25**	**3.3E-02**
NO_X	Delivery Trucks	T6 Instate Small	10.0	2,600	0.70	1.1E-02	7.8E-02	1.0E-02
	LBNL - RBC Shuttle	MDV	13	3,380	0.70	1.0E-03	9.3E-03	1.2E-03
	BART - RBC Shuttle	MDV	25	6,500	0.70	1.0E-03	1.8E-02	2.3E-03
	Employees	LDA	2,031	528,060	0.70	2.9E-04	0.41	5.4E-02
	Total NO_X Emissions						**0.52**	**6.8E-02**
CO	Delivery Trucks	T6 Instate Small	10.0	2,600	0.70	3.9E-03	2.7E-02	3.6E-03
	LBNL - RBC Shuttle	MDV	13	3,380	0.70	8.0E-03	7.2E-02	9.4E-03
	BART - RBC Shuttle	MDV	25	6,500	0.70	8.0E-03	0.14	1.8E-02
	Employees	LDA	2,031	528,060	0.70	3.3E-03	4.7	0.61
	Total CO Emissions						**4.9**	**0.64**
SO_2	Delivery Trucks	T6 Instate Small	10.0	2,600	0.70	0	0	0
	LBNL - RBC Shuttle	MDV	13	3,380	0.70	0	0	0
	BART - RBC Shuttle	MDV	25	6,500	0.70	0	0	0
	Employees	LDA	2,031	528,060	0.70	0	0	0
	Total SO_2 Emissions						**0**	**0**
PM_{10} Exhaust	Delivery Trucks	T6 Instate Small	10.0	2,600	0.70	2.8E-04	2.0E-03	2.5E-04
	LBNL - RBC Shuttle	MDV	13	3,380	0.70	1.9E-05	1.7E-04	2.2E-05
	BART - RBC Shuttle	MDV	25	6,500	0.70	1.9E-05	3.3E-04	4.2E-05
	Employees	LDA	2,031	528,060	0.70	1.6E-05	2.2E-02	2.9E-03
	Total PM_{10} Emissions						**2.5E-02**	**3.2E-03**
PM_{10} Tire/Brake	Delivery Trucks	T6 Instate Small	10.0	2,600	0.70	0	0	0
	LBNL - RBC Shuttle	MDV	13	3,380	0.70	0	0	0
	BART - RBC Shuttle	MDV	25	6,500	0.70	0	0	0
	Employees	LDA	2,031	528,060	0.70	0	0	0
	Total PM_{10} Emissions						**0**	**0**
$PM_{2.5}$ Exhaust	Delivery Trucks	T6 Instate Small	10.0	2,600	0.70	2.6E-04	1.8E-03	2.3E-04
	LBNL - RBC Shuttle	MDV	13	3,380	0.70	1.7E-05	1.6E-04	2.0E-05
	BART - RBC Shuttle	MDV	25	6,500	0.70	1.7E-05	3.0E-04	3.9E-05
	Employees	LDA	2,031	528,060	0.70	1.4E-05	2.0E-02	2.7E-03
	Total $PM_{2.5}$ Emissions						**2.3E-02**	**3.0E-03**
$PM_{2.5}$ Tire/Brake	Delivery Trucks	T6 Instate Small	10.0	2,600	0.70	0	0	0
	LBNL - RBC Shuttle	MDV	13	3,380	0.70	0	0	0
	BART - RBC Shuttle	MDV	25	6,500	0.70	0	0	0
	Employees	LDA	2,031	528,060	0.70	0	0	0
	Total $PM_{2.5}$ Emissions						**0**	**0**
CO_2	Delivery Trucks	T6 Instate Small	10.0	2,600	0.70	4.4	31	4.0
	LBNL - RBC Shuttle	MDV	13	3,380	0.70	2.6	24	3.1
	BART - RBC Shuttle	MDV	25	6,500	0.70	2.6	45	5.9
	Employees	LDA	2,031	528,060	0.70	1.3	1,888	245
	Total CO_2 Emissions						**1,988**	**258**

Notes:
(a) Maximum daily emissions estimate (lbs/day) = (Maximum daily round-trips [trips/day]) x (round-trip distance [miles]) x (emission factor [lbs/VMT])
(b) Annual average emissions estimate (tons/yr) = (Annual round-trips [trips/yr]) x (round-trip distance [miles]) x (emission factor [lbs/VMT]) x (ton/2,000 lbs)

References:
(1) See Table E-1, Phase 1 Operations Input Assumptions for Emission Rate Calculations.
(2) Emission Factors source: EMFAC 2011 (Model Years to 2018), 30 mph speed. Carbon dioxide emission factors are representative of post-Low Carbon Fuel Standard implementation.

Table E-4
Summary of Onsite Idling Exhaust Criteria Pollutant Emission Estimates

Pollutant	Vehicle Type	EMFAC Vehicle Class	Maximum Daily Round-Trips [1] (trips/day)	Total Annual Round-Trips [1] (trips/yr)	Idle Time per Trip [1] (hrs/trip)	Idle Emission Factor [2] (lbs/idle-hour)	Maximum Daily Emissions Estimate [a] (lbs/day)	Annual Average Emissions Estimate [b] (tons/yr)
ROG	Delivery Trucks	T6 Instate Small	10.0	2,600	8.3E-02	4.3E-03	3.6E-03	4.6E-04
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	3.6E-03	3.9E-03	5.1E-04
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	3.6E-03	7.5E-03	9.7E-04
	Employees	LDA	2,031	528,060	0	1.2E-03	0	0
	Total ROG Emissions						**1.5E-02**	**1.9E-03**
NO_X	Delivery Trucks	T6 Instate Small	10.0	2,600	8.3E-02	0.15	0.12	1.6E-02
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	6.0E-03	6.5E-03	8.4E-04
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	6.0E-03	1.2E-02	1.6E-03
	Employees	LDA	2,031	528,060	0	1.7E-03	0	0
	Total NO_X Emissions						**0.14**	**1.8E-02**
CO	Delivery Trucks	T6 Instate Small	10.0	2,600	8.3E-02	4.9E-02	4.1E-02	5.3E-03
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	4.7E-02	5.1E-02	6.6E-03
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	4.7E-02	9.8E-02	1.3E-02
	Employees	LDA	2,031	528,060	0	1.9E-02	0	0
	Total CO Emissions						**0.19**	**2.5E-02**
SO_2	Delivery Trucks	T6 Instate Small	10.0	2,600	8.3E-02	1.6E-04	1.3E-04	1.7E-05
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	0	0	0
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	0	0	0
	Employees	LDA	2,031	528,060	0	0	0	0
	Total SO_2 Emissions						**1.3E-04**	**1.7E-05**
PM_{10} Exhaust	Delivery Trucks	T6 Instate Small	10.0	2,600	8.3E-02	4.8E-04	4.0E-04	5.2E-05
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	1.5E-04	1.6E-04	2.1E-05
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	1.5E-04	3.1E-04	4.1E-05
	Employees	LDA	2,031	528,060	0	1.2E-04	0	0
	Total PM_{10} Emissions						**8.7E-04**	**1.1E-04**
$PM_{2.5}$ Exhaust	Delivery Trucks	T6 Instate Small	10.0	2,600	8.3E-02	4.4E-04	3.6E-04	4.7E-05
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	1.4E-04	1.5E-04	2.0E-05
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	1.4E-04	2.9E-04	3.8E-05
	Employees	LDA	2,031	528,060	0	1.1E-04	0	0
	Total $PM_{2.5}$ Emissions						**8.0E-04**	**1.0E-04**
CO_2	Delivery Trucks	T6 Instate Small	10.0	2,600	8.3E-02	16	13	1.7
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	18	19	2.5
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	18	37	4.8
	Employees	LDA	2,031	528,060	0	9.1	0	0
	Total CO_2 Emissions						**69**	**9.0**

Notes:
(a) Maximum daily emissions estimate (lbs/day) = (Maximum daily round-trips [trips/day]) x (idle time per trip [hrs/trip]) x (emission factor [lbs/idle-hr])
(b) Annual average emissions estimate (tons/yr) = (Annual round-trips [trips/yr]) x (idle time per trip [hrs/trip]) x (emission factor [lbs/idle-hr]) x (ton/2,000 lbs)

References:
(1) See Table E-1, Phase 1 Operations Input Assumptions for Emission Rate Calculations.
(2) Emission Factors source: EMFAC 2011 (Model Years to 2018). Emissions for Light Duty Vehicle Idling assumed to be negligible, and thus not quantified. Carbon dioxide emission factors are representative of post-Low Carbon Fuel Standard implementation.

Table E-5

Onsite Parking Lot Emission Estimates

Source		Parking Lot (total)
EMFAC Vehicle Class	(1)	LDA
Number of Vehicle Trips per Day	(2)	2,031
Number of Vehicle Trips per Year	(2)	528,060
Modeling ID		LOT_EX

Pollutant	Emission Factor (3) (lbs/trip)	Maximum Daily Emissions Estimate (a) (lbs/day)	Annual Average Emissions Estimate (b) (tons/yr)
PM_{10}	6.97E-06	0.014	1.8E-03
$PM_{2.5}$	6.45E-06	0.013	1.7E-03
NO_X	2.62E-04	0.53	0.069
CO	4.37E-03	8.88	1.15
SO_2	1.70E-06	3.5E-03	4.5E-04
ROG	7.14E-04	1.45	0.19
CO_2	0.16	330	42.9

Notes:

(a) Daily emissions estimate (lbs/day) = (Emission factor [lbs/trip]) x (number of vehicle trips per day)

(b) Annual emissions estimate (lbs/day) = (Emission factor [lbs/trip]) x (number of vehicle trips per year) x (ton/2,000 lbs)

References:

(1) LDA represents light-duty employee vehicles.

(2) See Table E-1, Phase 1 Operations Input Assumptions for Emission Rate Calculations.

(3) EMFAC 2011. Emission factors are based on the stationary starting exhaust, diurnal, hot soak, and resting loss vehicle portions of the LDA class emissions, on a per trip basis.

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Table E-6
Onsite Paved Road Dust Emission Estimates

Parameter		Employee Vehicles	Delivery Trucks	LBNL - RBC Shuttle	BART - RBC Shuttle	Total
Onsite Roundtrip Distance (mi/trip)	(1)	0.7	0.7	0.7	0.7	
Maximum Daily Trips (trips/day)	(1)	2,031	10	13	25	
Annual Trips (trips/yr)	(1)	528,060	2,600	3,380	6,500	

Pollutant	Daily Emission Factor [a] (lbs/VMT)	Annual Emission Factor [b] (lbs/VMT)	Maximum Daily Emissions Estimate [c] (lbs/day)	Annual Average Emissions Estimate [d] (tons/yr)	Maximum Daily Emissions Estimate [c] (lbs/day)	Annual Average Emissions Estimate [d] (tons/yr)	Maximum Daily Emissions Estimate [c] (lbs/day)	Annual Average Emissions Estimate [d] (tons/yr)	Maximum Daily Emissions Estimate [c] (lbs/day)	Annual Average Emissions Estimate [d] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate (tons/yr)
PM	9.9E-03	9.4E-03	14.0	1.74	0.069	8.6E-03	0.089	0.011	0.17	0.021	14.3	1.78
PM_{10}	2.0E-03	1.9E-03	2.79	0.35	0.014	1.7E-03	0.018	2.2E-03	0.034	4.3E-03	2.86	0.36
$PM_{2.5}$	4.8E-04	4.6E-04	0.69	0.085	3.4E-03	4.2E-04	4.4E-03	5.4E-04	8.4E-03	1.0E-03	0.70	0.087

Notes:

(a) Maximum daily emission factor (lbs/VMT) = $(k \times (sL)^{0.91} \times (W)^{1.02})$

k = aerodynamic particle size multiplier (PM) =	0.011	(2)
k = aerodynamic particle size multiplier (PM_{10}) =	0.0022	(2)
k = aerodynamic particle size multiplier ($PM_{2.5}$) =	0.00054	(2)
sL = surface material silt content (g/m^2) =	0.32	(3)
W = mean vehicle weight (tons) =	2.5	(4)

(b) Annual emission factor (lbs/VMT) = $(k \times (sL)^{0.91} \times (W)^{1.02}) \times ((1-P)/4N)$

k = aerodynamic particle size multiplier (PM) =	0.011	(2)
k = aerodynamic particle size multiplier (PM_{10}) =	0.0022	(2)
k = aerodynamic particle size multiplier ($PM_{2.5}$) =	0.00054	(2)
sL = surface material silt content (g/m^2) =	0.32	(3)
W = mean vehicle weight (tons) =	2.5	(4)
P = number of wet days (0.01 inches of precip.) =	62	(1)
N = number of days in averaging period =	365	

(c) Maximum daily emissions estimate (lbs/day) = (Emission factor [lbs/VMT]) x (maximum daily vehicle trips [trips/day]) x (onsite roundtrip distance [mi/trip]) x (1 - [control efficiency {%}] / 100)

Control efficiency (%) =	0%	(5)

(d) Annual emissions estimate (tons/yr) = (Emission factor [lbs/VMT]) x (annual vehicle trips [trips/yr]) x (onsite roundtrip distance [mi/trip]) x (ton/2,000 lbs) x (1 - [control efficiency {%}] / 100)

Control efficiency (%) =	0%	(5)

References:

(1) See Table E-1, Phase 1 Operations Input Assumptions for Emission Rate Calculations.
(2) AP-42 Chapter 13.2.1 (January, 2011), Table 13.2.1-1 "Particle Size Multipliers for Paved Road Equation".
(3) Section 7.9 of the CARB Emission Inventory Methodology. Assumes offsite roads are equivalent to local roads as shown in Table 3 (silt loading of 0.32 g/m^2).
(4) Mean vehicle weight is calculated as the weighted average of the individual vehicle weights (average of unloaded and loaded weight), weighted based on the individual annual truck trips divided by total annual truck trips.
(5) Engineering estimate.

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Table E-7
Offsite Paved Road Dust Emission Estimates

Parameter		Employee Vehicles	Delivery Trucks	LBNL - RBC Shuttle	BART - RBC Shuttle	Total
Offsite Roundtrip Distance (mi/trip)	(1)	21	14	16	8	
Maximum Daily Trips (trips/day)	(1)	2,031	10	13	25	
Annual Trips (trips/yr)	(1)	528,060	2,600	3,380	6,500	

Pollutant	Daily Emission Factor [a] (lbs/VMT)	Annual Emission Factor [b] (lbs/VMT)	Maximum Daily Emissions Estimate [c] (lbs/day)	Annual Average Emissions Estimate [d] (tons/yr)	Maximum Daily Emissions Estimate [c] (lbs/day)	Annual Average Emissions Estimate [d] (tons/yr)	Maximum Daily Emissions Estimate [c] (lbs/day)	Annual Average Emissions Estimate [d] (tons/yr)	Maximum Daily Emissions Estimate [c] (lbs/day)	Annual Average Emissions Estimate [d] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate (tons/yr)
PM	1.3E-03	1.2E-03	53.1	6.61	0.18	0.022	0.26	0.032	0.25	0.032	53.8	6.70
PM_{10}	2.5E-04	2.4E-04	10.6	1.32	0.035	4.4E-03	0.051	6.4E-03	0.051	6.3E-03	10.8	1.34
$PM_{2.5}$	6.2E-05	6.0E-05	2.61	0.32	8.7E-03	1.1E-03	0.013	1.6E-03	0.012	1.6E-03	2.64	0.33

Notes:

(a) Maximum daily emission factor (lbs/VMT) = $(k \times (sL)^{0.91} \times (W)^{1.02})$

k = aerodynamic particle size multiplier (PM) =	0.011	(2)
k = aerodynamic particle size multiplier (PM_{10}) =	0.0022	(2)
k = aerodynamic particle size multiplier ($PM_{2.5}$) =	0.00054	(2)
sL = surface material silt content (g/m^2) =	0.035	(3)
W = mean vehicle weight (tons) =	2.4	(3)

(b) Annual emission factor (lbs/VMT) = $(k \times (sL)^{0.91} \times (W)^{1.02}) \times ((1-P)/4N)$

k = aerodynamic particle size multiplier (PM) =	0.011	(2)
k = aerodynamic particle size multiplier (PM_{10}) =	0.0022	(2)
k = aerodynamic particle size multiplier ($PM_{2.5}$) =	0.00054	(2)
sL = surface material silt content (g/m^2) =	0.035	(3)
W = mean vehicle weight (tons) =	2.4	(3)
P = number of wet days (0.01 inches of precip.) =	62	(1)
N = number of days in averaging period =	365	

(c) Maximum daily emissions estimate (lbs/day) = (Emission factor [lbs/VMT]) x (maximum daily vehicle trips [trips/day]) x (offsite roundtrip distance [mi/trip]) x (1 - [control efficiency {%}] / 100)

Control efficiency (%) = 0% (4)

(d) Annual emissions estimate (tons/yr) = (Emission factor [lbs/VMT]) x (annual vehicle trips [trips/yr]) x (offsite roundtrip distance [mi/trip]) x (ton/2,000 lbs) x (1 - [control efficiency {%}] / 100)

Control efficiency (%) = 0% (4)

References:

(1) See Table E-1, Phase 1 Operations Input Assumptions for Emission Rate Calculations.
(2) AP-42 Chapter 13.2.1 (January, 2011), Table 13.2.1-1 "Particle Size Multipliers for Paved Road Equation".
(3) Section 7.9 of the CARB Emission Inventory Methodology. Assumes offsite roads are equivalent to major/collector roads as shown in Table 3 (silt loading of 0.035 g/m^2).
(4) Engineering estimate.

Table E-8
Natural Gas Boiler Criteria Emission Estimates

Source		Natural Gas Boiler - Building 9	Natural Gas Boiler - Building 8	Natural Gas Boiler - Buildings 6 and 7	Total
Maximum Hourly Fuel Usage (MMBtu/hr)	(1)	12	12	24	
Daily Hours of Operation (hrs/day)	(1)	24	24	24	
Annual Fuel Usage (MMBtu/yr)	(1)	21,000	21,000	42,000	
Modeling ID		NGB_B9	NGB_B8	NGB_B6_7	

Pollutant	Emission Factor (lbs/MMscf)		Maximum Daily Emissions Estimate [(a)] (lbs/day)	Annual Average Emissions Estimate [(b)] (tons/yr)	Maximum Daily Emissions Estimate [(a)] (lbs/day)	Annual Average Emissions Estimate [(b)] (tons/yr)	Maximum Daily Emissions Estimate [(a)] (lbs/day)	Annual Average Emissions Estimate [(b)] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate (tons/yr)
PM	7.60	(2)	2.15	0.078	2.15	0.078	4.29	0.16	8.58	0.31
PM_{10}	7.60	(3)	2.15	0.078	2.15	0.078	4.29	0.16	8.58	0.31
$PM_{2.5}$	7.60	(3)	2.15	0.078	2.15	0.078	4.29	0.16	8.58	0.31
NO_X	18.72	(c)	5.28	0.19	5.28	0.19	10.6	0.39	21.1	0.77
CO	84	(5)	23.7	0.86	23.7	0.86	47.4	1.73	94.9	3.46
SO_2	0.6	(2)	0.17	6.2E-03	0.17	6.2E-03	0.34	0.012	0.68	0.025
VOC	5.5	(2)	1.55	0.057	1.55	0.057	3.11	0.11	6.21	0.23
CO_2	120,162	(d)	33,928	1,237	33,928	1,237	67,856	2,474	135,712	4,948
CH_4	2.27	(e)	0.64	0.023	0.64	0.023	1.28	0.047	2.56	0.093
N_2O	0.23	(e)	0.064	2.3E-03	0.064	2.3E-03	0.13	4.7E-03	0.26	9.3E-03
CO_2e	120,280	(f)	33,961	1,238	33,961	1,238	67,923	2,476	135,846	4,953

Notes:

(a) Daily emissions estimate (lbs/day) = (Emission factor [lbs/MMscf]) x (maximum hourly heat input [MMBtu/hr]) x (daily hours of operation [hrs/day]) / (natural gas heat content [Btu/scf])

Natural gas heat content (Btu/scf) = 1,020 (2)

(b) Annual emissions estimate (tons/yr) = (emission factor [lbs/MMscf]) x (annual heat input [MMBtu/yr]) / (natural gas heat content [Btu/scf]) x (tons/2,000 lbs)

Natural gas heat content (Btu/scf) = 1,020 (2)

(c) Emission factor (lbs/MMscf) = (NO_2 or CO emission limit [ppmv @ 3% O_2]) x (10^{-6}) x (NO_2 or CO molecular weight [lbs/lb-mol]) x (lb-mol/385.44 ft^3) x (natural gas f-factor [8,710 dscf/MMBtu]) x (20.9% O_2/[20.9% O_2 - 3% O_2]) x (heat content [Btu/scf])

BAAQMD NO_X emission limit (ppmv @ 3% O_2) = 15 (4)

BAAQMD CO emission limit (ppmv @ 3% O_2) = 400 (4)

NO_2 molecular weight (lbs/lb-mol) = 46

CO molecular weight (lbs/lb-mol) = 28.01

Natural gas heat content (Btu/scf) = 1,028 (6)

(d) CO_2 emission factor [lbs/MMscf] = (CO_2 emission factor [kg CO_2/MMBtu]) x (default high heat value (MMBtu/scf)) x (10^6 scf/MMscf) x (lb/0.453592 kg)

CO_2 emission factor (kg/MMBtu) = 53.02 (6)

Default high heat value (MMBtu/scf) = 1.028E-03 (6)

(e) CH_4 or N_2O emission factor (lbs/MMscf) = (CH_4 or N_2O emission factor [kg/MMBtu]) x (lb/0.453592 kg) x (natural gas heat content [Btu/scf])

CH_4 emission factor (kg/MMBtu) = 1.0E-03 (7)

N_2O emission factor (kg/MMBtu) = 1.0E-04 (7)

Natural gas heat content (Btu/scf) = 1,028 (6)

(f) CO_2e emission factor (lbs/MMscf) = (CO_2 emission factor [lbs/MMscf]) + (CH_4 emission factor [lbs/MMscf] x CH_4 global warming potential) + (N_2O emission factor [lbs/MMscf] x N_2O global warming potential)

Global warming potential of CH_4 = 21 (8)

Global warming potential of N_2O = 310 (8)

References:

(1) See Table E-1, Phase 1 Operations Input Assumptions for Emission Rate Calculations.
(2) AP-42 Chapter 1.4 (July 1998), Table 1.4-2 "Emission Factors for Criteria Pollutants and Greenhouse Gases from Natural Gas Combustion".
(3) Assumes that 100% of PM is $PM_{2.5}$. Therefore, 100% of PM_{10} is $PM_{2.5}$.
(4) BAAQMD Emission Limits 307.2, 307.3, and 307.4 from Section 9-7-307.
(5) AP-42 Chapter 1.4 (July 1998), Table 1.4-1 "Emission Factors for NO_X and CO from Natural Gas Combustion".
(6) 40 CFR Part 98 Subpart C, Table C-1, Default CO_2 Emission Factors and High Heat Values for Various Types of Fuel.
(7) 40 CFR Part 98 Subpart C, Table C-2, Default CH_4 and N_2O Emission Factors for Various Types of Fuel.
(8) 40 CFR Part 98 Subpart A, Table A-1, Global Warming Potentials.

Table E-9

Emergency Diesel Generator Criteria Emission Estimates

Source	Diesel Generator - Building 9	Diesel Generator - Building 8	Diesel Generator - Building 6	Diesel Generator - Building 7	Total
Generator Power Rating (BHP) (1)	440	440	440	440	
Diesel Fuel Usage (gal/hr) (1)	22.3	22.3	22.3	22.3	
Load Factor (2)	0.74	0.74	0.74	0.74	
Annual Operation (hrs/yr) (1)	25.15	25.15	25.15	25.15	
Modeling ID	DG_B9	DG_B8	DG_B6	DG_B7	

Pollutant	Small Engine Emission Factor (g/hp-hr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate [a] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate [a] (tons/yr)	Large Engine Emission Factor (g/hp-hr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate [a] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate [a] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate (tons/yr)
PM	0.01 (3)	0.014 (b)	9.0E-05	0.014 (b)	9.0E-05	0.015 (4)	0.022 (b)	1.4E-04	0.022 (b)	1.4E-04	0.072	4.5E-04
PM_{10}	0.01 (3)	0.014 (b)	9.0E-05	0.014 (b)	9.0E-05	0.015 (4)	0.022 (b)	1.4E-04	0.022 (b)	1.4E-04	0.072	4.5E-04
$PM_{2.5}$	0.01 (3)	0.014 (b)	9.0E-05	0.014 (b)	9.0E-05	0.015 (4)	0.022 (b)	1.4E-04	0.022 (b)	1.4E-04	0.072	4.5E-04
NO_X	0.3 (4)	0.43 (b)	2.7E-03	0.43 (b)	2.7E-03	1.50 (4)	2.15 (b)	0.014	2.15 (b)	0.014	5.17	0.032
CO	2.2 (4)	3.16 (b)	0.020	3.16 (b)	0.020	2.60 (4)	3.73 (b)	0.023	3.73 (b)	0.023	13.8	0.087
SO_2	-- (5)	9.4E-03 (c)	5.9E-05	9.4E-03 (c)	5.9E-05	-- (5)	9.4E-03 (c)	5.9E-05	9.4E-03 (c)	5.9E-05	0.037	2.4E-04
VOC	0.14 (4)	0.20 (b)	1.3E-03	0.20 (b)	1.3E-03	0.14 (4)	0.20 (b)	1.3E-03	0.20 (b)	1.3E-03	0.80	5.1E-03
CO_2	-- (7)	996 (d)	6.26	996 (d)	6.26	-- (7)	996 (d)	6.26	996 (d)	6.26	3,984	25.1
CH_4	--	0.018 (9)	1.1E-04	0.018 (9)	1.1E-04	--	0.018 (9)	1.1E-04	0.018 (9)	1.1E-04	0.072	4.5E-04
CO_2e	--	996 (e)	6.27	996 (e)	6.27	--	996 (e)	6.27	996 (e)	6.27	3,986	25.1

Notes:

(a) Annual average emission estimate (tons/yr) = (Daily emissions [lbs/day]) / (daily hours of operation [hrs/day]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)

Daily hours of operation (hrs/day) = 2 (1)

(b) Maximum daily emission estimate (lbs/day) = (Emission factor [g/hp-hr]) x (generator power [hp]) x (load factor) x (maximum hours per day [hrs/day]) x (lb/453.59g)

Daily hours of operation (hrs/day) = 2 (1)

(c) Maximum daily emissions estimate (lbs/day) = (Fuel sulfur content [ppmw] / 10^6) x (generator fuel consumption [gal/hr]) x (generator usage [hrs/day]) x (diesel density [lbs/gal]) x ([SO_2 molecular weight {lbs/lb-mol}] / [sulfur molecular weight {lbs/lb-mol}])

Fuel sulfur content (ppmw) = 15 (6)
Diesel density (lbs/gal) = 7
SO_2 molecular weight (lbs/lb-mol) = 64
Sulfur molecular weight (lbs/lb-mol) = 32

(d) Maximum daily emissions estimate (lbs/day) = (Fuel carbon content [%] / 100) x (generator fuel consumption [gal/hr]) x (generator usage [hrs/day]) x (diesel density [lbs/gal]) x ([CO_2 molecular weight {lbs/lb-mol}] / [carbon molecular weight {lbs/lb-mol}])

Fuel carbon content (%) = 87 (8)
Diesel density (lbs/gal) = 7
CO_2 molecular weight (lbs/lb-mol) = 44.0
Carbon molecular weight (lbs/lb-mol) = 12.0

(e) CO_2e emissions (lbs/day) = (CO_2 emissions [lbs/day]) + (CH_4 emissions [lbs/day] x CH_4 global warming potential)

CH_4 Global Warming Potential (GWP) = 21 (10)

References:

(1) See Table E-1, Phase 1 Operations Input Assumptions for Emission Rate Calculations.
(2) Default load factor for generators in URBEMIS emissions model.
(3) LBNL has committed to purchasing engines that achieve 0.01 g/hp-hr particulate matter emissions. Assumes all PM is $PM_{2.5}$.
(4) CalEEMod Appendix D, Default Data Tables. Table 3.5, OFFROAD Emission Factor Based on Engine Tier. Assumes Tier 4 Final for LBNL-owned small engines (Buildings 9 and 8), and Tier 4 Interim for the Building 6&7 engine.
(5) Sulfur dioxide emissions calculated on a sulfur mass balance basis, assuming 100% of the fuel sulfur content is emitted as SO_2.
(6) California Code of Regulations Title 13, Division 3, Chapter 5, Article 2, Standards for Diesel Fuel.
(7) Carbon dioxide emissions calculated on a carbon mass balance basis, conservatively assuming 100% of the fuel carbon content is emitted as CO_2.
(8) AP-42 Chapter 3.3 (October 1996) and 3.4 (October 1996), Footnote to criteria emission factor table.
(9) Assumes methane is 9% of VOC, based on footnote f of Table 3.4-1 in AP-42, Chapter 3.4. VOC emission factor is shown as ROG/TOG in CalEEMod Appendix D ,Table 3.5.
(10) 40 CFR Part 98 Subpart A, Table A-1, Global Warming Potentials.

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Table E-10

Cooling Tower Particulate Emission Estimates

Source	Cooling Tower - Building 9	Cooling Tower - Building 8	Cooling Tower - Buildings 6 and 7	Total
Total Circulation Water Rate (gpm) (1)	4,500	4,500	9,000	
Drift Loss of Circulating Water (%) (2)	0.005	0.005	0.005	
Annual Operation (hrs/yr) (1)	6,360	6,360	6,360	
Modeling ID	CTB9C#	CTB8C#	CTB6_7C#	

Pollutant	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate [(a)] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate [(a)] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate [(a)] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate (tons/yr)
PM	1.45 (b)	0.19	1.45 (b)	0.19	2.90 (b)	0.38	5.79	0.77
PM_{10}	1.29 (c)	0.17	1.29 (c)	0.17	2.58 (c)	0.34	5.16	0.68
$PM_{2.5}$	0.77 (d)	0.10	0.77 (d)	0.10	1.55 (d)	0.21	3.09	0.41

Notes:

(a) Annual emissions estimate (tons/yr) = (Daily emissions [lbs/day]) / (daily hours of operation [hrs/day]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)

Daily hours of operation (hrs/day) = 24 (1)

(b) Maximum daily emissions estimate (lbs/day) = (Circulation water rate [gpm]) x (density of water [lbs/gal]) x (total dissolved solids concentration [ppmw]) x (10^{-6}) x (drift loss of circulating water [%] / 100) x (60 min/hr) x (daily hours of operation [hrs/day])

Total dissolved solids concentration (ppmw) = 536 (1)

Density of water (lbs/gal) = 8.34

Daily hours of operation (hrs/day) = 24 (1)

(c) Maximum daily emissions estimate (lbs/day) = (PM emissions estimate [lbs/day]) x (percent of PM_{10} emissions [%] / 100)

Percent of PM_{10} emissions (%) = 89.0 (3)

(d) Maximum daily emissions estimate (lbs/day) = (PM_{10} emissions estimate [lbs/day]) x ($PM_{2.5}$ fraction of PM_{10})

$PM_{2.5}$ fraction of PM_{10} = 0.6 (4)

References:

(1) See Table E-1, Phase 1 Operations Input Assumptions for Emission Rate Calculations.
(2) Engineering judgment based on past work with industrial cooling towers.
(3) From the technical paper "Calculating Realistic PM10 Emissions from Cooling Towers", by Joel Reisman and Gordon Frisbie. The percent PM_{10} is based on total dissolved content.
(4) From Appendix A - Updated CEIDARS Table with PM2.5 Fractions to the CEQA handbook, supplemental information.

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Table E-11
Phase 1 Operations Criteria Pollutant Emissions Summary

Source	Annual Days of Operation	TAC		Criteria												Greenhouse Gases							
		DPM		PM_{10}		$PM_{2.5}$		NO_X		CO		SO_2		VOC		CO_2		CH_4		N_2O		CO_2e	
		(lbs/day) [1]	(tons/yr)	(lbs/day) [1]	(tons/yr)	(lbs/day) [1]	(tons/yr)	(lbs/day) [1]	(tons/yr)	(lbs/day) [1]	(tons/yr)	(lbs/day) [1]	(tons/yr)	(lbs/day) [1]	(tons/yr)	(lbs/day) [1]	(tons/yr)	(lbs/day) [1]	(tons/yr)	(lbs/day) [1]	(tons/yr)	(lbs/day) [1]	(tons/yr)
Stationary Sources																							
Diesel generators	**260**	**3.5E-03**	**4.5E-04**	**3.5E-03**	**4.5E-04**	**3.5E-03**	**4.5E-04**	**0.25**	**3.2E-02**	**0.67**	**8.7E-02**	**1.8E-03**	**2.4E-04**	**3.9E-02**	**5.1E-03**	**193**	**25.1**	**3.5E-03**	**4.5E-04**	**--**	**--**	**193**	**25.1**
Natural Gas Boilers	**260**	**--**	**--**	**2.41**	**0.31**	**2.41**	**0.31**	**5.93**	**0.77**	**26.6**	**3.46**	**0.19**	**2.5E-02**	**1.74**	**0.23**	**38,060**	**4,948**	**0.72**	**9.3E-02**	**7.2E-02**	**9.3E-03**	**38,098**	**4,953**
Cooling Towers	**260**	**--**	**--**	**5.26**	**0.68**	**3.15**	**0.41**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**
Lab Chemicals	260	--	--	--	--	--	--	--	--	--	--	--	--	2.45	0.32	--	--	--	--	--	--	--	--
Total Onsite Stationary Source Emissions	**--**	**3.5E-03**	**4.5E-04**	**7.67**	**1.00**	**5.56**	**0.72**	**6.18**	**0.80**	**27.3**	**3.55**	**0.19**	**2.5E-02**	**4.23**	**0.55**	**38,253**	**4,973**	**0.72**	**9.4E-02**	**7.2E-02**	**9.3E-03**	**38,290**	**4,978**
Onsite On-Road Vehicle Emission Sources																							
Onsite On-Road Exhaust - Delivery Trucks	260	2.0E-03	2.5E-04	2.0E-03	2.5E-04	1.8E-03	2.3E-04	7.8E-02	1.0E-02	2.7E-02	3.6E-03	0	0	1.5E-02	1.9E-03	30.5	3.97	--	--	--	--	30.5	3.97
Onsite On-Road Exhaust - LBNL-RBC Shuttle	260	--	--	1.7E-04	2.2E-05	1.6E-04	2.0E-05	9.3E-03	1.2E-03	7.2E-02	9.4E-03	0	0	4.2E-03	5.5E-04	23.6	3.07	--	--	--	--	23.6	3.07
Onsite On-Road Exhaust - BART-RBC Shuttle	260	--	--	3.3E-04	4.2E-05	3.0E-04	3.9E-05	1.8E-02	2.3E-03	0.14	1.8E-02	0	0	8.1E-03	1.1E-03	45.4	5.90	--	--	--	--	45.4	5.90
Onsite On-Road Exhaust - Employee Vehicles	260	--	--	2.2E-02	2.9E-03	2.0E-02	2.7E-03	0.41	5.4E-02	4.67	0.61	0	0	0.23	2.9E-02	1,888	245	--	--	--	--	1,888	245
Onsite On-Road Dust - Delivery Trucks	260	--	--	1.3E-02	1.7E-03	3.2E-03	4.2E-04	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Onsite On-Road Dust - LBNL-RBC Shuttle	260	--	--	1.7E-02	2.2E-03	4.2E-03	5.4E-04	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Onsite On-Road Dust - BART-RBC Shuttle	260	--	--	3.3E-02	4.3E-03	8.1E-03	1.0E-03	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Onsite On-Road Dust - Employee Vehicles	260	--	--	2.68	0.35	0.66	8.5E-02	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Onsite Idling Exhaust - Delivery Trucks	260	4.0E-04	5.2E-05	4.0E-04	5.2E-05	3.6E-04	4.7E-05	0.12	1.6E-02	4.1E-02	5.3E-03	1.3E-04	1.7E-05	3.6E-03	4.6E-04	13.0	1.69	--	--	--	--	13.0	1.69
Onsite Idling Exhaust - LBNL-RBC Shuttle	260	--	--	1.6E-04	2.1E-05	1.5E-04	2.0E-05	6.5E-03	8.4E-04	5.1E-02	6.6E-03	0	0	3.9E-03	5.1E-04	19.1	2.49	--	--	--	--	19.1	2.49
Onsite Idling Exhaust - BART-RBC Shuttle	260	--	--	3.1E-04	4.1E-05	2.9E-04	3.8E-05	1.2E-02	1.6E-03	9.8E-02	1.3E-02	0	0	7.5E-03	9.7E-04	36.8	4.79	--	--	--	--	36.8	4.79
Total Onsite Vehicle Parking Lot Emissions	260	--	--	1.4E-02	1.8E-03	1.3E-02	1.7E-03	0.53	6.9E-02	8.88	1.15	3.5E-03	4.5E-04	1.45	0.19	330	42.9	--	--	--	--	330	42.9
Total Onsite On-Road Vehicle Emissions	**--**	**2.4E-03**	**3.1E-04**	**2.78**	**0.36**	**0.71**	**9.2E-02**	**1.19**	**0.16**	**14.0**	**1.82**	**3.6E-03**	**4.7E-04**	**1.72**	**0.22**	**2,387**	**310**	**--**	**--**	**--**	**--**	**2,387**	**310**
Offsite On-Road Emissions																							
Offsite On-Road Exhaust - Delivery Trucks	260	2.7E-02	3.5E-03	7.0E-02	9.1E-03	4.3E-02	5.5E-03	0.71	9.2E-02	0.19	2.4E-02	3.4E-03	4.5E-04	5.4E-02	7.1E-03	337	43.8	--	--	--	--	337	43.8
Offsite On-Road Exhaust - LBNL-RBC Shuttle	260	--	--	2.1E-02	2.7E-03	8.8E-03	1.1E-03	0.13	1.7E-02	0.92	0.12	2.6E-03	3.4E-04	7.5E-02	9.8E-03	221	28.7	--	--	--	--	221	28.7
Offsite On-Road Exhaust - BART-RBC Shuttle	260	--	--	2.1E-02	2.7E-03	8.7E-03	1.1E-03	0.13	1.7E-02	0.92	0.12	2.6E-03	3.4E-04	7.5E-02	9.7E-03	219	28.5	--	--	--	--	219	28.5
Offsite On-Road Exhaust - Employee Vehicles	260	--	--	4.28	0.56	1.78	0.23	8.09	1.05	79.8	10.4	0.31	4.1E-02	6.07	0.79	23,569	3,064	--	--	--	--	23,569	3,064
Offsite On-Road Dust - Delivery Trucks	260	--	--	3.4E-02	4.4E-03	8.3E-03	1.1E-03	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Offsite On-Road Dust - LBNL-RBC Shuttle	260	--	--	4.9E-02	6.4E-03	1.2E-02	1.6E-03	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Offsite On-Road Dust - BART-RBC Shuttle	260	--	--	4.9E-02	6.3E-03	1.2E-02	1.6E-03	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Offsite On-Road Dust - Employee Vehicles	260	--	--	10.2	1.32	2.50	0.32	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Offsite On-Road Vehicle Emissions	**--**	**2.7E-02**	**3.5E-03**	**14.7**	**1.91**	**4.37**	**0.57**	**9.06**	**1.18**	**81.9**	**10.6**	**0.32**	**4.2E-02**	**6.28**	**0.82**	**24,345**	**3,165**	**--**	**--**	**--**	**--**	**24,345**	**3,165**
Total Phase 1 Project Summary	**--**	**3.2E-02**	**4.2E-03**	**25.1**	**3.27**	**10.6**	**1.38**	**16.4**	**2.14**	**123**	**16.0**	**0.52**	**6.7E-02**	**12.2**	**1.59**	**64,985**	**8,448**	**0.72**	**9.4E-02**	**7.2E-02**	**9.3E-03**	**65,023**	**8,453**
Onsite Stationary Exhaust		**3.5E-03**	**4.5E-04**	**7.67**	**1.00**	**5.56**	**0.72**	**6.18**	**0.80**	**27.3**	**3.55**	**0.19**	**2.5E-02**	**4.23**	**0.55**	**38,253**	**4,973**	**0.72**	**9.4E-02**	**7.2E-02**	**9.3E-03**	**38,290**	**4,978**
Onsite Mobile Exhaust		**2.4E-03**	**3.1E-04**	**4.0E-02**	**5.1E-03**	**3.7E-02**	**4.8E-03**	**1.19**	**0.16**	**14.0**	**1.82**	**3.6E-03**	**4.7E-04**	**1.72**	**0.22**	**2,387**	**310**	**0**	**0**	**0**	**0**	**2,387**	**310**
Onsite Fugitive Dust		**0**	**0**	**2.74**	**0.36**	**0.67**	**8.7E-02**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**
Offsite Mobile Exhaust		**2.7E-02**	**3.5E-03**	**4.39**	**0.57**	**1.84**	**0.24**	**9.06**	**1.18**	**81.9**	**10.6**	**0.32**	**4.2E-02**	**6.28**	**0.82**	**24,345**	**3,165**	**0**	**0**	**0**	**0**	**24,345**	**3,165**
Offsite Fugitive Dust		**0**	**0**	**10.3**	**1.34**	**2.53**	**0.33**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**

References:

(1) Daily average emissions calculated by dividing the annual emissions by the annual days of operation and converting tons to lbs.

Table E-12
Onsite Employee Vehicle TAC Emission Estimates

Parameter		Parking Lot Emissions					Onroad Emissions
		Hot Soak / Running Evaporative	Resting Evaporative / Diurnal	Starting	Idling	Total	Running
Organic Speciation Profile	(1)	660	661	664	2105		2105
LDA TOG Emission Factor	(2)	8.19E-04 (lbs/trip)	1.52E-04 (lbs/trip)	3.33E-04 (lbs/trip)	1.99E-03 (lbs/hr)		1.74E-04 (lbs/VMT)
Maximum Daily Vehicle Trips (trips/day)	(3)	2,031	2,031	2,031	2,031		2,031
Annual Vehicle Trips (trips/yr)	(3)	528,060	528,060	528,060	528,060		528,060

TAC	CAS	TAC Emission Fraction of TOG (1)	Maximum Daily Emissions Estimate (a) (lbs/day)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Daily Emissions Estimate (a) (lbs/day)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Daily Emissions Estimate (a) (lbs/day)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Daily Emissions Estimate (c) (lbs/day)	Annual Average Emissions Estimate (d) (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Daily Emissions Estimate (e) (lbs/day)	Annual Average Emissions Estimate (f) (tons/yr)
1,3-Butadiene	106-99-0	No Data	--	--	No Data	--	--	7.0E-03	4.7E-03	6.2E-04	5.5E-03	0	0	4.7E-03	6.2E-04	5.5E-03	1.4E-03	1.8E-04
2-Butanone	78-93-3	No Data	--	--	No Data	--	--	6.0E-04	4.1E-04	5.3E-05	2.0E-04	0	0	4.1E-04	5.3E-05	2.0E-04	4.9E-05	6.4E-06
Acetaldehyde	75-07-0	No Data	--	--	No Data	--	--	5.2E-03	3.5E-03	4.6E-04	2.8E-03	0	0	3.5E-03	4.6E-04	2.8E-03	6.9E-04	9.0E-05
Acrolein	107-02-8	No Data	--	--	No Data	--	--	1.1E-03	7.4E-04	9.7E-05	1.3E-03	0	0	7.4E-04	9.7E-05	1.3E-03	3.2E-04	4.2E-05
Benzene	71-43-2	0.010	0.017	2.2E-03	3.6E-03	1.1E-03	1.4E-04	0.024	0.016	2.1E-03	0.025	0	0	0.034	4.4E-03	0.025	6.1E-03	7.9E-04
Ethylbenzene	100-41-4	0.016	0.027	3.5E-03	1.2E-03	3.7E-04	4.8E-05	0.016	0.011	1.4E-03	0.011	0	0	0.038	5.0E-03	0.011	2.6E-03	3.4E-04
Formaldehyde	50-00-0	No Data	--	--	No Data	--	--	0.013	8.5E-03	1.1E-03	0.016	0	0	8.5E-03	1.1E-03	0.016	3.9E-03	5.1E-04
Methanol	67-56-1	1.0E-04	1.7E-04	2.2E-05	No Data	--	--	2.9E-03	2.0E-03	2.5E-04	1.2E-03	0	0	2.1E-03	2.8E-04	1.2E-03	3.0E-04	3.8E-05
Naphthalene	91-20-3	1.4E-03	2.3E-03	3.0E-04	No Data	--	--	7.0E-04	4.7E-04	6.2E-05	5.0E-04	0	0	2.8E-03	3.6E-04	5.0E-04	1.2E-04	1.6E-05
n-Hexane	110-54-3	7.6E-03	0.013	1.6E-03	0.015	4.8E-03	6.2E-04	0.018	0.012	1.6E-03	0.016	0	0	0.029	3.8E-03	0.016	3.9E-03	5.1E-04
Propylene	115-07-1	No Data	--	--	No Data	--	--	0.033	0.023	2.9E-03	0.031	0	0	0.023	2.9E-03	0.031	7.5E-03	9.8E-04
Styrene	100-42-5	No Data	--	--	No Data	--	--	2.6E-03	1.8E-03	2.3E-04	1.2E-03	0	0	1.8E-03	2.3E-04	1.2E-03	3.0E-04	3.8E-05
Toluene	108-88-3	0.051	0.085	0.011	0.017	5.3E-03	6.8E-04	0.074	0.050	6.5E-03	0.058	0	0	0.14	0.018	0.058	0.014	1.8E-03
m-Xylene	108-38-3	0.027	0.045	5.8E-03	3.4E-03	1.1E-03	1.4E-04	0.053	0.036	4.7E-03	0.036	0	0	0.082	0.011	0.036	8.8E-03	1.1E-03
o-Xylene	95-47-6	0.016	0.027	3.5E-03	1.3E-03	4.0E-04	5.2E-05	0.018	0.012	1.6E-03	0.012	0	0	0.039	5.1E-03	0.012	3.1E-03	4.0E-04
p-Xylene	106-42-3	0.014	0.023	3.0E-03	1.1E-03	3.4E-04	4.4E-05	No Data	--	--	No Data	--	--	0.023	3.0E-03	No Data	--	--

Notes:

(a) Maximum daily emissions estimate (lbs/day) = (Emission factor [lbs/trip]) x (maximum daily vehicle trips [trips/day]) x (TAC emission fraction)

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/trip]) x (annual vehicle trips [trips/yr]) x (ton/2,000 lbs) x (TAC emission fraction)

(c) Maximum daily emissions estimate (lbs/day) = (Emission factor [lbs/hr]) x (maximum daily vehicle trips [trips/day]) x (idling time per trip [hrs/trip]) x (TAC emission fraction)
Idling time per trip (hrs/trip) = 0 (3)

(d) Annual emissions estimate (tons/yr) = (Emission factor [lbs/hr]) x (annual vehicle trips [trips/yr]) x (idling time per trip [hrs/trip]) x (ton/2,000 lbs) x (TAC emission fraction)
Idling time per trip (hrs/trip) = 0 (3)

(e) Maximum daily emissions estimate (lbs/day) = (Emission factor [lbs/VMT]) x (maximum daily vehicle trips [trips/day]) x (onsite roundtrip distance [mi/trip]) x (TAC emission fraction)
Onsite roundtrip distance (mi/trip) = 0.70 (3)

(f) Annual emissions estimate (tons/yr) = (Emission factor [lbs/VMT]) x (annual vehicle trips [trips/yr]) x (onsite roundtrip distance [mi/trip]) x (ton/2,000 lbs) x (TAC emission fraction)
Onsite roundtrip distance (mi/trip) = 0.70 (3)

References:

(1) California Air Resources Board Speciation Database. TAC emission fractions are derived from the individual speciation profiles listed. Profiles chosen to best represent the project vehicle fleet and existing gasoline formulation.

(2) Emission Factors source: EMFAC 2011 (model years to 2018). Onsite speed set to 15 mile per hour to conservatively estimate onsite emissions.

(3) See Table E-1, Phase 1 Operations Input Assumptions for Emission Rate Calculations.

Table E-13
Offsite Employee Vehicle TAC Emission Estimates

Parameter		Onroad Emissions						Total
		Running		Tire Wear		Brake Wear		
Speciation Profile	(1)	2105	(organic)	472	(particulate)	473	(particulate)	
LDA Emission Factor (lbs/VMT)	(2)	6.64E-05	(TOG)	1.8E-05	(PM_{10})	8.1E-05	(PM_{10})	
Maximum Daily Vehicle Trips (trips/day)	(3)	2,031		2,031		2,031		
Annual Vehicle Trips (trips/yr)	(3)	528,060		528,060		528,060		

TAC	CAS	TAC Emission Fraction of TOG (1)	Maximum Daily Emissions Estimate (a) (lbs/day)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of PM_{10} (1)	Maximum Daily Emissions Estimate (a) (lbs/day)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of PM_{10} (1)	Maximum Daily Emissions Estimate (a) (lbs/day)	Annual Average Emissions Estimate (b) (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate (tons/yr)
1,3-Butadiene	106-99-0	5.5E-03	0.015	2.0E-03	--	--	--	--	--	--	0.015	2.0E-03
2-Butanone	78-93-3	2.0E-04	5.5E-04	7.2E-05	--	--	--	--	--	--	5.5E-04	7.2E-05
Acetaldehyde	75-07-0	2.8E-03	7.8E-03	1.0E-03	--	--	--	--	--	--	7.8E-03	1.0E-03
Acrolein	107-02-8	1.3E-03	3.6E-03	4.7E-04	--	--	--	--	--	--	3.6E-03	4.7E-04
Benzene	71-43-2	0.025	0.069	8.9E-03	--	--	--	--	--	--	0.069	8.9E-03
Ethylbenzene	100-41-4	0.011	0.029	3.8E-03	--	--	--	--	--	--	0.029	3.8E-03
Formaldehyde	50-00-0	0.016	0.044	5.7E-03	--	--	--	--	--	--	0.044	5.7E-03
Methanol	67-56-1	1.2E-03	3.3E-03	4.3E-04	--	--	--	--	--	--	3.3E-03	4.3E-04
Naphthalene	91-20-3	5.0E-04	1.4E-03	1.8E-04	--	--	--	--	--	--	1.4E-03	1.8E-04
n-Hexane	110-54-3	0.016	0.044	5.8E-03	--	--	--	--	--	--	0.044	5.8E-03
Propylene	115-07-1	0.031	0.085	0.011	--	--	--	--	--	--	0.085	0.011
Styrene	100-42-5	1.2E-03	3.3E-03	4.3E-04	--	--	--	--	--	--	3.3E-03	4.3E-04
Toluene	108-88-3	0.058	0.16	0.021	--	--	--	--	--	--	0.16	0.021
m-Xylene	108-38-3	0.036	0.099	0.013	--	--	--	--	--	--	0.099	0.013
o-Xylene	95-47-6	0.012	0.034	4.5E-03	--	--	--	--	--	--	0.034	4.5E-03
Lead	7439-92-1	--	--	--	1.6E-04	1.2E-04	1.5E-05	5.0E-05	1.7E-04	2.2E-05	2.9E-04	3.7E-05
Manganese	7439-96-5	--	--	--	1.0E-04	7.4E-05	9.6E-06	1.7E-03	5.8E-03	7.5E-04	5.8E-03	7.6E-04
Nickel	7440-02-0	--	--	--	5.0E-05	3.7E-05	4.8E-06	6.6E-04	2.2E-03	2.9E-04	2.3E-03	3.0E-04
Arsenic	7440-38-2	--	--	--	No Data	--	--	1.0E-05	3.4E-05	4.4E-06	3.4E-05	4.4E-06
Copper	7440-50-8	--	--	--	4.9E-04	3.6E-04	4.7E-05	0.011	0.039	5.1E-03	0.039	5.1E-03
Vanadium	7440-62-2	--	--	--	No Data	--	--	6.6E-04	2.2E-03	2.9E-04	2.2E-03	2.9E-04
Bromine	7726-95-6	--	--	--	1.5E-05	1.1E-05	1.4E-06	4.0E-05	1.4E-04	1.8E-05	1.5E-04	1.9E-05
Selenium	7782-49-2	--	--	--	2.0E-05	1.5E-05	1.9E-06	2.0E-05	6.8E-05	8.8E-06	8.2E-05	1.1E-05
Chlorine	7782-50-5	--	--	--	7.8E-03	5.7E-03	7.5E-04	1.5E-03	5.1E-03	6.6E-04	0.011	1.4E-03

Notes:

(a) Maximum daily emissions estimate (lbs/day) = (Emission factor [lbs/VMT]) x (maximum daily vehicle trips [trips/day]) x (offsite roundtrip distance [mi/trip]) x (TAC emission fraction)
Offsite roundtrip distance (mi/trip) = 20.6 (3)

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/VMT]) x (annual vehicle trips [trips/yr]) x (offsite roundtrip distance [mi/trip]) x (ton/2,000 lbs) x (TAC emission fraction)
Offsite roundtrip distance (mi/trip) = 20.6 (3)

References:

(1) California Air Resources Board Speciation Database. TAC emission fractions are derived from the individual speciation profiles listed. Profiles chosen to best represent the project vehicle fleet and existing gasoline formulation.
(2) Emission Factors source: EMFAC 2011 (model years to 2018).
(3) See Table E-1, Phase 1 Operations Input Assumptions for Emission Rate Calculations.

Table E-14
Onsite Shuttle TAC Emission Estimates

Parameter		LBNL - RBC Shuttle		BART - RBC Shuttle		Total
		Idling	Running	Idling	Running	
Organic Speciation Profile	(1)	2105	2105	2105	2105	
MDV TOG Emission Factor	(2)	5.47E-03 (lbs/hr)	4.75E-04 (lbs/VMT)	5.47E-03 (lbs/hr)	4.75E-04 (lbs/VMT)	
Maximum Daily Vehicle Trips (trips/day)	(3)	13	13	25	25	
Annual Vehicle Trips (trips/yr)	(3)	3,380	3,380	6,500	6,500	
Idling Time per Trip (hrs/trip)	(3)	0.083	--	0.083	--	
Onsite Roundtrip Distance (mi/trip)	(3)	--	0.695	--	0.695	

TAC	CAS	TAC Emission Fraction of TOG [1]	Maximum Daily Emissions Estimate [a] (lbs/day)	Annual Average Emissions Estimate [b] (tons/yr)	TAC Emission Fraction of TOG [1]	Maximum Daily Emissions Estimate [c] (lbs/day)	Annual Average Emissions Estimate [d] (tons/yr)	TAC Emission Fraction of TOG [1]	Maximum Daily Emissions Estimate [a] (lbs/day)	Annual Average Emissions Estimate [b] (tons/yr)	TAC Emission Fraction of TOG [1]	Maximum Daily Emissions Estimate [c] (lbs/day)	Annual Average Emissions Estimate [d] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate (tons/yr)
1,3-Butadiene	106-99-0	5.5E-03	3.3E-05	4.2E-06	5.5E-03	2.4E-05	3.1E-06	5.5E-03	6.3E-05	8.2E-06	5.5E-03	4.5E-05	5.9E-06	1.6E-04	2.1E-05
2-Butanone	78-93-3	2.0E-04	1.2E-06	1.5E-07	2.0E-04	8.6E-07	1.1E-07	2.0E-04	2.3E-06	3.0E-07	2.0E-04	1.7E-06	2.1E-07	6.0E-06	7.8E-07
Acetaldehyde	75-07-0	2.8E-03	1.7E-05	2.2E-06	2.8E-03	1.2E-05	1.6E-06	2.8E-03	3.2E-05	4.1E-06	2.8E-03	2.3E-05	3.0E-06	8.4E-05	1.1E-05
Acrolein	107-02-8	1.3E-03	7.7E-06	1.0E-06	1.3E-03	5.6E-06	7.3E-07	1.3E-03	1.5E-05	1.9E-06	1.3E-03	1.1E-05	1.4E-06	3.9E-05	5.1E-06
Benzene	71-43-2	0.025	1.5E-04	1.9E-05	0.025	1.1E-04	1.4E-05	0.025	2.8E-04	3.7E-05	0.025	2.0E-04	2.7E-05	7.4E-04	9.6E-05
Ethylbenzene	100-41-4	0.011	6.2E-05	8.1E-06	0.011	4.5E-05	5.9E-06	0.011	1.2E-04	1.6E-05	0.011	8.7E-05	1.1E-05	3.1E-04	4.1E-05
Formaldehyde	50-00-0	0.016	9.4E-05	1.2E-05	0.016	6.8E-05	8.8E-06	0.016	1.8E-04	2.3E-05	0.016	1.3E-04	1.7E-05	4.7E-04	6.1E-05
Methanol	67-56-1	1.2E-03	7.1E-06	9.2E-07	1.2E-03	5.2E-06	6.7E-07	1.2E-03	1.4E-05	1.8E-06	1.2E-03	9.9E-06	1.3E-06	3.6E-05	4.7E-06
Naphthalene	91-20-3	5.0E-04	3.0E-06	3.9E-07	5.0E-04	2.1E-06	2.8E-07	5.0E-04	5.7E-06	7.4E-07	5.0E-04	4.1E-06	5.4E-07	1.5E-05	1.9E-06
n-Hexane	110-54-3	0.016	9.5E-05	1.2E-05	0.016	6.9E-05	8.9E-06	0.016	1.8E-04	2.4E-05	0.016	1.3E-04	1.7E-05	4.8E-04	6.2E-05
Propylene	115-07-1	0.031	1.8E-04	2.4E-05	0.031	1.3E-04	1.7E-05	0.031	3.5E-04	4.5E-05	0.031	2.5E-04	3.3E-05	9.1E-04	1.2E-04
Styrene	100-42-5	1.2E-03	7.1E-06	9.2E-07	1.2E-03	5.2E-06	6.7E-07	1.2E-03	1.4E-05	1.8E-06	1.2E-03	9.9E-06	1.3E-06	3.6E-05	4.7E-06
Toluene	108-88-3	0.058	3.4E-04	4.4E-05	0.058	2.5E-04	3.2E-05	0.058	6.6E-04	8.5E-05	0.058	4.8E-04	6.2E-05	1.7E-03	2.2E-04
m-Xylene	108-38-3	0.036	2.1E-04	2.7E-05	0.036	1.5E-04	2.0E-05	0.036	4.1E-04	5.3E-05	0.036	2.9E-04	3.8E-05	1.1E-03	1.4E-04
o-Xylene	95-47-6	0.012	7.4E-05	9.6E-06	0.012	5.3E-05	6.9E-06	0.012	1.4E-04	1.8E-05	0.012	1.0E-04	1.3E-05	3.7E-04	4.8E-05

Notes:

(a) Maximum daily emissions estimate (lbs/day) = (Emission factor [lbs/hr]) x (maximum daily vehicle trips [trips/day]) x (idling time per trip [hrs/trip]) x (TAC emission fraction)

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/hr]) x (annual vehicle trips [trips/yr]) x (idling time per trip [hrs/trip]) x (ton/2,000 lbs) x (TAC emission fraction)

(c) Maximum daily emissions estimate (lbs/day) = (Emission factor [lbs/VMT]) x (maximum daily vehicle trips [trips/day]) x (onsite roundtrip distance [mi/trip]) x (TAC emission fraction)

(d) Annual emissions estimate (tons/yr) = (Emission factor [lbs/VMT]) x (annual vehicle trips [trips/yr]) x (onsite roundtrip distance [mi/trip]) x (ton/2,000 lbs) x (TAC emission fraction)

References:

(1) California Air Resources Board Speciation Database. TAC emission fractions are derived from the individual speciation profiles listed. Profiles chosen to best represent the project vehicle fleet and existing gasoline formulation.

(2) Emission Factors source: EMFAC 2011 (model years to 2018). Onsite speed set to 15 mile per hour to conservatively estimate onsite emissions. No tire and brake wear emission factors are provided at 15 miles per hour.

(3) See Table E-1, Phase 1 Operations Input Assumptions for Emission Rate Calculations.

Table E-15
Offsite Shuttle TAC Emission Estimates

Parameter		LBNL - RBC Shuttle							BART - RBC Shuttle						
		Running		Tire Wear		Brake Wear		Total	Running		Tire Wear		Brake Wear		Total
Speciation Profile	(1)	2105	(organic)	472	(particulate)	473	(particulate)		2105	(organic)	472	(particulate)	473	(particulate)	
MDV Emission Factor (lbs/VMT)	(2)	1.79E-04	(TOG)	1.8E-05	(PM_{10})	8.1E-05	(PM_{10})		1.79E-04	(TOG)	1.8E-05	(PM_{10})	8.1E-05	(PM_{10})	
Maximum Daily Vehicle Trips (trips/day)	(3)	13		13		13			25		25		25		
Annual Vehicle Trips (trips/yr)	(3)	3,380		3,380		3,380			6,500		6,500		6,500		
Offsite Roundtrip Distance (mi/trip)	(3)	15.5		15.5		15.5			8.0		8.0		8.0		

TAC	CAS	TAC Emission Fraction of TOG (1)	Maximum Daily Emissions Estimate (a) (lbs/day)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of PM_{10} (1)	Maximum Daily Emissions Estimate (a) (lbs/day)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of PM_{10} (1)	Maximum Daily Emissions Estimate (a) (lbs/day)	Annual Average Emissions Estimate (b) (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Daily Emissions Estimate (a) (lbs/day)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of PM_{10} (1)	Maximum Daily Emissions Estimate (a) (lbs/day)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of PM_{10} (1)	Maximum Daily Emissions Estimate (a) (lbs/day)	Annual Average Emissions Estimate (b) (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate (tons/yr)
1,3-Butadiene	106-99-0	5.5E-03	2.0E-04	2.6E-05	--	--	--	--	--	--	2.0E-04	2.6E-05	5.5E-03	2.0E-04	2.6E-05	--	--	--	--	--	--	2.0E-04	2.6E-05
2-Butanone	78-93-3	2.0E-04	7.2E-06	9.4E-07	--	--	--	--	--	--	7.2E-06	9.4E-07	2.0E-04	7.2E-06	9.3E-07	--	--	--	--	--	--	7.2E-06	9.3E-07
Acetaldehyde	75-07-0	2.8E-03	1.0E-04	1.3E-05	--	--	--	--	--	--	1.0E-04	1.3E-05	2.8E-03	1.0E-04	1.3E-05	--	--	--	--	--	--	1.0E-04	1.3E-05
Acrolein	107-02-8	1.3E-03	4.7E-05	6.1E-06	--	--	--	--	--	--	4.7E-05	6.1E-06	1.3E-03	4.7E-05	6.1E-06	--	--	--	--	--	--	4.7E-05	6.1E-06
Benzene	71-43-2	0.025	8.9E-04	1.2E-04	--	--	--	--	--	--	8.9E-04	1.2E-04	0.025	8.8E-04	1.2E-04	--	--	--	--	--	--	8.8E-04	1.2E-04
Ethylbenzene	100-41-4	0.011	3.8E-04	4.9E-05	--	--	--	--	--	--	3.8E-04	4.9E-05	0.011	3.8E-04	4.9E-05	--	--	--	--	--	--	3.8E-04	4.9E-05
Formaldehyde	50-00-0	0.016	5.7E-04	7.4E-05	--	--	--	--	--	--	5.7E-04	7.4E-05	0.016	5.7E-04	7.4E-05	--	--	--	--	--	--	5.7E-04	7.4E-05
Methanol	67-56-1	1.2E-03	4.3E-05	5.6E-06	--	--	--	--	--	--	4.3E-05	5.6E-06	1.2E-03	4.3E-05	5.6E-06	--	--	--	--	--	--	4.3E-05	5.6E-06
Naphthalene	91-20-3	5.0E-04	1.8E-05	2.3E-06	--	--	--	--	--	--	1.8E-05	2.3E-06	5.0E-04	1.8E-05	2.3E-06	--	--	--	--	--	--	1.8E-05	2.3E-06
n-Hexane	110-54-3	0.016	5.8E-04	7.5E-05	--	--	--	--	--	--	5.8E-04	7.5E-05	0.016	5.7E-04	7.5E-05	--	--	--	--	--	--	5.7E-04	7.5E-05
Propylene	115-07-1	0.031	1.1E-03	1.4E-04	--	--	--	--	--	--	1.1E-03	1.4E-04	0.031	1.1E-03	1.4E-04	--	--	--	--	--	--	1.1E-03	1.4E-04
Styrene	100-42-5	1.2E-03	4.3E-05	5.6E-06	--	--	--	--	--	--	4.3E-05	5.6E-06	1.2E-03	4.3E-05	5.6E-06	--	--	--	--	--	--	4.3E-05	5.6E-06
Toluene	108-88-3	0.058	2.1E-03	2.7E-04	--	--	--	--	--	--	2.1E-03	2.7E-04	0.058	2.1E-03	2.7E-04	--	--	--	--	--	--	2.1E-03	2.7E-04
m-Xylene	108-38-3	0.036	1.3E-03	1.7E-04	--	--	--	--	--	--	1.3E-03	1.7E-04	0.036	1.3E-03	1.7E-04	--	--	--	--	--	--	1.3E-03	1.7E-04
o-Xylene	95-47-6	0.012	4.5E-04	5.8E-05	--	--	--	--	--	--	4.5E-04	5.8E-05	0.012	4.4E-04	5.8E-05	--	--	--	--	--	--	4.4E-04	5.8E-05
Lead	7439-92-1	--	--	--	1.6E-04	5.7E-07	7.4E-08	5.0E-05	8.2E-07	1.1E-07	1.4E-06	1.8E-07	--	--	--	1.6E-04	5.6E-07	7.3E-08	5.0E-05	8.1E-07	1.1E-07	1.4E-06	1.8E-07
Manganese	7439-96-5	--	--	--	1.0E-04	3.6E-07	4.6E-08	1.7E-03	2.8E-05	3.6E-06	2.8E-05	3.7E-06	--	--	--	1.0E-04	3.5E-07	4.6E-08	1.7E-03	2.8E-05	3.6E-06	2.8E-05	3.6E-06
Nickel	7440-02-0	--	--	--	5.0E-05	1.8E-07	2.3E-08	6.6E-04	1.1E-05	1.4E-06	1.1E-05	1.4E-06	--	--	--	5.0E-05	1.8E-07	2.3E-08	6.6E-04	1.1E-05	1.4E-06	1.1E-05	1.4E-06
Arsenic	7440-38-2	--	--	--	No Data	--	--	1.0E-05	1.6E-07	2.1E-08	1.6E-07	2.1E-08	--	--	--	No Data	--	--	1.0E-05	1.6E-07	2.1E-08	1.6E-07	2.1E-08
Copper	7440-50-8	--	--	--	4.9E-04	1.7E-06	2.3E-07	0.011	1.9E-04	2.4E-05	1.9E-04	2.5E-05	--	--	--	4.9E-04	1.7E-06	2.2E-07	0.011	1.9E-04	2.4E-05	1.9E-04	2.4E-05
Vanadium	7440-62-2	--	--	--	No Data	--	--	6.6E-04	1.1E-05	1.4E-06	1.1E-05	1.4E-06	--	--	--	No Data	--	--	6.6E-04	1.1E-05	1.4E-06	1.1E-05	1.4E-06
Bromine	7726-95-6	--	--	--	1.5E-05	5.3E-08	6.9E-09	4.0E-05	6.5E-07	8.5E-08	7.1E-07	9.2E-08	--	--	--	1.5E-05	5.3E-08	6.9E-09	4.0E-05	6.5E-07	8.4E-08	7.0E-07	9.1E-08
Selenium	7782-49-2	--	--	--	2.0E-05	7.1E-08	9.2E-09	2.0E-05	3.3E-07	4.2E-08	4.0E-07	5.2E-08	--	--	--	2.0E-05	7.1E-08	9.2E-09	2.0E-05	3.2E-07	4.2E-08	3.9E-07	5.1E-08
Chlorine	7782-50-5	--	--	--	7.8E-03	2.8E-05	3.6E-06	1.5E-03	2.4E-05	3.2E-06	5.2E-05	6.8E-06	--	--	--	7.8E-03	2.8E-05	3.6E-06	1.5E-03	2.4E-05	3.2E-06	5.2E-05	6.7E-06

Notes:

(a) Maximum daily emissions estimate (lbs/day) = (Emission factor [lbs/VMT]) x (maximum daily vehicle trips [trips/day]) x (offsite roundtrip distance [mi/trip]) x (TAC emission fraction)

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/VMT]) x (annual vehicle trips [trips/yr]) x (offsite roundtrip distance [mi/trip]) x (ton/2,000 lbs) x (TAC emission fraction)

References:

(1) California Air Resources Board Speciation Database. TAC emission fractions are derived from the individual speciation profiles listed. Profiles chosen to best represent the project vehicle fleet and existing gasoline formulation.

(2) Emission Factors source: EMFAC 2011 (model years to 2018).

(3) See Table E-1, Phase 1 Operations Input Assumptions for Emission Rate Calculations.

Table E-16
Natural Gas Boiler TAC Emission Estimates

Source	Natural Gas Boiler - Building 9	Natural Gas Boiler - Building 8	Natural Gas Boiler - Buildings 6 and 7	Total
Maximum Hourly Fuel Usage (MMBtu/hr) (1)	12	12	24	
Daily Hours of Operation (hrs/day) (1)	24	24	24	
Annual Fuel Usage (MMBtu/yr) (1)	21,000	21,000	42,000	
Modeling ID	NGB_B9	NGB_B8	NGB_B6_7	

TAC	CAS	Emission Factor (lbs/MMscf)	Maximum Daily Emissions Estimate (a) (lbs/day)	Annual Average Emissions Estimate (b) (tons/yr)	Maximum Daily Emissions Estimate (a) (lbs/day)	Annual Average Emissions Estimate (b) (tons/yr)	Maximum Daily Emissions Estimate (a) (lbs/day)	Annual Average Emissions Estimate (b) (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate (tons/yr)
7,12-Dimethylbenz(a)anthracene	57-97-6	1.6E-05 (2)	4.5E-06	1.6E-07	4.5E-06	1.6E-07	9.0E-06	3.3E-07	1.8E-05	6.6E-07
Acetaldehyde	75-07-0	8.9E-03 (3)	2.5E-03	9.1E-05	2.5E-03	9.1E-05	5.0E-03	1.8E-04	0.010	3.7E-04
Benzene	71-43-2	4.3E-03 (3)	1.2E-03	4.4E-05	1.2E-03	4.4E-05	2.4E-03	8.9E-05	4.9E-03	1.8E-04
Dichlorobenzene	25321-22-6	1.2E-03 (2)	3.4E-04	1.2E-05	3.4E-04	1.2E-05	6.8E-04	2.5E-05	1.4E-03	4.9E-05
Ethylbenzene	100-41-4	6.9E-03 (5)	1.9E-03	7.1E-05	1.9E-03	7.1E-05	3.9E-03	1.4E-04	7.8E-03	2.8E-04
Fluoranthene	206-44-0	3.0E-06 (2)	8.5E-07	3.1E-08	8.5E-07	3.1E-08	1.7E-06	6.2E-08	3.4E-06	1.2E-07
Formaldehyde	50-00-0	2.2E-01 (3)	0.062	2.3E-03	0.062	2.3E-03	0.12	4.6E-03	0.25	9.1E-03
n-Hexane	110-54-3	4.6E-03 (5)	1.3E-03	4.7E-05	1.3E-03	4.7E-05	2.6E-03	9.5E-05	5.2E-03	1.9E-04
Naphthalene	91-20-3	3.0E-04 (5)	8.5E-05	3.1E-06	8.5E-05	3.1E-06	1.7E-04	6.2E-06	3.4E-04	1.2E-05
Propylene	115-07-1	5.3E-01 (5)	0.15	5.5E-03	0.15	5.5E-03	0.30	0.011	0.60	0.022
Toluene	108-88-3	2.7E-02 (5)	7.5E-03	2.7E-04	7.5E-03	2.7E-04	0.015	5.5E-04	0.030	1.1E-03
Xylenes	1330-20-7	2.0E-02 (5)	5.6E-03	2.0E-04	5.6E-03	2.0E-04	0.011	4.1E-04	0.022	8.1E-04
Arsenic	7440-38-2	2.0E-04 (4)	5.6E-05	2.1E-06	5.6E-05	2.1E-06	1.1E-04	4.1E-06	2.3E-04	8.2E-06
Beryllium	7440-41-7	1.2E-05 (4)	3.4E-06	1.2E-07	3.4E-06	1.2E-07	6.8E-06	2.5E-07	1.4E-05	4.9E-07
Cadmium	7440-43-9	1.1E-03 (4)	3.1E-04	1.1E-05	3.1E-04	1.1E-05	6.2E-04	2.3E-05	1.2E-03	4.5E-05
Chromium VI	18540-29-9	2.4E-04 (6)	6.7E-05	2.5E-06	6.7E-05	2.5E-06	1.3E-04	4.9E-06	2.7E-04	9.8E-06
Cobalt	7440-48-4	8.4E-05 (4)	2.4E-05	8.6E-07	2.4E-05	8.6E-07	4.7E-05	1.7E-06	9.5E-05	3.5E-06
Copper	7440-50-8	8.5E-04 (4)	2.4E-04	8.8E-06	2.4E-04	8.8E-06	4.8E-04	1.8E-05	9.6E-04	3.5E-05
Lead	7439-92-1	5.0E-04 (7)	1.4E-04	5.1E-06	1.4E-04	5.1E-06	2.8E-04	1.0E-05	5.6E-04	2.1E-05
Manganese	7439-96-5	3.8E-04 (4)	1.1E-04	3.9E-06	1.1E-04	3.9E-06	2.1E-04	7.8E-06	4.3E-04	1.6E-05
Mercury	7439-97-6	2.6E-04 (4)	7.3E-05	2.7E-06	7.3E-05	2.7E-06	1.5E-04	5.4E-06	2.9E-04	1.1E-05
Nickel	7440-02-0	2.1E-03 (4)	5.9E-04	2.2E-05	5.9E-04	2.2E-05	1.2E-03	4.3E-05	2.4E-03	8.6E-05
Selenium	7782-49-2	2.4E-05 (4)	6.8E-06	2.5E-07	6.8E-06	2.5E-07	1.4E-05	4.9E-07	2.7E-05	9.9E-07

Notes:

(a) Daily emissions estimate (lbs/day) = (Emission factor [lbs/MMscf]) x (maximum hourly heat input [MMBtu/hr]) x (daily hours of operation [hrs/day]) / (natural gas heat content [Btu/scf])
Natural gas heat content (Btu/scf) = 1,020 (2)

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/MMscf]) x (annual heat input [MMBtu/yr]) / (natural gas heat content [Btu/scf]) x (tons/2,000 lbs)
Natural gas heat content (Btu/scf) = 1,020 (2)

References:

(1) See Table E-1, Phase 1 Operations Input Assumptions for Emission Rate Calculations.
(2) AP-42 Chapter 1.4 (July 1998), Table 1.4-3 "Emission Factors For Speciated Organic Compounds from Natural Gas Combustion".
(3) California Air Toxics Emission Factor (CATEF) Database under Natural Gas Boilers.
(4) AP-42 Chapter 1.4 (July 1998), Table 1.4-4 "Emission Factors For Metals from Natural Gas Combustion".
(5) Ventura Air Quality Management District emission factor database.
(6) The AP-42 total chromium emission factor was multiplied by 17% to correct for emissions of hexavalent chromium per EPA assumptions when regulating combustion sources under 40 CFR Part 63 Subpart DDDD.
(7) AP-42 Chapter 1.4 (July 1998), Table 1.4-2 "Emission Factors for Criteria Pollutants and Greenhouse Gases from Natural Gas Combustion".

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Table E-17
Emergency Diesel Generator TAC Emission Estimates

Source	Diesel Generator - Building 9	Diesel Generator - Building 8	Diesel Generator - Building 6	Diesel Generator - Building 7	Total
Generator Power Rating (BHP) (1)	440	440	440	440	
Diesel Fuel Usage (gal/hr) (1)	22.3	22.3	22.3	22.3	
Load Factor (2)	0.74	0.74	0.74	0.74	
Annual Operation (hrs/yr) (1)	25.15	25.15	25.15	25.15	
Modeling ID	DG_B9	DG_B8	DG_B6	DG_B7	

TAC	CAS	Emission Factor (lbs/10^3 gal)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate [a] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate [a] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate [a] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate [a] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate (tons/yr)
DPM	9901	-- (3)	0.014 [b]	9.0E-05	0.014 [b]	9.0E-05	0.022 [b]	1.4E-04	0.022 [b]	1.4E-04	0.072	4.5E-04
1,3-Butadiene	106-99-0	2.17E-01 (4)	7.2E-03 [c]	4.5E-05	7.2E-03 [c]	4.5E-05	7.2E-03 [c]	4.5E-05	7.2E-03 [c]	4.5E-05	0.029	1.8E-04
Acetaldehyde	75-07-0	3.47E-03 (5)	1.1E-04 [c]	7.2E-07	1.1E-04 [c]	7.2E-07	1.1E-04 [c]	7.2E-07	1.1E-04 [c]	7.2E-07	7.2E-07	4.6E-04	2.9E-06
Benzene	71-43-2	1.93E-01 (5)	6.4E-03 [c]	4.0E-05	6.4E-03 [c]	4.0E-05	6.4E-03 [c]	4.0E-05	6.4E-03 [c]	4.0E-05	0.026	1.6E-04
Benzo(a)anthracene	56-55-3	-- (6)	--	--	--	--	--	--	--	--	--	0
Benzo(b)fluoranthene	205-99-2	-- (6)	--	--	--	--	--	--	--	--	--	0
Benzo(k)fluoranthene	207-08-9	-- (6)	--	--	--	--	--	--	--	--	--	0
Chlorobenzene	108-90-7	2.00E-04 (4)	6.6E-06 [c]	4.2E-08	6.6E-06 [c]	4.2E-08	6.6E-06 [c]	4.2E-08	6.6E-06 [c]	4.2E-08	2.6E-05	1.7E-07
Chrysene	218-01-9	-- (6)	--	--	--	--	--	--	--	--	--	0
Dibenz(a,h)anthracene	53-70-3	-- (6)	--	--	--	--	--	--	--	--	--	0
Ethylbenzene	100-41-4	6.76E-03 (5)	2.2E-04 [c]	1.4E-06	2.2E-04 [c]	1.4E-06	2.2E-04 [c]	1.4E-06	2.2E-04 [c]	1.4E-06	8.9E-04	5.6E-06
Formaldehyde	50-00-0	5.06E-02 (5)	1.7E-03 [c]	1.0E-05	1.7E-03 [c]	1.0E-05	1.7E-03 [c]	1.0E-05	1.7E-03 [c]	1.0E-05	6.7E-03	4.2E-05
n-Hexane	110-54-3	1.39E-03 (5)	4.6E-05 [c]	2.9E-07	4.6E-05 [c]	2.9E-07	4.6E-05 [c]	2.9E-07	4.6E-05 [c]	2.9E-07	1.8E-04	1.2E-06
Hydrogen Chloride	7647-01-0	1.86E-01 (4)	6.2E-03 [c]	3.9E-05	6.2E-03 [c]	3.9E-05	6.2E-03 [c]	3.9E-05	6.2E-03 [c]	3.9E-05	0.025	1.5E-04
Indeno(1,2,3-cd)pyrene	193-39-5	-- (6)	--	--	--	--	--	--	--	--	--	0
Naphthalene	91-20-3	1.60E-02 (5)	5.3E-04 [c]	3.3E-06	5.3E-04 [c]	3.3E-06	5.3E-04 [c]	3.3E-06	5.3E-04 [c]	3.3E-06	2.1E-03	1.3E-05
Propylene	115-07-1	3.41E-01 (5)	0.011 [c]	7.1E-05	0.011 [c]	7.1E-05	0.011 [c]	7.1E-05	0.011 [c]	7.1E-05	0.045	2.8E-04
Toluene	108-88-3	6.12E-02 (5)	2.0E-03 [c]	1.3E-05	2.0E-03 [c]	1.3E-05	2.0E-03 [c]	1.3E-05	2.0E-03 [c]	1.3E-05	8.1E-03	5.1E-05
Xylenes	1330-20-7	4.24E-02 (4)	1.4E-03 [c]	8.8E-06	1.4E-03 [c]	8.8E-06	1.4E-03 [c]	8.8E-06	1.4E-03 [c]	8.8E-06	5.6E-03	3.5E-05
Arsenic	7440-38-2	1.60E-03 (4)	5.3E-05 [c]	3.3E-07	5.3E-05 [c]	3.3E-07	5.3E-05 [c]	3.3E-07	5.3E-05 [c]	3.3E-07	2.1E-04	1.3E-06
Cadmium	7440-43-9	1.50E-03 (4)	5.0E-05 [c]	3.1E-07	5.0E-05 [c]	3.1E-07	5.0E-05 [c]	3.1E-07	5.0E-05 [c]	3.1E-07	2.0E-04	1.2E-06
Chromium VI	18540-29-9	1.00E-04 (7)	3.3E-06 [c]	2.1E-08	3.3E-06 [c]	2.1E-08	3.3E-06 [c]	2.1E-08	3.3E-06 [c]	2.1E-08	1.3E-05	8.3E-08
Copper	7440-50-8	4.10E-03 (4)	1.4E-04 [c]	8.5E-07	1.4E-04 [c]	8.5E-07	1.4E-04 [c]	8.5E-07	1.4E-04 [c]	8.5E-07	5.4E-04	3.4E-06
Lead	7439-92-1	8.30E-03 (4)	2.7E-04 [c]	1.7E-06	2.7E-04 [c]	1.7E-06	2.7E-04 [c]	1.7E-06	2.7E-04 [c]	1.7E-06	1.1E-03	6.9E-06
Manganese	7439-96-5	3.10E-03 (4)	1.0E-04 [c]	6.4E-07	1.0E-04 [c]	6.4E-07	1.0E-04 [c]	6.4E-07	1.0E-04 [c]	6.4E-07	4.1E-04	2.6E-06
Mercury	7439-97-6	2.00E-03 (4)	6.6E-05 [c]	4.2E-07	6.6E-05 [c]	4.2E-07	6.6E-05 [c]	4.2E-07	6.6E-05 [c]	4.2E-07	2.6E-04	1.7E-06
Nickel	7440-02-0	3.90E-03 (4)	1.3E-04 [c]	8.1E-07	1.3E-04 [c]	8.1E-07	1.3E-04 [c]	8.1E-07	1.3E-04 [c]	8.1E-07	5.2E-04	3.2E-06
Selenium	7782-49-2	2.20E-03 (4)	7.3E-05 [c]	4.6E-07	7.3E-05 [c]	4.6E-07	7.3E-05 [c]	4.6E-07	7.3E-05 [c]	4.6E-07	2.9E-04	1.8E-06

Modeling ID	DG_B9	DG_B8	DG_B6	DG_B7
Diesel Particulate Emission Factor (g/hp-hr) (6)	0.01	0.01	0.015	0.015

Notes:

(a) Annual average emission estimate (tons/yr) = (Maximum daily emissions estimate [lbs/day]) / (maximum daily hours of operation [hrs/day]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)
Maximum daily hours of operation (hrs/day) = 2 (1)

(b) Daily diesel particulate emissions estimate (lbs/day) = (Emission factor [g/hp-hr]) x (engine horsepower [hp]) x (load factor) / (453.59 [g/lb]) x (maximum daily hours of operation [hrs/day])
Maximum daily hours of operation (hrs/day) = 2 (1)

(c) Daily emissions estimate (lbs/day) = (Emission factor [lbs/10^3 gal]) x (load factor) x (fuel usage [gal/hr]) x (0.001 [gal/10^3 gal]) x (maximum daily hours of operation [hrs/day])
Maximum daily hours of operation (hrs/day) = 2 (1)

References:

(1) See Table E-1, Phase 1 Operations Input Assumptions for Emission Rate Calculations.
(2) Default load factor for generators in URBEMIS emission model.
(3) See diesel particulate matter emission factors at the bottom of the table.
(4) Ventura County Air Pollution Control District AB 2588 Combustion Emission Factors Database, May 2001.
(5) California Toxic Emission Factor (CATEF) Database, except for Diesel PM. The emission factors for each TAC are averaged for diesel internal combustion engines operating at less than 13% oxygen in the exhaust. Per vendor information, the percent oxygen in the exhaust is less than 13% at loads greater than 50%. It is assumed that the generator would be run at 50% load or greater.
(6) Polycyclic Aromatic Hydrocarbons (PAHs) are assumed to be included in the particulate matter emission factor. PAHs that are not specifically listed in this table, but may be included in the particulate matter emission factor, include Acenaphthylene, Anthracene, Acenaphthene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(g,h,i)perylene, Chrysene, Dibenz(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene. For purposes of this inventory, it is assumed that all particulate is represented as Diesel Particulate Matter (DPM).
(7) The AP-42 total chromium emission factor was multiplied by 17% to correct for emissions of hexavalent chromium per EPA assumptions when regulating combustion sources under 40 CFR Part 63 Subpart DDDD.

Table E-18
Cooling Tower TAC Emission Estimates

Source	Cooling Tower - Building 9	Cooling Tower - Building 8	Cooling Tower - Buildings 6 and 7	Total
PM_{10} Emission Rate (lbs/day) (1)	1.29	1.29	2.58	
Annual Operation (hrs/yr) (2)	6,360	6,360	6,360	
Modeling ID	CTB9C#	CTB8C#	CTB6_7C#	

Pollutant	CAS	Maximum Daily Emissions Estimate [a] (lbs/day)	Annual Average Emissions Estimate [b] (tons/yr)	Maximum Daily Emissions Estimate [a] (lbs/day)	Annual Average Emissions Estimate [b] (tons/yr)	Maximum Daily Emissions Estimate [a] (lbs/day)	Annual Average Emissions Estimate [b] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate (tons/yr)
Bromine	7726-95-6	2.4E-03	3.2E-04	2.4E-03	3.2E-04	4.8E-03	6.4E-04	9.6E-03	1.3E-03

Notes:
(a) Maximum daily emissions estimate (lbs/day) = (PM_{10} emission rate [lbs/day]) x (ChemTreat CL-4910 bromine concentration [ppm]) / (total dissolved solids concentration [ppm])
ChemTreat CL-4910 bromine concentration (ppm) = 1 (3)
Total dissolved solids concentration (ppmw) = 536 (2)
(b) Annual emissions estimate (tons/yr) = (Daily emissions [lbs/day]) / (daily hours of operation [hrs/day]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)
Daily hours of operation (hrs/day) = 24 (2)

References:
(1) See Table E-10, Cooling Tower Particulate Emission Estimates.
(2) See Table E-1, Phase 1 Operations Input Assumptions for Emission Rate Calculations.
(3) Provided by ChemTreat.

Table E-19

Total Estimated Air Emissions of Laboratory Non-Radionuclide Liquid Chemicals [1]

TAC	CAS Number	Building 9 LAB_B9			Building 8 LAB_B8			Building 6 & 7 LAB_B6_7			Total	
		Estimated Emissions (grams/yr)	Daily Emissions Estimate (lbs/day) [a]	Annual Emissions Estimate (tons/yr) [b]	Estimated Emissions (grams/yr)	Daily Emissions Estimate (lbs/day) [a]	Annual Emissions Estimate (tons/yr) [b]	Estimated Emissions (grams/yr)	Daily Emissions Estimate (lbs/day) [a]	Annual Emissions Estimate (tons/yr) [b]	Daily Emissions Estimate (lbs/day)	Annual Emissions Estimate (tons/yr)
1,3-Butadiene	106-99-0	--	--	--	286	2.4E-03	3.2E-04	--	--	--	2.4E-03	3.2E-04
1,4-Dioxane	123-91-1	322	2.7E-03	3.5E-04	2,773	0.024	3.1E-03	--	--	--	0.026	3.4E-03
Acetaldehyde	75-07-0	--	--	--	144	1.2E-03	1.6E-04	--	--	--	1.2E-03	1.6E-04
Acrolein	107-02-8	--	--	--	--	--	--	70.1	5.9E-04	7.7E-05	5.9E-04	7.7E-05
Acrylic acid	79-10-7	--	--	--	9.99	8.5E-05	1.1E-05	--	--	--	8.5E-05	1.1E-05
Aniline	62-53-3	--	--	--	2.22	1.9E-05	2.4E-06	0.22	1.9E-06	2.4E-07	2.1E-05	2.7E-06
Benzene	71-43-2	467	4.0E-03	5.1E-04	1,005	8.5E-03	1.1E-03	467	4.0E-03	5.1E-04	0.016	2.1E-03
Benzyl chloride	100-44-7	--	--	--	5.16	4.4E-05	5.7E-06	--	--	--	4.4E-05	5.7E-06
Bromine	7726-95-6	--	--	--	1.13	9.5E-06	1.2E-06	--	--	--	9.5E-06	1.2E-06
Carbon tetrachloride	56-23-5	--	--	--	--	--	--	295	2.5E-03	3.2E-04	2.5E-03	3.2E-04
Chloroform	67-66-3	11255	0.095	0.012	16,775	0.14	0.018	18,574	0.16	0.020	0.40	0.051
Diethanolamine	111-42-2	8.6E-04	7.3E-09	9.5E-10	4.3E-04	3.7E-09	4.7E-10	1.7E-03	1.5E-08	1.9E-09	2.6E-08	3.3E-09
Dimethyl formamide	68-12-2	11.56	9.8E-05	1.3E-05	179	1.5E-03	2.0E-04	325	2.8E-03	3.6E-04	4.4E-03	5.7E-04
Epichlorohydrin	106-89-8	--	--	--	14.8	1.3E-04	1.6E-05	--	--	--	1.3E-04	1.6E-05
Ethylbenzene	100-41-4	--	--	--	90.7	7.7E-04	1.0E-04	--	--	--	7.7E-04	1.0E-04
Ethylene dichloride [EDC]	107-06-2	--	--	--	2,083	0.018	2.3E-03	--	--	--	0.018	2.3E-03
Ethylene glycol	107-21-1	1.59	1.3E-05	1.8E-06	1.06	9.0E-06	1.2E-06	2.76	2.3E-05	3.0E-06	4.6E-05	6.0E-06
Ethylene glycol monomethyl ether	109-86-4	--	--	--	76.9	6.5E-04	8.5E-05	--	--	--	6.5E-04	8.5E-05
Formaldehyde	50-00-0	1707	0.014	1.9E-03	788	6.7E-03	8.7E-04	9897	0.084	0.011	1.1E-01	0.014
Glutaraldehyde	111-30-8	9	7.6E-05	9.8E-06	3	2.5E-05	3.3E-06	33	2.8E-04	3.6E-05	3.8E-04	4.9E-05
n-Hexane	110-54-3	1975	0.017	2.2E-03	31772	0.27	0.035	6258	0.053	6.9E-03	3.4E-01	0.044
Hydrogen Chloride	7647-01-0	6332	0.054	7.0E-03	11097	0.094	0.012	20562	0.17	0.023	3.2E-01	0.042
Hydrogen fluoride	7664-39-3	--	--	--	--	--	--	37	3.2E-04	4.1E-05	3.2E-04	4.1E-05
Isopropyl alcohol	67-63-0	10455	0.089	0.012	10594	0.090	0.012	14334	0.12	0.016	3.0E-01	0.039
Lindane [gamma-Hexachlorocyclohexane]	58-89-9	--	--	--	--	--	--	1.2E-04	1.0E-09	1.3E-10	1.0E-09	1.3E-10
m-Cresol	108-39-4	--	--	--	5.9E-01	5.0E-06	6.5E-07	5.9E-01	5.0E-06	6.5E-07	1.0E-05	1.3E-06
Methanol	67-56-1	1910	0.016	2.1E-03	29593	0.25	0.033	13839	0.12	0.015	3.8E-01	0.050
2-Butanone	78-93-3	--	--	--	974	8.3E-03	1.1E-03	--	--	--	8.3E-03	1.1E-03
Methyl tert-butyl ether	1634-04-4	--	--	--	612	5.2E-03	6.7E-04	70	5.9E-04	7.7E-05	5.8E-03	7.5E-04
Methylene chloride [Dichloromethane]	75-09-2	70.3	6.0E-04	7.7E-05	49576	0.42	0.055	1054	8.9E-03	1.2E-03	4.3E-01	0.056
Nitric acid	7697-37-2	389	3.3E-03	4.3E-04	1477	0.013	1.6E-03	--	--	--	1.6E-02	2.1E-03
Tetrachloroehtene	127-18-4	--	--	--	236	2.0E-03	2.6E-04	--	--	--	2.0E-03	2.6E-04
Phosphoric acid	7664-38-2	1.4	1.2E-05	1.5E-06	2.29	1.9E-05	2.5E-06	2	1.4E-05	1.9E-06	4.6E-05	5.9E-06
Propylene glycol monomethyl ether	107-98-2	4.8	4.1E-05	5.3E-06	4.85	4.1E-05	5.3E-06	--	--	--	8.2E-05	1.1E-05
Propylene oxide	75-56-9	--	--	--	--	--	--	4.2E-01	3.6E-06	4.7E-07	3.6E-06	4.7E-07
Styrene	100-42-5	--	--	--	27.3	2.3E-04	3.0E-05	--	--	--	2.3E-04	3.0E-05
Sulfuric acid	7664-93-9	15.23	1.3E-04	1.7E-05	93.6	7.9E-04	1.0E-04	78	6.6E-04	8.6E-05	1.6E-03	2.1E-04
Toluene	108-88-3	70.0	5.9E-04	7.7E-05	2685	0.023	3.0E-03	1881	0.016	2.1E-03	3.9E-02	5.1E-03
Trichloroethylene	79-01-6	--	--	--	794	6.7E-03	8.8E-04	265	2.2E-03	2.9E-04	9.0E-03	1.2E-03
Triethylamine	121-44-8	--	--	--	992	8.4E-03	1.1E-03	285	2.4E-03	3.1E-04	1.1E-02	1.4E-03
Xylenes	1330-20-7	--	--	--	--	--	--	869	7.4E-03	9.6E-04	7.4E-03	9.6E-04
Total - All Chemicals Listed		**34,995**	**0.30**	**0.039**	**164,769**	**1.40**	**0.18**	**89,198**	**0.76**	**0.098**	**2.45**	**0.32**

Notes:

(a) Estimated emissions (lbs/day) = (Estimated emissions [grams/year]) x (lbs/453.59 grams) / (annual operation [days/year])
Annual operation for all buildings (days/year) = 260 (2)

(b) Estimated emissions (tons/yr) = (Estimated emissions [grams/yr]) x (lbs/453.59 g) x (tons/2,000 lbs)

References:

(1) See emission estimation methods in Appendix G.

(2) See Table E-1, Phase 1 Operations Input Assumptions for Emission Rate Calculations.

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Table E-20
Phase 1 Operations TAC Emissions Summary

TAC	CAS	Natural Gas Boilers		Diesel Generators		Cooling Towers		Laboratory Buildings		Onsite Onroad Exhaust		Offsite Onroad Exhaust		Total	
		(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)
DPM [1]	9-90-1	--	--	0.072	4.5E-04	--	--	--	--	2.4E-03	3.1E-04	0.027	3.5E-03	0.10	4.2E-03
1,3-Butadiene	106-99-0	--	--	0.029	1.8E-04	--	--	2.4E-03	3.2E-04	6.2E-03	8.1E-04	0.015	2.0E-03	0.053	3.3E-03
1,4-Dioxane	123-91-1	--	--	--	--	--	--	0.026	3.4E-03	--	--	--	--	0.026	3.4E-03
2-Butanone	78-93-3	--	--	--	--	--	--	8.3E-03	1.1E-03	4.6E-04	6.0E-05	5.6E-04	7.3E-05	9.3E-03	1.2E-03
7,12-Dimethylbenz(a)anthracene	57-97-6	1.8E-05	6.6E-07	--	--	--	--	--	--	--	--	--	--	1.8E-05	6.6E-07
Acetaldehyde	75-07-0	0.010	3.7E-04	4.6E-04	2.9E-06	--	--	1.2E-03	1.6E-04	4.3E-03	5.6E-04	7.9E-03	1.0E-03	0.024	2.1E-03
Acrolein	107-02-8	--	--	--	--	--	--	5.9E-04	7.7E-05	1.1E-03	1.4E-04	3.7E-03	4.7E-04	5.3E-03	7.0E-04
Acrylic acid	79-10-7	--	--	--	--	--	--	8.5E-05	1.1E-05	--	--	--	--	8.5E-05	1.1E-05
Aniline	62-53-3	--	--	--	--	--	--	2.1E-05	2.7E-06	--	--	--	--	2.1E-05	2.7E-06
Arsenic	7440-38-2	2.3E-04	8.2E-06	2.1E-04	1.3E-06	--	--	--	--	--	--	3.4E-05	4.4E-06	4.7E-04	1.4E-05
Benzene	71-43-2	4.9E-03	1.8E-04	0.026	1.6E-04	--	--	0.016	2.1E-03	0.041	5.3E-03	0.069	9.0E-03	0.16	0.017
Benzyl chloride	100-44-7	--	--	--	--	--	--	4.4E-05	5.7E-06	--	--	--	--	4.4E-05	5.7E-06
Beryllium	7440-41-7	1.4E-05	4.9E-07	--	--	--	--	--	--	--	--	--	--	1.4E-05	4.9E-07
Bromine	7726-95-6	--	--	--	--	9.6E-03	1.3E-03	9.5E-06	1.2E-06	--	--	1.5E-04	1.9E-05	9.8E-03	1.3E-03
Cadmium	7440-43-9	1.2E-03	4.5E-05	2.0E-04	1.2E-06	--	--	--	--	--	--	--	--	1.4E-03	4.7E-05
Carbon tetrachloride	56-23-5	--	--	--	--	--	--	2.5E-03	3.2E-04	--	--	--	--	2.5E-03	3.2E-04
Chlorine	7782-50-5	--	--	--	--	--	--	--	--	--	--	0.011	1.4E-03	0.011	1.4E-03
Chlorobenzene	108-90-7	--	--	2.6E-05	1.7E-07	--	--	--	--	--	--	--	--	2.6E-05	1.7E-07
Chloroform	67-66-3	--	--	--	--	--	--	0.40	0.051	--	--	--	--	0.40	0.051
Chromium VI	18540-29-9	2.7E-04	9.8E-06	1.3E-05	8.3E-08	--	--	--	--	--	--	--	--	2.8E-04	9.9E-06
Cobalt	7440-48-4	9.5E-05	3.5E-06	--	--	--	--	--	--	--	--	--	--	9.5E-05	3.5E-06
Copper	7440-50-8	9.6E-04	3.5E-05	5.4E-04	3.4E-06	--	--	--	--	--	--	0.039	5.1E-03	0.041	5.2E-03
Dichlorobenzene	25321-22-6	1.4E-03	4.9E-05	--	--	--	--	--	--	--	--	--	--	1.4E-03	4.9E-05
Diethanolamine	111-42-2	--	--	--	--	--	--	2.6E-08	3.3E-09	--	--	--	--	2.6E-08	3.3E-09
Dimethyl formamide	68-12-2	--	--	--	--	--	--	4.4E-03	5.7E-04	--	--	--	--	4.4E-03	5.7E-04
Epichlorohydrin	106-89-8	--	--	--	--	--	--	1.3E-04	1.6E-05	--	--	--	--	1.3E-04	1.6E-05
Ethylbenzene	100-41-4	7.8E-03	2.8E-04	8.9E-04	5.6E-06	--	--	7.7E-04	1.0E-04	0.041	5.4E-03	0.030	3.8E-03	0.080	9.6E-03
Ethylene dichloride [EDC]	107-06-2	--	--	--	--	--	--	0.018	2.3E-03	--	--	--	--	0.018	2.3E-03
Ethylene glycol	107-21-1	--	--	--	--	--	--	4.6E-05	6.0E-06	--	--	--	--	4.6E-05	6.0E-06
Ethylene glycol monomethyl ether	109-86-4	--	--	--	--	--	--	6.5E-04	8.5E-05	--	--	--	--	6.5E-04	8.5E-05
Fluoranthene	206-44-0	3.4E-06	1.2E-07	--	--	--	--	--	--	--	--	--	--	3.4E-06	1.2E-07
Formaldehyde	50-00-0	0.25	9.1E-03	6.7E-03	4.2E-05	--	--	0.11	0.014	0.013	1.7E-03	0.044	5.8E-03	0.42	0.030
Glutaraldehyde	111-30-8	--	--	--	--	--	--	3.8E-04	4.9E-05	--	--	--	--	3.8E-04	4.9E-05
Hydrogen Chloride	7647-01-0	--	--	0.025	1.5E-04	--	--	0.32	0.042	--	--	--	--	0.35	0.042
Hydrogen fluoride	7664-39-3	--	--	--	--	--	--	3.2E-04	4.1E-05	--	--	--	--	3.2E-04	4.1E-05
Isopropyl alcohol	67-63-0	--	--	--	--	--	--	0.30	0.039	--	--	--	--	0.30	0.039
Lead	7439-92-1	5.6E-04	2.1E-05	1.1E-03	6.9E-06	--	--	--	--	--	--	2.9E-04	3.8E-05	1.9E-03	6.5E-05
Lindane [gamma-Hexachlorocyclohexane]	58-89-9	--	--	--	--	--	--	1.0E-09	1.3E-10	--	--	--	--	1.0E-09	1.3E-10
Manganese	7439-96-5	4.3E-04	1.6E-05	4.1E-04	2.6E-06	--	--	--	--	--	--	5.9E-03	7.6E-04	6.7E-03	7.8E-04
m-Cresol	108-39-4	--	--	--	--	--	--	1.0E-05	1.3E-06	--	--	--	--	1.0E-05	1.3E-06
Mercury	7439-97-6	2.9E-04	1.1E-05	2.6E-04	1.7E-06	--	--	--	--	--	--	--	--	5.6E-04	1.2E-05
Methanol	67-56-1	--	--	--	--	--	--	0.38	0.050	2.5E-03	3.2E-04	3.4E-03	4.4E-04	0.39	0.051
Methyl tert-butyl ether	1634-04-4	--	--	--	--	--	--	5.8E-03	7.5E-04	--	--	--	--	5.8E-03	7.5E-04
Methylene chloride [Dichloromethane]	75-09-2	--	--	--	--	--	--	0.43	0.056	--	--	--	--	0.43	0.056
Naphthalene	91-20-3	3.4E-04	1.2E-05	2.1E-03	1.3E-05	--	--	--	--	2.9E-03	3.8E-04	1.4E-03	1.8E-04	6.8E-03	5.9E-04
n-Hexane	110-54-3	5.2E-03	1.9E-04	1.8E-04	1.2E-06	--	--	0.34	0.044	0.034	4.4E-03	0.045	5.8E-03	0.42	0.055
Nickel	7440-02-0	2.4E-03	8.6E-05	5.2E-04	3.2E-06	--	--	--	--	--	--	2.3E-03	3.0E-04	5.2E-03	3.9E-04
Nitric acid	7697-37-2	--	--	--	--	--	--	0.016	2.1E-03	--	--	--	--	0.016	2.1E-03
Phosphoric acid	7664-38-2	--	--	--	--	--	--	4.6E-05	5.9E-06	--	--	--	--	4.6E-05	5.9E-06
Propylene	115-07-1	0.60	0.022	0.045	2.8E-04	--	--	--	--	0.031	4.0E-03	0.086	0.011	0.76	0.037
Propylene glycol monomethyl ether	107-98-2	--	--	--	--	--	--	8.2E-05	1.1E-05	--	--	--	--	8.2E-05	1.1E-05
Propylene oxide	75-56-9	--	--	--	--	--	--	3.6E-06	4.7E-07	--	--	--	--	3.6E-06	4.7E-07
Selenium	7782-49-2	2.7E-05	9.9E-07	2.9E-04	1.8E-06	--	--	--	--	--	--	8.3E-05	1.1E-05	4.0E-04	1.4E-05
Styrene	100-42-5	--	--	--	--	--	--	2.3E-04	3.0E-05	2.1E-03	2.7E-04	3.4E-03	4.4E-04	5.7E-03	7.4E-04
Sulfuric acid	7664-93-9	--	--	--	--	--	--	1.6E-03	2.1E-04	--	--	--	--	1.6E-03	2.1E-04
Tetrachloroehtene	127-18-4	--	--	--	--	--	--	2.0E-03	2.6E-04	--	--	--	--	2.0E-03	2.6E-04
Toluene	108-88-3	0.030	1.1E-03	8.1E-03	5.1E-05	--	--	0.039	5.1E-03	0.16	0.020	0.16	0.021	0.40	0.048
Trichloroethylene	79-01-6	--	--	--	--	--	--	9.0E-03	1.2E-03	--	--	--	--	9.0E-03	1.2E-03
Triethylamine	121-44-8	--	--	--	--	--	--	0.011	1.4E-03	--	--	--	--	0.011	1.4E-03
Vanadium	7440-62-2	--	--	--	--	--	--	--	--	--	--	2.2E-03	2.9E-04	2.2E-03	2.9E-04
m-Xylene	108-38-3	--	--	--	--	--	--	--	--	0.092	0.012	0.10	0.013	0.19	0.025
o-Xylene	95-47-6	--	--	--	--	--	--	--	--	0.043	5.6E-03	0.035	4.5E-03	0.078	0.010
p-Xylene	106-42-3	--	--	--	--	--	--	--	--	0.023	3.0E-03	--	--	0.023	3.0E-03
Xylenes	1330-20-7	0.022	8.1E-04	5.6E-03	3.5E-05	--	--	7.4E-03	9.6E-04	--	--	--	--	0.035	1.8E-03
NO_2	10102-44-0	21.1	0.77	5.17	0.032	--	--	--	--	1.19	0.16	9.06	1.18	36.6	2.14
SO_2	7446-09-5	0.68	0.025	0.037	2.4E-04	--	--	--	--	3.6E-03	4.7E-04	0.32	0.042	1.04	0.067
CO	630-08-0	94.9	3.46	13.8	0.087	--	--	--	--	14.0	1.82	81.9	10.6	204	16.0

References:

(1) On-site DPM emissions. Assumes all PM10 emissions from mobile source combustion equals diesel particulate matter (DPM). See Table E-11, Criteria Pollutant Emissions Summary, for DPM emissions from onsite onroad sources.

Appendix F

Emissions Estimates – Full LRDP Operations

Table F-1
LRDP Operations Input Assumptions for Emission Rate Calculations

Source	*Building Size (gsf)*	*Diesel Emergency Generators*		*Natural Gas Boilers*			*Cooling Towers*		
		Engine Size (BHP)	Fuel Usage (gal/hr)	Maximum Heat Input (MMBtu/hr)	Daily Operation (hrs/day)	Annual Fuel Usage (MMBtu/yr)	Number of Cells	Cell Size (tons/cell)	Total Recirc. Rate (gpm)
Building NRLF	352,000	700	35.5 [a]	23	24	31,923	8	500	12,000 [b]
Buildings 6 and 7	253,954	--	--	24 [4]	24	42,000 [4]	6 [4]	500 [4]	9,000 [b]
Building 6	--	440 [3]	22.3 [a]	--	--	--	--	--	--
Building 7	--	440 [3]	22.3 [a]	--	--	--	--	--	--
Building 8	110,510	440 [4]	22.3 [a]	12 [4]	24	21,000 [4]	3 [4]	500 [4]	4,500 [b]
Building 9	137,451	440 [4]	22.3 [a]	12 [4]	24	21,000 [4]	3 [4]	500 [4]	4,500 [b]
Building 10	117,700	410	20.8 [a]	11	24	15,267	3	500	4,500 [b]
Building 11	67,280	240	12.2 [a]	6	24	8,328	2	400	2,400 [b]
Building 12	119,504	420	21.3 [a]	11	24	15,267	3	500	4,500 [b]
Building 13	84,894	170	8.6 [a]	6	24	8,328	2	400	2,400 [b]
Building 14	81,472	290	14.7 [a]	8	24	11,104	2	500	3,000 [b]
Building 15	137,820	480	24.3 [a]	13	24	18,043	3	500	4,500 [b]
Building 16	160,604	560	28.4 [a]	15	24	20,819	4	500	6,000 [b]
Building 17	170,085	600	30.4 [a]	16	24	22,207	4	500	6,000 [b]
Building 18	144,805	510	25.9 [a]	14	24	19,431	3	600	5,400 [b]
Building 19	129,795	460	23.3 [a]	12	24	16,655	3	500	4,500 [b]
Building 20	128,560	450	22.8 [a]	12	24	16,655	3	500	4,500 [b]
Building 21	290,240	510 [3]	25.9 [a]	28	24	38,863	7	500	10,500 [b]
Building 21 (Generator B)	--	510 [3]	25.9 [a]	--	--	--	--	--	--
Building 22	200,645	700	35.5 [a]	19	24	26,371	5	500	7,500 [b]
Building 23	151,650	530	26.9 [a]	14	24	19,431	4	500	6,000 [b]
Building 24	130,000	460	23.3 [a]	12	24	16,655	3	500	4,500 [b]
Building 25	180,770	630	32.0 [a]	17	24	23,595	4	500	6,000 [b]
Building 26	174,400	610	30.9 [a]	17	24	23,595	4	500	6,000 [b]
Building 27	167,612	590	29.9 [a]	16	24	22,207	4	500	6,000 [b]
Building 28	66,808	230	11.7 [a]	6	24	8,328	2	400	2,400 [b]
Building 29	90,216	180	9.1 [a]	6	24	8,328	2	400	2,400 [b]
Building 30	169,768	600	30.4 [a]	16	24	22,207	4	500	6,000 [b]
Building 31	90,927	180	9.1 [a]	6	24	8,328	2	400	2,400 [b]
Building 32	138,545	490	24.9 [a]	13	24	18,043	3	500	4,500 [b]
Building 33	165,490	580	29.4 [a]	16	24	22,207	4	500	6,000 [b]
Building 34	173,790	610	30.9 [a]	17	24	23,595	4	500	6,000 [b]
Building 35	199,630	700	35.5 [a]	19	24	26,371	5	500	7,500 [b]
Building 36	193,275	680	34.5 [a]	18	24	24,983	5	500	7,500 [b]
Building 37	209,615	740	37.5 [a]	20	24	27,759	5	500	7,500 [b]
Building 38	112,761	230	11.7 [a]	8	24	11,104	2	500	3,000 [b]
Total	5,102,576	16810	852.7	463	--	660,000 [5]	--	--	179,400

Table F-1 (continued)
LRDP Operations Input Assumptions for Emission Rate Calculations

Source	Source Parameter		Short Term Input (units)	Annual Input (units)
Employee and Facility Data				
	Number of Employees		10,000 (4)	--
	Average Building Occupancy		10 (hrs/day) (6)	260 (days/yr) (7)
	Emergency Generator Usage		2 (hrs/day) (8)	25.15 (hrs/yr) (8)
	Cooling Tower Usage		24 (hrs/day)	6,360 (hrs/yr) (9)
Vehicle Data				
	Vehicle Trips	**Daily Operation (hrs/day)**	**Maximum Daily (trips/day)**	**Average Annual (trips/yr)**
	Employee Trips	16	20,081 (10)	5,221,060 (11)
	Delivery Truck Trips	16	102 (12)	26,432 (13)
	LBNL - RBC Shuttle Trips	13 (14)	13 (14)	3,380 (14)
	BART - RBC Shuttle Trips	13 (14)	25 (14)	6,500 (14)
	Total trips		20,221	5,257,372
	Vehicle Idling Times and Round Trip Distances	**Onsite Idling Time (min/trip)**	**Onsite Round Trip Distance (mi/trip)**	**Offsite Round Trip Distance (mi/trip)**
	Employee Vehicles	0 (15)	0.685 (16)	20.6 (c)
	Delivery Trucks	0.08 (20)	1.680 (16)	12.9 (21)
	LBNL - RBC Shuttle	0.08 (22)	0.730 (16)	15.5 (23)
	BART - RBC Shuttle	0.08 (22)	0.730 (16)	8 (23)
	Employee Offsite Round Trip Distance - Modeling (mi/trip)			0.685 (16)
	Delivery Truck Offsite Round Trip Distance - Modeling (mi/trip)			2.434 (16)
	LBNL - RBC Shuttle Round Trip Distance - Modeling (mi/trip)			1.770 (16)
	BART - RBC Shuttle Round Trip Distance (mi/trip)			1.770 (16)
	Average Vehicle Weights			**Average Weight (tons)**
	Employee Vehicles			2.4 (24)
	Delivery Trucks			13 (25)
	LBNL - RBC Shuttle			4.2 (26)
	BART - RBC Shuttle			4.2 (26)
	Mean Vehicle Weight Calculation		**Daily Basis (tons)**	**Annual Basis (tons)**
	Employee Mean Vehicle Weight portion (ton)		2.38 (d)	2.38 (d)
	Delivery Truck Mean Vehicle Weight Portion (ton)		0.065 (d)	0.065 (d)
	LBNL - RBC Shuttle Mean Vehicle Weight Portion (ton)		0.003 (d)	0.003 (d)
	BART - RBC Shuttle Mean Vehicle Weight Portion (ton)		0.005 (d)	0.005 (d)
	Mean Vehicle Weight - sum of weight portions (ton)		2.46	2.46
Additional Site-Specific Data and Constants Used for Emission Calculations				
	Cooling Towers - Equivalent Ton Water Usage (gpm/ton)		3	(e)
	Cooling Towers - Total Dissolved Solids Concentration (ppm)		536	(27)
	Roads - P = No. of Days with Precip. > 0.01 in. (days/yr)		62	(28)

Table F-1 (continued)
LRDP Operations Input Assumptions for Emission Rate Calculations

Notes:

(a) Engine fuel consumption (gal/hr) = (Engine size [hp]) x (average brake-specific fuel consumption [Btu/hp-hr]) / (liquid fuel higher heating value [Btu/gal])

Average brake-specific fuel consumption (Btu/hp-hr) =	7,000	(1)
Liquid fuel higher heating value (Btu/gal) =	138,000	(2)

(b) Recirculation rate (gpm) = (Number of cooling tower cells) x (heat removal equivalent tons per cell [tons/cell]) x (equivalent ton water usage [gpm/ton])

(c) Offsite round trip distance (mi/trip) = {(Primary trip length [mi]) x (primary trip percentage [%]) + (primary trip length [mi]) x (diverted trip percentage [%]) x (diverted trip percentage of primary trip length [%]) + (pass-by trip percentage [%]) x (pass-by trip length [mi])} x 2 - (onsite round trip distance [mi/trip])

Primary trip length (mi) =	12.4	(17)
Primary trip percentage (%) =	82	(18)
Diverted trip percentage of primary trip length (%) =	25	(19)
Diverted trip percentage (%) =	15	(18)
Pass-by trip length (mi) =	0.1	(19)
Pass-by trip percentage (%) =	3	(18)

(d) Mean vehicle weight portions (tons) = (Individual vehicle trips [trips/day or trips/yr]) / (total vehicle trips [trips/day or trips/yr]) x (individual vehicle average weight [tons])

(e) Equivalent ton water usage (gpm/ton) = (15,000 Btu/hr/ton) x (hr/60 min) x (gal/8.337 lbs) / (1 Btu/lb-°F) / (10 °F temperature differential)

References:

(1) AP-42 Chapter 3.3 (October 1996), Footnote to Table 3.3-1, "Emission Factors for Uncontrolled Gasoline and Diesel Industrial Engines".
(2) ULSD higher heating value.
(3) Buildings 6 & 7 and Building 21 will each have two generators. For Buildings 6 & 7, the generators will total 880 hp and for Building 21, the generators will total 1,020 hp.
(4) January 17, 2013 LBNL responses.
(5) The annual fuel usage is described in the project description.
(6) Assumes laboratory work is conducted over 10 hours per day. This conservatively estimates hourly emissions .
(7) Assumes employees will generally be visiting the site 5 days per week, 52 weeks per year. This provides a conservative value to calculation the annual employee vehicle trips.
(8) Hourly value conservatively assumes a maximum of 2 hours per day of operation for maintenance and testing. Annual value is based on the average historical emergency engine usage from the LBNL LRDP.
(9) January 31, 2013 I.R. responses. Assumes cooling tower fans are off 2,400 hours per year, and only operate at full speed 260 hours per year.
(10) January 17, 2013 LBNL response - population increase by approx. 1,000 over the current 300. Assume 1,300 trips per day.
(11) Assumes daily worker trips will occur 5 days per week, 52 weeks per year.
(12) LRDP Daily truck trips equal to Phase 1 trips (10/day) x (LRDP gsf / Phase 1 gsf).
(13) January 31, 2013 I.R. responses. Assumes that the 10 weekly trips will occur over 5 days per week, 52 weeks per year.
(14) Shuttle schedule provided by LBNL. Assumes shuttle trips occur 5 days per week, 52 weeks per year.
(15) It is assumed that employee vehicles will have negligible idling time.
(16) Onsite and offsite modeling trip distances approximated using the AERMOD modeling software.
(17) CalEEMod Appendix D Table 4.2 "Mobile Trip Characteristics Dependent on Location", Bay Area AQMD. Light duty employee vehicle route is based on the urban home to work (H-W) trip length. Trip lengths in CalEEMod are one way.
(18) CalEEMod Appendix D Table 4.3 "Mobile Trip Rates, Trip Purpose, Trip Type by Land Use", Commercial Land Use Type, Research and Development Land Use Sub Type.
(19) CalEEMod Appendix A Section 5.1, Vehicle Trips. "For pass-by trip links the trip length will be 0.1 miles and diverted trip links the trip length will be 25% of the primary trip length".
(20) Assumes 5 minutes at idle time consistent with California Code of Regulations Section 2485, Airborne Toxic Control Measure to Limit Diesel-Fueled Commercial Motor Vehicle Idling.
(21) CalEEMod Appendix D Table 4.2 "Mobile Trip Characteristics Dependent on Location", Bay Area AQMD. Delivery truck route is based on the urban commercial-NW route. Trip lengths in CalEEMod are one way.
(22) Conservative estimate of idling time for each shuttle drop-off event.
(23) Shuttle bus routes and schedules provided by LBNL.
(24) CalEEMod Appendix D Table 4.1 "Road Characteristics". Average vehicle weight for Bay Area AQMD.
(25) Based on the EMFAC vehicle class used for estimating emissions: T6 instate small, which has the higher VMT of all comparable categories, and is representative of delivery trucks. Max GVWR = 26,000 lbs. Also assumes that LBNL would not be the final destination for deliveries, so only a nominal difference between loaded and unloaded weights is used.
(26) Ford E150 XLT - 5,700 lb curb weight, plus 15 passengers at ~180 lbs/person.
(27) From CRT project emissions calculations, provided by Impact Sciences.
(28) Comparative Climatic Data, National Climatic Data Center, NOAA, 2011. 84 year average for San Francisco AP, CA.

Table F-2
Summary of Offsite On-Road Exhaust Criteria Pollutant Emission Estimates

Pollutant	Vehicle Type	EMFAC Vehicle Class	Maximum Daily Round-Trips [1] (trips/day)	Total Annual Round-Trips [1] (trips/yr)	Round-Trip Distance [1] (miles)	Emission Factors [2] (lbs/VMT)	Maximum Daily Emissions Estimate [a] (lbs/day)	Annual Average Emissions Estimate [b] (tons/yr)
ROG	Delivery Trucks	T6 Instate Small	102	26,432	13	2.5E-04	0.33	4.3E-02
	LBNL - RBC Shuttle	MDV	13	3,380	16	2.4E-04	4.8E-02	6.3E-03
	BART - RBC Shuttle	MDV	25	6,500	8.0	2.4E-04	4.8E-02	6.2E-03
	Employees	LDA	20,081	5,221,060	21	8.6E-05	36	4.6
	Total ROG Emissions						**36**	**4.7**
NO_X	Delivery Trucks	T6 Instate Small	102	26,432	13	2.2E-03	2.9	0.38
	LBNL - RBC Shuttle	MDV	13	3,380	16	2.4E-04	4.9E-02	6.3E-03
	BART - RBC Shuttle	MDV	25	6,500	8.0	2.4E-04	4.8E-02	6.3E-03
	Employees	LDA	20,081	5,221,060	21	1.2E-04	50	6.5
	Total NO_X Emissions						**53**	**6.9**
CO	Delivery Trucks	T6 Instate Small	102	26,432	13	8.8E-04	1.2	0.15
	LBNL - RBC Shuttle	MDV	13	3,380	16	2.1E-03	0.42	5.4E-02
	BART - RBC Shuttle	MDV	25	6,500	8.0	2.1E-03	0.41	5.4E-02
	Employees	LDA	20,081	5,221,060	21	1.2E-03	482	63
	Total CO Emissions						**484**	**63**
SO_2	Delivery Trucks	T6 Instate Small	102	26,432	13	2.5E-05	3.2E-02	4.2E-03
	LBNL - RBC Shuttle	MDV	13	3,380	16	1.3E-05	2.6E-03	3.4E-04
	BART - RBC Shuttle	MDV	25	6,500	8.0	1.3E-05	2.6E-03	3.4E-04
	Employees	LDA	20,081	5,221,060	21	7.5E-06	3.1	0.40
	Total SO_2 Emissions						**3.1**	**0.41**
PM_{10} Exhaust	Delivery Trucks	T6 Instate Small	102	26,432	13	8.2E-05	0.11	1.4E-02
	LBNL - RBC Shuttle	MDV	13	3,380	16	4.3E-06	8.7E-04	1.1E-04
	BART - RBC Shuttle	MDV	25	6,500	8.0	4.3E-06	8.7E-04	1.1E-04
	Employees	LDA	20,081	5,221,060	21	4.5E-06	1.9	0.24
	Total PM_{10} Emissions						**2.0**	**0.26**
PM_{10} Tire/Brake	Delivery Trucks	T6 Instate Small	102	26,432	13	3.1E-04	0.41	5.4E-02
	LBNL - RBC Shuttle	MDV	13	3,380	16	9.9E-05	2.0E-02	2.6E-03
	BART - RBC Shuttle	MDV	25	6,500	8.0	9.9E-05	2.0E-02	2.6E-03
	Employees	LDA	20,081	5,221,060	21	9.9E-05	41	5.3
	Total PM_{10} Emissions						**41**	**5.4**
$PM_{2.5}$ Exhaust	Delivery Trucks	T6 Instate Small	102	26,432	13	7.6E-05	1.0E-01	1.3E-02
	LBNL - RBC Shuttle	MDV	13	3,380	16	4.0E-06	8.1E-04	1.1E-04
	BART - RBC Shuttle	MDV	25	6,500	8.0	4.0E-06	8.0E-04	1.0E-04
	Employees	LDA	20,081	5,221,060	21	4.2E-06	1.7	0.23
	Total $PM_{2.5}$ Emissions						**1.8**	**0.24**
$PM_{2.5}$ Tire/Brake	Delivery Trucks	T6 Instate Small	102	26,432	13	1.3E-04	0.17	2.2E-02
	LBNL - RBC Shuttle	MDV	13	3,380	16	3.9E-05	7.9E-03	1.0E-03
	BART - RBC Shuttle	MDV	25	6,500	8.0	3.9E-05	7.8E-03	1.0E-03
	Employees	LDA	20,081	5,221,060	21	3.9E-05	16	2.1
	Total $PM_{2.5}$ Emissions						**16**	**2.1**
CO_2	Delivery Trucks	T6 Instate Small	102	26,432	13	2.3	3,048	396
	LBNL - RBC Shuttle	MDV	13	3,380	16	0.92	185	24
	BART - RBC Shuttle	MDV	25	6,500	8.0	0.92	184	24
	Employees	LDA	20,081	5,221,060	21	0.45	185,182	24,074
	Total CO_2 Emissions						**188,599**	**24,518**

Notes:
(a) Maximum daily emissions estimate (lbs/day) = (Maximum daily round-trips [trips/day]) x (round-trip distance [miles]) x (emission factor [lbs/VMT])
(b) Annual average emissions estimate (tons/yr) = (Annual round-trips [trips/yr]) x (round-trip distance [miles]) x (emission factor [lbs/VMT]) x (ton/2,000 lbs)

References:
(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) Emission Factors source: Emfac 2011 (Model Years to 2034), typical speed distribution. Carbon dioxide emission factors are representative of post-Low Carbon Fuel Standard implementation.

Table F-3
Summary of Onsite On-Road Exhaust Criteria Pollutant Emission Estimates

Pollutant	Vehicle Type	EMFAC Vehicle Class	Maximum Daily Round-Trips [1] (trips/day)	Total Annual Round-Trips [1] (trips/yr)	Round-Trip Distance [1] (miles)	Emission Factor [2] (lbs/VMT)	Maximum Daily Emissions Estimate [a] (lbs/day)	Annual Average Emissions Estimate [b] (tons/yr)
ROG	Delivery Trucks	T6 Instate Small	102	26,432	1.7	1.3E-03	0.23	3.0E-02
	LBNL - RBC Shuttle	MDV	13	3,380	0.73	1.6E-04	1.6E-03	2.0E-04
	BART - RBC Shuttle	MDV	25	6,500	0.73	1.6E-04	3.0E-03	3.9E-04
	Employees	LDA	20,081	5,221,060	1.7	8.2E-05	2.8	0.36
	Total ROG Emissions						**3.0**	**0.39**
NO_X	Delivery Trucks	T6 Instate Small	102	26,432	1.7	5.1E-03	0.87	0.11
	LBNL - RBC Shuttle	MDV	13	3,380	0.73	3.9E-04	3.7E-03	4.8E-04
	BART - RBC Shuttle	MDV	25	6,500	0.73	3.9E-04	7.1E-03	9.2E-04
	Employees	LDA	20,081	5,221,060	1.7	1.9E-04	6.4	0.84
	Total NO_X Emissions						**7.3**	**0.95**
CO	Delivery Trucks	T6 Instate Small	102	26,432	1.7	2.5E-03	0.43	5.6E-02
	LBNL - RBC Shuttle	MDV	13	3,380	0.73	3.5E-03	3.4E-02	4.4E-03
	BART - RBC Shuttle	MDV	25	6,500	0.73	3.5E-03	6.5E-02	8.4E-03
	Employees	LDA	20,081	5,221,060	1.7	2.0E-03	66	8.6
	Total CO Emissions						**66**	**8.6**
SO_2	Delivery Trucks	T6 Instate Small	102	26,432	1.7	0	0	0
	LBNL - RBC Shuttle	MDV	13	3,380	0.73	0	0	0
	BART - RBC Shuttle	MDV	25	6,500	0.73	0	0	0
	Employees	LDA	20,081	5,221,060	1.7	0	0	0
	Total SO_2 Emissions						**0**	**0**
PM_{10} Exhaust	Delivery Trucks	T6 Instate Small	102	26,432	1.7	7.8E-05	1.3E-02	1.7E-03
	LBNL - RBC Shuttle	MDV	13	3,380	0.73	1.9E-05	1.8E-04	2.3E-05
	BART - RBC Shuttle	MDV	25	6,500	0.73	1.9E-05	3.4E-04	4.4E-05
	Employees	LDA	20,081	5,221,060	1.7	1.9E-05	0.65	8.4E-02
	Total PM_{10} Emissions						**0.66**	**8.6E-02**
PM_{10} Tire/Brake	Delivery Trucks	T6 Instate Small	102	26,432	1.7	0	0	0
	LBNL - RBC Shuttle	MDV	13	3,380	0.73	0	0	0
	BART - RBC Shuttle	MDV	25	6,500	0.73	0	0	0
	Employees	LDA	20,081	5,221,060	1.7	0	0	0
	Total PM_{10} Emissions						**0**	**0**
$PM_{2.5}$ Exhaust	Delivery Trucks	T6 Instate Small	102	26,432	1.7	7.2E-05	1.2E-02	1.6E-03
	LBNL - RBC Shuttle	MDV	13	3,380	0.73	1.7E-05	1.6E-04	2.1E-05
	BART - RBC Shuttle	MDV	25	6,500	0.73	1.7E-05	3.1E-04	4.1E-05
	Employees	LDA	20,081	5,221,060	1.7	1.8E-05	0.60	7.8E-02
	Total $PM_{2.5}$ Emissions						**0.62**	**8.0E-02**
$PM_{2.5}$ Tire/Brake	Delivery Trucks	T6 Instate Small	102	26,432	1.7	0	0	0
	LBNL - RBC Shuttle	MDV	13	3,380	0.73	0	0	0
	BART - RBC Shuttle	MDV	25	6,500	0.73	0	0	0
	Employees	LDA	20,081	5,221,060	1.7	0	0	0
	Total $PM_{2.5}$ Emissions						**0**	**0**
CO_2	Delivery Trucks	T6 Instate Small	102	26,432	1.7	4.2	717	93
	LBNL - RBC Shuttle	MDV	13	3,380	0.73	2.2	21	2.7
	BART - RBC Shuttle	MDV	25	6,500	0.73	2.2	40	5.2
	Employees	LDA	20,081	5,221,060	1.7	1.1	35,750	4,647
	Total CO_2 Emissions						**36,527**	**4,749**

Notes:
(a) Maximum daily emissions estimate (lbs/day) = (Maximum daily round-trips [trips/day]) x (round-trip distance [miles]) x (emission factor [lbs/VMT])
(b) Annual average emissions estimate (tons/yr) = (Annual round-trips [trips/yr]) x (round-trip distance [miles]) x (emission factor [lbs/VMT]) x (ton/2,000 lbs)

References:
(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) Emission Factors source: EMFAC 2011 (Model Years to 2034), 10 mph speed to represent average onsite speeds. Carbon dioxide emission factors are representative of post-Low Carbon Fuel Standard implementation.

Table F-4
Summary of Onsite Idling Exhaust Criteria Pollutant Emission Estimates

Pollutant	Vehicle Type	EMFAC Vehicle Class	Maximum Daily Round-Trips [1] (trips/day)	Total Annual Round-Trips [1] (trips/yr)	Idle Time per Trip [1] (hrs/trip)	Idle Emission Factor [2] (lbs/idle-hour)	Maximum Daily Emissions Estimate [a] (lbs/day)	Annual Average Emissions Estimate [b] (tons/yr)
ROG	Delivery Trucks	T6 Instate Small	102	26,432	8.3E-02	4.7E-03	4.0E-02	5.2E-03
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	1.3E-03	1.4E-03	1.8E-04
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	1.3E-03	2.7E-03	3.5E-04
	Employees	LDA	20,081	5,221,060	0	6.6E-04	0	0
	Total ROG Emissions						**4.4E-02**	**5.7E-03**
NO_X	Delivery Trucks	T6 Instate Small	102	26,432	8.3E-02	8.5E-02	0.72	9.4E-02
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	2.2E-03	2.4E-03	3.1E-04
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	2.2E-03	4.6E-03	6.0E-04
	Employees	LDA	20,081	5,221,060	0	1.1E-03	0	0
	Total NO_X Emissions						**0.73**	**9.5E-02**
CO	Delivery Trucks	T6 Instate Small	102	26,432	8.3E-02	5.6E-02	0.47	6.2E-02
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	2.0E-02	2.1E-02	2.8E-03
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	2.0E-02	4.1E-02	5.3E-03
	Employees	LDA	20,081	5,221,060	0	1.1E-02	0	0
	Total CO Emissions						**0.54**	**7.0E-02**
SO_2	Delivery Trucks	T6 Instate Small	102	26,432	8.3E-02	1.6E-04	1.4E-03	1.8E-04
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	0	0	0
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	0	0	0
	Employees	LDA	20,081	5,221,060	0	0	0	0
	Total SO_2 Emissions						**1.4E-03**	**1.8E-04**
PM_{10} Exhaust	Delivery Trucks	T6 Instate Small	102	26,432	8.3E-02	2.0E-04	1.7E-03	2.2E-04
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	1.5E-04	1.6E-04	2.1E-05
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	1.5E-04	3.1E-04	4.0E-05
	Employees	LDA	20,081	5,221,060	0	1.5E-04	0	0
	Total PM_{10} Emissions						**2.2E-03**	**2.8E-04**
$PM_{2.5}$ Exhaust	Delivery Trucks	T6 Instate Small	102	26,432	8.3E-02	1.8E-04	1.6E-03	2.0E-04
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	1.4E-04	1.5E-04	1.9E-05
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	1.4E-04	2.9E-04	3.7E-05
	Employees	LDA	20,081	5,221,060	0	1.4E-04	0	0
	Total $PM_{2.5}$ Emissions						**2.0E-03**	**2.6E-04**
CO_2	Delivery Trucks	T6 Instate Small	102	26,432	8.3E-02	15	128	17
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	15	16	2.1
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	15	31	4.0
	Employees	LDA	20,081	5,221,060	0	7.2	0	0
	Total CO_2 Emissions						**175**	**23**

Notes:
(a) Maximum daily emissions estimate (lbs/day) = (Maximum daily round-trips [trips/day]) x (idle time per trip [hrs/trip]) x (emission factor [lbs/idle-hr])
(b) Annual average emissions estimate (tons/yr) = (Annual round-trips [trips/yr]) x (idle time per trip [hrs/trip]) x (emission factor [lbs/idle-hr]) x (ton/2,000 lbs)

References:
(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) Emission Factors source: EMFAC 2011 (Model Years to 2034). Emissions for Light Duty Vehicle Idling assumed to be negligible, and thus not quantified. Carbon dioxide emission factors are representative of post-Low Carbon Fuel Standard implementation.

Table F-5

Onsite Parking Lot Emission Estimates

Source		Parking Lot (total)
EMFAC Vehicle Class	(1)	LDA
Number of Vehicle Trips per Day	(2)	20,081
Number of Vehicle Trips per Year	(2)	5,221,060
Modeling ID		LOT_EX

Pollutant	Emission Factor (3) (lbs/trip)	Maximum Daily Emissions Estimate (a) (lbs/day)	Annual Average Emissions Estimate (b) (tons/yr)
PM_{10}	1.16E-05	0.23	0.030
$PM_{2.5}$	1.08E-05	0.22	0.028
NO_X	1.24E-04	2.49	0.32
CO	2.17E-03	43.6	5.67
SO_2	1.67E-06	0.034	4.4E-03
ROG	3.15E-04	6.32	0.82
CO_2	0.16	3,287	427

Notes:

(a) Daily emissions estimate (lbs/day) =(Emission factor [lbs/trip]) x (number of vehicle trips per day)

(b) Annual emissions estimate (lbs/day) =(Emission factor [lbs/trip]) x (number of vehicle trips per year) x (ton/2,000 lbs)

References:

(1) LDA represents light-duty employee vehicles.

(2) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.

(3) EMFAC 2011. Emission factors are based on the stationary starting exhaust, diurnal, hot soak, and resting loss vehicle portions of the LDA class emissions, on a per trip basis.

Table F-6
Onsite Paved Road Dust Emission Estimates

Parameter		Employee Vehicles	Delivery Trucks	LBNL - RBC Shuttle	BART - RBC Shuttle	Total
Onsite Roundtrip Distance (mi/trip)	(1)	0.7	1.7	0.7	0.7	
Maximum Daily Trips (trips/day)	(1)	20,081	102	13	25	
Annual Trips (trips/yr)	(1)	5,221,060	26,432	3,380	6,500	

Pollutant	Daily Emission Factor [a] (lbs/VMT)	Annual Emission Factor [b] (lbs/VMT)	Maximum Daily Emissions Estimate [c] (lbs/day)	Annual Average Emissions Estimate [d] (tons/yr)	Maximum Daily Emissions Estimate [c] (lbs/day)	Annual Average Emissions Estimate [d] (tons/yr)	Maximum Daily Emissions Estimate [c] (lbs/day)	Annual Average Emissions Estimate [d] (tons/yr)	Maximum Daily Emissions Estimate [c] (lbs/day)	Annual Average Emissions Estimate [d] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate (tons/yr)
PM	9.8E-03	9.3E-03	134	16.7	1.67	0.21	0.093	0.012	0.18	0.022	136	16.9
PM_{10}	2.0E-03	1.9E-03	26.8	3.34	0.33	0.041	0.019	2.3E-03	0.036	4.4E-03	27.2	3.39
$PM_{2.5}$	4.8E-04	4.6E-04	6.58	0.82	0.082	0.010	4.5E-03	5.7E-04	8.7E-03	1.1E-03	6.68	0.83

Notes:

(a) Maximum daily emission factor (lbs/VMT) = $(k \times (sL)^{0.91} \times (W)^{1.02})$

k = aerodynamic particle size multiplier (PM) =	0.011	(2)
k = aerodynamic particle size multiplier (PM_{10}) =	0.0022	(2)
k = aerodynamic particle size multiplier ($PM_{2.5}$) =	0.00054	(2)
sL = surface material silt content (g/m^2) =	0.32	(3)
W = mean vehicle weight (tons) =	2.5	(4)

(b) Annual emission factor (lbs/VMT) = $(k \times (sL)^{0.91} \times (W)^{1.02}) \times ((1-P)/4N)$

k = aerodynamic particle size multiplier (PM) =	0.011	(2)
k = aerodynamic particle size multiplier (PM_{10}) =	0.0022	(2)
k = aerodynamic particle size multiplier ($PM_{2.5}$) =	0.00054	(2)
sL = surface material silt content (g/m^2) =	0.32	(3)
W = mean vehicle weight (tons) =	2.5	(4)
P = number of wet days (0.01 inches of precip.) =	62	(1)
N = number of days in averaging period =	365	

(c) Maximum daily emissions estimate (lbs/day) = (Emission factor [lbs/VMT]) x (maximum daily vehicle trips [trips/day]) x (onsite roundtrip distance [mi/trip]) x (1 - [control efficiency {%}] / 100)

Control efficiency (%) =	0%	(5)

(d) Annual emissions estimate (tons/yr) = (Emission factor [lbs/VMT]) x (annual vehicle trips [trips/yr]) x (onsite roundtrip distance [mi/trip]) x (ton/2,000 lbs) x (1 - [control efficiency {%}] / 100)

Control efficiency (%) =	0%	(5)

References:

(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) AP-42 Chapter 13.2.1 (January, 2011), Table 13.2.1-1 "Particle Size Multipliers for Paved Road Equation".
(3) Section 7.9 of the CARB Emission Inventory Methodology. Assumes offsite roads are equivalent to local roads as shown in Table 3 (silt loading of 0.32 g/m^2).
(4) Mean vehicle weight is calculated as the weighted average of the individual vehicle weights (average of unloaded and loaded weight), weighted based on the individual annual truck trips divided by total annual truck trips.
(5) Engineering estimate.

Table F-7
Offsite Paved Road Dust Emission Estimates

Parameter		Employee Vehicles	Delivery Trucks	LBNL - RBC Shuttle	BART - RBC Shuttle	Total
Offsite Roundtrip Distance (mi/trip)	(1)	21	13	16	8	
Maximum Daily Trips (trips/day)	(1)	20,081	102	13	25	
Annual Trips (trips/yr)	(1)	5,221,060	26,432	3,380	6,500	

Pollutant	Daily Emission Factor [(a)] (lbs/VMT)	Annual Emission Factor [(b)] (lbs/VMT)	Maximum Daily Emissions Estimate [(c)] (lbs/day)	Annual Average Emissions Estimate [(d)] (tons/yr)	Maximum Daily Emissions Estimate [(c)] (lbs/day)	Annual Average Emissions Estimate [(d)] (tons/yr)	Maximum Daily Emissions Estimate [(c)] (lbs/day)	Annual Average Emissions Estimate [(d)] (tons/yr)	Maximum Daily Emissions Estimate [(c)] (lbs/day)	Annual Average Emissions Estimate [(d)] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate (tons/yr)
PM	1.3E-03	1.2E-03	526	65.4	1.67	0.21	0.26	0.032	0.25	0.032	528	65.7
PM_{10}	2.5E-04	2.4E-04	105	13.1	0.33	0.042	0.051	6.4E-03	0.051	6.3E-03	106	13.1
$PM_{2.5}$	6.2E-05	6.0E-05	25.8	3.21	0.082	0.010	0.013	1.6E-03	0.012	1.6E-03	25.9	3.23

Notes:

(a) Maximum daily emission factor (lbs/VMT) = $(k \times (sL)^{0.91} \times (W)^{1.02})$

k = aerodynamic particle size multiplier (PM) =	0.011	(2)
k = aerodynamic particle size multiplier (PM_{10}) =	0.0022	(2)
k = aerodynamic particle size multiplier ($PM_{2.5}$) =	0.00054	(2)
sL = surface material silt content (g/m^2) =	0.035	(3)
W = mean vehicle weight (tons) =	2.4	(3)

(b) Annual emission factor (lbs/VMT) = $(k \times (sL)^{0.91} \times (W)^{1.02}) \times ((1-P)/4N)$

k = aerodynamic particle size multiplier (PM) =	0.011	(2)
k = aerodynamic particle size multiplier (PM_{10}) =	0.0022	(2)
k = aerodynamic particle size multiplier ($PM_{2.5}$) =	0.00054	(2)
sL = surface material silt content (g/m^2) =	0.035	(3)
W = mean vehicle weight (tons) =	2.4	(3)
P = number of wet days (0.01 inches of precip.) =	62	(1)
N = number of days in averaging period =	365	

(c) Maximum daily emissions estimate (lbs/day) = (Emission factor [lbs/VMT]) x (maximum daily vehicle trips [trips/day]) x (offsite roundtrip distance [mi/trip]) x (1 - [control efficiency {%}] / 100)

Control efficiency (%) =	0%	(4)

(d) Annual emissions estimate (tons/yr) = (Emission factor [lbs/VMT]) x (annual vehicle trips [trips/yr]) x (offsite roundtrip distance [mi/trip]) x (ton/2,000 lbs) x (1 - [control efficiency {%}] / 100)

Control efficiency (%) =	0%	(4)

References:

(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) AP-42 Chapter 13.2.1 (January, 2011), Table 13.2.1-1 "Particle Size Multipliers for Paved Road Equation".
(3) Section 7.9 of the CARB Emission Inventory Methodology. Assumes offsite roads are equivalent to major/collector roads as shown in Table 3 (silt loading of 0.035 g/m^2).
(4) Engineering estimate.

Table F-8
Natural Gas Boiler Criteria Emission Estimates

Pollutant					PM		PM_{10}		$PM_{2.5}$		NO_x		CO		SO_2		VOC		CO_2		CH_4		N_2O		CO_2e	
Emission Factor (lbs/MMscf)					7.60 (1)		7.60 (2)		7.60 (2)		18.72 (a)		84 (4)		0.6 (1)		5.5 (1)		120,162 (b)		2.27 (c)		0.23 (c)		120,280 (d)	
					Emission Estimates																					
Source	Modeling ID	Maximum Hourly Fuel Usage (8) (MMBtu/hr)	Daily Operation (8) (hrs/day)	Annual Fuel Usage (8) (MMBtu/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)
Natural Gas Boiler - Building NRLF	NGB_NRLF	23	24	31,923	4.08	0.12	4.08	0.12	4.08	0.12	10.0	0.29	45.1	1.30	0.32	9.3E-03	2.95	0.085	64,523	1,866	1.22	0.035	0.12	3.5E-03	64,586	1,868
Natural Gas Boiler - Buildings 6 and 7	NGB_B6_7	24	24	42,000	4.26	0.16	4.26	0.16	4.26	0.16	10.5	0.38	47.1	1.72	0.34	0.012	3.08	0.11	67,328	2,455	1.27	0.046	0.13	4.6E-03	67,394	2,457
Natural Gas Boiler - Building 8	NGB_B8	12	24	21,000	2.13	0.078	2.13	0.078	2.13	0.078	5.24	0.19	23.5	0.86	0.17	6.1E-03	1.54	0.056	33,664	1,227	0.63	0.023	0.063	2.3E-03	33,697	1,229
Natural Gas Boiler - Building 9	NGB_B9	12	24	21,000	2.13	0.078	2.13	0.078	2.13	0.078	5.24	0.19	23.5	0.86	0.17	6.1E-03	1.54	0.056	33,664	1,227	0.63	0.023	0.063	2.3E-03	33,697	1,229
Natural Gas Boiler - Building 10	NGB_B10	11	24	15,267	1.95	0.056	1.95	0.056	1.95	0.056	4.81	0.14	21.6	0.62	0.15	4.5E-03	1.41	0.041	30,859	892	0.58	0.017	0.058	1.7E-03	30,889	893
Natural Gas Boiler - Building 11	NGB_B11	6	24	8,328	1.06	0.031	1.06	0.031	1.06	0.031	2.62	0.076	11.8	0.34	0.084	2.4E-03	0.77	0.022	16,832	487	0.32	9.2E-03	0.032	9.2E-04	16,849	487
Natural Gas Boiler - Building 12	NGB_B12	11	24	15,267	1.95	0.056	1.95	0.056	1.95	0.056	4.81	0.14	21.6	0.62	0.15	4.5E-03	1.41	0.041	30,859	892	0.58	0.017	0.058	1.7E-03	30,889	893
Natural Gas Boiler - Building 13	NGB_B13	6	24	8,328	1.06	0.031	1.06	0.031	1.06	0.031	2.62	0.076	11.8	0.34	0.084	2.4E-03	0.77	0.022	16,832	487	0.32	9.2E-03	0.032	9.2E-04	16,849	487
Natural Gas Boiler - Building 14	NGB_B14	8	24	11,104	1.42	0.041	1.42	0.041	1.42	0.041	3.50	0.10	15.7	0.45	0.11	3.2E-03	1.03	0.030	22,443	649	0.42	0.012	0.042	1.2E-03	22,465	650
Natural Gas Boiler - Building 15	NGB_B15	13	24	18,043	2.31	0.067	2.31	0.067	2.31	0.067	5.68	0.16	25.5	0.74	0.18	5.3E-03	1.67	0.048	36,469	1,055	0.69	0.020	0.069	2.0E-03	36,505	1,056
Natural Gas Boiler - Building 16	NGB_B16	15	24	20,819	2.66	0.077	2.66	0.077	2.66	0.077	6.55	0.19	29.4	0.85	0.21	6.1E-03	1.93	0.056	42,080	1,217	0.79	0.023	0.079	2.3E-03	42,121	1,218
Natural Gas Boiler - Building 17	NGB_B17	16	24	22,207	2.84	0.082	2.84	0.082	2.84	0.082	6.99	0.20	31.4	0.91	0.22	6.5E-03	2.05	0.059	44,885	1,298	0.85	0.024	0.085	2.4E-03	44,929	1,299
Natural Gas Boiler - Building 18	NGB_B18	14	24	19,431	2.48	0.072	2.48	0.072	2.48	0.072	6.12	0.18	27.5	0.79	0.20	5.7E-03	1.80	0.052	39,275	1,136	0.74	0.021	0.074	2.1E-03	39,313	1,137
Natural Gas Boiler - Building 19	NGB_B19	12	24	16,655	2.13	0.062	2.13	0.062	2.13	0.062	5.24	0.15	23.5	0.68	0.17	4.9E-03	1.54	0.045	33,664	973	0.63	0.018	0.063	1.8E-03	33,697	974
Natural Gas Boiler - Building 20	NGB_B20	12	24	16,655	2.13	0.062	2.13	0.062	2.13	0.062	5.24	0.15	23.5	0.68	0.17	4.9E-03	1.54	0.045	33,664	973	0.63	0.018	0.063	1.8E-03	33,697	974
Natural Gas Boiler - Building 21	NGB_B21	28	24	38,863	4.97	0.14	4.97	0.14	4.97	0.14	12.2	0.35	54.9	1.59	0.39	0.011	3.60	0.10	78,550	2,271	1.48	0.043	0.15	4.3E-03	78,627	2,274
Natural Gas Boiler - Building 22	NGB_B22	19	24	26,371	3.37	0.097	3.37	0.097	3.37	0.097	8.30	0.24	37.3	1.08	0.27	7.7E-03	2.44	0.071	53,301	1,541	1.01	0.029	0.10	2.9E-03	53,354	1,543
Natural Gas Boiler - Building 23	NGB_B23	14	24	19,431	2.48	0.072	2.48	0.072	2.48	0.072	6.12	0.18	27.5	0.79	0.20	5.7E-03	1.80	0.052	39,275	1,136	0.74	0.021	0.074	2.1E-03	39,313	1,137
Natural Gas Boiler - Building 24	NGB_B24	12	24	16,655	2.13	0.062	2.13	0.062	2.13	0.062	5.24	0.15	23.5	0.68	0.17	4.9E-03	1.54	0.045	33,664	973	0.63	0.018	0.063	1.8E-03	33,697	974
Natural Gas Boiler - Building 25	NGB_B25	17	24	23,595	3.02	0.087	3.02	0.087	3.02	0.087	7.43	0.21	33.3	0.96	0.24	6.9E-03	2.18	0.063	47,691	1,379	0.90	0.026	0.090	2.6E-03	47,738	1,380
Natural Gas Boiler - Building 26	NGB_B26	17	24	23,595	3.02	0.087	3.02	0.087	3.02	0.087	7.43	0.21	33.3	0.96	0.24	6.9E-03	2.18	0.063	47,691	1,379	0.90	0.026	0.090	2.6E-03	47,738	1,380
Natural Gas Boiler - Building 27	NGB_B27	16	24	22,207	2.84	0.082	2.84	0.082	2.84	0.082	6.99	0.20	31.4	0.91	0.22	6.5E-03	2.05	0.059	44,885	1,298	0.85	0.024	0.085	2.4E-03	44,929	1,299
Natural Gas Boiler - Building 28	NGB_B28	6	24	8,328	1.06	0.031	1.06	0.031	1.06	0.031	2.62	0.076	11.8	0.34	0.084	2.4E-03	0.77	0.022	16,832	487	0.32	9.2E-03	0.032	9.2E-04	16,849	487
Natural Gas Boiler - Building 29	NGB_B29	6	24	8,328	1.06	0.031	1.06	0.031	1.06	0.031	2.62	0.076	11.8	0.34	0.084	2.4E-03	0.77	0.022	16,832	487	0.32	9.2E-03	0.032	9.2E-04	16,849	487
Natural Gas Boiler - Building 30	NGB_B30	16	24	22,207	2.84	0.082	2.84	0.082	2.84	0.082	6.99	0.20	31.4	0.91	0.22	6.5E-03	2.05	0.059	44,885	1,298	0.85	0.024	0.085	2.4E-03	44,929	1,299
Natural Gas Boiler - Building 31	NGB_B31	6	24	8,328	1.06	0.031	1.06	0.031	1.06	0.031	2.62	0.076	11.8	0.34	0.084	2.4E-03	0.77	0.022	16,832	487	0.32	9.2E-03	0.032	9.2E-04	16,849	487
Natural Gas Boiler - Building 32	NGB_B32	13	24	18,043	2.31	0.067	2.31	0.067	2.31	0.067	5.68	0.16	25.5	0.74	0.18	5.3E-03	1.67	0.048	36,469	1,055	0.69	0.020	0.069	2.0E-03	36,505	1,056
Natural Gas Boiler - Building 33	NGB_B33	16	24	22,207	2.84	0.082	2.84	0.082	2.84	0.082	6.99	0.20	31.4	0.91	0.22	6.5E-03	2.05	0.059	44,885	1,298	0.85	0.024	0.085	2.4E-03	44,929	1,299
Natural Gas Boiler - Building 34	NGB_B34	17	24	23,595	3.02	0.087	3.02	0.087	3.02	0.087	7.43	0.21	33.3	0.96	0.24	6.9E-03	2.18	0.063	47,691	1,379	0.90	0.026	0.090	2.6E-03	47,738	1,380
Natural Gas Boiler - Building 35	NGB_B35	19	24	26,371	3.37	0.097	3.37	0.097	3.37	0.097	8.30	0.24	37.3	1.08	0.27	7.7E-03	2.44	0.071	53,301	1,541	1.01	0.029	0.10	2.9E-03	53,354	1,543
Natural Gas Boiler - Building 36	NGB_B36	18	24	24,983	3.19	0.092	3.19	0.092	3.19	0.092	7.86	0.23	35.3	1.02	0.25	7.3E-03	2.31	0.067	50,496	1,460	0.95	0.028	0.095	2.8E-03	50,546	1,462
Natural Gas Boiler - Building 37	NGB_B37	20	24	27,759	3.55	0.10	3.55	0.10	3.55	0.10	8.74	0.25	39.2	1.13	0.28	8.1E-03	2.57	0.074	56,107	1,622	1.06	0.031	0.11	3.1E-03	56,162	1,624
Natural Gas Boiler - Building 38	NGB_B38	8	24	11,104	1.42	0.041	1.42	0.041	1.42	0.041	3.50	0.10	15.7	0.45	0.11	3.2E-03	1.03	0.030	22,443	649	0.42	0.012	0.042	1.2E-03	22,465	650
Total					**82.2**	**2.44**	**82.2**	**2.44**	**82.2**	**2.44**	**202**	**6.01**	**908**	**27.0**	**6.49**	**0.19**	**59.5**	**1.77**	**1,298,873**	**38,573**	**24.5**	**0.73**	**2.45**	**0.073**	**1,300,147**	**38,611**

Notes:

(a) Emission factor (lbs/MMscf) = (NO_2 or CO emission limit [ppmv @ 3% O_2]) x (10^{-6}) x (NO_2 or CO molecular weight [lbs/lb-mol]) x (lb-mol/385.44 ft^3) x (natural gas f-factor [8,710 dscf/MMBtu]) x (20.9% O_2/[20.9% O_2 - 3% O_2]) x (heat content [Btu/scf])

BAAQMD NO_x emission limit (ppmv @ 3% O_2) =	15	(3)
BAAQMD CO emission limit (ppmv @ 3% O_2) =	400	(3)
NO_2 molecular weight (lbs/lb-mol) =	46	
CO molecular weight (lbs/lb-mol) =	28.01	
Natural gas heat content (Btu/scf) =	1,028	(5)

(b) CO_2 emission factor (lbs/MMscf) = (CO_2 emission factor [kg CO_2/MMBtu]) x (default high heat value (MMBtu/scf)) x (10^6 scf/MMscf) x (lb/0.453592 kg)

CO_2 emission factor (kg/MMBtu) =	53.02	(5)
Default high heat value (MMBtu/scf) =	1.028E-03	(5)

(c) CH_4 or N_2O emission factor (lbs/MMscf) = (CH_4 or N_2O emission factor [kg/MMBtu]) x (lb/0.453592 kg) x (natural gas heat content [Btu/scf])

CH_4 emission factor (kg/MMBtu) =	1.0E-03	(6)
N_2O emission factor (kg/MMBtu) =	1.0E-04	(6)
Natural gas heat content (Btu/scf) =	1,028	(5)

(d) CO_2e emission factor (lbs/MMscf) = (CO_2 emission factor [lbs/MMscf]) + (CH_4 emission factor [lbs/MMscf] x CH_4 global warming potential) + (N_2O emission factor [lbs/MMscf] x N_2O global warming potential)

Global warming potential of CH_4 =	21	(7)
Global warming potential of N_2O =	310	(7)

(e) Daily emissions estimate (lbs/day) = (Emission factor [lbs/MMscf]) x (maximum hourly heat input [MMBtu/hr]) x (daily hours of operation [hrs/day]) / (natural gas heat content [Btu/scf])

Natural gas heat content (Btu/scf) =	1,028	(5)

(f) Annual emissions estimate (tons/yr) = (emission factor [lbs/MMscf]) x (annual heat input [MMBtu/yr]) / (natural gas heat content [Btu/scf]) x (tons/2,000 lbs)

Natural gas heat content (Btu/scf) =	1,028	(5)

References:

(1) AP-42 Chapter 1.4 (July 1998), Table 1.4-2 "Emission Factors for Criteria Pollutants and Greenhouse Gases from Natural Gas Combustion".
(2) Assumes that 100% of PM is $PM_{2.5}$. Therefore, 100% of PM_{10} is $PM_{2.5}$.
(3) BAAQMD Emission Limits 307.2, 307.3, and 307.4 from Section 9-7-307..
(4) AP-42 Chapter 1.4 (July 1998), Table 1.4-1 "Emission Factors for NO_X and CO from Natural Gas Combustion".
(5) 40 CFR Part 98 Subpart C, Table C-1, Default CO_2 Emission Factors and High Heat Values for Various Types of Fuel.
(6) 40 CFR Part 98 Subpart C, Table C-2, Default CH_4 and N_2O Emission Factors for Various Types of Fuel.
(7) 40 CFR Part 98 Subpart A, Table A-1, Global Warming Potentials.
(8) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.

Table F-9
Emergency Diesel Generator Criteria Emission Estimates

Pollutant		Min HP	Max HP	PM	PM_{10}	$PM_{2.5}$	NO_X	CO	SO_2	VOC	CO_2	CH_4	CO_2e
Emission Factor - Phase 1 Tier 4 Final (g/hp-hr)	(1)	440		0.01 (1)	0.01 (1)	0.01 (1)	0.3 (2)	2.2 (2)	-- (3)	0.14 (2)	-- (4)	--	--
Emission Factor - Tier 4 Final (g/hp-hr)	(1)	100	174	0.015 (1)	0.015 (1)	0.015 (1)	0.3 (2)	3.7 (2)	-- (3)	0.14 (2)	-- (4)	--	--
Emission Factor - Tier 4 Final (g/hp-hr)	(1)	175	749	0.015 (1)	0.015 (1)	0.015 (1)	0.3 (2)	2.2 (2)	-- (3)	0.14 (2)	-- (4)	--	--
Emission Factor - Tier 4 Final (g/hp-hr)	(1)	750	2,000	0.03 (1)	0.03 (1)	0.03 (1)	2.6 (2)	2.2 (2)	-- (3)	0.14 (2)	-- (4)	--	--
Emission Factor - Phase 1 Tier 4 Interim (g/hp-hr)	(1)	440		0.015 (2)	0.015 (2)	0.015 (2)	1.5 (2)	2.6 (2)	-- (3)	0.14 (2)	-- (4)	--	--

Source	Modeling ID	Generator Power Rating (5) (BHP)	Diesel Fuel Usage (5) (gal/hr)	Load Factor (6)	Annual Operation (5) (hrs/yr)	PM Daily (a) (lbs/day)	PM Average (b) (tons/yr)	PM_{10} Daily (a) (lbs/day)	PM_{10} Average (b) (tons/yr)	$PM_{2.5}$ Daily (a) (lbs/day)	$PM_{2.5}$ Average (b) (tons/yr)	NO_X Daily (a) (lbs/day)	NO_X Average (b) (tons/yr)	CO Daily (a) (lbs/day)	CO Average (b) (tons/yr)	SO_2 Daily (c) (lbs/day)	SO_2 Average (b) (tons/yr)	VOC Daily (a) (lbs/day)	VOC Average (b) (tons/yr)	CO_2 Daily (d) (lbs/day)	CO_2 Average (b) (tons/yr)	CH_4 Daily (9) (lbs/day)	CH_4 Average (b) (tons/yr)	CO_2e Daily (e) (lbs/day)	CO_2e Average (b) (tons/yr)
Tier 4 Final - Emission Estimates																									
Diesel Generator - Building NRLF	DG_NRLF	700	35.5	0.74	25.15	0.034	2.2E-04	0.034	2.2E-04	0.034	2.2E-04	0.69	4.3E-03	5.02	0.032	0.015	9.4E-05	0.32	2.0E-03	1,585	9.96	0.029	1.8E-04	1,585	9.97
Diesel Generator - Building 8	DG_B8	440	22.3	0.74	25.15	0.014	9.0E-05	0.014	9.0E-05	0.014	9.0E-05	0.43	2.7E-03	3.16	0.020	9.4E-03	5.9E-05	0.20	1.3E-03	996	6.26	0.018	1.1E-04	996	6.27
Diesel Generator - Building 9	DG_B9	440	22.3	0.74	25.15	0.014	9.0E-05	0.014	9.0E-05	0.014	9.0E-05	0.43	2.7E-03	3.16	0.020	9.4E-03	5.9E-05	0.20	1.3E-03	996	6.26	0.018	1.1E-04	996	6.27
Diesel Generator - Building 10	DG_B10	410	20.8	0.74	25.15	0.020	1.3E-04	0.020	1.3E-04	0.020	1.3E-04	0.40	2.5E-03	2.94	0.019	8.7E-03	5.5E-05	0.19	1.2E-03	928	5.84	0.017	1.1E-04	929	5.84
Diesel Generator - Building 11	DG_B11	240	12.2	0.74	25.15	0.012	7.4E-05	0.012	7.4E-05	0.012	7.4E-05	0.23	1.5E-03	1.72	0.011	5.1E-03	3.2E-05	0.11	6.9E-04	543	3.42	9.9E-03	6.2E-05	544	3.42
Diesel Generator - Building 12	DG_B12	420	21.3	0.74	25.15	0.021	1.3E-04	0.021	1.3E-04	0.021	1.3E-04	0.41	2.6E-03	3.01	0.019	8.9E-03	5.6E-05	0.19	1.2E-03	951	5.98	0.017	1.1E-04	951	5.98
Diesel Generator - Building 13	DG_B13	170	8.6	0.74	25.15	8.3E-03	5.2E-05	8.3E-03	5.2E-05	8.3E-03	5.2E-05	0.17	1.0E-03	2.05	0.013	3.6E-03	2.3E-05	0.078	4.9E-04	385	2.42	7.0E-03	4.4E-05	385	2.42
Diesel Generator - Building 14	DG_B14	290	14.7	0.74	25.15	0.014	8.9E-05	0.014	8.9E-05	0.014	8.9E-05	0.28	1.8E-03	2.08	0.013	6.2E-03	3.9E-05	0.13	8.3E-04	657	4.13	0.012	7.5E-05	657	4.13
Diesel Generator - Building 15	DG_B15	480	24.3	0.74	25.15	0.023	1.5E-04	0.023	1.5E-04	0.023	1.5E-04	0.47	3.0E-03	3.45	0.022	0.010	6.4E-05	0.22	1.4E-03	1,087	6.83	0.020	1.2E-04	1,087	6.84
Diesel Generator - Building 16	DG_B16	560	28.4	0.74	25.15	0.027	1.7E-04	0.027	1.7E-04	0.027	1.7E-04	0.55	3.4E-03	4.02	0.025	0.012	7.5E-05	0.26	1.6E-03	1,268	7.97	0.023	1.4E-04	1,268	7.97
Diesel Generator - Building 17	DG_B17	600	30.4	0.74	25.15	0.029	1.8E-04	0.029	1.8E-04	0.029	1.8E-04	0.59	3.7E-03	4.31	0.027	0.013	8.0E-05	0.27	1.7E-03	1,358	8.54	0.025	1.6E-04	1,359	8.54
Diesel Generator - Building 18	DG_B18	510	25.9	0.74	25.15	0.025	1.6E-04	0.025	1.6E-04	0.025	1.6E-04	0.50	3.1E-03	3.66	0.023	0.011	6.8E-05	0.23	1.5E-03	1,155	7.26	0.021	1.3E-04	1,155	7.26
Diesel Generator - Building 19	DG_B19	460	23.3	0.74	25.15	0.023	1.4E-04	0.023	1.4E-04	0.023	1.4E-04	0.45	2.8E-03	3.30	0.021	9.8E-03	6.2E-05	0.21	1.3E-03	1,041	6.55	0.019	1.2E-04	1,042	6.55
Diesel Generator - Building 20	DG_B20	450	22.8	0.74	25.15	0.022	1.4E-04	0.022	1.4E-04	0.022	1.4E-04	0.44	2.8E-03	3.23	0.020	9.6E-03	6.0E-05	0.21	1.3E-03	1,019	6.41	0.019	1.2E-04	1,019	6.41
Diesel Generator A - Building 21	DG_B21A	510	25.9	0.74	25.15	0.025	1.6E-04	0.025	1.6E-04	0.025	1.6E-04	0.50	3.1E-03	3.66	0.023	0.011	6.8E-05	0.23	1.5E-03	1,155	7.26	0.021	1.3E-04	1,155	7.26
Diesel Generator B - Building 21	DG_B21B	510	25.9	0.74	25.15	0.025	1.6E-04	0.025	1.6E-04	0.025	1.6E-04	0.50	3.1E-03	3.66	0.023	0.011	6.8E-05	0.23	1.5E-03	1,155	7.26	0.021	1.3E-04	1,155	7.26
Diesel Generator - Building 22	DG_B22	700	35.5	0.74	25.15	0.034	2.2E-04	0.034	2.2E-04	0.034	2.2E-04	0.69	4.3E-03	5.02	0.032	0.015	9.4E-05	0.32	2.0E-03	1,585	9.96	0.029	1.8E-04	1,585	9.97
Diesel Generator - Building 23	DG_B23	530	26.9	0.74	25.15	0.026	1.6E-04	0.026	1.6E-04	0.026	1.6E-04	0.52	3.3E-03	3.80	0.024	0.011	7.1E-05	0.24	1.5E-03	1,200	7.54	0.022	1.4E-04	1,200	7.55
Diesel Generator - Building 24	DG_B24	460	23.3	0.74	25.15	0.023	1.4E-04	0.023	1.4E-04	0.023	1.4E-04	0.45	2.8E-03	3.30	0.021	9.8E-03	6.2E-05	0.21	1.3E-03	1,041	6.55	0.019	1.2E-04	1,042	6.55
Diesel Generator - Building 25	DG_B25	630	32.0	0.74	25.15	0.031	1.9E-04	0.031	1.9E-04	0.031	1.9E-04	0.62	3.9E-03	4.52	0.028	0.013	8.4E-05	0.29	1.8E-03	1,426	8.97	0.026	1.6E-04	1,427	8.97
Diesel Generator - Building 26	DG_B26	610	30.9	0.74	25.15	0.030	1.9E-04	0.030	1.9E-04	0.030	1.9E-04	0.60	3.8E-03	4.38	0.028	0.013	8.2E-05	0.28	1.8E-03	1,381	8.68	0.025	1.6E-04	1,381	8.69
Diesel Generator - Building 27	DG_B27	590	29.9	0.74	25.15	0.029	1.8E-04	0.029	1.8E-04	0.029	1.8E-04	0.58	3.6E-03	4.24	0.027	0.013	7.9E-05	0.27	1.7E-03	1,336	8.40	0.024	1.5E-04	1,336	8.40
Diesel Generator - Building 28	DG_B28	230	11.7	0.74	25.15	0.011	7.1E-05	0.011	7.1E-05	0.011	7.1E-05	0.23	1.4E-03	1.65	0.010	4.9E-03	3.1E-05	0.11	6.6E-04	521	3.27	9.5E-03	5.9E-05	521	3.28
Diesel Generator - Building 29	DG_B29	180	9.1	0.74	25.15	8.8E-03	5.5E-05	8.8E-03	5.5E-05	8.8E-03	5.5E-05	0.18	1.1E-03	1.29	8.1E-03	3.8E-03	2.4E-05	0.082	5.2E-04	407	2.56	7.4E-03	4.7E-05	408	2.56
Diesel Generator - Building 30	DG_B30	600	30.4	0.74	25.15	0.029	1.8E-04	0.029	1.8E-04	0.029	1.8E-04	0.59	3.7E-03	4.31	0.027	0.013	8.0E-05	0.27	1.7E-03	1,358	8.54	0.025	1.6E-04	1,359	8.54
Diesel Generator - Building 31	DG_B31	180	9.1	0.74	25.15	8.8E-03	5.5E-05	8.8E-03	5.5E-05	8.8E-03	5.5E-05	0.18	1.1E-03	1.29	8.1E-03	3.8E-03	2.4E-05	0.082	5.2E-04	407	2.56	7.4E-03	4.7E-05	408	2.56
Diesel Generator - Building 32	DG_B32	490	24.9	0.74	25.15	0.024	1.5E-04	0.024	1.5E-04	0.024	1.5E-04	0.48	3.0E-03	3.52	0.022	0.010	6.6E-05	0.22	1.4E-03	1,109	6.97	0.020	1.3E-04	1,110	6.98
Diesel Generator - Building 33	DG_B33	580	29.4	0.74	25.15	0.028	1.8E-04	0.028	1.8E-04	0.028	1.8E-04	0.57	3.6E-03	4.16	0.026	0.012	7.8E-05	0.26	1.7E-03	1,313	8.26	0.024	1.5E-04	1,314	8.26
Diesel Generator - Building 34	DG_B34	610	30.9	0.74	25.15	0.030	1.9E-04	0.030	1.9E-04	0.030	1.9E-04	0.60	3.8E-03	4.38	0.028	0.013	8.2E-05	0.28	1.8E-03	1,381	8.68	0.025	1.6E-04	1,381	8.69
Diesel Generator - Building 35	DG_B35	700	35.5	0.74	25.15	0.034	2.2E-04	0.034	2.2E-04	0.034	2.2E-04	0.69	4.3E-03	5.02	0.032	0.015	9.4E-05	0.32	2.0E-03	1,585	9.96	0.029	1.8E-04	1,585	9.97
Diesel Generator - Building 36	DG_B36	680	34.5	0.74	25.15	0.033	2.1E-04	0.033	2.1E-04	0.033	2.1E-04	0.67	4.2E-03	4.88	0.031	0.014	9.1E-05	0.31	2.0E-03	1,539	9.68	0.028	1.8E-04	1,540	9.68
Diesel Generator - Building 37	DG_B37	740	37.5	0.74	25.15	0.036	2.3E-04	0.036	2.3E-04	0.036	2.3E-04	0.72	4.6E-03	5.31	0.033	0.016	9.9E-05	0.34	2.1E-03	1,675	10.5	0.030	1.9E-04	1,676	10.5
Diesel Generator - Building 38	DG_B38	230	11.7	0.74	25.15	0.011	7.1E-05	0.011	7.1E-05	0.011	7.1E-05	0.23	1.4E-03	1.65	0.010	4.9E-03	3.1E-05	0.11	6.6E-04	521	3.27	9.5E-03	5.9E-05	521	3.28
Tier 4 Interim - Emission Estimates																									
Diesel Generator - Building 6	DG_B6	440	22.3	0.74	25.15	0.022	1.4E-04	0.022	1.4E-04	0.022	1.4E-04	2.15	0.014	3.73	0.023	9.4E-03	5.9E-05	0.20	1.3E-03	996	6.26	0.018	1.1E-04	996	6.27
Diesel Generator - Building 7	DG_B7	440	22.3	0.74	25.15	0.022	1.4E-04	0.022	1.4E-04	0.022	1.4E-04	2.15	0.014	3.73	0.023	9.4E-03	5.9E-05	0.20	1.3E-03	996	6.26	0.018	1.1E-04	996	6.27
Total						**0.81**	**5.1E-03**	**0.81**	**5.1E-03**	**0.81**	**5.1E-03**	**19.9**	**0.13**	**123**	**0.77**	**0.36**	**2.3E-03**	**7.68**	**0.048**	**38,056**	**239**	**0.69**	**4.3E-03**	**38,070**	**239**

Notes:

(a) Maximum daily emission estimate (lbs/day) = (Emission factor [g/hp-hr]) x (generator power [hp]) x (load factor) x (maximum hours per day [hrs/day]) x (lb/453.59g)

Daily hours of operation (hrs/day) = 2 (5)

(b) Annual average emission estimate (tons/yr) = (Daily emissions [lbs/day]) / (daily hours of operation [hrs/day]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)

Daily hours of operation (hrs/day) = 2 (5)

(c) Maximum daily emissions estimate (lbs/day) = (Fuel sulfur content [ppmw] / 1,000,000) x (generator fuel consumption [gal/hr]) x (daily hours of operation [hrs/day]) x (diesel density [lbs/gal]) x ([SO_2 molecular weight {lbs/lb-mol}] / [sulfur molecular weight {lbs/lb-mol}])

Fuel sulfur content (ppmw) = 15 (7)
Daily hours of operation (hrs/day) = 2 (5)
Diesel density (lbs/gal) = 7
SO_2 molecular weight (lbs/lb-mol) = 64
Sulfur molecular weight (lbs/lb-mol) = 32

(d) Maximum daily emissions estimate (lbs/day) = (Fuel carbon content [%] / 100) x (generator fuel consumption [gal/hr]) x (daily hours of operation [hrs/day]) x (diesel density [lbs/gal]) x ([CO_2 molecular weight {lbs/lb-mol}] / [carbon molecular weight {lbs/lb-mol}])

Fuel carbon content (%) = 87 (8)
Daily hours of operation (hrs/day) = 2 (5)
Diesel density (lbs/gal) = 7
CO_2 molecular weight (lbs/lb-mol) = 44.0
Carbon molecular weight (lbs/lb-mol) = 12.0

(e) CO_2e emissions (lbs/day) = (CO_2 emissions [lbs/day]) + (CH_4 emissions [lbs/day] x CH_4 global warming potential) + (N_2O emissions [lbs/day] x N_2O global warming potential)

CH_4 Global Warming Potential (GWP) = 21 (10)
N_2O Global Warming Potential (GWP) = 310 (10)

References:

(1) LBNL has committed to purchasing engines for buildings 7 and 8 that achieve 0.01 g/hp-hr particulate matter emissions. Buildings 6 and 7 will not be under the control of LBNL, so interim Tier IV emission factors are assumed. All other engines will be based on Tier IV emission factors. Assumes all PM is PM2.5.
(2) CalEEMod Appendix D, Default Data Tables. Table 3.5, OFFROAD Emission Factor Based on Engine Tier. Assumes Tier 4 Final for LBNL-owned small engines (Buildings 9 and 8), and Tier 4 Interim for the Building 6&7 engine.
(3) Sulfur dioxide emissions calculated on a sulfur mass balance basis, assuming 100% of the fuel sulfur content is emitted as SO_2.
(4) Carbon dioxide emissions calculated on a carbon mass balance basis, conservatively assuming 100% of the fuel carbon content is emitted as CO_2.
(5) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(6) Default load factor for generators in URBEMIS emissions model.
(7) California Code of Regulations Title 13, Division 3, Chapter 5, Article 2, Standards for Diesel Fuel.
(8) AP-42 Chapter 3.3 (October 1996) and 3.4 (October 1996), Footnote to criteria emission factor table.
(9) Assumes methane is 9% of VOC, based on footnote f of Table 3.4-1 in AP-42, Chapter 3.4. VOC emission factor is shown as ROG/TOG in CalEEMod Appendix D ,Table 3.5.
(10) 40 CFR Part 98 Subpart A, Table A-1, Global Warming Potentials.

Table F-10
Cooling Tower Particulate Emission Estimates

Pollutant					PM		PM_{10}		$PM_{2.5}$	
					Emission Estimates					
Source	Modeling ID	Total Circulation Water Rate [1] (gpm)	Drift Loss of Circulating Water [2] (%)	Annual Operation [1] (hrs/yr)	Maximum Daily [a] (lbs/day)	Annual Average [b] (tons/yr)	Maximum Daily [c] (lbs/day)	Annual Average [b] (tons/yr)	Maximum Daily [d] (lbs/day)	Annual Average [b] (tons/yr)
Cooling Tower - Building NRLF	CT_NRLF#	12,000	0.005	6,360	3.86	0.51	3.44	0.46	2.06	0.27
Cooling Tower - Building 8	CTB8C#	4,500	0.005	6,360	1.45	0.19	1.29	0.17	0.77	0.10
Cooling Tower - Building 9	CTB9C#	4,500	0.005	6,360	1.45	0.19	1.29	0.17	0.77	0.10
Cooling Tower - Building 10	CTB10C#	4,500	0.005	6,360	1.45	0.19	1.29	0.17	0.77	0.10
Cooling Tower - Building 11	CTB11C#	2,400	0.005	6,360	0.77	0.10	0.69	0.091	0.41	0.055
Cooling Tower - Building 12	CTB12C#	4,500	0.005	6,360	1.45	0.19	1.29	0.17	0.77	0.10
Cooling Tower - Building 13	CTB13C#	2,400	0.005	6,360	0.77	0.10	0.69	0.091	0.41	0.055
Cooling Tower - Building 14	CTB14C#	3,000	0.005	6,360	0.97	0.13	0.86	0.11	0.52	0.068
Cooling Tower - Building 15	CTB15C#	4,500	0.005	6,360	1.45	0.19	1.29	0.17	0.77	0.10
Cooling Tower - Building 16	CTB16C#	6,000	0.005	6,360	1.93	0.26	1.72	0.23	1.03	0.14
Cooling Tower - Building 17	CTB17C#	6,000	0.005	6,360	1.93	0.26	1.72	0.23	1.03	0.14
Cooling Tower - Building 18	CTB18C#	5,400	0.005	6,360	1.74	0.23	1.55	0.21	0.93	0.12
Cooling Tower - Building 19	CTB19C#	4,500	0.005	6,360	1.45	0.19	1.29	0.17	0.77	0.10
Cooling Tower - Building 20	CTB20C#	4,500	0.005	6,360	1.45	0.19	1.29	0.17	0.77	0.10
Cooling Tower - Building 21	CTB21C#	10,500	0.005	6,360	3.38	0.45	3.01	0.40	1.81	0.24
Cooling Tower - Building 22	CTB22C#	7,500	0.005	6,360	2.41	0.32	2.15	0.28	1.29	0.17
Cooling Tower - Building 23	CTB23C#	6,000	0.005	6,360	1.93	0.26	1.72	0.23	1.03	0.14
Cooling Tower - Building 24	CTB24C#	4,500	0.005	6,360	1.45	0.19	1.29	0.17	0.77	0.10
Cooling Tower - Building 25	CTB25C#	6,000	0.005	6,360	1.93	0.26	1.72	0.23	1.03	0.14
Cooling Tower - Building 26	CTB26C#	6,000	0.005	6,360	1.93	0.26	1.72	0.23	1.03	0.14
Cooling Tower - Building 27	CTB27C#	6,000	0.005	6,360	1.93	0.26	1.72	0.23	1.03	0.14
Cooling Tower - Building 28	CTB28C#	2,400	0.005	6,360	0.77	0.10	0.69	0.091	0.41	0.055
Cooling Tower - Building 29	CTB29C#	2,400	0.005	6,360	0.77	0.10	0.69	0.091	0.41	0.055
Cooling Tower - Building 30	CTB30C#	6,000	0.005	6,360	1.93	0.26	1.72	0.23	1.03	0.14
Cooling Tower - Building 31	CTB31C#	2,400	0.005	6,360	0.77	0.10	0.69	0.091	0.41	0.055
Cooling Tower - Building 32	CTB32C#	4,500	0.005	6,360	1.45	0.19	1.29	0.17	0.77	0.10
Cooling Tower - Building 33	CTB33C#	6,000	0.005	6,360	1.93	0.26	1.72	0.23	1.03	0.14
Cooling Tower - Building 34	CTB34C#	6,000	0.005	6,360	1.93	0.26	1.72	0.23	1.03	0.14
Cooling Tower - Building 35	CTB35C#	7,500	0.005	6,360	2.41	0.32	2.15	0.28	1.29	0.17
Cooling Tower - Building 36	CTB36C#	7,500	0.005	6,360	2.41	0.32	2.15	0.28	1.29	0.17
Cooling Tower - Building 37	CTB37C#	7,500	0.005	6,360	2.41	0.32	2.15	0.28	1.29	0.17
Cooling Tower - Building 38	CTB38C#	3,000	0.005	6,360	0.97	0.13	0.86	0.11	0.52	0.068
Cooling Tower - Buildings 6 and 7	CTB6_7C#	9000	0.005	6,360	2.90	0.38	2.58	0.34	1.55	0.21
Total					**57.7**	**7.65**	**51.4**	**6.81**	**30.8**	**4.09**

Notes:

(a) Maximum daily emissions estimate (lbs/day) = (Circulation water rate [gpm]) x (density of water [lbs/gal]) x (total dissolved solids concentration [ppmw]) x (10^{-6}) x (drift loss of circulating water [%] / 100) x (60 min/hr) x (daily hours of operation [hrs/day])

Total dissolved solids concentration (ppmw) = 536 (1)
Density of water (lbs/gal) = 8.34
Daily hours of operation (hrs/day) = 24 (1)

(b) Annual emissions estimate (tons/yr) = (Daily emissions [lbs/day]) / (daily hours of operation [hrs/day]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)

Daily hours of operation (hrs/day) = 24 (1)

(c) Maximum daily emissions estimate (lbs/day) = (PM emissions estimate [lbs/day]) x (percent of PM_{10} emissions [%] / 100)

Percent of PM_{10} emissions (%) = 89.0 (3)

(d) Maximum daily emissions estimate (lbs/day) = (PM_{10} emissions estimate [lbs/day]) x ($PM_{2.5}$ fraction of PM_{10})

$PM_{2.5}$ fraction of PM_{10} = 0.6 (4)

References:

(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) Engineering judgment based on past work with industrial cooling towers.
(3) From the technical paper "Calculating Realistic PM10 Emissions from Cooling Towers", by Joel Reisman and Gordon Frisbie. The percent PM_{10} is based on total dissolved content.
(4) From Appendix A - Updated CEIDARS Table with PM2.5 Fractions to the CEQA handbook, supplemental information.

Table F-11
LRDP Operations Criteria Pollutant Emissions Summary - Annual Average Daily Emission Rates (1)

Source	Annual Operation (days/yr)	TAC		Criteria												Greenhouse Gases							
		DPM		PM_{10}		$PM_{2.5}$		NO_X		CO		SO_2		VOC		CO_2		CH_4		N_2O		CO_2e	
		(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)
Stationary Sources																							
Diesel generators	260	3.9E-02	5.1E-03	3.9E-02	5.1E-03	3.9E-02	5.1E-03	0.96	0.13	5.93	0.77	1.7E-02	2.3E-03	0.37	4.8E-02	1,841	239	3.3E-02	4.3E-03	0	0	1,841	239
Natural Gas Boilers	260	--	--	18.8	2.44	18.8	2.44	46.2	6.01	207	27.0	1.48	0.19	13.6	1.77	296,719	38,573	5.60	0.73	0.56	7.3E-02	297,010	38,611
Cooling Towers	260	--	--	52.4	6.81	31.4	4.09	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lab Chemicals	260	--	--	--	--	--	--	--	--	--	--	--	--	76.1	9.89	--	--	--	--	--	--	--	--
Total Onsite Stationary Source Emissions	**--**	**3.9E-02**	**5.1E-03**	**71.2**	**9.26**	**50.2**	**6.53**	**47.2**	**6.13**	**213**	**27.7**	**1.50**	**0.19**	**90.1**	**11.7**	**298,559**	**38,813**	**5.63**	**0.73**	**0.56**	**7.3E-02**	**298,851**	**38,851**
Onsite On-Road Vehicle Emission Sources																							
Onsite On-Road Exhaust - Delivery Trucks	260	1.3E-02	1.7E-03	1.3E-02	1.7E-03	1.2E-02	1.6E-03	0.87	0.11	0.43	5.6E-02	0	0	0.23	3.0E-02	717	93.2	--	--	--	--	717	93.2
Onsite On-Road Exhaust - LBNL-RBC Shuttle	260	--	--	1.8E-04	2.3E-05	1.6E-04	2.1E-05	3.7E-03	4.8E-04	3.4E-02	4.4E-03	0	0	1.6E-03	2.0E-04	20.7	2.70	--	--	--	--	20.7	2.70
Onsite On-Road Exhaust - BART-RBC Shuttle	260	--	--	3.4E-04	4.4E-05	3.1E-04	4.1E-05	7.1E-03	9.2E-04	6.5E-02	8.4E-03	0	0	3.0E-03	3.9E-04	39.9	5.19	--	--	--	--	39.9	5.19
Onsite On-Road Exhaust - Employee Vehicles	260	--	--	0.65	8.4E-02	0.60	7.8E-02	6.44	0.84	65.9	8.57	0	0	2.78	0.36	35,750	4,647	--	--	--	--	35,750	4,647
Onsite On-Road Dust - Delivery Trucks	260	--	--	0.32	4.1E-02	7.8E-02	1.0E-02	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Onsite On-Road Dust - LBNL-RBC Shuttle	260	--	--	1.8E-02	2.3E-03	4.4E-03	5.7E-04	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Onsite On-Road Dust - BART-RBC Shuttle	260	--	--	3.4E-02	4.4E-03	8.4E-03	1.1E-03	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Onsite On-Road Dust - Employee Vehicles	260	--	--	25.7	3.34	6.30	0.82	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Onsite Idling Exhaust - Delivery Trucks	260	1.7E-03	2.2E-04	1.7E-03	2.2E-04	1.6E-03	2.0E-04	0.72	9.4E-02	0.47	6.2E-02	1.4E-03	1.8E-04	4.0E-02	5.2E-03	128	16.7	--	--	--	--	128	16.7
Onsite Idling Exhaust - LBNL-RBC Shuttle	260	--	--	1.6E-04	2.1E-05	1.5E-04	1.9E-05	2.4E-03	3.1E-04	2.1E-02	2.8E-03	0	0	1.4E-03	1.8E-04	16.1	2.09	--	--	--	--	16.1	2.09
Onsite Idling Exhaust - BART-RBC Shuttle	260	--	--	3.1E-04	4.0E-05	2.9E-04	3.7E-05	4.6E-03	6.0E-04	4.1E-02	5.3E-03	0	0	2.7E-03	3.5E-04	30.9	4.02	--	--	--	--	30.9	4.02
Total Onsite Vehicle Parking Lot Emissions	**260**	**--**	**--**	**0.23**	**3.0E-02**	**0.22**	**2.8E-02**	**2.49**	**0.32**	**43.6**	**5.67**	**3.4E-02**	**4.4E-03**	**6.32**	**0.82**	**3,287**	**427**	**--**	**--**	**--**	**--**	**3,287**	**427**
Total Onsite On-Road Vehicle Emissions	**--**	**1.5E-02**	**2.0E-03**	**27.0**	**3.50**	**7.23**	**0.94**	**10.5**	**1.37**	**111**	**14.4**	**3.5E-02**	**4.5E-03**	**9.38**	**1.22**	**39,989**	**5,199**	**--**	**--**	**--**	**--**	**39,989**	**5,199**
Offsite On-Road Emissions																							
Offsite On-Road Exhaust - Delivery Trucks	260	0.11	1.4E-02	0.52	6.8E-02	0.27	3.5E-02	2.94	0.38	1.16	0.15	3.2E-02	4.2E-03	0.33	4.3E-02	3,048	396	--	--	--	--	3,048	396
Offsite On-Road Exhaust - LBNL-RBC Shuttle	260	--	--	2.1E-02	2.7E-03	8.7E-03	1.1E-03	4.9E-02	6.3E-03	0.42	5.4E-02	2.6E-03	3.4E-04	4.8E-02	6.3E-03	185	24.1	--	--	--	--	185	24.1
Offsite On-Road Exhaust - BART-RBC Shuttle	260	--	--	2.1E-02	2.7E-03	8.6E-03	1.1E-03	4.8E-02	6.3E-03	0.41	5.4E-02	2.6E-03	3.4E-04	4.8E-02	6.2E-03	184	23.9	--	--	--	--	184	23.9
Offsite On-Road Exhaust - Employee Vehicles	260	--	--	42.7	5.55	17.9	2.33	49.9	6.48	482	62.6	3.10	0.40	35.7	4.64	185,182	24,074	--	--	--	--	185,182	24,074
Offsite On-Road Dust - Delivery Trucks	260	--	--	0.32	4.2E-02	7.9E-02	1.0E-02	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Offsite On-Road Dust - LBNL-RBC Shuttle	260	--	--	4.9E-02	6.4E-03	1.2E-02	1.6E-03	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Offsite On-Road Dust - BART-RBC Shuttle	260	--	--	4.9E-02	6.3E-03	1.2E-02	1.6E-03	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Offsite On-Road Dust - Employee Vehicles	260	--	--	101	13.1	24.7	3.21	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Offsite On-Road Vehicle Emissions	**--**	**0.11**	**1.4E-02**	**144**	**18.8**	**43.0**	**5.59**	**52.9**	**6.88**	**484**	**62.9**	**3.14**	**0.41**	**36.1**	**4.70**	**188,599**	**24,518**	**--**	**--**	**--**	**--**	**188,599**	**24,518**
Total Phase 1 Project Summary	**--**	**0.16**	**2.1E-02**	**242**	**31.5**	**100**	**13.1**	**111**	**14.4**	**808**	**105**	**4.67**	**0.61**	**136**	**17.6**	**527,147**	**68,529**	**5.63**	**0.73**	**0.56**	**7.3E-02**	**527,439**	**68,567**
Onsite Stationary Exhaust	**--**	**3.9E-02**	**5.1E-03**	**71.2**	**9.26**	**50.2**	**6.53**	**47.2**	**6.13**	**213**	**27.7**	**1.50**	**0.19**	**90.1**	**11.7**	**298,559**	**38,813**	**5.63**	**0.73**	**0.56**	**7.3E-02**	**298,851**	**38,851**
Onsite Mobile Exhaust	**--**	**1.5E-02**	**2.0E-03**	**0.90**	**0.12**	**0.83**	**0.11**	**10.5**	**1.37**	**111**	**14.4**	**3.5E-02**	**4.5E-03**	**9.38**	**1.22**	**39,989**	**5,199**	**0**	**0**	**0**	**0**	**39,989**	**5,199**
Onsite Fugitive Dust	**--**	**0**	**0**	**26.1**	**3.39**	**6.40**	**0.83**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**
Offsite Mobile Exhaust	**--**	**0.11**	**1.4E-02**	**43.2**	**5.62**	**18.2**	**2.37**	**52.9**	**6.88**	**484**	**62.9**	**3.14**	**0.41**	**36.1**	**4.70**	**188,599**	**24,518**	**0**	**0**	**0**	**0**	**188,599**	**24,518**
Offsite Fugitive Dust	**--**	**0**	**0**	**101**	**13.1**	**24.8**	**3.23**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**

References:

(1) Daily emission rates are annual average daily emission rates, which are calculated by dividing the annual emission rate by the annual days of operation, and converting form tons to pounds. Annual days of operation is set to 5 days per week, 52 weeks per year.

Table F-12
Onsite Employee Vehicle TAC Emission Estimates

Parameter		Parking Lot Emissions					Onroad Emissions
		Hot Soak / Running Evaporative	Resting Evaporative / Diurnal	Starting	Idling	Total	Running
Organic Speciation Profile	(1)	660	661	664	2105		2105
LDA TOG Emission Factor	(2)	4.85E-04 (lbs/vehicle)	6.63E-05 (lbs/vehicle)	1.41E-04 (lbs/vehicle)	1.21E-03 (lbs/hr)		1.01E-04 (lbs/VMT)
Maximum Daily Vehicle Trips (trips/day)	(3)	20,081	20,081	20,081	20,081		20,081
Annual Vehicle Trips (trips/yr)	(3)	5,221,060	5,221,060	5,221,060	5,221,060		5,221,060

TAC	CAS	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (c) (lbs/hr)	Annual Average Emissions Estimate (d) (tons/yr)	Maximum Hourly Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (e) (lbs/hr)	Annual Average Emissions Estimate (f) (tons/yr)
1,3-Butadiene	106-99-0	No Data	--	--	No Data	--	--	7.0E-03	1.2E-03	2.6E-03	5.5E-03	0	0	1.2E-03	2.6E-03	5.5E-03	4.8E-04	9.9E-04
2-Butanone	78-93-3	No Data	--	--	No Data	--	--	6.0E-04	1.1E-04	2.2E-04	2.0E-04	0	0	1.1E-04	2.2E-04	2.0E-04	1.7E-05	3.6E-05
Acetaldehyde	75-07-0	No Data	--	--	No Data	--	--	5.2E-03	9.2E-04	1.9E-03	2.8E-03	0	0	9.2E-04	1.9E-03	2.8E-03	2.4E-04	5.0E-04
Acrolein	107-02-8	No Data	--	--	No Data	--	--	1.1E-03	1.9E-04	4.0E-04	1.3E-03	0	0	1.9E-04	4.0E-04	1.3E-03	1.1E-04	2.3E-04
Benzene	71-43-2	0.010	6.1E-03	0.013	3.6E-03	3.0E-04	6.2E-04	0.024	4.3E-03	8.9E-03	0.025	0	0	0.011	0.022	0.025	2.1E-03	4.4E-03
Ethylbenzene	100-41-4	0.016	1.0E-02	0.021	1.2E-03	1.0E-04	2.1E-04	0.016	2.8E-03	5.8E-03	0.011	0	0	0.013	0.027	0.011	9.1E-04	1.9E-03
Formaldehyde	50-00-0	No Data	--	--	No Data	--	--	0.013	2.2E-03	4.6E-03	0.016	0	0	2.2E-03	4.6E-03	0.016	1.4E-03	2.8E-03
Methanol	67-56-1	1.0E-04	6.1E-05	1.3E-04	No Data	--	--	2.9E-03	5.1E-04	1.1E-03	1.2E-03	0	0	5.7E-04	1.2E-03	1.2E-03	1.0E-04	2.2E-04
Naphthalene	91-20-3	1.4E-03	8.5E-04	1.8E-03	No Data	--	--	7.0E-04	1.2E-04	2.6E-04	5.0E-04	0	0	9.8E-04	2.0E-03	5.0E-04	4.3E-05	9.0E-05
n-Hexane	110-54-3	7.6E-03	4.6E-03	9.6E-03	0.015	1.3E-03	2.7E-03	0.018	3.2E-03	6.6E-03	0.016	0	0	9.1E-03	0.019	0.016	1.4E-03	2.9E-03
Propylene	115-07-1	No Data	--	--	No Data	--	--	0.033	5.9E-03	0.012	0.031	0	0	5.9E-03	0.012	0.031	2.6E-03	5.5E-03
Styrene	100-42-5	No Data	--	--	No Data	--	--	2.6E-03	4.6E-04	9.5E-04	1.2E-03	0	0	4.6E-04	9.5E-04	1.2E-03	1.0E-04	2.2E-04
Toluene	108-88-3	0.051	0.031	0.065	0.017	1.4E-03	2.9E-03	0.074	0.013	0.027	0.058	0	0	0.046	0.095	0.058	5.0E-03	0.010
m-Xylene	108-38-3	0.027	0.016	0.034	3.4E-03	2.8E-04	5.9E-04	0.053	9.4E-03	0.019	0.036	0	0	0.026	0.054	0.036	3.1E-03	6.4E-03
o-Xylene	95-47-6	0.016	9.7E-03	0.020	1.3E-03	1.1E-04	2.3E-04	0.018	3.2E-03	6.7E-03	0.012	0	0	0.013	0.027	0.012	1.1E-03	2.2E-03
p-Xylene	106-42-3	0.014	8.5E-03	0.018	1.1E-03	9.2E-05	1.9E-04	No Data	--	--	No Data	--	--	8.5E-03	0.018	No Data	--	--

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/vehicle]) x (maximum daily vehicle trips [trips/day]) x (TAC emission fraction) / (daily hours of operation [hrs/day])
Daily hours of operation (hrs/day) = 16 (3)

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/vehicle]) x (annual vehicle trips [trips/yr]) x (ton/2,000 lbs) x (TAC emission fraction)

(c) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/hr]) x (maximum daily vehicle trips [trips/day]) x (idling time per trip [hrs/trip]) x (TAC emission fraction) / (daily hours of operation [hrs/day])
Idling time per trip (hrs/trip) = 0 (3)
Daily hours of operation (hrs/day) = 16 (3)

(d) Annual emissions estimate (tons/yr) = (Emission factor [lbs/hr]) x (annual vehicle trips [trips/yr]) x (idling time per trip [hrs/trip]) x (ton/2,000 lbs) x (TAC emission fraction)
Idling time per trip (hrs/trip) = 0 (3)

(e) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/VMT]) x (maximum daily vehicle trips [trips/day]) x (onsite roundtrip distance [mi/trip]) x (TAC emission fraction) / (daily hours of operation [hrs/day])
Onsite roundtrip distance (mi/trip) = 0.68 (3)
Daily hours of operation (hrs/day) = 16 (3)

(f) Annual emissions estimate (tons/yr) = (Emission factor [lbs/VMT]) x (annual vehicle trips [trips/yr]) x (onsite roundtrip distance [mi/trip]) x (ton/2,000 lbs) x (TAC emission fraction)
Onsite roundtrip distance (mi/trip) = 0.68 (3)

References:

(1) California Air Resources Board Speciation Database. TAC emission fractions are derived from the individual speciation profiles listed. Profiles chosen to best represent the project vehicle fleet and existing gasoline formulation.
(2) Emission Factors source: EMFAC 2011 (Model Years to 2034). Onsite speed set to 15 mile per hour to conservatively estimate onsite emissions. No tire and brake wear emission factors are provided at 15 miles per hour.
(3) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.

Table F-13
Offsite Employee Vehicle TAC Emission Estimates

Parameter		Onroad Emissions						Total
		Running		Tire Wear		Brake Wear		
Speciation Profile	(1)	2105	(organic)	472	(particulate)	473	(particulate)	
LDA Emission Factor (lbs/VMT)	(2)	3.61E-05	(TOG)	1.8E-05	(PM_{10})	8.1E-05	(PM_{10})	
Maximum Daily Vehicle Trips (trips/day)	(3)	20,081		20,081		20,081		
Annual Vehicle Trips (trips/yr)	(3)	5,221,060		5,221,060		5,221,060		

TAC	CAS	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of PM_{10} (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of PM_{10} (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	Maximum Hourly Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)
1,3-Butadiene	106-99-0	5.5E-03	5.1E-03	0.011	--	--	--	--	--	--	5.1E-03	0.011
2-Butanone	78-93-3	2.0E-04	1.9E-04	3.9E-04	--	--	--	--	--	--	1.9E-04	3.9E-04
Acetaldehyde	75-07-0	2.8E-03	2.6E-03	5.4E-03	--	--	--	--	--	--	2.6E-03	5.4E-03
Acrolein	107-02-8	1.3E-03	1.2E-03	2.5E-03	--	--	--	--	--	--	1.2E-03	2.5E-03
Benzene	71-43-2	0.025	0.023	0.048	--	--	--	--	--	--	0.023	0.048
Ethylbenzene	100-41-4	0.011	9.8E-03	0.020	--	--	--	--	--	--	9.8E-03	0.020
Formaldehyde	50-00-0	0.016	0.015	0.031	--	--	--	--	--	--	0.015	0.031
Methanol	67-56-1	1.2E-03	1.1E-03	2.3E-03	--	--	--	--	--	--	1.1E-03	2.3E-03
Naphthalene	91-20-3	5.0E-04	4.7E-04	9.7E-04	--	--	--	--	--	--	4.7E-04	9.7E-04
n-Hexane	110-54-3	0.016	0.015	0.031	--	--	--	--	--	--	0.015	0.031
Propylene	115-07-1	0.031	0.029	0.059	--	--	--	--	--	--	0.029	0.059
Styrene	100-42-5	1.2E-03	1.1E-03	2.3E-03	--	--	--	--	--	--	1.1E-03	2.3E-03
Toluene	108-88-3	0.058	0.054	0.11	--	--	--	--	--	--	0.054	0.11
m-Xylene	108-38-3	0.036	0.033	0.069	--	--	--	--	--	--	0.033	0.069
o-Xylene	95-47-6	0.012	0.012	0.024	--	--	--	--	--	--	0.012	0.024
Lead	7439-92-1	--	--	--	1.6E-04	7.3E-05	1.5E-04	5.0E-05	1.0E-04	2.2E-04	1.8E-04	3.7E-04
Manganese	7439-96-5	--	--	--	1.0E-04	4.6E-05	9.5E-05	1.7E-03	3.6E-03	7.4E-03	3.6E-03	7.5E-03
Nickel	7440-02-0	--	--	--	5.0E-05	2.3E-05	4.7E-05	6.6E-04	1.4E-03	2.9E-03	1.4E-03	2.9E-03
Arsenic	7440-38-2	--	--	--	No Data	--	--	1.0E-05	2.1E-05	4.4E-05	2.1E-05	4.4E-05
Copper	7440-50-8	--	--	--	4.9E-04	2.2E-04	4.6E-04	0.011	0.024	0.050	0.024	0.050
Vanadium	7440-62-2	--	--	--	No Data	--	--	6.6E-04	1.4E-03	2.9E-03	1.4E-03	2.9E-03
Bromine	7726-95-6	--	--	--	1.5E-05	6.8E-06	1.4E-05	4.0E-05	8.4E-05	1.7E-04	9.1E-05	1.9E-04
Selenium	7782-49-2	--	--	--	2.0E-05	9.1E-06	1.9E-05	2.0E-05	4.2E-05	8.7E-05	5.1E-05	1.1E-04
Chlorine	7782-50-5	--	--	--	7.8E-03	3.6E-03	7.4E-03	1.5E-03	3.1E-03	6.5E-03	6.7E-03	0.014

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/VMT]) x (maximum daily vehicle trips [trips/day]) x (offsite roundtrip distance [mi/trip]) x (TAC emission fraction) / (daily hours of operation [hrs/day])

Offsite roundtrip distance (mi/trip) = 20.6 (3)

Daily hours of operation (hrs/day) = 16 (3)

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/VMT]) x (annual vehicle trips [trips/yr]) x (offsite roundtrip distance [mi/trip]) x (ton/2,000 lbs) x (TAC emission fraction)

Offsite roundtrip distance (mi/trip) = 20.6 (3)

References:

(1) California Air Resources Board Speciation Database. TAC emission fractions are derived from the individual speciation profiles listed. Profiles chosen to best represent the project vehicle fleet and existing gasoline formulation.

(2) Emission Factors source: EMFAC 2011 (Model Years to 2034).

(3) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.

Table F-14
Onsite Shuttle TAC Emission Estimates

Parameter		LBNL - RBC Shuttle		BART - RBC Shuttle		Total
		Idling	Running	Idling	Running	
Organic Speciation Profile	(1)	2105	2105	2105	2105	
MDV TOG Emission Factor	(2)	2.27E-03 (lbs/hr)	1.91E-04 (lbs/VMT)	2.27E-03 (lbs/hr)	1.91E-04 (lbs/VMT)	
Maximum Daily Vehicle Trips (trips/day)	(3)	13	13	25	25	
Annual Vehicle Trips (trips/yr)	(3)	3,380	3,380	6,500	6,500	
Idling Time per Trip (hrs/trip)	(3)	0.083	--	0.083	--	
Daily Hours of Operation (hrs/day)	(3)	13	13	13	13	
Onsite Roundtrip[Distance (mi/trip)	(3)	--	0.730	--	0.730	

TAC	CAS	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (c) (lbs/hr)	Annual Average Emissions Estimate (d) (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (c) (lbs/hr)	Annual Average Emissions Estimate (d) (tons/yr)	Maximum Hourly Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)
1,3-Butadiene	106-99-0	5.5E-03	1.0E-06	1.8E-06	5.5E-03	7.7E-07	1.3E-06	5.5E-03	2.0E-06	3.4E-06	5.5E-03	1.5E-06	2.5E-06	5.3E-06	8.9E-06
2-Butanone	78-93-3	2.0E-04	3.8E-08	6.4E-08	2.0E-04	2.8E-08	4.7E-08	2.0E-04	7.3E-08	1.2E-07	2.0E-04	5.4E-08	9.1E-08	1.9E-07	3.2E-07
Acetaldehyde	75-07-0	2.8E-03	5.3E-07	9.0E-07	2.8E-03	3.9E-07	6.6E-07	2.8E-03	1.0E-06	1.7E-06	2.8E-03	7.5E-07	1.3E-06	2.7E-06	4.5E-06
Acrolein	107-02-8	1.3E-03	2.5E-07	4.2E-07	1.3E-03	1.8E-07	3.1E-07	1.3E-03	4.7E-07	8.0E-07	1.3E-03	3.5E-07	5.9E-07	1.2E-06	2.1E-06
Benzene	71-43-2	0.025	4.7E-06	7.9E-06	0.025	3.5E-06	5.8E-06	0.025	9.0E-06	1.5E-05	0.025	6.6E-06	1.1E-05	2.4E-05	4.0E-05
Ethylbenzene	100-41-4	0.011	2.0E-06	3.4E-06	0.011	1.5E-06	2.5E-06	0.011	3.8E-06	6.5E-06	0.011	2.8E-06	4.8E-06	1.0E-05	1.7E-05
Formaldehyde	50-00-0	0.016	3.0E-06	5.1E-06	0.016	2.2E-06	3.7E-06	0.016	5.7E-06	9.7E-06	0.016	4.2E-06	7.2E-06	1.5E-05	2.6E-05
Methanol	67-56-1	1.2E-03	2.3E-07	3.8E-07	1.2E-03	1.7E-07	2.8E-07	1.2E-03	4.4E-07	7.4E-07	1.2E-03	3.2E-07	5.4E-07	1.2E-06	1.9E-06
Naphthalene	91-20-3	5.0E-04	9.5E-08	1.6E-07	5.0E-04	7.0E-08	1.2E-07	5.0E-04	1.8E-07	3.1E-07	5.0E-04	1.3E-07	2.3E-07	4.8E-07	8.1E-07
n-Hexane	110-54-3	0.016	3.0E-06	5.1E-06	0.016	2.2E-06	3.8E-06	0.016	5.8E-06	9.8E-06	0.016	4.3E-06	7.3E-06	1.5E-05	2.6E-05
Propylene	115-07-1	0.031	5.8E-06	9.8E-06	0.031	4.3E-06	7.2E-06	0.031	1.1E-05	1.9E-05	0.031	8.2E-06	1.4E-05	2.9E-05	5.0E-05
Styrene	100-42-5	1.2E-03	2.3E-07	3.8E-07	1.2E-03	1.7E-07	2.8E-07	1.2E-03	4.4E-07	7.4E-07	1.2E-03	3.2E-07	5.4E-07	1.2E-06	1.9E-06
Toluene	108-88-3	0.058	1.1E-05	1.8E-05	0.058	8.0E-06	1.4E-05	0.058	2.1E-05	3.5E-05	0.058	1.5E-05	2.6E-05	5.5E-05	9.4E-05
m-Xylene	108-38-3	0.036	6.7E-06	1.1E-05	0.036	5.0E-06	8.4E-06	0.036	1.3E-05	2.2E-05	0.036	9.6E-06	1.6E-05	3.4E-05	5.8E-05
o-Xylene	95-47-6	0.012	2.3E-06	4.0E-06	0.012	1.7E-06	2.9E-06	0.012	4.5E-06	7.6E-06	0.012	3.3E-06	5.6E-06	1.2E-05	2.0E-05

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/hr]) x (maximum daily vehicle trips [trips/day]) x (idling time per trip [hrs/trip]) x (TAC emission fraction) / (daily hours of operation [hrs/day])

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/hr]) x (annual vehicle trips [trips/yr]) x (idling time per trip [hrs/trip]) x (ton/2,000 lbs) x (TAC emission fraction)

(c) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/VMT]) x (maximum daily vehicle trips [trips/day]) x (onsite roundtrip distance [mi/trip]) x (TAC emission fraction) / (daily hours of operation [hrs/day])
Offsite roundtrip distance (mi/trip) = 0.68 (3)

(d) Annual emissions estimate (tons/yr) = (Emission factor [lbs/VMT]) x (annual vehicle trips [trips/yr]) x (onsite roundtrip distance [mi/trip]) x (ton/2,000 lbs) x (TAC emission fraction)
Offsite roundtrip distance (mi/trip) = 0.68 (3)

References:

(1) California Air Resources Board Speciation Database. TAC emission fractions are derived from the individual speciation profiles listed. Profiles chosen to best represent the project vehicle fleet and existing gasoline formulation.

(2) Emission Factors source: EMFAC 2011 (Model Years to 2034). Onsite speed set to 15 mile per hour to conservatively estimate onsite emissions. No tire and brake wear emission factors are provided at 15 miles per hour.

(3) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.

Table F-15
Offsite Shuttle TAC Emission Estimates

Parameter		LBNL - RBC Shuttle							BART - RBC Shuttle						
		Running		Tire Wear		Brake Wear		Total	Running		Tire Wear		Brake Wear		Total
Speciation Profile	(1)	2105	(organic)	472	(particulate)	473	(particulate)		2105	(organic)	472	(particulate)	473	(particulate)	
MDV Emission Factor (lbs/VMT)	(2)	6.78E-05	(TOG)	1.8E-05	(PM_{10})	8.1E-05	(PM_{10})		6.78E-05	(TOG)	1.8E-05	(PM_{10})	8.1E-05	(PM_{10})	
Maximum Daily Vehicle Trips (trips/day)	(3)	13		13		13			25		25		25		
Annual Vehicle Trips (trips/yr)	(3)	3,380		3,380		3,380			6,500		6,500		6,500		
Daily Hours of Operation (hrs/day)	(3)	13		13		13			13		13		13		
Offsite Roundtrip[Distance (mi/trip)	(3)	15.5		15.5		15.5			8.0		8.0		8.0		

TAC	CAS	LBNL - RBC Shuttle												BART - RBC Shuttle									
		Running			Tire Wear			Brake Wear			Total			Running			Tire Wear			Brake Wear			Total	
		TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of PM_{10} (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of PM_{10} (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	Maximum Hourly Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of PM_{10} (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of PM_{10} (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	Maximum Hourly Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)
1,3-Butadiene	106-99-0	5.5E-03	5.8E-06	9.8E-06	--	--	--	--	--	--	5.8E-06	9.8E-06	5.5E-03	5.7E-06	9.7E-06	--	--	--	--	--	--	5.7E-06	9.7E-06
2-Butanone	78-93-3	2.0E-04	2.1E-07	3.6E-07	--	--	--	--	--	--	2.1E-07	3.6E-07	2.0E-04	2.1E-07	3.5E-07	--	--	--	--	--	--	2.1E-07	3.5E-07
Acetaldehyde	75-07-0	2.8E-03	2.9E-06	5.0E-06	--	--	--	--	--	--	2.9E-06	5.0E-06	2.8E-03	2.9E-06	4.9E-06	--	--	--	--	--	--	2.9E-06	4.9E-06
Acrolein	107-02-8	1.3E-03	1.4E-06	2.3E-06	--	--	--	--	--	--	1.4E-06	2.3E-06	1.3E-03	1.4E-06	2.3E-06	--	--	--	--	--	--	1.4E-06	2.3E-06
Benzene	71-43-2	0.025	2.6E-05	4.4E-05	--	--	--	--	--	--	2.6E-05	4.4E-05	0.025	2.6E-05	4.4E-05	--	--	--	--	--	--	2.6E-05	4.4E-05
Ethylbenzene	100-41-4	0.011	1.1E-05	1.9E-05	--	--	--	--	--	--	1.1E-05	1.9E-05	0.011	1.1E-05	1.9E-05	--	--	--	--	--	--	1.1E-05	1.9E-05
Formaldehyde	50-00-0	0.016	1.7E-05	2.8E-05	--	--	--	--	--	--	1.7E-05	2.8E-05	0.016	1.6E-05	2.8E-05	--	--	--	--	--	--	1.6E-05	2.8E-05
Methanol	67-56-1	1.2E-03	1.3E-06	2.1E-06	--	--	--	--	--	--	1.3E-06	2.1E-06	1.2E-03	1.3E-06	2.1E-06	--	--	--	--	--	--	1.3E-06	2.1E-06
Naphthalene	91-20-3	5.0E-04	5.3E-07	8.9E-07	--	--	--	--	--	--	5.3E-07	8.9E-07	5.0E-04	5.2E-07	8.8E-07	--	--	--	--	--	--	5.2E-07	8.8E-07
n-Hexane	110-54-3	0.016	1.7E-05	2.8E-05	--	--	--	--	--	--	1.7E-05	2.8E-05	0.016	1.7E-05	2.8E-05	--	--	--	--	--	--	1.7E-05	2.8E-05
Propylene	115-07-1	0.031	3.2E-05	5.4E-05	--	--	--	--	--	--	3.2E-05	5.4E-05	0.031	3.2E-05	5.4E-05	--	--	--	--	--	--	3.2E-05	5.4E-05
Styrene	100-42-5	1.2E-03	1.3E-06	2.1E-06	--	--	--	--	--	--	1.3E-06	2.1E-06	1.2E-03	1.3E-06	2.1E-06	--	--	--	--	--	--	1.3E-06	2.1E-06
Toluene	108-88-3	0.058	6.1E-05	1.0E-04	--	--	--	--	--	--	6.1E-05	1.0E-04	0.058	6.0E-05	1.0E-04	--	--	--	--	--	--	6.0E-05	1.0E-04
m-Xylene	108-38-3	0.036	3.7E-05	6.3E-05	--	--	--	--	--	--	3.7E-05	6.3E-05	0.036	3.7E-05	6.3E-05	--	--	--	--	--	--	3.7E-05	6.3E-05
o-Xylene	95-47-6	0.012	1.3E-05	2.2E-05	--	--	--	--	--	--	1.3E-05	2.2E-05	0.012	1.3E-05	2.2E-05	--	--	--	--	--	--	1.3E-05	2.2E-05
Lead	7439-92-1	--	--	--	1.6E-04	4.4E-08	7.4E-08	5.0E-05	6.3E-08	1.1E-07	1.1E-07	1.8E-07	--	--	--	1.6E-04	4.3E-08	7.3E-08	5.0E-05	6.2E-08	1.1E-07	1.1E-07	1.8E-07
Manganese	7439-96-5	--	--	--	1.0E-04	2.7E-08	4.6E-08	1.7E-03	2.1E-06	3.6E-06	2.2E-06	3.7E-06	--	--	--	1.0E-04	2.7E-08	4.6E-08	1.7E-03	2.1E-06	3.6E-06	2.1E-06	3.6E-06
Nickel	7440-02-0	--	--	--	5.0E-05	1.4E-08	2.3E-08	6.6E-04	8.3E-07	1.4E-06	8.4E-07	1.4E-06	--	--	--	5.0E-05	1.4E-08	2.3E-08	6.6E-04	8.2E-07	1.4E-06	8.4E-07	1.4E-06
Arsenic	7440-38-2	--	--	--	No Data	--	--	1.0E-05	1.3E-08	2.1E-08	1.3E-08	2.1E-08	--	--	--	No Data	--	--	1.0E-05	1.2E-08	2.1E-08	1.2E-08	2.1E-08
Copper	7440-50-8	--	--	--	4.9E-04	1.3E-07	2.3E-07	0.011	1.4E-05	2.4E-05	1.5E-05	2.5E-05	--	--	--	4.9E-04	1.3E-07	2.2E-07	0.011	1.4E-05	2.4E-05	1.4E-05	2.4E-05
Vanadium	7440-62-2	--	--	--	No Data	--	--	6.6E-04	8.3E-07	1.4E-06	8.3E-07	1.4E-06	--	--	--	No Data	--	--	6.6E-04	8.2E-07	1.4E-06	8.2E-07	1.4E-06
Bromine	7726-95-6	--	--	--	1.5E-05	4.1E-09	6.9E-09	4.0E-05	5.0E-08	8.5E-08	5.4E-08	9.2E-08	--	--	--	1.5E-05	4.1E-09	6.9E-09	4.0E-05	5.0E-08	8.4E-08	5.4E-08	9.1E-08
Selenium	7782-49-2	--	--	--	2.0E-05	5.5E-09	9.2E-09	2.0E-05	2.5E-08	4.2E-08	3.1E-08	5.2E-08	--	--	--	2.0E-05	5.4E-09	9.2E-09	2.0E-05	2.5E-08	4.2E-08	3.0E-08	5.1E-08
Chlorine	7782-50-5	--	--	--	7.8E-03	2.1E-06	3.6E-06	1.5E-03	1.9E-06	3.2E-06	4.0E-06	6.8E-06	--	--	--	7.8E-03	2.1E-06	3.6E-06	1.5E-03	1.9E-06	3.2E-06	4.0E-06	6.7E-06

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/VMT]) x (maximum daily vehicle trips [trips/day]) x (offsite roundtrip distance [mi/trip]) x (TAC emission fraction) / (daily hours of operation [hrs/day])

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/VMT]) x (annual vehicle trips [trips/yr]) x (offsite roundtrip distance [mi/trip]) x (ton/2,000 lbs) x (TAC emission fraction)

References:

(1) California Air Resources Board Speciation Database. TAC emission fractions are derived from the individual speciation profiles listed. Profiles chosen to best represent the project vehicle fleet and existing gasoline formulation.

(2) Emission Factors source: EMFAC 2011 (Model Years to 2034).

(3) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.

Table F-16
Natural Gas Boiler TAC Emission Estimates

Source			Natural Gas Boiler - Buildings 6 and 7		Natural Gas Boiler - Building NRLF		Natural Gas Boiler - Building 8		Natural Gas Boiler - Building 9		Natural Gas Boiler - Building 10		Natural Gas Boiler - Building 11		Natural Gas Boiler - Building 12	
Maximum Hourly Fuel Usage (MMBtu/hr)	(1)		24		23		12		12		11		6		11	
Daily Hours of Operation (hrs/day)	(1)		24		24		24		24		24		24		24	
Annual Fuel Usage (MMBtu/yr)	(1)		42,000		31,923		21,000		21,000		15,267		8,328		15,267	
Modeling ID			NGB_B6_7		NGB_NRLF		NGB_B8		NGB_B9		NGB_B10		NGB_B11		NGB_B12	
TAC	**CAS**	**Emission Factor (lbs/MMscf)**	**Maximum Hourly [a] (lbs/hr)**	**Annual Average [b] (tons/yr)**	**Maximum Hourly [a] (lbs/hr)**	**Annual Average [b] (tons/yr)**	**Maximum Hourly [a] (lbs/hr)**	**Annual Average [b] (tons/yr)**	**Maximum Hourly [a] (lbs/hr)**	**Annual Average [b] (tons/yr)**	**Maximum Hourly [a] (lbs/hr)**	**Annual Average [b] (tons/yr)**	**Maximum Hourly [a] (lbs/hr)**	**Annual Average [b] (tons/yr)**	**Maximum Hourly [a] (lbs/hr)**	**Annual Average [b] (tons/yr)**
7,12-Dimethylbenz(a)anthracene	57-97-6	1.6E-05 [2]	3.8E-07	3.3E-07	3.6E-07	2.5E-07	1.9E-07	1.6E-07	1.9E-07	1.6E-07	1.7E-07	1.2E-07	9.4E-08	6.5E-08	1.7E-07	1.2E-07
Acetaldehyde	75-07-0	8.9E-03 [3]	2.1E-04	1.8E-04	2.0E-04	1.4E-04	1.0E-04	9.1E-05	1.0E-04	9.1E-05	9.6E-05	6.6E-05	5.2E-05	3.6E-05	9.6E-05	6.6E-05
Benzene	71-43-2	4.3E-03 [3]	1.0E-04	8.9E-05	9.7E-05	6.7E-05	5.1E-05	4.4E-05	5.1E-05	4.4E-05	4.6E-05	3.2E-05	2.5E-05	1.8E-05	4.6E-05	3.2E-05
Dichlorobenzene	25321-22-6	1.2E-03 [4]	2.8E-05	2.5E-05	2.7E-05	1.9E-05	1.4E-05	1.2E-05	1.4E-05	1.2E-05	1.3E-05	9.0E-06	7.1E-06	4.9E-06	1.3E-05	9.0E-06
Ethylbenzene	100-41-4	6.9E-03 [5]	1.6E-04	1.4E-04	1.6E-04	1.1E-04	8.1E-05	7.1E-05	8.1E-05	7.1E-05	7.4E-05	5.2E-05	4.1E-05	2.8E-05	7.4E-05	5.2E-05
Fluoranthene	206-44-0	3.0E-06 [2]	7.1E-08	6.2E-08	6.8E-08	4.7E-08	3.5E-08	3.1E-08	3.5E-08	3.1E-08	3.2E-08	2.2E-08	1.8E-08	1.2E-08	3.2E-08	2.2E-08
Formaldehyde	50-00-0	2.2E-01 [3]	5.2E-03	4.6E-03	5.0E-03	3.5E-03	2.6E-03	2.3E-03	2.6E-03	2.3E-03	2.4E-03	1.7E-03	1.3E-03	9.0E-04	2.4E-03	1.7E-03
n-Hexane	110-54-3	4.6E-03 [5]	1.1E-04	9.5E-05	1.0E-04	7.2E-05	5.4E-05	4.7E-05	5.4E-05	4.7E-05	5.0E-05	3.4E-05	2.7E-05	1.9E-05	5.0E-05	3.4E-05
Naphthalene	91-20-3	3.0E-04 [5]	7.1E-06	6.2E-06	6.8E-06	4.7E-06	3.5E-06	3.1E-06	3.5E-06	3.1E-06	3.2E-06	2.2E-06	1.8E-06	1.2E-06	3.2E-06	2.2E-06
Propylene	115-07-1	5.3E-01 [5]	0.012	0.011	0.012	8.3E-03	6.2E-03	5.5E-03	6.2E-03	5.5E-03	5.7E-03	4.0E-03	3.1E-03	2.2E-03	5.7E-03	4.0E-03
Toluene	108-88-3	2.7E-02 [5]	6.2E-04	5.5E-04	6.0E-04	4.1E-04	3.1E-04	2.7E-04	3.1E-04	2.7E-04	2.9E-04	2.0E-04	1.6E-04	1.1E-04	2.9E-04	2.0E-04
Xylenes	1330-20-7	2.0E-02 [5]	4.6E-04	4.1E-04	4.4E-04	3.1E-04	2.3E-04	2.0E-04	2.3E-04	2.0E-04	2.1E-04	1.5E-04	1.2E-04	8.0E-05	2.1E-04	1.5E-04
Arsenic	7440-38-2	2.0E-04 [4]	4.7E-06	4.1E-06	4.5E-06	3.1E-06	2.4E-06	2.1E-06	2.4E-06	2.1E-06	2.2E-06	1.5E-06	1.2E-06	8.2E-07	2.2E-06	1.5E-06
Beryllium	7440-41-7	1.2E-05 [4]	2.8E-07	2.5E-07	2.7E-07	1.9E-07	1.4E-07	1.2E-07	1.4E-07	1.2E-07	1.3E-07	9.0E-08	7.1E-08	4.9E-08	1.3E-07	9.0E-08
Cadmium	7440-43-9	1.1E-03 [4]	2.6E-05	2.3E-05	2.5E-05	1.7E-05	1.3E-05	1.1E-05	1.3E-05	1.1E-05	1.2E-05	8.2E-06	6.5E-06	4.5E-06	1.2E-05	8.2E-06
Chromium VI	18540-29-9	2.4E-04 [6]	5.6E-06	4.9E-06	5.4E-06	3.7E-06	2.8E-06	2.5E-06	2.8E-06	2.5E-06	2.6E-06	1.8E-06	1.4E-06	9.7E-07	2.6E-06	1.8E-06
Cobalt	7440-48-4	8.4E-05 [4]	2.0E-06	1.7E-06	1.9E-06	1.3E-06	9.9E-07	8.6E-07	9.9E-07	8.6E-07	9.1E-07	6.3E-07	4.9E-07	3.4E-07	9.1E-07	6.3E-07
Copper	7440-50-8	8.5E-04 [4]	2.0E-05	1.8E-05	1.9E-05	1.3E-05	1.0E-05	8.8E-06	1.0E-05	8.8E-06	9.2E-06	6.4E-06	5.0E-06	3.5E-06	9.2E-06	6.4E-06
Lead	7439-92-1	5.0E-04 [4]	1.2E-05	1.0E-05	1.1E-05	7.8E-06	5.9E-06	5.1E-06	5.9E-06	5.1E-06	5.4E-06	3.7E-06	2.9E-06	2.0E-06	5.4E-06	3.7E-06
Manganese	7439-96-5	3.8E-04 [4]	8.9E-06	7.8E-06	8.6E-06	5.9E-06	4.5E-06	3.9E-06	4.5E-06	3.9E-06	4.1E-06	2.8E-06	2.2E-06	1.6E-06	4.1E-06	2.8E-06
Mercury	7439-97-6	2.6E-04 [4]	6.1E-06	5.4E-06	5.9E-06	4.1E-06	3.1E-06	2.7E-06	3.1E-06	2.7E-06	2.8E-06	1.9E-06	1.5E-06	1.1E-06	2.8E-06	1.9E-06
Nickel	7440-02-0	2.1E-03 [4]	4.9E-05	4.3E-05	4.7E-05	3.3E-05	2.5E-05	2.2E-05	2.5E-05	2.2E-05	2.3E-05	1.6E-05	1.2E-05	8.6E-06	2.3E-05	1.6E-05
Selenium	7782-49-2	2.4E-05 [4]	5.6E-07	4.9E-07	5.4E-07	3.8E-07	2.8E-07	2.5E-07	2.8E-07	2.5E-07	2.6E-07	1.8E-07	1.4E-07	9.8E-08	2.6E-07	1.8E-07

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/MMscf]) x (maximum hourly heat input [MMBtu/hr])/ (natural gas heat content [Btu/scf])
Natural gas heat content (Btu/scf) = 1,020 (2)

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/MMscf]) x (annual heat input [MMBtu/yr]) / (natural gas heat content [Btu/scf]) x (tons/2,000 lbs)
Natural gas heat content (Btu/scf) = 1,020 (2)

References:

(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) AP-42 Chapter 1.4 (July 1998), Table 1.4-3 "Emission Factors For Speciated Organic Compounds from Natural Gas Combustion".
(3) California Air Toxics Emission Factor (CATEF) Database under Natural Gas Boilers.
(4) AP-42 Chapter 1.4 (July 1998), Table 1.4-4 "Emission Factors For Metals from Natural Gas Combustion".
(5) Ventura Air Quality Management District emission factor database.
(6) The AP-42 total chromium emission factor was multiplied by 17% to correct for emissions of hexavalent chromium per EPA assumptions when regulating combustion sources under 40 CFR Part 63 Subpart DDDD.

Table F-16
Natural Gas Boiler TAC Emission Estimates

Source	Natural Gas Boiler - Building 13	Natural Gas Boiler - Building 14	Natural Gas Boiler - Building 15	Natural Gas Boiler - Building 16	Natural Gas Boiler - Building 17	Natural Gas Boiler - Building 18	Natural Gas Boiler - Building 19
Maximum Hourly Fuel Usage (MMBtu/hr) (1)	6	8	13	15	16	14	12
Daily Hours of Operation (hrs/day) (1)	24	24	24	24	24	24	24
Annual Fuel Usage (MMBtu/yr) (1)	8,328	11,104	18,043	20,819	22,207	19,431	16,655
Modeling ID	NGB_B13	NGB_B14	NGB_B15	NGB_B16	NGB_B17	NGB_B18	NGB_B19

TAC	CAS	Emission Factor (lbs/MMscf)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)
7,12-Dimethylbenz(a)anthracene	57-97-6	1.6E-05 (2)	9.4E-08	6.5E-08	1.3E-07	8.7E-08	2.0E-07	1.4E-07	2.4E-07	1.6E-07	2.5E-07	1.7E-07	2.2E-07	1.5E-07	1.9E-07	1.3E-07
Acetaldehyde	75-07-0	8.9E-03 (3)	5.2E-05	3.6E-05	7.0E-05	4.8E-05	1.1E-04	7.8E-05	1.3E-04	9.1E-05	1.4E-04	9.7E-05	1.2E-04	8.4E-05	1.0E-04	7.2E-05
Benzene	71-43-2	4.3E-03 (3)	2.5E-05	1.8E-05	3.4E-05	2.3E-05	5.5E-05	3.8E-05	6.3E-05	4.4E-05	6.8E-05	4.7E-05	5.9E-05	4.1E-05	5.1E-05	3.5E-05
Dichlorobenzene	25321-22-6	1.2E-03 (4)	7.1E-06	4.9E-06	9.4E-06	6.5E-06	1.5E-05	1.1E-05	1.8E-05	1.2E-05	1.9E-05	1.3E-05	1.6E-05	1.1E-05	1.4E-05	9.8E-06
Ethylbenzene	100-41-4	6.9E-03 (5)	4.1E-05	2.8E-05	5.4E-05	3.8E-05	8.8E-05	6.1E-05	1.0E-04	7.0E-05	1.1E-04	7.5E-05	9.5E-05	6.6E-05	8.1E-05	5.6E-05
Fluoranthene	206-44-0	3.0E-06 (2)	1.8E-08	1.2E-08	2.4E-08	1.6E-08	3.8E-08	2.7E-08	4.4E-08	3.1E-08	4.7E-08	3.3E-08	4.1E-08	2.9E-08	3.5E-08	2.4E-08
Formaldehyde	50-00-0	2.2E-01 (3)	1.3E-03	9.0E-04	1.7E-03	1.2E-03	2.8E-03	2.0E-03	3.3E-03	2.3E-03	3.5E-03	2.4E-03	3.0E-03	2.1E-03	2.6E-03	1.8E-03
n-Hexane	110-54-3	4.6E-03 (5)	2.7E-05	1.9E-05	3.6E-05	2.5E-05	5.9E-05	4.1E-05	6.8E-05	4.7E-05	7.2E-05	5.0E-05	6.3E-05	4.4E-05	5.4E-05	3.8E-05
Naphthalene	91-20-3	3.0E-04 (5)	1.8E-06	1.2E-06	2.4E-06	1.6E-06	3.8E-06	2.7E-06	4.4E-06	3.1E-06	4.7E-06	3.3E-06	4.1E-06	2.9E-06	3.5E-06	2.4E-06
Propylene	115-07-1	5.3E-01 (5)	3.1E-03	2.2E-03	4.2E-03	2.9E-03	6.8E-03	4.7E-03	7.8E-03	5.4E-03	8.3E-03	5.8E-03	7.3E-03	5.0E-03	6.2E-03	4.3E-03
Toluene	108-88-3	2.7E-02 (5)	1.6E-04	1.1E-04	2.1E-04	1.4E-04	3.4E-04	2.3E-04	3.9E-04	2.7E-04	4.2E-04	2.9E-04	3.6E-04	2.5E-04	3.1E-04	2.2E-04
Xylenes	1330-20-7	2.0E-02 (5)	1.2E-04	8.0E-05	1.5E-04	1.1E-04	2.5E-04	1.7E-04	2.9E-04	2.0E-04	3.1E-04	2.1E-04	2.7E-04	1.9E-04	2.3E-04	1.6E-04
Arsenic	7440-38-2	2.0E-04 (4)	1.2E-06	8.2E-07	1.6E-06	1.1E-06	2.5E-06	1.8E-06	2.9E-06	2.0E-06	3.1E-06	2.2E-06	2.7E-06	1.9E-06	2.4E-06	1.6E-06
Beryllium	7440-41-7	1.2E-05 (4)	7.1E-08	4.9E-08	9.4E-08	6.5E-08	1.5E-07	1.1E-07	1.8E-07	1.2E-07	1.9E-07	1.3E-07	1.6E-07	1.1E-07	1.4E-07	9.8E-08
Cadmium	7440-43-9	1.1E-03 (4)	6.5E-06	4.5E-06	8.6E-06	6.0E-06	1.4E-05	9.7E-06	1.6E-05	1.1E-05	1.7E-05	1.2E-05	1.5E-05	1.0E-05	1.3E-05	9.0E-06
Chromium VI	18540-29-9	2.4E-04 (6)	1.4E-06	9.7E-07	1.9E-06	1.3E-06	3.0E-06	2.1E-06	3.5E-06	2.4E-06	3.7E-06	2.6E-06	3.3E-06	2.3E-06	2.8E-06	1.9E-06
Cobalt	7440-48-4	8.4E-05 (4)	4.9E-07	3.4E-07	6.6E-07	4.6E-07	1.1E-06	7.4E-07	1.2E-06	8.6E-07	1.3E-06	9.1E-07	1.2E-06	8.0E-07	9.9E-07	6.9E-07
Copper	7440-50-8	8.5E-04 (4)	5.0E-06	3.5E-06	6.7E-06	4.6E-06	1.1E-05	7.5E-06	1.3E-05	8.7E-06	1.3E-05	9.3E-06	1.2E-05	8.1E-06	1.0E-05	6.9E-06
Lead	7439-92-1	5.0E-04 (4)	2.9E-06	2.0E-06	3.9E-06	2.7E-06	6.4E-06	4.4E-06	7.4E-06	5.1E-06	7.8E-06	5.4E-06	6.9E-06	4.8E-06	5.9E-06	4.1E-06
Manganese	7439-96-5	3.8E-04 (4)	2.2E-06	1.6E-06	3.0E-06	2.1E-06	4.8E-06	3.4E-06	5.6E-06	3.9E-06	6.0E-06	4.1E-06	5.2E-06	3.6E-06	4.5E-06	3.1E-06
Mercury	7439-97-6	2.6E-04 (4)	1.5E-06	1.1E-06	2.0E-06	1.4E-06	3.3E-06	2.3E-06	3.8E-06	2.7E-06	4.1E-06	2.8E-06	3.6E-06	2.5E-06	3.1E-06	2.1E-06
Nickel	7440-02-0	2.1E-03 (4)	1.2E-05	8.6E-06	1.6E-05	1.1E-05	2.7E-05	1.9E-05	3.1E-05	2.1E-05	3.3E-05	2.3E-05	2.9E-05	2.0E-05	2.5E-05	1.7E-05
Selenium	7782-49-2	2.4E-05 (4)	1.4E-07	9.8E-08	1.9E-07	1.3E-07	3.1E-07	2.1E-07	3.5E-07	2.4E-07	3.8E-07	2.6E-07	3.3E-07	2.3E-07	2.8E-07	2.0E-07

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/MMscf]) x (maximum hourly heat input [MMBtu/hr])/ (natural gas heat content [Btu/scf])
Natural gas heat content (Btu/scf) = 1,020 (2)

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/MMscf]) x (annual heat input [MMBtu/yr]) / (natural gas heat content [Btu/scf]) x (tons/2,000 lbs)
Natural gas heat content (Btu/scf) = 1,020 (2)

References:

(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) AP-42 Chapter 1.4 (July 1998), Table 1.4-3 "Emission Factors For Speciated Organic Compounds from Natural Gas Combustion".
(3) California Air Toxics Emission Factor (CATEF) Database under Natural Gas Boilers.
(4) AP-42 Chapter 1.4 (July 1998), Table 1.4-4 "Emission Factors For Metals from Natural Gas Combustion".
(5) Ventura Air Quality Management District emission factor database.
(6) The AP-42 total chromium emission factor was multiplied by 17% to correct for emissions of hexavalent chromium per EPA assumptions when regulating combustion sources under 40 CFR Part 63 Subpart DDDD.

Table F-16
Natural Gas Boiler TAC Emission Estimates

Source	Natural Gas Boiler - Building 20	Natural Gas Boiler - Building 21	Natural Gas Boiler - Building 22	Natural Gas Boiler - Building 23	Natural Gas Boiler - Building 24	Natural Gas Boiler - Building 25	Natural Gas Boiler - Building 26
Maximum Hourly Fuel Usage (MMBtu/hr) (1)	12	28	19	14	12	17	17
Daily Hours of Operation (hrs/day) (1)	24	24	24	24	24	24	24
Annual Fuel Usage (MMBtu/yr) (1)	16,655	38,863	26,371	19,431	16,655	23,595	23,595
Modeling ID	NGB_B20	NGB_B21	NGB_B22	NGB_B23	NGB_B24	NGB_B25	NGB_B26

TAC	CAS	Emission Factor (lbs/MMscf)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)
7,12-Dimethylbenz(a)anthracene	57-97-6	1.6E-05 (2)	1.9E-07	1.3E-07	4.4E-07	3.0E-07	3.0E-07	2.1E-07	2.2E-07	1.5E-07	1.9E-07	1.3E-07	2.7E-07	1.9E-07	2.7E-07	1.9E-07
Acetaldehyde	75-07-0	8.9E-03 (3)	1.0E-04	7.2E-05	2.4E-04	1.7E-04	1.7E-04	1.1E-04	1.2E-04	8.4E-05	1.0E-04	7.2E-05	1.5E-04	1.0E-04	1.5E-04	1.0E-04
Benzene	71-43-2	4.3E-03 (3)	5.1E-05	3.5E-05	1.2E-04	8.2E-05	8.0E-05	5.6E-05	5.9E-05	4.1E-05	5.1E-05	3.5E-05	7.2E-05	5.0E-05	7.2E-05	5.0E-05
Dichlorobenzene	25321-22-6	1.2E-03 (4)	1.4E-05	9.8E-06	3.3E-05	2.3E-05	2.2E-05	1.6E-05	1.6E-05	1.1E-05	1.4E-05	9.8E-06	2.0E-05	1.4E-05	2.0E-05	1.4E-05
Ethylbenzene	100-41-4	6.9E-03 (5)	8.1E-05	5.6E-05	1.9E-04	1.3E-04	1.3E-04	8.9E-05	9.5E-05	6.6E-05	8.1E-05	5.6E-05	1.2E-04	8.0E-05	1.2E-04	8.0E-05
Fluoranthene	206-44-0	3.0E-06 (2)	3.5E-08	2.4E-08	8.2E-08	5.7E-08	5.6E-08	3.9E-08	4.1E-08	2.9E-08	3.5E-08	2.4E-08	5.0E-08	3.5E-08	5.0E-08	3.5E-08
Formaldehyde	50-00-0	2.2E-01 (3)	2.6E-03	1.8E-03	6.1E-03	4.2E-03	4.1E-03	2.9E-03	3.0E-03	2.1E-03	2.6E-03	1.8E-03	3.7E-03	2.6E-03	3.7E-03	2.6E-03
n-Hexane	110-54-3	4.6E-03 (5)	5.4E-05	3.8E-05	1.3E-04	8.8E-05	8.6E-05	5.9E-05	6.3E-05	4.4E-05	5.4E-05	3.8E-05	7.7E-05	5.3E-05	7.7E-05	5.3E-05
Naphthalene	91-20-3	3.0E-04 (5)	3.5E-06	2.4E-06	8.2E-06	5.7E-06	5.6E-06	3.9E-06	4.1E-06	2.9E-06	3.5E-06	2.4E-06	5.0E-06	3.5E-06	5.0E-06	3.5E-06
Propylene	115-07-1	5.3E-01 (5)	6.2E-03	4.3E-03	0.015	0.010	9.9E-03	6.9E-03	7.3E-03	5.0E-03	6.2E-03	4.3E-03	8.8E-03	6.1E-03	8.8E-03	6.1E-03
Toluene	108-88-3	2.7E-02 (5)	3.1E-04	2.2E-04	7.3E-04	5.0E-04	4.9E-04	3.4E-04	3.6E-04	2.5E-04	3.1E-04	2.2E-04	4.4E-04	3.1E-04	4.4E-04	3.1E-04
Xylenes	1330-20-7	2.0E-02 (5)	2.3E-04	1.6E-04	5.4E-04	3.8E-04	3.7E-04	2.5E-04	2.7E-04	1.9E-04	2.3E-04	1.6E-04	3.3E-04	2.3E-04	3.3E-04	2.3E-04
Arsenic	7440-38-2	2.0E-04 (4)	2.4E-06	1.6E-06	5.5E-06	3.8E-06	3.7E-06	2.6E-06	2.7E-06	1.9E-06	2.4E-06	1.6E-06	3.3E-06	2.3E-06	3.3E-06	2.3E-06
Beryllium	7440-41-7	1.2E-05 (4)	1.4E-07	9.8E-08	3.3E-07	2.3E-07	2.2E-07	1.6E-07	1.6E-07	1.1E-07	1.4E-07	9.8E-08	2.0E-07	1.4E-07	2.0E-07	1.4E-07
Cadmium	7440-43-9	1.1E-03 (4)	1.3E-05	9.0E-06	3.0E-05	2.1E-05	2.0E-05	1.4E-05	1.5E-05	1.0E-05	1.3E-05	9.0E-06	1.8E-05	1.3E-05	1.8E-05	1.3E-05
Chromium VI	18540-29-9	2.4E-04 (6)	2.8E-06	1.9E-06	6.5E-06	4.5E-06	4.4E-06	3.1E-06	3.3E-06	2.3E-06	2.8E-06	1.9E-06	4.0E-06	2.8E-06	4.0E-06	2.8E-06
Cobalt	7440-48-4	8.4E-05 (4)	9.9E-07	6.9E-07	2.3E-06	1.6E-06	1.6E-06	1.1E-06	1.2E-06	8.0E-07	9.9E-07	6.9E-07	1.4E-06	9.7E-07	1.4E-06	9.7E-07
Copper	7440-50-8	8.5E-04 (4)	1.0E-05	6.9E-06	2.3E-05	1.6E-05	1.6E-05	1.1E-05	1.2E-05	8.1E-06	1.0E-05	6.9E-06	1.4E-05	9.8E-06	1.4E-05	9.8E-06
Lead	7439-92-1	5.0E-04 (4)	5.9E-06	4.1E-06	1.4E-05	9.5E-06	9.3E-06	6.5E-06	6.9E-06	4.8E-06	5.9E-06	4.1E-06	8.3E-06	5.8E-06	8.3E-06	5.8E-06
Manganese	7439-96-5	3.8E-04 (4)	4.5E-06	3.1E-06	1.0E-05	7.2E-06	7.1E-06	4.9E-06	5.2E-06	3.6E-06	4.5E-06	3.1E-06	6.3E-06	4.4E-06	6.3E-06	4.4E-06
Mercury	7439-97-6	2.6E-04 (4)	3.1E-06	2.1E-06	7.1E-06	5.0E-06	4.8E-06	3.4E-06	3.6E-06	2.5E-06	3.1E-06	2.1E-06	4.3E-06	3.0E-06	4.3E-06	3.0E-06
Nickel	7440-02-0	2.1E-03 (4)	2.5E-05	1.7E-05	5.8E-05	4.0E-05	3.9E-05	2.7E-05	2.9E-05	2.0E-05	2.5E-05	1.7E-05	3.5E-05	2.4E-05	3.5E-05	2.4E-05
Selenium	7782-49-2	2.4E-05 (4)	2.8E-07	2.0E-07	6.6E-07	4.6E-07	4.5E-07	3.1E-07	3.3E-07	2.3E-07	2.8E-07	2.0E-07	4.0E-07	2.8E-07	4.0E-07	2.8E-07

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/MMscf]) x (maximum hourly heat input [MMBtu/hr])/ (natural gas heat content [Btu/scf])
Natural gas heat content (Btu/scf) = 1,020 (2)

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/MMscf]) x (annual heat input [MMBtu/yr]) / (natural gas heat content [Btu/scf]) x (tons/2,000 lbs)
Natural gas heat content (Btu/scf) = 1,020 (2)

References:

(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) AP-42 Chapter 1.4 (July 1998), Table 1.4-3 "Emission Factors For Speciated Organic Compounds from Natural Gas Combustion".
(3) California Air Toxics Emission Factor (CATEF) Database under Natural Gas Boilers.
(4) AP-42 Chapter 1.4 (July 1998), Table 1.4-4 "Emission Factors For Metals from Natural Gas Combustion".
(5) Ventura Air Quality Management District emission factor database.
(6) The AP-42 total chromium emission factor was multiplied by 17% to correct for emissions of hexavalent chromium per EPA assumptions when regulating combustion sources under 40 CFR Part 63 Subpart DDDD.

Table F-16
Natural Gas Boiler TAC Emission Estimates

Source	Natural Gas Boiler - Building 27	Natural Gas Boiler - Building 28	Natural Gas Boiler - Building 29	Natural Gas Boiler - Building 30	Natural Gas Boiler - Building 31	Natural Gas Boiler - Building 32	Natural Gas Boiler - Building 33
Maximum Hourly Fuel Usage (MMBtu/hr) (1)	16	6	6	16	6	13	16
Daily Hours of Operation (hrs/day) (1)	24	24	24	24	24	24	24
Annual Fuel Usage (MMBtu/yr) (1)	22,207	8,328	8,328	22,207	8,328	18,043	22,207
Modeling ID	NGB_B27	NGB_B28	NGB_B29	NGB_B30	NGB_B31	NGB_B32	NGB_B33

TAC	CAS	Emission Factor (lbs/MMscf)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)
7,12-Dimethylbenz(a)anthracene	57-97-6	1.6E-05 (2)	2.5E-07	1.7E-07	9.4E-08	6.5E-08	9.4E-08	6.5E-08	2.5E-07	1.7E-07	9.4E-08	6.5E-08	2.0E-07	1.4E-07	2.5E-07	1.7E-07
Acetaldehyde	75-07-0	8.9E-03 (3)	1.4E-04	9.7E-05	5.2E-05	3.6E-05	5.2E-05	3.6E-05	1.4E-04	9.7E-05	5.2E-05	3.6E-05	1.1E-04	7.8E-05	1.4E-04	9.7E-05
Benzene	71-43-2	4.3E-03 (3)	6.8E-05	4.7E-05	2.5E-05	1.8E-05	2.5E-05	1.8E-05	6.8E-05	4.7E-05	2.5E-05	1.8E-05	5.5E-05	3.8E-05	6.8E-05	4.7E-05
Dichlorobenzene	25321-22-6	1.2E-03 (4)	1.9E-05	1.3E-05	7.1E-06	4.9E-06	7.1E-06	4.9E-06	1.9E-05	1.3E-05	7.1E-06	4.9E-06	1.5E-05	1.1E-05	1.9E-05	1.3E-05
Ethylbenzene	100-41-4	6.9E-03 (5)	1.1E-04	7.5E-05	4.1E-05	2.8E-05	4.1E-05	2.8E-05	1.1E-04	7.5E-05	4.1E-05	2.8E-05	8.8E-05	6.1E-05	1.1E-04	7.5E-05
Fluoranthene	206-44-0	3.0E-06 (2)	4.7E-08	3.3E-08	1.8E-08	1.2E-08	1.8E-08	1.2E-08	4.7E-08	3.3E-08	1.8E-08	1.2E-08	3.8E-08	2.7E-08	4.7E-08	3.3E-08
Formaldehyde	50-00-0	2.2E-01 (3)	3.5E-03	2.4E-03	1.3E-03	9.0E-04	1.3E-03	9.0E-04	3.5E-03	2.4E-03	1.3E-03	9.0E-04	2.8E-03	2.0E-03	3.5E-03	2.4E-03
n-Hexane	110-54-3	4.6E-03 (5)	7.2E-05	5.0E-05	2.7E-05	1.9E-05	2.7E-05	1.9E-05	7.2E-05	5.0E-05	2.7E-05	1.9E-05	5.9E-05	4.1E-05	7.2E-05	5.0E-05
Naphthalene	91-20-3	3.0E-04 (5)	4.7E-06	3.3E-06	1.8E-06	1.2E-06	1.8E-06	1.2E-06	4.7E-06	3.3E-06	1.8E-06	1.2E-06	3.8E-06	2.7E-06	4.7E-06	3.3E-06
Propylene	115-07-1	5.3E-01 (5)	8.3E-03	5.8E-03	3.1E-03	2.2E-03	3.1E-03	2.2E-03	8.3E-03	5.8E-03	3.1E-03	2.2E-03	6.8E-03	4.7E-03	8.3E-03	5.8E-03
Toluene	108-88-3	2.7E-02 (5)	4.2E-04	2.9E-04	1.6E-04	1.1E-04	1.6E-04	1.1E-04	4.2E-04	2.9E-04	1.6E-04	1.1E-04	3.4E-04	2.3E-04	4.2E-04	2.9E-04
Xylenes	1330-20-7	2.0E-02 (5)	3.1E-04	2.1E-04	1.2E-04	8.0E-05	1.2E-04	8.0E-05	3.1E-04	2.1E-04	1.2E-04	8.0E-05	2.5E-04	1.7E-04	3.1E-04	2.1E-04
Arsenic	7440-38-2	2.0E-04 (4)	3.1E-06	2.2E-06	1.2E-06	8.2E-07	1.2E-06	8.2E-07	3.1E-06	2.2E-06	1.2E-06	8.2E-07	2.5E-06	1.8E-06	3.1E-06	2.2E-06
Beryllium	7440-41-7	1.2E-05 (4)	1.9E-07	1.3E-07	7.1E-08	4.9E-08	7.1E-08	4.9E-08	1.9E-07	1.3E-07	7.1E-08	4.9E-08	1.5E-07	1.1E-07	1.9E-07	1.3E-07
Cadmium	7440-43-9	1.1E-03 (4)	1.7E-05	1.2E-05	6.5E-06	4.5E-06	6.5E-06	4.5E-06	1.7E-05	1.2E-05	6.5E-06	4.5E-06	1.4E-05	9.7E-06	1.7E-05	1.2E-05
Chromium VI	18540-29-9	2.4E-04 (6)	3.7E-06	2.6E-06	1.4E-06	9.7E-07	1.4E-06	9.7E-07	3.7E-06	2.6E-06	1.4E-06	9.7E-07	3.0E-06	2.1E-06	3.7E-06	2.6E-06
Cobalt	7440-48-4	8.4E-05 (4)	1.3E-06	9.1E-07	4.9E-07	3.4E-07	4.9E-07	3.4E-07	1.3E-06	9.1E-07	4.9E-07	3.4E-07	1.1E-06	7.4E-07	1.3E-06	9.1E-07
Copper	7440-50-8	8.5E-04 (4)	1.3E-05	9.3E-06	5.0E-06	3.5E-06	5.0E-06	3.5E-06	1.3E-05	9.3E-06	5.0E-06	3.5E-06	1.1E-05	7.5E-06	1.3E-05	9.3E-06
Lead	7439-92-1	5.0E-04 (4)	7.8E-06	5.4E-06	2.9E-06	2.0E-06	2.9E-06	2.0E-06	7.8E-06	5.4E-06	2.9E-06	2.0E-06	6.4E-06	4.4E-06	7.8E-06	5.4E-06
Manganese	7439-96-5	3.8E-04 (4)	6.0E-06	4.1E-06	2.2E-06	1.6E-06	2.2E-06	1.6E-06	6.0E-06	4.1E-06	2.2E-06	1.6E-06	4.8E-06	3.4E-06	6.0E-06	4.1E-06
Mercury	7439-97-6	2.6E-04 (4)	4.1E-06	2.8E-06	1.5E-06	1.1E-06	1.5E-06	1.1E-06	4.1E-06	2.8E-06	1.5E-06	1.1E-06	3.3E-06	2.3E-06	4.1E-06	2.8E-06
Nickel	7440-02-0	2.1E-03 (4)	3.3E-05	2.3E-05	1.2E-05	8.6E-06	1.2E-05	8.6E-06	3.3E-05	2.3E-05	1.2E-05	8.6E-06	2.7E-05	1.9E-05	3.3E-05	2.3E-05
Selenium	7782-49-2	2.4E-05 (4)	3.8E-07	2.6E-07	1.4E-07	9.8E-08	1.4E-07	9.8E-08	3.8E-07	2.6E-07	1.4E-07	9.8E-08	3.1E-07	2.1E-07	3.8E-07	2.6E-07

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/MMscf]) x (maximum hourly heat input [MMBtu/hr])/ (natural gas heat content [Btu/scf])
Natural gas heat content (Btu/scf) = 1,020 (2)

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/MMscf]) x (annual heat input [MMBtu/yr]) / (natural gas heat content [Btu/scf]) x (tons/2,000 lbs)
Natural gas heat content (Btu/scf) = 1,020 (2)

References:

(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) AP-42 Chapter 1.4 (July 1998), Table 1.4-3 "Emission Factors For Speciated Organic Compounds from Natural Gas Combustion".
(3) California Air Toxics Emission Factor (CATEF) Database under Natural Gas Boilers.
(4) AP-42 Chapter 1.4 (July 1998), Table 1.4-4 "Emission Factors For Metals from Natural Gas Combustion".
(5) Ventura Air Quality Management District emission factor database.
(6) The AP-42 total chromium emission factor was multiplied by 17% to correct for emissions of hexavalent chromium per EPA assumptions when regulating combustion sources under 40 CFR Part 63 Subpart DDDD.

Table F-16
Natural Gas Boiler TAC Emission Estimates

Source	Natural Gas Boiler - Building 34	Natural Gas Boiler - Building 35	Natural Gas Boiler - Building 36	Natural Gas Boiler - Building 37	Natural Gas Boiler - Building 38	Total
Maximum Hourly Fuel Usage (MMBtu/hr) (1)	17	19	18	20	8	
Daily Hours of Operation (hrs/day) (1)	24	24	24	24	24	
Annual Fuel Usage (MMBtu/yr) (1)	23,595	26,371	24,983	27,759	11,104	
Modeling ID	NGB_B34	NGB_B35	NGB_B36	NGB_B37	NGB_B38	

TAC	CAS	Emission Factor (lbs/MMscf)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)
7,12-Dimethylbenz(a)anthracene	57-97-6	1.6E-05 (2)	2.7E-07	1.9E-07	3.0E-07	2.1E-07	2.8E-07	2.0E-07	3.1E-07	2.2E-07	1.3E-07	8.7E-08	7.3E-06	5.2E-06
Acetaldehyde	75-07-0	8.9E-03 (3)	1.5E-04	1.0E-04	1.7E-04	1.1E-04	1.6E-04	1.1E-04	1.7E-04	1.2E-04	7.0E-05	4.8E-05	4.0E-03	2.9E-03
Benzene	71-43-2	4.3E-03 (3)	7.2E-05	5.0E-05	8.0E-05	5.6E-05	7.6E-05	5.3E-05	8.5E-05	5.9E-05	3.4E-05	2.3E-05	2.0E-03	1.4E-03
Dichlorobenzene	25321-22-6	1.2E-03 (4)	2.0E-05	1.4E-05	2.2E-05	1.6E-05	2.1E-05	1.5E-05	2.4E-05	1.6E-05	9.4E-06	6.5E-06	5.4E-04	3.9E-04
Ethylbenzene	100-41-4	6.9E-03 (5)	1.2E-04	8.0E-05	1.3E-04	8.9E-05	1.2E-04	8.5E-05	1.4E-04	9.4E-05	5.4E-05	3.8E-05	3.1E-03	2.2E-03
Fluoranthene	206-44-0	3.0E-06 (2)	5.0E-08	3.5E-08	5.6E-08	3.9E-08	5.3E-08	3.7E-08	5.9E-08	4.1E-08	2.4E-08	1.6E-08	1.4E-06	9.7E-07
Formaldehyde	50-00-0	2.2E-01 (3)	3.7E-03	2.6E-03	4.1E-03	2.9E-03	3.9E-03	2.7E-03	4.3E-03	3.0E-03	1.7E-03	1.2E-03	0.10	0.072
n-Hexane	110-54-3	4.6E-03 (5)	7.7E-05	5.3E-05	8.6E-05	5.9E-05	8.1E-05	5.6E-05	9.0E-05	6.3E-05	3.6E-05	2.5E-05	2.1E-03	1.5E-03
Naphthalene	91-20-3	3.0E-04 (5)	5.0E-06	3.5E-06	5.6E-06	3.9E-06	5.3E-06	3.7E-06	5.9E-06	4.1E-06	2.4E-06	1.6E-06	1.4E-04	9.7E-05
Propylene	115-07-1	5.3E-01 (5)	8.8E-03	6.1E-03	9.9E-03	6.9E-03	9.4E-03	6.5E-03	0.010	7.2E-03	4.2E-03	2.9E-03	0.24	0.17
Toluene	108-88-3	2.7E-02 (5)	4.4E-04	3.1E-04	4.9E-04	3.4E-04	4.7E-04	3.2E-04	5.2E-04	3.6E-04	2.1E-04	1.4E-04	0.012	8.6E-03
Xylenes	1330-20-7	2.0E-02 (5)	3.3E-04	2.3E-04	3.7E-04	2.5E-04	3.5E-04	2.4E-04	3.9E-04	2.7E-04	1.5E-04	1.1E-04	8.9E-03	6.4E-03
Arsenic	7440-38-2	2.0E-04 (4)	3.3E-06	2.3E-06	3.7E-06	2.6E-06	3.5E-06	2.4E-06	3.9E-06	2.7E-06	1.6E-06	1.1E-06	9.1E-05	6.5E-05
Beryllium	7440-41-7	1.2E-05 (4)	2.0E-07	1.4E-07	2.2E-07	1.6E-07	2.1E-07	1.5E-07	2.4E-07	1.6E-07	9.4E-08	6.5E-08	5.4E-06	3.9E-06
Cadmium	7440-43-9	1.1E-03 (4)	1.8E-05	1.3E-05	2.0E-05	1.4E-05	1.9E-05	1.3E-05	2.2E-05	1.5E-05	8.6E-06	6.0E-06	5.0E-04	3.6E-04
Chromium VI	18540-29-9	2.4E-04 (6)	4.0E-06	2.8E-06	4.4E-06	3.1E-06	4.2E-06	2.9E-06	4.7E-06	3.2E-06	1.9E-06	1.3E-06	1.1E-04	7.7E-05
Cobalt	7440-48-4	8.4E-05 (4)	1.4E-06	9.7E-07	1.6E-06	1.1E-06	1.5E-06	1.0E-06	1.6E-06	1.1E-06	6.6E-07	4.6E-07	3.8E-05	2.7E-05
Copper	7440-50-8	8.5E-04 (4)	1.4E-05	9.8E-06	1.6E-05	1.1E-05	1.5E-05	1.0E-05	1.7E-05	1.2E-05	6.7E-06	4.6E-06	3.9E-04	2.8E-04
Lead	7439-92-1	5.0E-04 (4)	8.3E-06	5.8E-06	9.3E-06	6.5E-06	8.8E-06	6.1E-06	9.8E-06	6.8E-06	3.9E-06	2.7E-06	2.3E-04	1.6E-04
Manganese	7439-96-5	3.8E-04 (4)	6.3E-06	4.4E-06	7.1E-06	4.9E-06	6.7E-06	4.7E-06	7.5E-06	5.2E-06	3.0E-06	2.1E-06	1.7E-04	1.2E-04
Mercury	7439-97-6	2.6E-04 (4)	4.3E-06	3.0E-06	4.8E-06	3.4E-06	4.6E-06	3.2E-06	5.1E-06	3.5E-06	2.0E-06	1.4E-06	1.2E-04	8.4E-05
Nickel	7440-02-0	2.1E-03 (4)	3.5E-05	2.4E-05	3.9E-05	2.7E-05	3.7E-05	2.6E-05	4.1E-05	2.9E-05	1.6E-05	1.1E-05	9.5E-04	6.8E-04
Selenium	7782-49-2	2.4E-05 (4)	4.0E-07	2.8E-07	4.5E-07	3.1E-07	4.2E-07	2.9E-07	4.7E-07	3.3E-07	1.9E-07	1.3E-07	1.1E-05	7.8E-06

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/MMscf]) x (maximum hourly heat input [MMBtu/hr])/ (natural gas heat content [Btu/scf])
Natural gas heat content (Btu/scf) = 1,020 (2)

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/MMscf]) x (annual heat input [MMBtu/yr]) / (natural gas heat content [Btu/scf]) x (tons/2,000 lbs)
Natural gas heat content (Btu/scf) = 1,020 (2)

References:

(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) AP-42 Chapter 1.4 (July 1998), Table 1.4-3 "Emission Factors For Speciated Organic Compounds from Natural Gas Combustion".
(3) California Air Toxics Emission Factor (CATEF) Database under Natural Gas Boilers.
(4) AP-42 Chapter 1.4 (July 1998), Table 1.4-4 "Emission Factors For Metals from Natural Gas Combustion".
(5) Ventura Air Quality Management District emission factor database.
(6) The AP-42 total chromium emission factor was multiplied by 17% to correct for emissions of hexavalent chromium per EPA assumptions when regulating combustion sources under 40 CFR Part 63 Subpart DDDD.

Table F-17
Emergency Diesel Generator TAC Emission Estimates

Source	Diesel Generator - Building 6	Diesel Generator - Building 7	Diesel Generator - Building NRLF	Diesel Generator - Building 8	Diesel Generator - Building 9	Diesel Generator - Building 10	Diesel Generator - Building 11	Diesel Generator - Building 12	Diesel Generator - Building 13
BHP [1]	440	440	700	440	440	410	240	420	170
Diesel Fuel Combustion (gal/hr) [1]	22.3	22.3	35.5	22.3	22.3	20.8	12.2	21.3	8.6
Load Factor [2]	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
Annual Operation (hrs/yr) [1]	25.15	25.15	25.15	25.15	25.15	25.15	25.15	25.15	25.15
Modeling ID	DG_B6	DG_B7	DG_NRLF	DG_B8	DG_B9	DG_B10	DG_B11	DG_B12	DG_B13

TAC	CAS	Emission Factor (lbs/10^3 gal)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)
DPM	9901	-- [3]	0.011 [b]	1.4E-04	0.011 [b]	1.4E-04	0.017 [b]	2.2E-04	7.2E-03 [b]	9.0E-05	7.2E-03 [b]	9.0E-05	0.010 [b]	1.3E-04	5.9E-03 [b]	7.4E-05	0.010 [b]	1.3E-04	4.2E-03 [b]	5.2E-05
1,3-Butadiene	106-99-0	2.17E-01 [4]	3.6E-03 [c]	4.5E-05	3.6E-03 [c]	4.5E-05	5.7E-03 [c]	7.2E-05	3.6E-03 [c]	4.5E-05	3.6E-03 [c]	4.5E-05	3.3E-03 [c]	4.2E-05	2.0E-03 [c]	2.5E-05	3.4E-03 [c]	4.3E-05	1.4E-03 [c]	1.7E-05
Acetaldehyde	75-07-0	3.47E-03 [5]	5.7E-05 [c]	7.2E-07	5.7E-05 [c]	7.2E-07	9.1E-05 [c]	1.1E-06	5.7E-05 [c]	7.2E-07	5.7E-05 [c]	7.2E-07	5.3E-05 [c]	6.7E-07	3.1E-05 [c]	3.9E-07	5.5E-05 [c]	6.9E-07	2.2E-05 [c]	2.8E-07
Benzene	71-43-2	1.93E-01 [5]	3.2E-03 [c]	4.0E-05	3.2E-03 [c]	4.0E-05	5.1E-03 [c]	6.4E-05	3.2E-03 [c]	4.0E-05	3.2E-03 [c]	4.0E-05	3.0E-03 [c]	3.7E-05	1.7E-03 [c]	2.2E-05	3.0E-03 [c]	3.8E-05	1.2E-03 [c]	1.5E-05
Benzo(a)anthracene	56-55-3	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	205-99-2	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(k)fluoranthene	207-08-9	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chlorobenzene	108-90-7	2.00E-04 [4]	3.3E-06 [c]	4.2E-08	3.3E-06 [c]	4.2E-08	5.3E-06 [c]	6.6E-08	3.3E-06 [c]	4.2E-08	3.3E-06 [c]	4.2E-08	3.1E-06 [c]	3.9E-08	1.8E-06 [c]	2.3E-08	3.2E-06 [c]	4.0E-08	1.3E-06 [c]	1.6E-08
Chrysene	218-01-9	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dibenz(a,h)anthracene	53-70-3	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ethylbenzene	100-41-4	6.76E-03 [5]	1.1E-04 [c]	1.4E-06	1.1E-04 [c]	1.4E-06	1.8E-04 [c]	2.2E-06	1.1E-04 [c]	1.4E-06	1.1E-04 [c]	1.4E-06	1.0E-04 [c]	1.3E-06	6.1E-05 [c]	7.7E-07	1.1E-04 [c]	1.3E-06	4.3E-05 [c]	5.4E-07
Formaldehyde	50-00-0	5.06E-02 [5]	8.3E-04 [c]	1.0E-05	8.3E-04 [c]	1.0E-05	1.3E-03 [c]	1.7E-05	8.3E-04 [c]	1.0E-05	8.3E-04 [c]	1.0E-05	7.8E-04 [c]	9.8E-06	4.6E-04 [c]	5.7E-06	8.0E-04 [c]	1.0E-05	3.2E-04 [c]	4.1E-06
n-Hexane	110-54-3	1.39E-03 [5]	2.3E-05 [c]	2.9E-07	2.3E-05 [c]	2.9E-07	3.7E-05 [c]	4.6E-07	2.3E-05 [c]	2.9E-07	2.3E-05 [c]	2.9E-07	2.1E-05 [c]	2.7E-07	1.3E-05 [c]	1.6E-07	2.2E-05 [c]	2.8E-07	8.9E-06 [c]	1.1E-07
Hydrogen Chloride	7647-01-0	1.86E-01 [4]	3.1E-03 [c]	3.9E-05	3.1E-03 [c]	3.9E-05	4.9E-03 [c]	6.2E-05	3.1E-03 [c]	3.9E-05	3.1E-03 [c]	3.9E-05	2.9E-03 [c]	3.6E-05	1.7E-03 [c]	2.1E-05	2.9E-03 [c]	3.7E-05	1.2E-03 [c]	1.5E-05
Indeno(1,2,3-cd)pyrene	193-39-5	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Naphthalene	91-20-3	1.60E-02 [5]	2.6E-04 [c]	3.3E-06	2.6E-04 [c]	3.3E-06	4.2E-04 [c]	5.3E-06	2.6E-04 [c]	3.3E-06	2.6E-04 [c]	3.3E-06	2.5E-04 [c]	3.1E-06	1.4E-04 [c]	1.8E-06	2.5E-04 [c]	3.2E-06	1.0E-04 [c]	1.3E-06
Propylene	115-07-1	3.41E-01 [5]	5.6E-03 [c]	7.1E-05	5.6E-03 [c]	7.1E-05	9.0E-03 [c]	1.1E-04	5.6E-03 [c]	7.1E-05	5.6E-03 [c]	7.1E-05	5.2E-03 [c]	6.6E-05	3.1E-03 [c]	3.9E-05	5.4E-03 [c]	6.8E-05	2.2E-03 [c]	2.7E-05
Toluene	108-88-3	6.12E-02 [5]	1.0E-03 [c]	1.3E-05	1.0E-03 [c]	1.3E-05	1.6E-03 [c]	2.0E-05	1.0E-03 [c]	1.3E-05	1.0E-03 [c]	1.3E-05	9.4E-04 [c]	1.2E-05	5.5E-04 [c]	6.9E-06	9.6E-04 [c]	1.2E-05	3.9E-04 [c]	4.9E-06
Xylenes	1330-20-7	4.24E-02 [4]	7.0E-04 [c]	8.8E-06	7.0E-04 [c]	8.8E-06	1.1E-03 [c]	1.4E-05	7.0E-04 [c]	8.8E-06	7.0E-04 [c]	8.8E-06	6.5E-04 [c]	8.2E-06	3.8E-04 [c]	4.8E-06	6.7E-04 [c]	8.4E-06	2.7E-04 [c]	3.4E-06
Arsenic	7440-38-2	1.60E-03 [4]	2.6E-05 [c]	3.3E-07	2.6E-05 [c]	3.3E-07	4.2E-05 [c]	5.3E-07	2.6E-05 [c]	3.3E-07	2.6E-05 [c]	3.3E-07	2.5E-05 [c]	3.1E-07	1.4E-05 [c]	1.8E-07	2.5E-05 [c]	3.2E-07	1.0E-05 [c]	1.3E-07
Cadmium	7440-43-9	1.50E-03 [4]	2.5E-05 [c]	3.1E-07	2.5E-05 [c]	3.1E-07	3.9E-05 [c]	5.0E-07	2.5E-05 [c]	3.1E-07	2.5E-05 [c]	3.1E-07	2.3E-05 [c]	2.9E-07	1.4E-05 [c]	1.7E-07	2.4E-05 [c]	3.0E-07	9.6E-06 [c]	1.2E-07
Chromium VI	18540-29-9	1.00E-04 [7]	1.7E-06 [c]	2.1E-08	1.7E-06 [c]	2.1E-08	2.6E-06 [c]	3.3E-08	1.7E-06 [c]	2.1E-08	1.7E-06 [c]	2.1E-08	1.5E-06 [c]	1.9E-08	9.0E-07 [c]	1.1E-08	1.6E-06 [c]	2.0E-08	6.4E-07 [c]	8.0E-09
Copper	7440-50-8	4.10E-03 [4]	6.8E-05 [c]	8.5E-07	6.8E-05 [c]	8.5E-07	1.1E-04 [c]	1.4E-06	6.8E-05 [c]	8.5E-07	6.8E-05 [c]	8.5E-07	6.3E-05 [c]	7.9E-07	3.7E-05 [c]	4.6E-07	6.5E-05 [c]	8.1E-07	2.6E-05 [c]	3.3E-07
Lead	7439-92-1	8.30E-03 [4]	1.4E-04 [c]	1.7E-06	1.4E-04 [c]	1.7E-06	2.2E-04 [c]	2.7E-06	1.4E-04 [c]	1.7E-06	1.4E-04 [c]	1.7E-06	1.3E-04 [c]	1.6E-06	7.5E-05 [c]	9.4E-07	1.3E-04 [c]	1.6E-06	5.3E-05 [c]	6.7E-07
Manganese	7439-96-5	3.10E-03 [4]	5.1E-05 [c]	6.4E-07	5.1E-05 [c]	6.4E-07	8.1E-05 [c]	1.0E-06	5.1E-05 [c]	6.4E-07	5.1E-05 [c]	6.4E-07	4.8E-05 [c]	6.0E-07	2.8E-05 [c]	3.5E-07	4.9E-05 [c]	6.1E-07	2.0E-05 [c]	2.5E-07
Mercury	7439-97-6	2.00E-03 [4]	3.3E-05 [c]	4.2E-07	3.3E-05 [c]	4.2E-07	5.3E-05 [c]	6.6E-07	3.3E-05 [c]	4.2E-07	3.3E-05 [c]	4.2E-07	3.1E-05 [c]	3.9E-07	1.8E-05 [c]	2.3E-07	3.2E-05 [c]	4.0E-07	1.3E-05 [c]	1.6E-07
Nickel	7440-02-0	3.90E-03 [4]	6.4E-05 [c]	8.1E-07	6.4E-05 [c]	8.1E-07	1.0E-04 [c]	1.3E-06	6.4E-05 [c]	8.1E-07	6.4E-05 [c]	8.1E-07	6.0E-05 [c]	7.5E-07	3.5E-05 [c]	4.4E-07	6.1E-05 [c]	7.7E-07	2.5E-05 [c]	3.1E-07
Selenium	7782-49-2	2.20E-03 [4]	3.6E-05 [c]	4.6E-07	3.6E-05 [c]	4.6E-07	5.8E-05 [c]	7.3E-07	3.6E-05 [c]	4.6E-07	3.6E-05 [c]	4.6E-07	3.4E-05 [c]	4.3E-07	2.0E-05 [c]	2.5E-07	3.5E-05 [c]	4.4E-07	1.4E-05 [c]	1.8E-07

Modeling ID	DG_B6	DG_B7	DG_NRLF	DG_B8	DG_B9	DG_B10	DG_B11	DG_B12	DG_B13
Diesel Particulate Emission factor (g/hp-hr) [6]	0.015	0.015	0.015	0.01	0.01	0.015	0.015	0.015	0.015

Notes:

(a) Annual average emission estimate (tons/yr) = (Maximum hourly emissions estimate [lbs/hr]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)
(b) Maximum hourly diesel particulate emissions estimate (lbs/hr) = (Emission factor [g/hp-hr]) x (engine horsepower [hp]) x (load factor) / (453.59 [g/lb])
(c) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/10^3 gal]) x (load factor) x (fuel usage [gal/hr]) x (0.001 gal/10^3 gal)

References:

(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) Default load factor for generators in URBEMIS emission model.
(3) See diesel particulate matter emission factors at the bottom of the table.
(4) Ventura County Air Pollution Control District AB 2588 Combustion Emission Factors Database, May 2001.
(5) California Toxic Emission Factor (CATEF) Database, except for Diesel PM. The emission factors for each TAC are averaged for diesel internal combustion engines operating at less than 13% oxygen in the exhaust. Per vendor information, the percent oxygen in the exhaust is less than 13% at loads greater than 50%. It is assumed that the generator would be run at 50% load or greater.
(6) Polycyclic Aromatic Hydrocarbons (PAHs) are assumed to be included in the particulate matter emission factor. PAHs that are not specifically listed in this table, but may be included in the particulate matter emission factor, include Acenaphthylene, Anthracene, Acenaphthene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(g,h,i)perylene, Chrysene, Dibenz(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene. For purposes of this inventory, it is assumed that all particulate is represented as Diesel Particulate Matter (DPM).
(7) The AP-42 total chromium emission factor was multiplied by 17% to correct for emissions of hexavalent chromium per EPA assumptions when regulating combustion sources under 40 CFR Part 63 Subpart DDDD.

Table F-17
Emergency Diesel Generator TAC Emission Estimates

Source	Diesel Generator - Building 14	Diesel Generator - Building 15	Diesel Generator - Building 16	Diesel Generator - Building 17	Diesel Generator - Building 18	Diesel Generator - Building 19	Diesel Generator - Building 20	Diesel Generator A - Building 21	Diesel Generator B - Building 21
BHP [1]	290	480	560	600	510	460	450	510	510
Diesel Fuel Combustion (gal/hr) [1]	14.7	24.3	28.4	30.4	25.9	23.3	22.8	25.9	25.9
Load Factor [2]	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
Annual Operation (hrs/yr) [1]	25.15	25.15	25.15	25.15	25.15	25.15	25.15	25.15	25.15
Modeling ID	DG_B14	DG_B15	DG_B16	DG_B17	DG_B18	DG_B19	DG_B20	DG_B21A	DG_B21B

TAC	CAS	Emission Factor (lbs/10^3 gal)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)
DPM	9901	-- [3]	7.1E-03 [b]	8.9E-05	0.012 [b]	1.5E-04	0.014 [b]	1.7E-04	0.015 [b]	1.8E-04	0.012 [b]	1.6E-04	0.011 [b]	1.4E-04	0.011 [b]	1.4E-04	0.012 [b]	1.6E-04	0.012 [b]	1.6E-04
1,3-Butadiene	106-99-0	2.17E-01 [4]	2.4E-03 [c]	3.0E-05	3.9E-03 [c]	4.9E-05	4.6E-03 [c]	5.7E-05	4.9E-03 [c]	6.2E-05	4.2E-03 [c]	5.2E-05	3.8E-03 [c]	4.7E-05	3.7E-03 [c]	4.6E-05	4.2E-03 [c]	5.2E-05	4.2E-03 [c]	5.2E-05
Acetaldehyde	75-07-0	3.47E-03 [5]	3.8E-05 [c]	4.7E-07	6.3E-05 [c]	7.9E-07	7.3E-05 [c]	9.2E-07	7.8E-05 [c]	9.8E-07	6.6E-05 [c]	8.4E-07	6.0E-05 [c]	7.5E-07	5.9E-05 [c]	7.4E-07	6.6E-05 [c]	8.4E-07	6.6E-05 [c]	8.4E-07
Benzene	71-43-2	1.93E-01 [5]	2.1E-03 [c]	2.6E-05	3.5E-03 [c]	4.4E-05	4.1E-03 [c]	5.1E-05	4.3E-03 [c]	5.5E-05	3.7E-03 [c]	4.6E-05	3.3E-03 [c]	4.2E-05	3.3E-03 [c]	4.1E-05	3.7E-03 [c]	4.6E-05	3.7E-03 [c]	4.6E-05
Benzo(a)anthracene	56-55-3	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	205-99-2	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(k)fluoranthene	207-08-9	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chlorobenzene	108-90-7	2.00E-04 [4]	2.2E-06 [c]	2.7E-08	3.6E-06 [c]	4.5E-08	4.2E-06 [c]	5.3E-08	4.5E-06 [c]	5.7E-08	3.8E-06 [c]	4.8E-08	3.5E-06 [c]	4.3E-08	3.4E-06 [c]	4.2E-08	3.8E-06 [c]	4.8E-08	3.8E-06 [c]	4.8E-08
Chrysene	218-01-9	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dibenz(a,h)anthracene	53-70-3	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ethylbenzene	100-41-4	6.76E-03 [5]	7.4E-05 [c]	9.3E-07	1.2E-04 [c]	1.5E-06	1.4E-04 [c]	1.8E-06	1.5E-04 [c]	1.9E-06	1.3E-04 [c]	1.6E-06	1.2E-04 [c]	1.5E-06	1.1E-04 [c]	1.4E-06	1.3E-04 [c]	1.6E-06	1.3E-04 [c]	1.6E-06
Formaldehyde	50-00-0	5.06E-02 [5]	5.5E-04 [c]	6.9E-06	9.1E-04 [c]	1.1E-05	1.1E-03 [c]	1.3E-05	1.1E-03 [c]	1.4E-05	9.7E-04 [c]	1.2E-05	8.7E-04 [c]	1.1E-05	8.5E-04 [c]	1.1E-05	9.7E-04 [c]	1.2E-05	9.7E-04 [c]	1.2E-05
n-Hexane	110-54-3	1.39E-03 [5]	1.5E-05 [c]	1.9E-07	2.5E-05 [c]	3.1E-07	2.9E-05 [c]	3.7E-07	3.1E-05 [c]	3.9E-07	2.7E-05 [c]	3.3E-07	2.4E-05 [c]	3.0E-07	2.3E-05 [c]	3.0E-07	2.7E-05 [c]	3.3E-07	2.7E-05 [c]	3.3E-07
Hydrogen Chloride	7647-01-0	1.86E-01 [4]	2.0E-03 [c]	2.6E-05	3.4E-03 [c]	4.2E-05	3.9E-03 [c]	4.9E-05	4.2E-03 [c]	5.3E-05	3.6E-03 [c]	4.5E-05	3.2E-03 [c]	4.0E-05	3.1E-03 [c]	4.0E-05	3.6E-03 [c]	4.5E-05	3.6E-03 [c]	4.5E-05
Indeno(1,2,3-cd)pyrene	193-39-5	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Naphthalene	91-20-3	1.60E-02 [5]	1.7E-04 [c]	2.2E-06	2.9E-04 [c]	3.6E-06	3.4E-04 [c]	4.2E-06	3.6E-04 [c]	4.5E-06	3.1E-04 [c]	3.8E-06	2.8E-04 [c]	3.5E-06	2.7E-04 [c]	3.4E-06	3.1E-04 [c]	3.8E-06	3.1E-04 [c]	3.8E-06
Propylene	115-07-1	3.41E-01 [5]	3.7E-03 [c]	4.7E-05	6.1E-03 [c]	7.7E-05	7.2E-03 [c]	9.0E-05	7.7E-03 [c]	9.7E-05	6.5E-03 [c]	8.2E-05	5.9E-03 [c]	7.4E-05	5.8E-03 [c]	7.2E-05	6.5E-03 [c]	8.2E-05	6.5E-03 [c]	8.2E-05
Toluene	108-88-3	6.12E-02 [5]	6.7E-04 [c]	8.4E-06	1.1E-03 [c]	1.4E-05	1.3E-03 [c]	1.6E-05	1.4E-03 [c]	1.7E-05	1.2E-03 [c]	1.5E-05	1.1E-03 [c]	1.3E-05	1.0E-03 [c]	1.3E-05	1.2E-03 [c]	1.5E-05	1.2E-03 [c]	1.5E-05
Xylenes	1330-20-7	4.24E-02 [4]	4.6E-04 [c]	5.8E-06	7.6E-04 [c]	9.6E-06	8.9E-04 [c]	1.1E-05	9.5E-04 [c]	1.2E-05	8.1E-04 [c]	1.0E-05	7.3E-04 [c]	9.2E-06	7.2E-04 [c]	9.0E-06	8.1E-04 [c]	1.0E-05	8.1E-04 [c]	1.0E-05
Arsenic	7440-38-2	1.60E-03 [4]	1.7E-05 [c]	2.2E-07	2.9E-05 [c]	3.6E-07	3.4E-05 [c]	4.2E-07	3.6E-05 [c]	4.5E-07	3.1E-05 [c]	3.9E-07	2.8E-05 [c]	3.5E-07	2.7E-05 [c]	3.4E-07	3.1E-05 [c]	3.9E-07	3.1E-05 [c]	3.9E-07
Cadmium	7440-43-9	1.50E-03 [4]	1.6E-05 [c]	2.1E-07	2.7E-05 [c]	3.4E-07	3.2E-05 [c]	4.0E-07	3.4E-05 [c]	4.2E-07	2.9E-05 [c]	3.6E-07	2.6E-05 [c]	3.3E-07	2.5E-05 [c]	3.2E-07	2.9E-05 [c]	3.6E-07	2.9E-05 [c]	3.6E-07
Chromium VI	18540-29-9	1.00E-04 [7]	1.1E-06 [c]	1.4E-08	1.8E-06 [c]	2.3E-08	2.1E-06 [c]	2.6E-08	2.3E-06 [c]	2.8E-08	1.9E-06 [c]	2.4E-08	1.7E-06 [c]	2.2E-08	1.7E-06 [c]	2.1E-08	1.9E-06 [c]	2.4E-08	1.9E-06 [c]	2.4E-08
Copper	7440-50-8	4.10E-03 [4]	4.5E-05 [c]	5.6E-07	7.4E-05 [c]	9.3E-07	8.6E-05 [c]	1.1E-06	9.2E-05 [c]	1.2E-06	7.8E-05 [c]	9.9E-07	7.1E-05 [c]	8.9E-07	6.9E-05 [c]	8.7E-07	7.8E-05 [c]	9.9E-07	7.8E-05 [c]	9.9E-07
Lead	7439-92-1	8.30E-03 [4]	9.0E-05 [c]	1.1E-06	1.5E-04 [c]	1.9E-06	1.7E-04 [c]	2.2E-06	1.9E-04 [c]	2.4E-06	1.6E-04 [c]	2.0E-06	1.4E-04 [c]	1.8E-06	1.4E-04 [c]	1.8E-06	1.6E-04 [c]	2.0E-06	1.6E-04 [c]	2.0E-06
Manganese	7439-96-5	3.10E-03 [4]	3.4E-05 [c]	4.2E-07	5.6E-05 [c]	7.0E-07	6.5E-05 [c]	8.2E-07	7.0E-05 [c]	8.8E-07	5.9E-05 [c]	7.5E-07	5.4E-05 [c]	6.7E-07	5.2E-05 [c]	6.6E-07	5.9E-05 [c]	7.5E-07	5.9E-05 [c]	7.5E-07
Mercury	7439-97-6	2.00E-03 [4]	2.2E-05 [c]	2.7E-07	3.6E-05 [c]	4.5E-07	4.2E-05 [c]	5.3E-07	4.5E-05 [c]	5.7E-07	3.8E-05 [c]	4.8E-07	3.5E-05 [c]	4.3E-07	3.4E-05 [c]	4.2E-07	3.8E-05 [c]	4.8E-07	3.8E-05 [c]	4.8E-07
Nickel	7440-02-0	3.90E-03 [4]	4.2E-05 [c]	5.3E-07	7.0E-05 [c]	8.8E-07	8.2E-05 [c]	1.0E-06	8.8E-05 [c]	1.1E-06	7.5E-05 [c]	9.4E-07	6.7E-05 [c]	8.5E-07	6.6E-05 [c]	8.3E-07	7.5E-05 [c]	9.4E-07	7.5E-05 [c]	9.4E-07
Selenium	7782-49-2	2.20E-03 [4]	2.4E-05 [c]	3.0E-07	4.0E-05 [c]	5.0E-07	4.6E-05 [c]	5.8E-07	5.0E-05 [c]	6.2E-07	4.2E-05 [c]	5.3E-07	3.8E-05 [c]	4.8E-07	3.7E-05 [c]	4.7E-07	4.2E-05 [c]	5.3E-07	4.2E-05 [c]	5.3E-07

Modeling ID	DG_B14	DG_B15	DG_B16	DG_B17	DG_B18	DG_B19	DG_B20	DG_B21A	DG_B21B
Diesel Particulate Emission factor (g/hp-hr) [6]	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015

Notes:

(a) Annual average emission estimate (tons/yr) = (Maximum hourly emissions estimate [lbs/hr]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)
(b) Maximum hourly diesel particulate emissions estimate (lbs/hr) = (Emission factor [g/hp-hr]) x (engine horsepower [hp]) x (load factor) / (453.59 [g/lb])
(c) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/103 gal]) x (load factor) x (fuel usage [gal/hr]) x (0.001 gal/103 gal)

References:

(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) Default load factor for generators in URBEMIS emission model.
(3) See diesel particulate matter emission factors at the bottom of the table.
(4) Ventura County Air Pollution Control District AB 2588 Combustion Emission Factors Database, May 2001.
(5) California Toxic Emission Factor (CATEF) Database, except for Diesel PM. The emission factors for each TAC are averaged for diesel internal combustion engines operating at less than 13% oxygen in the exhaust. Per vendor information, the percent oxygen in the exhaust is less than 13% at loads greater than 50%. It is assumed that the generator would be run at 50% load or greater.
(6) Polycyclic Aromatic Hydrocarbons (PAHs) are assumed to be included in the particulate matter emission factor. PAHs that are not specifically listed in this table, but may be included in the particulate matter emission factor, include Acenaphthylene, Anthracene, Acenaphthene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(g,h,i)perylene, Chrysene, Dibenz(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene. For purposes of this inventory, it is assumed that all particulate is represented as Diesel Particulate Matter (DPM).
(7) The AP-42 total chromium emission factor was multiplied by 17% to correct for emissions of hexavalent chromium per EPA assumptions when regulating combustion sources under 40 CFR Part 63 Subpart DDDD.

Table F-17
Emergency Diesel Generator TAC Emission Estimates

Source	Diesel Generator - Building 22	Diesel Generator - Building 23	Diesel Generator - Building 24	Diesel Generator - Building 25	Diesel Generator - Building 26	Diesel Generator - Building 27	Diesel Generator - Building 28	Diesel Generator - Building 29	Diesel Generator - Building 30
BHP [1]	700	530	460	630	610	590	230	180	600
Diesel Fuel Combustion (gal/hr) [1]	35.5	26.9	23.3	32.0	30.9	29.9	11.7	9.1	30.4
Load Factor [2]	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
Annual Operation (hrs/yr) [1]	25.15	25.15	25.15	25.15	25.15	25.15	25.15	25.15	25.15
Modeling ID	DG_B22	DG_B23	DG_B24	DG_B25	DG_B26	DG_B27	DG_B28	DG_B29	DG_B30

TAC	CAS	Emission Factor (lbs/10^3 gal)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)
DPM	9901	-- [3]	0.017 [b]	2.2E-04	0.013 [b]	1.6E-04	0.011 [b]	1.4E-04	0.015 [b]	1.9E-04	0.015 [b]	1.9E-04	0.014 [b]	1.8E-04	5.6E-03 [b]	7.1E-05	4.4E-03 [b]	5.5E-05	0.015 [b]	1.8E-04
1,3-Butadiene	106-99-0	2.17E-01 [4]	5.7E-03 [c]	7.2E-05	4.3E-03 [c]	5.4E-05	3.8E-03 [c]	4.7E-05	5.1E-03 [c]	6.5E-05	5.0E-03 [c]	6.3E-05	4.8E-03 [c]	6.1E-05	1.9E-03 [c]	2.4E-05	1.5E-03 [c]	1.8E-05	4.9E-03 [c]	6.2E-05
Acetaldehyde	75-07-0	3.47E-03 [5]	9.1E-05 [c]	1.1E-06	6.9E-05 [c]	8.7E-07	6.0E-05 [c]	7.5E-07	8.2E-05 [c]	1.0E-06	7.9E-05 [c]	1.0E-06	7.7E-05 [c]	9.7E-07	3.0E-05 [c]	3.8E-07	2.3E-05 [c]	2.9E-07	7.8E-05 [c]	9.8E-07
Benzene	71-43-2	1.93E-01 [5]	5.1E-03 [c]	6.4E-05	3.8E-03 [c]	4.8E-05	3.3E-03 [c]	4.2E-05	4.6E-03 [c]	5.7E-05	4.4E-03 [c]	5.6E-05	4.3E-03 [c]	5.4E-05	1.7E-03 [c]	2.1E-05	1.3E-03 [c]	1.6E-05	4.3E-03 [c]	5.5E-05
Benzo(a)anthracene	56-55-3	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	205-99-2	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(k)fluoranthene	207-08-9	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chlorobenzene	108-90-7	2.00E-04 [4]	5.3E-06 [c]	6.6E-08	4.0E-06 [c]	5.0E-08	3.5E-06 [c]	4.3E-08	4.7E-06 [c]	5.9E-08	4.6E-06 [c]	5.8E-08	4.4E-06 [c]	5.6E-08	1.7E-06 [c]	2.2E-08	1.4E-06 [c]	1.7E-08	4.5E-06 [c]	5.7E-08
Chrysene	218-01-9	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dibenz(a,h)anthracene	53-70-3	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ethylbenzene	100-41-4	6.76E-03 [5]	1.8E-04 [c]	2.2E-06	1.3E-04 [c]	1.7E-06	1.2E-04 [c]	1.5E-06	1.6E-04 [c]	2.0E-06	1.5E-04 [c]	1.9E-06	1.5E-04 [c]	1.9E-06	5.8E-05 [c]	7.3E-07	4.6E-05 [c]	5.7E-07	1.5E-04 [c]	1.9E-06
Formaldehyde	50-00-0	5.06E-02 [5]	1.3E-03 [c]	1.7E-05	1.0E-03 [c]	1.3E-05	8.7E-04 [c]	1.1E-05	1.2E-03 [c]	1.5E-05	1.2E-03 [c]	1.5E-05	1.1E-03 [c]	1.4E-05	4.4E-04 [c]	5.5E-06	3.4E-04 [c]	4.3E-06	1.1E-03 [c]	1.4E-05
n-Hexane	110-54-3	1.39E-03 [5]	3.7E-05 [c]	4.6E-07	2.8E-05 [c]	3.5E-07	2.4E-05 [c]	3.0E-07	3.3E-05 [c]	4.1E-07	3.2E-05 [c]	4.0E-07	3.1E-05 [c]	3.9E-07	1.2E-05 [c]	1.5E-07	9.4E-06 [c]	1.2E-07	3.1E-05 [c]	3.9E-07
Hydrogen Chloride	7647-01-0	1.86E-01 [4]	4.9E-03 [c]	6.2E-05	3.7E-03 [c]	4.7E-05	3.2E-03 [c]	4.0E-05	4.4E-03 [c]	5.5E-05	4.3E-03 [c]	5.4E-05	4.1E-03 [c]	5.2E-05	1.6E-03 [c]	2.0E-05	1.3E-03 [c]	1.6E-05	4.2E-03 [c]	5.3E-05
Indeno(1,2,3-cd)pyrene	193-39-5	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Naphthalene	91-20-3	1.60E-02 [5]	4.2E-04 [c]	5.3E-06	3.2E-04 [c]	4.0E-06	2.8E-04 [c]	3.5E-06	3.8E-04 [c]	4.7E-06	3.7E-04 [c]	4.6E-06	3.5E-04 [c]	4.4E-06	1.4E-04 [c]	1.7E-06	1.1E-04 [c]	1.4E-06	3.6E-04 [c]	4.5E-06
Propylene	115-07-1	3.41E-01 [5]	9.0E-03 [c]	1.1E-04	6.8E-03 [c]	8.5E-05	5.9E-03 [c]	7.4E-05	8.1E-03 [c]	1.0E-04	7.8E-03 [c]	9.8E-05	7.6E-03 [c]	9.5E-05	2.9E-03 [c]	3.7E-05	2.3E-03 [c]	2.9E-05	7.7E-03 [c]	9.7E-05
Toluene	108-88-3	6.12E-02 [5]	1.6E-03 [c]	2.0E-05	1.2E-03 [c]	1.5E-05	1.1E-03 [c]	1.3E-05	1.4E-03 [c]	1.8E-05	1.4E-03 [c]	1.8E-05	1.4E-03 [c]	1.7E-05	5.3E-04 [c]	6.6E-06	4.1E-04 [c]	5.2E-06	1.4E-03 [c]	1.7E-05
Xylenes	1330-20-7	4.24E-02 [4]	1.1E-03 [c]	1.4E-05	8.4E-04 [c]	1.1E-05	7.3E-04 [c]	9.2E-06	1.0E-03 [c]	1.3E-05	9.7E-04 [c]	1.2E-05	9.4E-04 [c]	1.2E-05	3.7E-04 [c]	4.6E-06	2.9E-04 [c]	3.6E-06	9.5E-04 [c]	1.2E-05
Arsenic	7440-38-2	1.60E-03 [4]	4.2E-05 [c]	5.3E-07	3.2E-05 [c]	4.0E-07	2.8E-05 [c]	3.5E-07	3.8E-05 [c]	4.8E-07	3.7E-05 [c]	4.6E-07	3.5E-05 [c]	4.5E-07	1.4E-05 [c]	1.7E-07	1.1E-05 [c]	1.4E-07	3.6E-05 [c]	4.5E-07
Cadmium	7440-43-9	1.50E-03 [4]	3.9E-05 [c]	5.0E-07	3.0E-05 [c]	3.8E-07	2.6E-05 [c]	3.3E-07	3.5E-05 [c]	4.5E-07	3.4E-05 [c]	4.3E-07	3.3E-05 [c]	4.2E-07	1.3E-05 [c]	1.6E-07	1.0E-05 [c]	1.3E-07	3.4E-05 [c]	4.2E-07
Chromium VI	18540-29-9	1.00E-04 [7]	2.6E-06 [c]	3.3E-08	2.0E-06 [c]	2.5E-08	1.7E-06 [c]	2.2E-08	2.4E-06 [c]	3.0E-08	2.3E-06 [c]	2.9E-08	2.2E-06 [c]	2.8E-08	8.6E-07 [c]	1.1E-08	6.8E-07 [c]	8.5E-09	2.3E-06 [c]	2.8E-08
Copper	7440-50-8	4.10E-03 [4]	1.1E-04 [c]	1.4E-06	8.2E-05 [c]	1.0E-06	7.1E-05 [c]	8.9E-07	9.7E-05 [c]	1.2E-06	9.4E-05 [c]	1.2E-06	9.1E-05 [c]	1.1E-06	3.5E-05 [c]	4.5E-07	2.8E-05 [c]	3.5E-07	9.2E-05 [c]	1.2E-06
Lead	7439-92-1	8.30E-03 [4]	2.2E-04 [c]	2.7E-06	1.7E-04 [c]	2.1E-06	1.4E-04 [c]	1.8E-06	2.0E-04 [c]	2.5E-06	1.9E-04 [c]	2.4E-06	1.8E-04 [c]	2.3E-06	7.2E-05 [c]	9.0E-07	5.6E-05 [c]	7.1E-07	1.9E-04 [c]	2.4E-06
Manganese	7439-96-5	3.10E-03 [4]	8.1E-05 [c]	1.0E-06	6.2E-05 [c]	7.8E-07	5.4E-05 [c]	6.7E-07	7.3E-05 [c]	9.2E-07	7.1E-05 [c]	8.9E-07	6.9E-05 [c]	8.6E-07	2.7E-05 [c]	3.4E-07	2.1E-05 [c]	2.6E-07	7.0E-05 [c]	8.8E-07
Mercury	7439-97-6	2.00E-03 [4]	5.3E-05 [c]	6.6E-07	4.0E-05 [c]	5.0E-07	3.5E-05 [c]	4.3E-07	4.7E-05 [c]	5.9E-07	4.6E-05 [c]	5.8E-07	4.4E-05 [c]	5.6E-07	1.7E-05 [c]	2.2E-07	1.4E-05 [c]	1.7E-07	4.5E-05 [c]	5.7E-07
Nickel	7440-02-0	3.90E-03 [4]	1.0E-04 [c]	1.3E-06	7.8E-05 [c]	9.8E-07	6.7E-05 [c]	8.5E-07	9.2E-05 [c]	1.2E-06	8.9E-05 [c]	1.1E-06	8.6E-05 [c]	1.1E-06	3.4E-05 [c]	4.2E-07	2.6E-05 [c]	3.3E-07	8.8E-05 [c]	1.1E-06
Selenium	7782-49-2	2.20E-03 [4]	5.8E-05 [c]	7.3E-07	4.4E-05 [c]	5.5E-07	3.8E-05 [c]	4.8E-07	5.2E-05 [c]	6.5E-07	5.0E-05 [c]	6.3E-07	4.9E-05 [c]	6.1E-07	1.9E-05 [c]	2.4E-07	1.5E-05 [c]	1.9E-07	5.0E-05 [c]	6.2E-07

Modeling ID	DG_B22	DG_B23	DG_B24	DG_B25	DG_B26	DG_B27	DG_B28	DG_B29	DG_B30
Diesel Particulate Emission factor (g/hp-hr) [6]	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015

Notes:

(a) Annual average emission estimate (tons/yr) = (Maximum hourly emissions estimate [lbs/hr]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)
(b) Maximum hourly diesel particulate emissions estimate (lbs/hr) = (Emission factor [g/hp-hr]) x (engine horsepower [hp]) x (load factor) / (453.59 [g/lb])
(c) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/103 gal]) x (load factor) x (fuel usage [gal/hr]) x (0.001 gal/103 gal)

References:

(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) Default load factor for generators in URBEMIS emission model.
(3) See diesel particulate matter emission factors at the bottom of the table.
(4) Ventura County Air Pollution Control District AB 2588 Combustion Emission Factors Database, May 2001.
(5) California Toxic Emission Factor (CATEF) Database, except for Diesel PM. The emission factors for each TAC are averaged for diesel internal combustion engines operating at less than 13% oxygen in the exhaust. Per vendor information, the percent oxygen in the exhaust is less than 13% at loads greater than 50%. It is assumed that the generator would be run at 50% load or greater.
(6) Polycyclic Aromatic Hydrocarbons (PAHs) are assumed to be included in the particulate matter emission factor. PAHs that are not specifically listed in this table, but may be included in the particulate matter emission factor, include Acenaphthylene, Anthracene, Acenaphthene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(g,h,i)perylene, Chrysene, Dibenz(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene. For purposes of this inventory, it is assumed that all particulate is represented as Diesel Particulate Matter (DPM).
(7) The AP-42 total chromium emission factor was multiplied by 17% to correct for emissions of hexavalent chromium per EPA assumptions when regulating combustion sources under 40 CFR Part 63 Subpart DDDD.

Table F-17
Emergency Diesel Generator TAC Emission Estimates

Source	Diesel Generator - Building 31	Diesel Generator - Building 32	Diesel Generator - Building 33	Diesel Generator - Building 34	Diesel Generator - Building 35	Diesel Generator - Building 36	Diesel Generator - Building 37	Diesel Generator - Building 38	Total
BHP [1]	180	490	580	610	700	680	740	230	
Diesel Fuel Combustion (gal/hr) [1]	9.1	24.9	29.4	30.9	35.5	34.5	37.5	11.7	
Load Factor [2]	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	
Annual Operation (hrs/yr) [1]	25.15	25.15	25.15	25.15	25.15	25.15	25.15	25.15	
Modeling ID	DG_B31	DG_B32	DG_B33	DG_B34	DG_B35	DG_B36	DG_B37	DG_B38	

TAC	CAS	Emission Factor (lbs/10^3 gal)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)
DPM	9901	-- [3]	4.4E-03 [b]	5.5E-05	0.012 [b]	1.5E-04	0.014 [b]	1.8E-04	0.015 [b]	1.9E-04	0.017 [b]	2.2E-04	0.017 [b]	2.1E-04	0.018 [b]	2.3E-04	5.6E-03 [b]	7.1E-05	0.40	5.1E-03
1,3-Butadiene	106-99-0	2.17E-01 [4]	1.5E-03 [c]	1.8E-05	4.0E-03 [c]	5.0E-05	4.7E-03 [c]	6.0E-05	5.0E-03 [c]	6.3E-05	5.7E-03 [c]	7.2E-05	5.5E-03 [c]	7.0E-05	6.0E-03 [c]	7.6E-05	1.9E-03 [c]	2.4E-05	0.14	1.7E-03
Acetaldehyde	75-07-0	3.47E-03 [5]	2.3E-05 [c]	2.9E-07	6.4E-05 [c]	8.0E-07	7.6E-05 [c]	9.5E-07	7.9E-05 [c]	1.0E-06	9.1E-05 [c]	1.1E-06	8.9E-05 [c]	1.1E-06	9.6E-05 [c]	1.2E-06	3.0E-05 [c]	3.8E-07	2.2E-03	2.8E-05
Benzene	71-43-2	1.93E-01 [5]	1.3E-03 [c]	1.6E-05	3.5E-03 [c]	4.5E-05	4.2E-03 [c]	5.3E-05	4.4E-03 [c]	5.6E-05	5.1E-03 [c]	6.4E-05	4.9E-03 [c]	6.2E-05	5.4E-03 [c]	6.7E-05	1.7E-03 [c]	2.1E-05	0.12	1.5E-03
Benzo(a)anthracene	56-55-3	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
Benzo(b)fluoranthene	205-99-2	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
Benzo(k)fluoranthene	207-08-9	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
Chlorobenzene	108-90-7	2.00E-04 [4]	1.4E-06 [c]	1.7E-08	3.7E-06 [c]	4.6E-08	4.4E-06 [c]	5.5E-08	4.6E-06 [c]	5.8E-08	5.3E-06 [c]	6.6E-08	5.1E-06 [c]	6.4E-08	5.6E-06 [c]	7.0E-08	1.7E-06 [c]	2.2E-08	1.3E-04	1.6E-06
Chrysene	218-01-9	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
Dibenz(a,h)anthracene	53-70-3	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
Ethylbenzene	100-41-4	6.76E-03 [5]	4.6E-05 [c]	5.7E-07	1.2E-04 [c]	1.6E-06	1.5E-04 [c]	1.9E-06	1.5E-04 [c]	1.9E-06	1.8E-04 [c]	2.2E-06	1.7E-04 [c]	2.2E-06	1.9E-04 [c]	2.4E-06	5.8E-05 [c]	7.3E-07	4.3E-03	5.4E-05
Formaldehyde	50-00-0	5.06E-02 [5]	3.4E-04 [c]	4.3E-06	9.3E-04 [c]	1.2E-05	1.1E-03 [c]	1.4E-05	1.2E-03 [c]	1.5E-05	1.3E-03 [c]	1.7E-05	1.3E-03 [c]	1.6E-05	1.4E-03 [c]	1.8E-05	4.4E-04 [c]	5.5E-06	0.032	4.0E-04
n-Hexane	110-54-3	1.39E-03 [5]	9.4E-06 [c]	1.2E-07	2.6E-05 [c]	3.2E-07	3.0E-05 [c]	3.8E-07	3.2E-05 [c]	4.0E-07	3.7E-05 [c]	4.6E-07	3.5E-05 [c]	4.5E-07	3.9E-05 [c]	4.9E-07	1.2E-05 [c]	1.5E-07	8.8E-04	1.1E-05
Hydrogen Chloride	7647-01-0	1.86E-01 [4]	1.3E-03 [c]	1.6E-05	3.4E-03 [c]	4.3E-05	4.1E-03 [c]	5.1E-05	4.3E-03 [c]	5.4E-05	4.9E-03 [c]	6.2E-05	4.8E-03 [c]	6.0E-05	5.2E-03 [c]	6.5E-05	1.6E-03 [c]	2.0E-05	0.12	1.5E-03
Indeno(1,2,3-cd)pyrene	193-39-5	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
Naphthalene	91-20-3	1.60E-02 [5]	1.1E-04 [c]	1.4E-06	2.9E-04 [c]	3.7E-06	3.5E-04 [c]	4.4E-06	3.7E-04 [c]	4.6E-06	4.2E-04 [c]	5.3E-06	4.1E-04 [c]	5.1E-06	4.4E-04 [c]	5.6E-06	1.4E-04 [c]	1.7E-06	0.010	1.3E-04
Propylene	115-07-1	3.41E-01 [5]	2.3E-03 [c]	2.9E-05	6.3E-03 [c]	7.9E-05	7.4E-03 [c]	9.3E-05	7.8E-03 [c]	9.8E-05	9.0E-03 [c]	1.1E-04	8.7E-03 [c]	1.1E-04	9.5E-03 [c]	1.2E-04	2.9E-03 [c]	3.7E-05	0.22	2.7E-03
Toluene	108-88-3	6.12E-02 [5]	4.1E-04 [c]	5.2E-06	1.1E-03 [c]	1.4E-05	1.3E-03 [c]	1.7E-05	1.4E-03 [c]	1.8E-05	1.6E-03 [c]	2.0E-05	1.6E-03 [c]	2.0E-05	1.7E-03 [c]	2.1E-05	5.3E-04 [c]	6.6E-06	0.039	4.9E-04
Xylenes	1330-20-7	4.24E-02 [4]	2.9E-04 [c]	3.6E-06	7.8E-04 [c]	9.8E-06	9.2E-04 [c]	1.2E-05	9.7E-04 [c]	1.2E-05	1.1E-03 [c]	1.4E-05	1.1E-03 [c]	1.4E-05	1.2E-03 [c]	1.5E-05	3.7E-04 [c]	4.6E-06	0.027	3.4E-04
Arsenic	7440-38-2	1.60E-03 [4]	1.1E-05 [c]	1.4E-07	2.9E-05 [c]	3.7E-07	3.5E-05 [c]	4.4E-07	3.7E-05 [c]	4.6E-07	4.2E-05 [c]	5.3E-07	4.1E-05 [c]	5.1E-07	4.4E-05 [c]	5.6E-07	1.4E-05 [c]	1.7E-07	1.0E-03	1.3E-05
Cadmium	7440-43-9	1.50E-03 [4]	1.0E-05 [c]	1.3E-07	2.8E-05 [c]	3.5E-07	3.3E-05 [c]	4.1E-07	3.4E-05 [c]	4.3E-07	3.9E-05 [c]	5.0E-07	3.8E-05 [c]	4.8E-07	4.2E-05 [c]	5.2E-07	1.3E-05 [c]	1.6E-07	9.5E-04	1.2E-05
Chromium VI	18540-29-9	1.00E-04 [7]	6.8E-07 [c]	8.5E-09	1.8E-06 [c]	2.3E-08	2.2E-06 [c]	2.7E-08	2.3E-06 [c]	2.9E-08	2.6E-06 [c]	3.3E-08	2.6E-06 [c]	3.2E-08	2.8E-06 [c]	3.5E-08	8.6E-07 [c]	1.1E-08	6.3E-05	7.9E-07
Copper	7440-50-8	4.10E-03 [4]	2.8E-05 [c]	3.5E-07	7.5E-05 [c]	9.5E-07	8.9E-05 [c]	1.1E-06	9.4E-05 [c]	1.2E-06	1.1E-04 [c]	1.4E-06	1.0E-04 [c]	1.3E-06	1.1E-04 [c]	1.4E-06	3.5E-05 [c]	4.5E-07	2.6E-03	3.3E-05
Lead	7439-92-1	8.30E-03 [4]	5.6E-05 [c]	7.1E-07	1.5E-04 [c]	1.9E-06	1.8E-04 [c]	2.3E-06	1.9E-04 [c]	2.4E-06	2.2E-04 [c]	2.7E-06	2.1E-04 [c]	2.7E-06	2.3E-04 [c]	2.9E-06	7.2E-05 [c]	9.0E-07	5.2E-03	6.6E-05
Manganese	7439-96-5	3.10E-03 [4]	2.1E-05 [c]	2.6E-07	5.7E-05 [c]	7.2E-07	6.7E-05 [c]	8.5E-07	7.1E-05 [c]	8.9E-07	8.1E-05 [c]	1.0E-06	7.9E-05 [c]	1.0E-06	8.6E-05 [c]	1.1E-06	2.7E-05 [c]	3.4E-07	2.0E-03	2.5E-05
Mercury	7439-97-6	2.00E-03 [4]	1.4E-05 [c]	1.7E-07	3.7E-05 [c]	4.6E-07	4.4E-05 [c]	5.5E-07	4.6E-05 [c]	5.8E-07	5.3E-05 [c]	6.6E-07	5.1E-05 [c]	6.4E-07	5.6E-05 [c]	7.0E-07	1.7E-05 [c]	2.2E-07	1.3E-03	1.6E-05
Nickel	7440-02-0	3.90E-03 [4]	2.6E-05 [c]	3.3E-07	7.2E-05 [c]	9.0E-07	8.5E-05 [c]	1.1E-06	8.9E-05 [c]	1.1E-06	1.0E-04 [c]	1.3E-06	1.0E-04 [c]	1.3E-06	1.1E-04 [c]	1.4E-06	3.4E-05 [c]	4.2E-07	2.5E-03	3.1E-05
Selenium	7782-49-2	2.20E-03 [4]	1.5E-05 [c]	1.9E-07	4.0E-05 [c]	5.1E-07	4.8E-05 [c]	6.0E-07	5.0E-05 [c]	6.3E-07	5.8E-05 [c]	7.3E-07	5.6E-05 [c]	7.1E-07	6.1E-05 [c]	7.7E-07	1.9E-05 [c]	2.4E-07	1.4E-03	1.7E-05

Modeling ID	DG_B31	DG_B32	DG_B33	DG_B34	DG_B35	DG_B36	DG_B37	DG_B38
Diesel Particulate Emission factor (g/hp-hr) [6]	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015

Notes:

(a) Annual average emission estimate (tons/yr) = (Maximum hourly emissions estimate [lbs/hr]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)
(b) Maximum hourly diesel particulate emissions estimate (lbs/hr) = (Emission factor [g/hp-hr]) x (engine horsepower [hp]) x (load factor) / (453.59 [g/lb])
(c) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/103 gal]) x (load factor) x (fuel usage [gal/hr]) x (0.001 gal/103 gal)

References:

(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) Default load factor for generators in URBEMIS emission model.
(3) See diesel particulate matter emission factors at the bottom of the table.
(4) Ventura County Air Pollution Control District AB 2588 Combustion Emission Factors Database, May 2001.
(5) California Toxic Emission Factor (CATEF) Database, except for Diesel PM. The emission factors for each TAC are averaged for diesel internal combustion engines operating at less than 13% oxygen in the exhaust. Per vendor information, the percent oxygen in the exhaust is less than 13% at loads greater than 50%. It is assumed that the generator would be run at 50% load or greater.
(6) Polycyclic Aromatic Hydrocarbons (PAHs) are assumed to be included in the particulate matter emission factor. PAHs that are not specifically listed in this table, but may be included in the particulate matter emission factor, include Acenaphthylene, Anthracene, Acenaphthene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(g,h,i)perylene, Chrysene, Dibenz(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene. For purposes of this inventory, it is assumed that all particulate is represented as Diesel Particulate Matter (DPM).
(7) The AP-42 total chromium emission factor was multiplied by 17% to correct for emissions of hexavalent chromium per EPA assumptions when regulating combustion sources under 40 CFR Part 63 Subpart DDDD.

Golder Associates

Table F-18
Cooling Tower Particulate Emission Estimates

Pollutant				Bromine	
				Emissions Estimates	
Source	Modeling ID	PM_{10} Emission Rate [1] (lbs/day)	Annual Operation [1] (hrs/yr)	Maximum Daily [a] (lbs/hr)	Annual Average [b] (tons/yr)
Cooling Tower - Building NRLF	CT_NRLF#	3.44	6,360	2.7E-04	8.5E-04
Cooling Tower - Building 8	CTB8C#	1.29	6,360	1.0E-04	3.2E-04
Cooling Tower - Building 9	CTB9C#	1.29	6,360	1.0E-04	3.2E-04
Cooling Tower - Building 10	CTB10C#	1.29	6,360	1.0E-04	3.2E-04
Cooling Tower - Building 11	CTB11C#	0.69	6,360	5.3E-05	1.7E-04
Cooling Tower - Building 12	CTB12C#	1.29	6,360	1.0E-04	3.2E-04
Cooling Tower - Building 13	CTB13C#	0.69	6,360	5.3E-05	1.7E-04
Cooling Tower - Building 14	CTB14C#	0.86	6,360	6.7E-05	2.1E-04
Cooling Tower - Building 15	CTB15C#	1.29	6,360	1.0E-04	3.2E-04
Cooling Tower - Building 16	CTB16C#	1.72	6,360	1.3E-04	4.3E-04
Cooling Tower - Building 17	CTB17C#	1.72	6,360	1.3E-04	4.3E-04
Cooling Tower - Building 18	CTB18C#	1.55	6,360	1.2E-04	3.8E-04
Cooling Tower - Building 19	CTB19C#	1.29	6,360	1.0E-04	3.2E-04
Cooling Tower - Building 20	CTB20C#	1.29	6,360	1.0E-04	3.2E-04
Cooling Tower - Building 21	CTB21C#	3.01	6,360	2.3E-04	7.4E-04
Cooling Tower - Building 22	CTB22C#	2.15	6,360	1.7E-04	5.3E-04
Cooling Tower - Building 23	CTB23C#	1.72	6,360	1.3E-04	4.3E-04
Cooling Tower - Building 24	CTB24C#	1.29	6,360	1.0E-04	3.2E-04
Cooling Tower - Building 25	CTB25C#	1.72	6,360	1.3E-04	4.3E-04
Cooling Tower - Building 26	CTB26C#	1.72	6,360	1.3E-04	4.3E-04
Cooling Tower - Building 27	CTB27C#	1.72	6,360	1.3E-04	4.3E-04
Cooling Tower - Building 28	CTB28C#	0.69	6,360	5.3E-05	1.7E-04
Cooling Tower - Building 29	CTB29C#	0.69	6,360	5.3E-05	1.7E-04
Cooling Tower - Building 30	CTB30C#	1.72	6,360	1.3E-04	4.3E-04
Cooling Tower - Building 31	CTB31C#	0.69	6,360	5.3E-05	1.7E-04
Cooling Tower - Building 32	CTB32C#	1.29	6,360	1.0E-04	3.2E-04
Cooling Tower - Building 33	CTB33C#	1.72	6,360	1.3E-04	4.3E-04
Cooling Tower - Building 34	CTB34C#	1.72	6,360	1.3E-04	4.3E-04
Cooling Tower - Building 35	CTB35C#	2.15	6,360	1.7E-04	5.3E-04
Cooling Tower - Building 36	CTB36C#	2.15	6,360	1.7E-04	5.3E-04
Cooling Tower - Building 37	CTB37C#	2.15	6,360	1.7E-04	5.3E-04
Cooling Tower - Building 38	CTB38C#	0.86	6,360	6.7E-05	2.1E-04
Cooling Tower - Buildings 6 and 7	CTB6_7C#	2.58	6,360	2.0E-04	6.4E-04
Total				**3.7E-03**	**0.012**

Notes:

(a) Maximum daily emissions estimate (lbs/day) = (PM_{10} emission rate [lbs/day]) x (ChemTreat CL-4910 bromine concentration [ppm]) / (total dissolved solids concentration [ppm]) / (daily hours of operation [hrs/day])

ChemTreat CL-4910 bromine concentration (ppm) =	1	(2)
Total dissolved solids concentration (ppmw) =	536	(3)
Daily hours of operation (hrs/day) =	24	(3)

(b) Annual emissions estimate (tons/yr) = (Hourly emissions [lbs/hr]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)

References:

(1) See Table F-10, Cooling Tower Particulate Emission Estimates.
(2) Provided by ChemTreat.
(3) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.

Table F-19
Total Estimated Air Emissions of Laboratory Non-Radionuclide Liquid Chemicals

Source						Lab Hood Exhaust Stack - Buildings 6 and 7		Lab Hood Exhaust Stack - Building 8		Lab Hood Exhaust Stack - Building 9		Lab Hood Exhaust Stack - Building 10		Lab Hood Exhaust Stack - Building 11		Lab Hood Exhaust Stack - Building 12		Lab Hood Exhaust Stack - Building 14	
Building size (gsf)					[1]	253,954		110,510		137,451		117,700		67,280		119,504		81,472	
Modeling ID						LAB_B6_7		LAB_B8		LAB_B9		LAB_B10		LAB_B11		LAB_B12		LAB_B14	
TAC	CAS	Total Phase I Emissions [2] (tons/yr)	LBNL Chemical Emission Factor (tons/R&D gsf/yr)	UCB Chemical Emission Factor (tons/R&D gsf/yr)	Average Lab Chemical Emission Factor [a] (tons/R&D gsf/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [c] (tons/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [c] (tons/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [c] (tons/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [c] (tons/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [c] (tons/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [c] (tons/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [c] (tons/yr)
1,3-Butadiene	106-99-0	3.2E-04	6.3E-10 [d]	--	2.3E-10	2.4E-04	5.9E-05	1.0E-04	2.6E-05	1.3E-04	3.2E-05	1.1E-04	2.7E-05	6.2E-05	1.6E-05	1.1E-04	2.8E-05	7.5E-05	1.9E-05
1,4-Dioxane	123-91-1	3.4E-03	6.8E-09 [d]	--	2.5E-09	2.5E-03	6.4E-04	1.1E-03	2.8E-04	1.4E-03	3.5E-04	1.2E-03	3.0E-04	6.7E-04	1.7E-04	1.2E-03	3.0E-04	8.2E-04	2.1E-04
Acetaldehyde	75-07-0	1.6E-04	3.2E-10 [d]	--	1.2E-10	1.2E-04	3.0E-05	5.2E-05	1.3E-05	6.4E-05	1.6E-05	5.5E-05	1.4E-05	3.1E-05	7.9E-06	5.6E-05	1.4E-05	3.8E-05	9.5E-06
Acrolein	107-02-8	7.7E-05	1.5E-10 [d]	--	5.7E-11	5.8E-05	1.4E-05	2.5E-05	6.3E-06	3.1E-05	7.8E-06	2.7E-05	6.7E-06	1.5E-05	3.8E-06	2.7E-05	6.8E-06	1.9E-05	4.6E-06
Acrylic acid	79-10-7	1.1E-05	2.2E-11 [d]	--	8.1E-12	8.2E-06	2.1E-06	3.6E-06	9.0E-07	4.5E-06	1.1E-06	3.8E-06	9.6E-07	2.2E-06	5.5E-07	3.9E-06	9.7E-07	2.6E-06	6.6E-07
Aniline	62-53-3	2.7E-06	5.4E-12 [d]	--	2.0E-12	2.0E-06	5.0E-07	8.7E-07	2.2E-07	1.1E-06	2.7E-07	9.3E-07	2.3E-07	5.3E-07	1.3E-07	9.4E-07	2.4E-07	6.4E-07	1.6E-07
Benzene	71-43-2	2.1E-03	4.3E-09 [d]	--	1.6E-09	1.6E-03	4.0E-04	6.9E-04	1.7E-04	8.6E-04	2.2E-04	7.4E-04	1.9E-04	4.2E-04	1.1E-04	7.5E-04	1.9E-04	5.1E-04	1.3E-04
Benzyl chloride	100-44-7	5.7E-06	1.1E-11 [d]	--	4.2E-12	4.2E-06	1.1E-06	1.8E-06	4.6E-07	2.3E-06	5.8E-07	2.0E-06	4.9E-07	1.1E-06	2.8E-07	2.0E-06	5.0E-07	1.4E-06	3.4E-07
Bromine	7726-95-6	1.2E-06	2.5E-12 [d]	1.8E-10 [e]	1.1E-10	1.1E-04	2.9E-05	5.0E-05	1.2E-05	6.2E-05	1.5E-05	5.3E-05	1.3E-05	3.0E-05	7.6E-06	5.4E-05	1.3E-05	3.7E-05	9.2E-06
Carbon tetrachloride	56-23-5	3.2E-04	6.5E-10 [d]	1.3E-08 [e]	8.4E-09	8.5E-03	2.1E-03	3.7E-03	9.2E-04	4.6E-03	1.1E-03	3.9E-03	9.8E-04	2.2E-03	5.6E-04	4.0E-03	1.0E-03	2.7E-03	6.8E-04
Chloroform	67-66-3	0.051	1.0E-07 [d]	1.7E-07 [e]	1.5E-07	0.15	0.037	0.065	0.016	0.080	0.020	0.069	0.017	0.039	9.9E-03	0.070	0.018	0.048	0.012
Diethanolamine	111-42-2	3.3E-09	6.6E-15 [d]	--	2.5E-15	2.5E-09	6.2E-10	1.1E-09	2.7E-10	1.3E-09	3.4E-10	1.2E-09	2.9E-10	6.6E-10	1.7E-10	1.2E-09	2.9E-10	8.0E-10	2.0E-10
Dimethyl formamide	68-12-2	5.7E-04	1.1E-09 [d]	6.5E-09 [e]	4.5E-09	4.6E-03	1.1E-03	2.0E-03	5.0E-04	2.5E-03	6.2E-04	2.1E-03	5.3E-04	1.2E-03	3.0E-04	2.1E-03	5.4E-04	1.5E-03	3.7E-04
Epichlorohydrin	106-89-8	1.6E-05	3.2E-11 [d]	--	1.2E-11	1.2E-05	3.1E-06	5.3E-06	1.3E-06	6.6E-06	1.7E-06	5.6E-06	1.4E-06	3.2E-06	8.1E-07	5.7E-06	1.4E-06	3.9E-06	9.8E-07
Ethylbenzene	100-41-4	1.0E-04	2.0E-10 [d]	--	7.4E-11	7.5E-05	1.9E-05	3.3E-05	8.2E-06	4.0E-05	1.0E-05	3.5E-05	8.7E-06	2.0E-05	5.0E-06	3.5E-05	8.8E-06	2.4E-05	6.0E-06
Ethylene dichloride [EDC]	107-06-2	2.3E-03	4.6E-09 [d]	--	1.7E-09	1.7E-03	4.3E-04	7.5E-04	1.9E-04	9.3E-04	2.3E-04	7.9E-04	2.0E-04	4.5E-04	1.1E-04	8.1E-04	2.0E-04	5.5E-04	1.4E-04
Ethylene glycol	107-21-1	6.0E-06	1.2E-11 [d]	--	4.4E-12	4.5E-06	1.1E-06	1.9E-06	4.9E-07	2.4E-06	6.1E-07	2.1E-06	5.2E-07	1.2E-06	3.0E-07	2.1E-06	5.3E-07	1.4E-06	3.6E-07
Ethylene glycol monomethyl ether	109-86-4	8.5E-05	1.7E-10 [d]	--	6.3E-11	6.3E-05	1.6E-05	2.8E-05	6.9E-06	3.4E-05	8.6E-06	2.9E-05	7.4E-06	1.7E-05	4.2E-06	3.0E-05	7.5E-06	2.0E-05	5.1E-06
Formaldehyde	50-00-0	0.014	2.7E-08 [d]	1.6E-07 [e]	1.1E-07	0.11	0.028	0.049	0.012	0.061	0.015	0.053	0.013	0.030	7.5E-03	0.053	0.013	0.036	9.1E-03
Glutaraldehyde	111-30-8	4.9E-05	9.8E-11 [d]	5.1E-09 [e]	3.2E-09	3.3E-03	8.2E-04	1.4E-03	3.6E-04	1.8E-03	4.5E-04	1.5E-03	3.8E-04	8.7E-04	2.2E-04	1.5E-03	3.9E-04	1.1E-03	2.6E-04
n-Hexane	110-54-3	0.044	8.8E-08 [d]	--	3.3E-08	0.033	8.3E-03	0.014	3.6E-03	0.018	4.5E-03	0.015	3.8E-03	8.7E-03	2.2E-03	0.015	3.9E-03	0.011	2.7E-03
Hydrogen Chloride	7647-01-0	0.042	8.3E-08 [d]	4.2E-07 [e]	2.9E-07	0.30	0.074	0.13	0.032	0.16	0.040	0.14	0.035	0.079	0.020	0.14	0.035	0.095	0.024
Hydrogen fluoride	7664-39-3	4.1E-05	8.2E-11 [d]	3.1E-09 [e]	2.0E-09	2.0E-03	5.1E-04	8.9E-04	2.2E-04	1.1E-03	2.8E-04	9.4E-04	2.4E-04	5.4E-04	1.4E-04	9.6E-04	2.4E-04	6.5E-04	1.6E-04
Isopropyl alcohol	67-63-0	0.039	7.8E-08 [d]	5.3E-07 [e]	3.6E-07	0.36	0.091	0.16	0.040	0.20	0.049	0.17	0.042	0.097	0.024	0.17	0.043	0.12	0.029
Lindane [gamma-Hexachlorocyclohexane]	58-89-9	1.3E-10	2.6E-16 [d]	--	9.7E-17	9.8E-11	2.5E-11	4.3E-11	1.1E-11	5.3E-11	1.3E-11	4.5E-11	1.1E-11	2.6E-11	6.5E-12	4.6E-11	1.2E-11	3.1E-11	7.9E-12
m-Cresol	108-39-4	1.3E-06	2.6E-12 [d]	--	9.6E-13	9.7E-07	2.4E-07	4.2E-07	1.1E-07	5.3E-07	1.3E-07	4.5E-07	1.1E-07	2.6E-07	6.5E-08	4.6E-07	1.2E-07	3.1E-07	7.8E-08
Methanol	67-56-1	0.050	1.0E-07 [d]	1.9E-06 [e]	1.2E-06	1.23	0.31	0.53	0.13	0.66	0.17	0.57	0.14	0.32	0.082	0.58	0.14	0.39	0.099
2-Butanone	78-93-3	1.1E-03	2.1E-09 [d]	--	7.9E-10	8.0E-04	2.0E-04	3.5E-04	8.8E-05	4.3E-04	1.1E-04	3.7E-04	9.3E-05	2.1E-04	5.3E-05	3.8E-04	9.5E-05	2.6E-04	6.5E-05
Methyl tert-butyl ether	1634-04-4	7.5E-04	1.5E-09 [d]	--	5.6E-10	5.6E-04	1.4E-04	2.4E-04	6.1E-05	3.0E-04	7.6E-05	2.6E-04	6.5E-05	1.5E-04	3.7E-05	2.6E-04	6.6E-05	1.8E-04	4.5E-05
Methylene chloride [Dichloromethane]	75-09-2	0.056	1.1E-07 [d]	--	4.1E-08	0.042	0.010	0.018	4.6E-03	0.023	5.7E-03	0.019	4.9E-03	0.011	2.8E-03	0.020	4.9E-03	0.013	3.4E-03
Nitric acid	7697-37-2	2.1E-03	4.1E-09 [d]	--	1.5E-09	1.5E-03	3.9E-04	6.7E-04	1.7E-04	8.3E-04	2.1E-04	7.1E-04	1.8E-04	4.1E-04	1.0E-04	7.2E-04	1.8E-04	4.9E-04	1.2E-04
Tetrachloroehtene	127-18-4	2.6E-04	5.2E-10 [d]	--	1.9E-10	1.9E-04	4.9E-05	8.4E-05	2.1E-05	1.1E-04	2.6E-05	9.0E-05	2.3E-05	5.1E-05	1.3E-05	9.1E-05	2.3E-05	6.2E-05	1.6E-05
Phosphoric acid	7664-38-2	5.9E-06	1.2E-11 [d]	--	4.4E-12	4.4E-06	1.1E-06	1.9E-06	4.8E-07	2.4E-06	6.0E-07	2.0E-06	5.1E-07	1.2E-06	2.9E-07	2.1E-06	5.2E-07	1.4E-06	3.6E-07
Propylene glycol monomethyl ether	107-98-2	1.1E-05	2.1E-11 [d]	--	7.9E-12	8.0E-06	2.0E-06	3.5E-06	8.7E-07	4.3E-06	1.1E-06	3.7E-06	9.3E-07	2.1E-06	5.3E-07	3.8E-06	9.4E-07	2.6E-06	6.4E-07
Propylene oxide	75-56-9	4.7E-07	9.3E-13 [d]	--	3.4E-13	3.5E-07	8.7E-08	1.5E-07	3.8E-08	1.9E-07	4.7E-08	1.6E-07	4.0E-08	9.2E-08	2.3E-08	1.6E-07	4.1E-08	1.1E-07	2.8E-08
Styrene	100-42-5	3.0E-05	6.0E-11 [d]	--	2.2E-11	2.2E-05	5.6E-06	9.8E-06	2.4E-06	1.2E-05	3.0E-06	1.0E-05	2.6E-06	5.9E-06	1.5E-06	1.1E-05	2.6E-06	7.2E-06	1.8E-06
Sulfuric acid	7664-93-9	2.1E-04	4.1E-10 [d]	--	1.5E-10	1.5E-04	3.9E-05	6.7E-05	1.7E-05	8.3E-05	2.1E-05	7.1E-05	1.8E-05	4.1E-05	1.0E-05	7.3E-05	1.8E-05	4.9E-05	1.2E-05
Toluene	108-88-3	5.1E-03	1.0E-08 [d]	1.6E-08 [e]	1.4E-08	0.014	3.5E-03	6.1E-03	1.5E-03	7.6E-03	1.9E-03	6.5E-03	1.6E-03	3.7E-03	9.4E-04	6.6E-03	1.7E-03	4.5E-03	1.1E-03
Trichloroethylene	79-01-6	1.2E-03	2.3E-09 [d]	--	8.6E-10	8.7E-04	2.2E-04	3.8E-04	9.5E-05	4.7E-04	1.2E-04	4.0E-04	1.0E-04	2.3E-04	5.8E-05	4.1E-04	1.0E-04	2.8E-04	7.0E-05
Triethylamine	121-44-8	1.4E-03	2.8E-09 [d]	--	1.0E-09	1.1E-03	2.6E-04	4.6E-04	1.1E-04	5.7E-04	1.4E-04	4.9E-04	1.2E-04	2.8E-04	7.0E-05	4.9E-04	1.2E-04	3.4E-04	8.5E-05
Xylenes	1330-20-7	9.6E-04	1.9E-09 [d]	3.2E-08 [e]	2.1E-08	0.021	5.3E-03	9.2E-03	2.3E-03	0.011	2.9E-03	9.8E-03	2.5E-03	5.6E-03	1.4E-03	1.0E-02	2.5E-03	6.8E-03	1.7E-03
Hydrazine	302-01-2	--	--	1.4E-10 [e]	8.9E-11	9.0E-05	2.3E-05	3.9E-05	9.8E-06	4.9E-05	1.2E-05	4.2E-05	1.0E-05	2.4E-05	6.0E-06	4.2E-05	1.1E-05	2.9E-05	7.2E-06
1,1,1-Trichloroethane	71-55-6	--	--	5.0E-10 [e]	3.1E-10	3.2E-04	7.9E-05	1.4E-04	3.4E-05	1.7E-04	4.3E-05	1.5E-04	3.7E-05	8.4E-05	2.1E-05	1.5E-04	3.7E-05	1.0E-04	2.5E-05
Total - All Chemicals Listed		**0.32**				**2.29**	**0.57**	**1.00**	**0.25**	**1.24**	**0.31**	**1.06**	**0.27**	**0.61**	**0.15**	**1.08**	**0.27**	**0.73**	**0.18**

Notes:

(a) Average lab chemical emission factor (tons/R&D gsf/yr) = (LBNL chemical emission factor [tons/R&D gsf/yr] x LBNL percentage of total lab space [%] / 100)
+ (UCB chemical emission factor [tons/R&D gsf/yr] x UCB percentage of total lab space [%] / 100)
LBNL percentage of total lab space (%) = 37 (2)
UCB percentage of total lab space (%) = 63 (2)

(b) Maximum hourly emissions estimate (lbs/hr) = (Annual average emissions [tons/year]) / (annual operation [days/year])
/ (daily operation [hrs/day]) x (2,000 lbs/ton) x (conversion factor)
Annual operation for all buildings (days/year) = 260 (1)
Daily operation for all buildings (hrs/day) = 10 (1)
Conversion factor = 5.18 (4)

(c) Annual average emissions estimate (tons/yr) = (Phase I emissions fraction [tons/gsf/yr]) x (building size [gsf])

(d) Lab chemical emission factor (tons/R&D gsf/yr) = (Phase I emissions [tons/yr]) / (total Phase I R&D building gsf)
Total Phase I building gsf = 501,915 (1)

(e) Lab chemical emission factor (tons/R&D gsf/yr) = (UCB emission factor [g/lab gsf/s]) x (lab fraction of R&D building gsf [lab gsf/R&D gsf]) x (lb/453.59 g) x (ton/2,000 lb) x (3,600 s/hr) x (8,760 hrs/yr)
Lab fraction of R&D building gsf (lab gsf/R&D gsf) = 0.60 (5)
UCB emission factor (g/lab gsf/s) = see (6)

References:

(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) Provided by the University.
(3) Phase 1 Laboratory emissions calculated as part of the Phase 1 assessment. See Appendix G.
(4) Based in studies comparing maximum to average emission rates for laboratories. See text for further information.
(5) Based on average of existing and planned laboratory sizes.
(6) Emission factors provided by UC Berkeley.

Table F-19
Total Estimated Air Emissions of Laboratory Non-Radionuclide Liquid Chemicals

Source						Lab Hood Exhaust Stack - Building 15		Lab Hood Exhaust Stack - Building 16		Lab Hood Exhaust Stack - Building 17		Lab Hood Exhaust Stack - Building 18		Lab Hood Exhaust Stack - Building 19		Lab Hood Exhaust Stack - Building 20		Lab Hood Exhaust Stack - Building 21	
Building size (gsf)					(1)	137,820		160,604		170,085		144,805		129,795		128,560		290,240	
Modeling ID						LAB_B15		LAB_B16		LAB_B17		LAB_B18		LAB_B19		LAB_B20		LAB_B21	
TAC	**CAS**	**Total Phase I Emissions (2) (tons/yr)**	**LBNL Chemical Emission Factor (tons/R&D gsf/yr)**	**UCB Chemical Emission Factor (tons/R&D gsf/yr)**	**Average Lab Chemical Emission Factor (a) (tons/R&D gsf/yr)**	**Maximum Hourly (b) (lbs/hr)**	**Annual Average (c) (tons/yr)**	**Maximum Hourly (b) (lbs/hr)**	**Annual Average (c) (tons/yr)**	**Maximum Hourly (b) (lbs/hr)**	**Annual Average (c) (tons/yr)**	**Maximum Hourly (b) (lbs/hr)**	**Annual Average (c) (tons/yr)**	**Maximum Hourly (b) (lbs/hr)**	**Annual Average (c) (tons/yr)**	**Maximum Hourly (b) (lbs/hr)**	**Annual Average (c) (tons/yr)**	**Maximum Hourly (b) (lbs/hr)**	**Annual Average (c) (tons/yr)**
1,3-Butadiene	106-99-0	3.2E-04	6.3E-10 (d)	--	2.3E-10	1.3E-04	3.2E-05	1.5E-04	3.7E-05	1.6E-04	4.0E-05	1.3E-04	3.4E-05	1.2E-04	3.0E-05	1.2E-04	3.0E-05	2.7E-04	6.7E-05
1,4-Dioxane	123-91-1	3.4E-03	6.8E-09 (d)	--	2.5E-09	1.4E-03	3.5E-04	1.6E-03	4.0E-04	1.7E-03	4.3E-04	1.5E-03	3.6E-04	1.3E-03	3.3E-04	1.3E-03	3.2E-04	2.9E-03	7.3E-04
Acetaldehyde	75-07-0	1.6E-04	3.2E-10 (d)	--	1.2E-10	6.4E-05	1.6E-05	7.5E-05	1.9E-05	7.9E-05	2.0E-05	6.8E-05	1.7E-05	6.1E-05	1.5E-05	6.0E-05	1.5E-05	1.4E-04	3.4E-05
Acrolein	107-02-8	7.7E-05	1.5E-10 (d)	--	5.7E-11	3.1E-05	7.9E-06	3.6E-05	9.2E-06	3.9E-05	9.7E-06	3.3E-05	8.3E-06	2.9E-05	7.4E-06	2.9E-05	7.3E-06	6.6E-05	1.7E-05
Acrylic acid	79-10-7	1.1E-05	2.2E-11 (d)	--	8.1E-12	4.5E-06	1.1E-06	5.2E-06	1.3E-06	5.5E-06	1.4E-06	4.7E-06	1.2E-06	4.2E-06	1.1E-06	4.2E-06	1.0E-06	9.4E-06	2.4E-06
Aniline	62-53-3	2.7E-06	5.4E-12 (d)	--	2.0E-12	1.1E-06	2.7E-07	1.3E-06	3.2E-07	1.3E-06	3.4E-07	1.1E-06	2.9E-07	1.0E-06	2.6E-07	1.0E-06	2.5E-07	2.3E-06	5.8E-07
Benzene	71-43-2	2.1E-03	4.3E-09 (d)	--	1.6E-09	8.7E-04	2.2E-04	1.0E-03	2.5E-04	1.1E-03	2.7E-04	9.1E-04	2.3E-04	8.2E-04	2.0E-04	8.1E-04	2.0E-04	1.8E-03	4.6E-04
Benzyl chloride	100-44-7	5.7E-06	1.1E-11 (d)	--	4.2E-12	2.3E-06	5.8E-07	2.7E-06	6.7E-07	2.8E-06	7.1E-07	2.4E-06	6.1E-07	2.2E-06	5.4E-07	2.1E-06	5.4E-07	4.9E-06	1.2E-06
Bromine	7726-95-6	1.2E-06	2.5E-12 (d)	1.8E-10 (e)	1.1E-10	6.2E-05	1.6E-05	7.2E-05	1.8E-05	7.6E-05	1.9E-05	6.5E-05	1.6E-05	5.8E-05	1.5E-05	5.8E-05	1.4E-05	1.3E-04	3.3E-05
Carbon tetrachloride	56-23-5	3.2E-04	6.5E-10 (d)	1.3E-08 (e)	8.4E-09	4.6E-03	1.2E-03	5.3E-03	1.3E-03	5.7E-03	1.4E-03	4.8E-03	1.2E-03	4.3E-03	1.1E-03	4.3E-03	1.1E-03	9.7E-03	2.4E-03
Chloroform	67-66-3	0.051	1.0E-07 (d)	1.7E-07 (e)	1.5E-07	0.080	0.020	0.094	0.024	0.099	0.025	0.085	0.021	0.076	0.019	0.075	0.019	0.17	0.043
Diethanolamine	111-42-2	3.3E-09	6.6E-15 (d)	--	2.5E-15	1.3E-09	3.4E-10	1.6E-09	3.9E-10	1.7E-09	4.2E-10	1.4E-09	3.6E-10	1.3E-09	3.2E-10	1.3E-09	3.2E-10	2.8E-09	7.1E-10
Dimethyl formamide	68-12-2	5.7E-04	1.1E-09 (d)	6.5E-09 (e)	4.5E-09	2.5E-03	6.2E-04	2.9E-03	7.2E-04	3.1E-03	7.7E-04	2.6E-03	6.5E-04	2.3E-03	5.8E-04	2.3E-03	5.8E-04	5.2E-03	1.3E-03
Epichlorohydrin	106-89-8	1.6E-05	3.2E-11 (d)	--	1.2E-11	6.6E-06	1.7E-06	7.7E-06	1.9E-06	8.2E-06	2.0E-06	6.9E-06	1.7E-06	6.2E-06	1.6E-06	6.2E-06	1.5E-06	1.4E-05	3.5E-06
Ethylbenzene	100-41-4	1.0E-04	2.0E-10 (d)	--	7.4E-11	4.1E-05	1.0E-05	4.7E-05	1.2E-05	5.0E-05	1.3E-05	4.3E-05	1.1E-05	3.8E-05	9.6E-06	3.8E-05	9.5E-06	8.5E-05	2.1E-05
Ethylene dichloride [EDC]	107-06-2	2.3E-03	4.6E-09 (d)	--	1.7E-09	9.3E-04	2.3E-04	1.1E-03	2.7E-04	1.1E-03	2.9E-04	9.8E-04	2.5E-04	8.8E-04	2.2E-04	8.7E-04	2.2E-04	2.0E-03	4.9E-04
Ethylene glycol	107-21-1	6.0E-06	1.2E-11 (d)	--	4.4E-12	2.4E-06	6.1E-07	2.8E-06	7.1E-07	3.0E-06	7.5E-07	2.5E-06	6.4E-07	2.3E-06	5.7E-07	2.3E-06	5.7E-07	5.1E-06	1.3E-06
Ethylene glycol monomethyl ether	109-86-4	8.5E-05	1.7E-10 (d)	--	6.3E-11	3.4E-05	8.6E-06	4.0E-05	1.0E-05	4.2E-05	1.1E-05	3.6E-05	9.1E-06	3.2E-05	8.1E-06	3.2E-05	8.0E-06	7.2E-05	1.8E-05
Formaldehyde	50-00-0	0.014	2.7E-08 (d)	1.6E-07 (e)	1.1E-07	0.062	0.015	0.072	0.018	0.076	0.019	0.065	0.016	0.058	0.015	0.057	0.014	0.13	0.033
Glutaraldehyde	111-30-8	4.9E-05	9.8E-11 (d)	5.1E-09 (e)	3.2E-09	1.8E-03	4.5E-04	2.1E-03	5.2E-04	2.2E-03	5.5E-04	1.9E-03	4.7E-04	1.7E-03	4.2E-04	1.7E-03	4.2E-04	3.7E-03	9.4E-04
n-Hexane	110-54-3	0.044	8.8E-08 (d)	--	3.3E-08	0.018	4.5E-03	0.021	5.2E-03	0.022	5.5E-03	0.019	4.7E-03	0.017	4.2E-03	0.017	4.2E-03	0.038	9.4E-03
Hydrogen Chloride	7647-01-0	0.042	8.3E-08 (d)	4.2E-07 (e)	2.9E-07	0.16	0.040	0.19	0.047	0.20	0.050	0.17	0.042	0.15	0.038	0.15	0.038	0.34	0.085
Hydrogen fluoride	7664-39-3	4.1E-05	8.2E-11 (d)	3.1E-09 (e)	2.0E-09	1.1E-03	2.8E-04	1.3E-03	3.2E-04	1.4E-03	3.4E-04	1.2E-03	2.9E-04	1.0E-03	2.6E-04	1.0E-03	2.6E-04	2.3E-03	5.8E-04
Isopropyl alcohol	67-63-0	0.039	7.8E-08 (d)	5.3E-07 (e)	3.6E-07	0.20	0.050	0.23	0.058	0.24	0.061	0.21	0.052	0.19	0.047	0.18	0.046	0.42	0.10
Lindane [gamma-Hexachlorocyclohexane]	58-89-9	1.3E-10	2.6E-16 (d)	--	9.7E-17	5.3E-11	1.3E-11	6.2E-11	1.6E-11	6.6E-11	1.6E-11	5.6E-11	1.4E-11	5.0E-11	1.3E-11	5.0E-11	1.2E-11	1.1E-10	2.8E-11
m-Cresol	108-39-4	1.3E-06	2.6E-12 (d)	--	9.6E-13	5.3E-07	1.3E-07	6.2E-07	1.5E-07	6.5E-07	1.6E-07	5.6E-07	1.4E-07	5.0E-07	1.2E-07	4.9E-07	1.2E-07	1.1E-06	2.8E-07
Methanol	67-56-1	0.050	1.0E-07 (d)	1.9E-06 (e)	1.2E-06	0.67	0.17	0.78	0.19	0.82	0.21	0.70	0.18	0.63	0.16	0.62	0.16	1.40	0.35
2-Butanone	78-93-3	1.1E-03	2.1E-09 (d)	--	7.9E-10	4.4E-04	1.1E-04	5.1E-04	1.3E-04	5.4E-04	1.3E-04	4.6E-04	1.1E-04	4.1E-04	1.0E-04	4.1E-04	1.0E-04	9.2E-04	2.3E-04
Methyl tert-butyl ether	1634-04-4	7.5E-04	1.5E-09 (d)	--	5.6E-10	3.0E-04	7.6E-05	3.6E-04	8.9E-05	3.8E-04	9.4E-05	3.2E-04	8.0E-05	2.9E-04	7.2E-05	2.8E-04	7.1E-05	6.4E-04	1.6E-04
Methylene chloride [Dichloromethane]	75-09-2	0.056	1.1E-07 (d)	--	4.1E-08	0.023	5.7E-03	0.026	6.6E-03	0.028	7.0E-03	0.024	6.0E-03	0.021	5.4E-03	0.021	5.3E-03	0.048	0.012
Nitric acid	7697-37-2	2.1E-03	4.1E-09 (d)	--	1.5E-09	8.3E-04	2.1E-04	9.7E-04	2.4E-04	1.0E-03	2.6E-04	8.8E-04	2.2E-04	7.8E-04	2.0E-04	7.8E-04	2.0E-04	1.8E-03	4.4E-04
Tetrachloroehtene	127-18-4	2.6E-04	5.2E-10 (d)	--	1.9E-10	1.1E-04	2.6E-05	1.2E-04	3.1E-05	1.3E-04	3.3E-05	1.1E-04	2.8E-05	9.9E-05	2.5E-05	9.8E-05	2.5E-05	2.2E-04	5.6E-05
Phosphoric acid	7664-38-2	5.9E-06	1.2E-11 (d)	--	4.4E-12	2.4E-06	6.0E-07	2.8E-06	7.0E-07	3.0E-06	7.4E-07	2.5E-06	6.3E-07	2.3E-06	5.7E-07	2.2E-06	5.6E-07	5.0E-06	1.3E-06
Propylene glycol monomethyl ether	107-98-2	1.1E-05	2.1E-11 (d)	--	7.9E-12	4.3E-06	1.1E-06	5.0E-06	1.3E-06	5.3E-06	1.3E-06	4.6E-06	1.1E-06	4.1E-06	1.0E-06	4.0E-06	1.0E-06	9.1E-06	2.3E-06
Propylene oxide	75-56-9	4.7E-07	9.3E-13 (d)	--	3.4E-13	1.9E-07	4.7E-08	2.2E-07	5.5E-08	2.3E-07	5.9E-08	2.0E-07	5.0E-08	1.8E-07	4.5E-08	1.8E-07	4.4E-08	4.0E-07	1.0E-07
Styrene	100-42-5	3.0E-05	6.0E-11 (d)	--	2.2E-11	1.2E-05	3.1E-06	1.4E-05	3.6E-06	1.5E-05	3.8E-06	1.3E-05	3.2E-06	1.1E-05	2.9E-06	1.1E-05	2.8E-06	2.6E-05	6.4E-06
Sulfuric acid	7664-93-9	2.1E-04	4.1E-10 (d)	--	1.5E-10	8.4E-05	2.1E-05	9.7E-05	2.4E-05	1.0E-04	2.6E-05	8.8E-05	2.2E-05	7.9E-05	2.0E-05	7.8E-05	2.0E-05	1.8E-04	4.4E-05
Toluene	108-88-3	5.1E-03	1.0E-08 (d)	1.6E-08 (e)	1.4E-08	7.7E-03	1.9E-03	8.9E-03	2.2E-03	9.4E-03	2.4E-03	8.0E-03	2.0E-03	7.2E-03	1.8E-03	7.1E-03	1.8E-03	0.016	4.0E-03
Trichloroethylene	79-01-6	1.2E-03	2.3E-09 (d)	--	8.6E-10	4.7E-04	1.2E-04	5.5E-04	1.4E-04	5.8E-04	1.5E-04	5.0E-04	1.2E-04	4.5E-04	1.1E-04	4.4E-04	1.1E-04	1.0E-03	2.5E-04
Triethylamine	121-44-8	1.4E-03	2.8E-09 (d)	--	1.0E-09	5.7E-04	1.4E-04	6.6E-04	1.7E-04	7.0E-04	1.8E-04	6.0E-04	1.5E-04	5.4E-04	1.3E-04	5.3E-04	1.3E-04	1.2E-03	3.0E-04
Xylenes	1330-20-7	9.6E-04	1.9E-09 (d)	3.2E-08 (e)	2.1E-08	0.012	2.9E-03	0.013	3.4E-03	0.014	3.6E-03	0.012	3.0E-03	0.011	2.7E-03	0.011	2.7E-03	0.024	6.1E-03
Hydrazine	302-01-2	--	--	1.4E-10 (e)	8.9E-11	4.9E-05	1.2E-05	5.7E-05	1.4E-05	6.0E-05	1.5E-05	5.1E-05	1.3E-05	4.6E-05	1.2E-05	4.6E-05	1.1E-05	1.0E-04	2.6E-05
1,1,1-Trichloroethane	71-55-6	--	--	5.0E-10 (e)	3.1E-10	1.7E-04	4.3E-05	2.0E-04	5.0E-05	2.1E-04	5.3E-05	1.8E-04	4.5E-05	1.6E-04	4.0E-05	1.6E-04	4.0E-05	3.6E-04	9.0E-05
Total - All Chemicals Listed		**0.32**				**1.24**	**0.31**	**1.45**	**0.36**	**1.53**	**0.38**	**1.31**	**0.33**	**1.17**	**0.29**	**1.16**	**0.29**	**2.62**	**0.66**

Notes:

(a) Average lab chemical emission factor (tons/R&D gsf/yr) = (LBNL chemical emission factor [tons/R&D gsf/yr] x LBNL percentage of total lab space [%] / 100)
+ (UCB chemical emission factor [tons/R&D gsf/yr] x UCB percentage of total lab space [%] / 100)
LBNL percentage of total lab space (%) = 37 (2)
UCB percentage of total lab space (%) = 63 (2)

(b) Maximum hourly emissions estimate (lbs/hr) = (Annual average emissions [tons/year]) / (annual operation [days/year])
/ (daily operation [hrs/day]) x (2,000 lbs/ton) x (conversion factor)
Annual operation for all buildings (days/year) = 260 (1)
Daily operation for all buildings (hrs/day) = 10 (1)
Conversion factor = 5.18 (4)

(c) Annual average emissions estimate (tons/yr) = (Phase I emissions fraction [tons/gsf/yr]) x (building size [gsf])

(d) Lab chemical emission factor (tons/R&D gsf/yr) = (Phase I emissions [tons/yr]) / (total Phase I R&D building gsf)
Total Phase I building gsf = 501,915 (1)

(e) Lab chemical emission factor (tons/R&D gsf/yr) = (UCB emission factor [g/lab gsf/s]) x (lab fraction of R&D building gsf [lab gsf/R&D gsf]) x (lb/453.59 g) x (ton/2,000 lb) x (3,600 s/hr) x (8,760 hrs/yr)
Lab fraction of R&D building gsf (lab gsf/R&D gsf) = 0.60 (5)
UCB emission factor (g/lab gsf/s) = see (6)

References:

(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) Provided by the University.
(3) Phase 1 Laboratory emissions calculated as part of the Phase 1 assessment. See Appendix G.
(4) Based in studies comparing maximum to average emission rates for laboratories. See text for further information.
(5) Based on average of existing and planned laboratory sizes.
(6) Emission factors provided by UC Berkeley.

Table F-19
Total Estimated Air Emissions of Laboratory Non-Radionuclide Liquid Chemicals

Source						Lab Hood Exhaust Stack - Building 22		Lab Hood Exhaust Stack - Building 23		Lab Hood Exhaust Stack - Building 24		Lab Hood Exhaust Stack - Building 25		Lab Hood Exhaust Stack - Building 26		Lab Hood Exhaust Stack - Building 27		Lab Hood Exhaust Stack - Building 28	
Building size (gsf)					(1)	200,645		151,650		130,000		180,770		174,400		167,612		66,808	
Modeling ID						LAB_B22		LAB_B23		LAB_B24		LAB_B25		LAB_B26		LAB_B27		LAB_B28	
TAC	**CAS**	**Total Phase I Emissions (2) (tons/yr)**	**LBNL Chemical Emission Factor (tons/R&D gsf/yr)**	**UCB Chemical Emission Factor (tons/R&D gsf/yr)**	**Average Lab Chemical Emission Factor (a) (tons/R&D gsf/yr)**	**Maximum Hourly (b) (lbs/hr)**	**Annual Average (c) (tons/yr)**	**Maximum Hourly (b) (lbs/hr)**	**Annual Average (c) (tons/yr)**	**Maximum Hourly (b) (lbs/hr)**	**Annual Average (c) (tons/yr)**	**Maximum Hourly (b) (lbs/hr)**	**Annual Average (c) (tons/yr)**	**Maximum Hourly (b) (lbs/hr)**	**Annual Average (c) (tons/yr)**	**Maximum Hourly (b) (lbs/hr)**	**Annual Average (c) (tons/yr)**	**Maximum Hourly (b) (lbs/hr)**	**Annual Average (c) (tons/yr)**
1,3-Butadiene	106-99-0	3.2E-04	6.3E-10 (d)	--	2.3E-10	1.9E-04	4.7E-05	1.4E-04	3.5E-05	1.2E-04	3.0E-05	1.7E-04	4.2E-05	1.6E-04	4.1E-05	1.6E-04	3.9E-05	6.2E-05	1.6E-05
1,4-Dioxane	123-91-1	3.4E-03	6.8E-09 (d)	--	2.5E-09	2.0E-03	5.1E-04	1.5E-03	3.8E-04	1.3E-03	3.3E-04	1.8E-03	4.6E-04	1.7E-03	4.4E-04	1.7E-03	4.2E-04	6.7E-04	1.7E-04
Acetaldehyde	75-07-0	1.6E-04	3.2E-10 (d)	--	1.2E-10	9.4E-05	2.4E-05	7.1E-05	1.8E-05	6.1E-05	1.5E-05	8.4E-05	2.1E-05	8.1E-05	2.0E-05	7.8E-05	2.0E-05	3.1E-05	7.8E-06
Acrolein	107-02-8	7.7E-05	1.5E-10 (d)	--	5.7E-11	4.6E-05	1.1E-05	3.4E-05	8.6E-06	3.0E-05	7.4E-06	4.1E-05	1.0E-05	4.0E-05	9.9E-06	3.8E-05	9.6E-06	1.5E-05	3.8E-06
Acrylic acid	79-10-7	1.1E-05	2.2E-11 (d)	--	8.1E-12	6.5E-06	1.6E-06	4.9E-06	1.2E-06	4.2E-06	1.1E-06	5.9E-06	1.5E-06	5.6E-06	1.4E-06	5.4E-06	1.4E-06	2.2E-06	5.4E-07
Aniline	62-53-3	2.7E-06	5.4E-12 (d)	--	2.0E-12	1.6E-06	4.0E-07	1.2E-06	3.0E-07	1.0E-06	2.6E-07	1.4E-06	3.6E-07	1.4E-06	3.5E-07	1.3E-06	3.3E-07	5.3E-07	1.3E-07
Benzene	71-43-2	2.1E-03	4.3E-09 (d)	--	1.6E-09	1.3E-03	3.2E-04	9.5E-04	2.4E-04	8.2E-04	2.1E-04	1.1E-03	2.9E-04	1.1E-03	2.8E-04	1.1E-03	2.6E-04	4.2E-04	1.1E-04
Benzyl chloride	100-44-7	5.7E-06	1.1E-11 (d)	--	4.2E-12	3.4E-06	8.4E-07	2.5E-06	6.4E-07	2.2E-06	5.5E-07	3.0E-06	7.6E-07	2.9E-06	7.3E-07	2.8E-06	7.0E-07	1.1E-06	2.8E-07
Bromine	7726-95-6	1.2E-06	2.5E-12 (d)	1.8E-10 (e)	1.1E-10	9.0E-05	2.3E-05	6.8E-05	1.7E-05	5.8E-05	1.5E-05	8.1E-05	2.0E-05	7.8E-05	2.0E-05	7.5E-05	1.9E-05	3.0E-05	7.5E-06
Carbon tetrachloride	56-23-5	3.2E-04	6.5E-10 (d)	1.3E-08 (e)	8.4E-09	6.7E-03	1.7E-03	5.0E-03	1.3E-03	4.3E-03	1.1E-03	6.0E-03	1.5E-03	5.8E-03	1.5E-03	5.6E-03	1.4E-03	2.2E-03	5.6E-04
Chloroform	67-66-3	0.051	1.0E-07 (d)	1.7E-07 (e)	1.5E-07	0.12	0.029	0.089	0.022	0.076	0.019	0.11	0.026	0.10	0.026	0.098	0.025	0.039	9.8E-03
Diethanolamine	111-42-2	3.3E-09	6.6E-15 (d)	--	2.5E-15	2.0E-09	4.9E-10	1.5E-09	3.7E-10	1.3E-09	3.2E-10	1.8E-09	4.4E-10	1.7E-09	4.3E-10	1.6E-09	4.1E-10	6.5E-10	1.6E-10
Dimethyl formamide	68-12-2	5.7E-04	1.1E-09 (d)	6.5E-09 (e)	4.5E-09	3.6E-03	9.0E-04	2.7E-03	6.8E-04	2.3E-03	5.9E-04	3.2E-03	8.1E-04	3.1E-03	7.9E-04	3.0E-03	7.5E-04	1.2E-03	3.0E-04
Epichlorohydrin	106-89-8	1.6E-05	3.2E-11 (d)	--	1.2E-11	9.6E-06	2.4E-06	7.3E-06	1.8E-06	6.2E-06	1.6E-06	8.7E-06	2.2E-06	8.4E-06	2.1E-06	8.0E-06	2.0E-06	3.2E-06	8.0E-07
Ethylbenzene	100-41-4	1.0E-04	2.0E-10 (d)	--	7.4E-11	5.9E-05	1.5E-05	4.5E-05	1.1E-05	3.8E-05	9.6E-06	5.3E-05	1.3E-05	5.1E-05	1.3E-05	4.9E-05	1.2E-05	2.0E-05	4.9E-06
Ethylene dichloride [EDC]	107-06-2	2.3E-03	4.6E-09 (d)	--	1.7E-09	1.4E-03	3.4E-04	1.0E-03	2.6E-04	8.8E-04	2.2E-04	1.2E-03	3.1E-04	1.2E-03	3.0E-04	1.1E-03	2.8E-04	4.5E-04	1.1E-04
Ethylene glycol	107-21-1	6.0E-06	1.2E-11 (d)	--	4.4E-12	3.5E-06	8.8E-07	2.7E-06	6.7E-07	2.3E-06	5.7E-07	3.2E-06	8.0E-07	3.1E-06	7.7E-07	2.9E-06	7.4E-07	1.2E-06	2.9E-07
Ethylene glycol monomethyl ether	109-86-4	8.5E-05	1.7E-10 (d)	--	6.3E-11	5.0E-05	1.3E-05	3.8E-05	9.5E-06	3.2E-05	8.1E-06	4.5E-05	1.1E-05	4.3E-05	1.1E-05	4.2E-05	1.0E-05	1.7E-05	4.2E-06
Formaldehyde	50-00-0	0.014	2.7E-08 (d)	1.6E-07 (e)	1.1E-07	0.090	0.022	0.068	0.017	0.058	0.015	0.081	0.020	0.078	0.020	0.075	0.019	0.030	7.5E-03
Glutaraldehyde	111-30-8	4.9E-05	9.8E-11 (d)	5.1E-09 (e)	3.2E-09	2.6E-03	6.5E-04	2.0E-03	4.9E-04	1.7E-03	4.2E-04	2.3E-03	5.9E-04	2.3E-03	5.7E-04	2.2E-03	5.4E-04	8.6E-04	2.2E-04
n-Hexane	110-54-3	0.044	8.8E-08 (d)	--	3.3E-08	0.026	6.5E-03	0.020	4.9E-03	0.017	4.2E-03	0.023	5.9E-03	0.023	5.7E-03	0.022	5.5E-03	8.7E-03	2.2E-03
Hydrogen Chloride	7647-01-0	0.042	8.3E-08 (d)	4.2E-07 (e)	2.9E-07	0.23	0.059	0.18	0.044	0.15	0.038	0.21	0.053	0.20	0.051	0.20	0.049	0.078	0.020
Hydrogen fluoride	7664-39-3	4.1E-05	8.2E-11 (d)	3.1E-09 (e)	2.0E-09	1.6E-03	4.0E-04	1.2E-03	3.0E-04	1.0E-03	2.6E-04	1.4E-03	3.6E-04	1.4E-03	3.5E-04	1.3E-03	3.4E-04	5.4E-04	1.3E-04
Isopropyl alcohol	67-63-0	0.039	7.8E-08 (d)	5.3E-07 (e)	3.6E-07	0.29	0.072	0.22	0.055	0.19	0.047	0.26	0.065	0.25	0.063	0.24	0.060	0.096	0.024
Lindane [gamma-Hexachlorocyclohexane]	58-89-9	1.3E-10	2.6E-16 (d)	--	9.7E-17	7.8E-11	1.9E-11	5.9E-11	1.5E-11	5.0E-11	1.3E-11	7.0E-11	1.8E-11	6.7E-11	1.7E-11	6.5E-11	1.6E-11	2.6E-11	6.5E-12
m-Cresol	108-39-4	1.3E-06	2.6E-12 (d)	--	9.6E-13	7.7E-07	1.9E-07	5.8E-07	1.5E-07	5.0E-07	1.3E-07	6.9E-07	1.7E-07	6.7E-07	1.7E-07	6.4E-07	1.6E-07	2.6E-07	6.4E-08
Methanol	67-56-1	0.050	1.0E-07 (d)	1.9E-06 (e)	1.2E-06	0.97	0.24	0.73	0.18	0.63	0.16	0.87	0.22	0.84	0.21	0.81	0.20	0.32	0.081
2-Butanone	78-93-3	1.1E-03	2.1E-09 (d)	--	7.9E-10	6.3E-04	1.6E-04	4.8E-04	1.2E-04	4.1E-04	1.0E-04	5.7E-04	1.4E-04	5.5E-04	1.4E-04	5.3E-04	1.3E-04	2.1E-04	5.3E-05
Methyl tert-butyl ether	1634-04-4	7.5E-04	1.5E-09 (d)	--	5.6E-10	4.4E-04	1.1E-04	3.4E-04	8.4E-05	2.9E-04	7.2E-05	4.0E-04	1.0E-04	3.9E-04	9.7E-05	3.7E-04	9.3E-05	1.5E-04	3.7E-05
Methylene chloride [Dichloromethane]	75-09-2	0.056	1.1E-07 (d)	--	4.1E-08	0.033	8.3E-03	0.025	6.3E-03	0.021	5.4E-03	0.030	7.5E-03	0.029	7.2E-03	0.028	6.9E-03	0.011	2.8E-03
Nitric acid	7697-37-2	2.1E-03	4.1E-09 (d)	--	1.5E-09	1.2E-03	3.0E-04	9.2E-04	2.3E-04	7.9E-04	2.0E-04	1.1E-03	2.7E-04	1.1E-03	2.6E-04	1.0E-03	2.5E-04	4.0E-04	1.0E-04
Tetrachloroehtene	127-18-4	2.6E-04	5.2E-10 (d)	--	1.9E-10	1.5E-04	3.8E-05	1.2E-04	2.9E-05	9.9E-05	2.5E-05	1.4E-04	3.5E-05	1.3E-04	3.3E-05	1.3E-04	3.2E-05	5.1E-05	1.3E-05
Phosphoric acid	7664-38-2	5.9E-06	1.2E-11 (d)	--	4.4E-12	3.5E-06	8.8E-07	2.6E-06	6.6E-07	2.3E-06	5.7E-07	3.1E-06	7.9E-07	3.0E-06	7.6E-07	2.9E-06	7.3E-07	1.2E-06	2.9E-07
Propylene glycol monomethyl ether	107-98-2	1.1E-05	2.1E-11 (d)	--	7.9E-12	6.3E-06	1.6E-06	4.8E-06	1.2E-06	4.1E-06	1.0E-06	5.7E-06	1.4E-06	5.5E-06	1.4E-06	5.3E-06	1.3E-06	2.1E-06	5.3E-07
Propylene oxide	75-56-9	4.7E-07	9.3E-13 (d)	--	3.4E-13	2.8E-07	6.9E-08	2.1E-07	5.2E-08	1.8E-07	4.5E-08	2.5E-07	6.2E-08	2.4E-07	6.0E-08	2.3E-07	5.8E-08	9.2E-08	2.3E-08
Styrene	100-42-5	3.0E-05	6.0E-11 (d)	--	2.2E-11	1.8E-05	4.4E-06	1.3E-05	3.4E-06	1.1E-05	2.9E-06	1.6E-05	4.0E-06	1.5E-05	3.9E-06	1.5E-05	3.7E-06	5.9E-06	1.5E-06
Sulfuric acid	7664-93-9	2.1E-04	4.1E-10 (d)	--	1.5E-10	1.2E-04	3.1E-05	9.2E-05	2.3E-05	7.9E-05	2.0E-05	1.1E-04	2.8E-05	1.1E-04	2.7E-05	1.0E-04	2.6E-05	4.1E-05	1.0E-05
Toluene	108-88-3	5.1E-03	1.0E-08 (d)	1.6E-08 (e)	1.4E-08	0.011	2.8E-03	8.4E-03	2.1E-03	7.2E-03	1.8E-03	0.010	2.5E-03	9.7E-03	2.4E-03	9.3E-03	2.3E-03	3.7E-03	9.3E-04
Trichloroethylene	79-01-6	1.2E-03	2.3E-09 (d)	--	8.6E-10	6.9E-04	1.7E-04	5.2E-04	1.3E-04	4.5E-04	1.1E-04	6.2E-04	1.6E-04	6.0E-04	1.5E-04	5.8E-04	1.4E-04	2.3E-04	5.8E-05
Triethylamine	121-44-8	1.4E-03	2.8E-09 (d)	--	1.0E-09	8.3E-04	2.1E-04	6.3E-04	1.6E-04	5.4E-04	1.3E-04	7.5E-04	1.9E-04	7.2E-04	1.8E-04	6.9E-04	1.7E-04	2.8E-04	6.9E-05
Xylenes	1330-20-7	9.6E-04	1.9E-09 (d)	3.2E-08 (e)	2.1E-08	0.017	4.2E-03	0.013	3.2E-03	0.011	2.7E-03	0.015	3.8E-03	0.015	3.7E-03	0.014	3.5E-03	5.6E-03	1.4E-03
Hydrazine	302-01-2	--	--	1.4E-10 (e)	8.9E-11	7.1E-05	1.8E-05	5.4E-05	1.3E-05	4.6E-05	1.2E-05	6.4E-05	1.6E-05	6.2E-05	1.6E-05	5.9E-05	1.5E-05	2.4E-05	5.9E-06
1,1,1-Trichloroethane	71-55-6	--	--	5.0E-10 (e)	3.1E-10	2.5E-04	6.3E-05	1.9E-04	4.7E-05	1.6E-04	4.1E-05	2.2E-04	5.6E-05	2.2E-04	5.4E-05	2.1E-04	5.2E-05	8.3E-05	2.1E-05
Total - All Chemicals Listed		**0.32**				**1.81**	**0.45**	**1.37**	**0.34**	**1.17**	**0.29**	**1.63**	**0.41**	**1.57**	**0.39**	**1.51**	**0.38**	**0.60**	**0.15**

Notes:

(a) Average lab chemical emission factor (tons/R&D gsf/yr) = (LBNL chemical emission factor [tons/R&D gsf/yr] x LBNL percentage of total lab space [%] / 100)
+ (UCB chemical emission factor [tons/R&D gsf/yr] x UCB percentage of total lab space [%] / 100)
LBNL percentage of total lab space (%) = 37 (2)
UCB percentage of total lab space (%) = 63 (2)

(b) Maximum hourly emissions estimate (lbs/hr) = (Annual average emissions [tons/year]) / (annual operation [days/year])
/ (daily operation [hrs/day]) x (2,000 lbs/ton) x (conversion factor)
Annual operation for all buildings (days/year) = 260 (1)
Daily operation for all buildings (hrs/day) = 10 (1)
Conversion factor = 5.18 (4)

(c) Annual average emissions estimate (tons/yr) = (Phase I emissions fraction [tons/gsf/yr]) x (building size [gsf])

(d) Lab chemical emission factor (tons/R&D gsf/yr) = (Phase I emissions [tons/yr]) / (total Phase I R&D building gsf)
Total Phase I building gsf = 501,915 (1)

(e) Lab chemical emission factor (tons/R&D gsf/yr) = (UCB emission factor [g/lab gsf/s]) x (lab fraction of R&D building gsf [lab gsf/R&D gsf]) x (lb/453.59 g) x (ton/2,000 lb) x (3,600 s/hr) x (8,760 hrs/yr)
Lab fraction of R&D building gsf (lab gsf/R&D gsf) = 0.60 (5)
UCB emission factor (g/lab gsf/s) = see (6)

References:

(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) Provided by the University.
(3) Phase 1 Laboratory emissions calculated as part of the Phase 1 assessment. See Appendix G.
(4) Based in studies comparing maximum to average emission rates for laboratories. See text for further information.
(5) Based on average of existing and planned laboratory sizes.
(6) Emission factors provided by UC Berkeley.

Table F-19
Total Estimated Air Emissions of Laboratory Non-Radionuclide Liquid Chemicals

Source						Lab Hood Exhaust Stack - Building 30		Lab Hood Exhaust Stack - Building 32		Lab Hood Exhaust Stack - Building 33		Lab Hood Exhaust Stack - Building 34		Lab Hood Exhaust Stack - Building 35		Lab Hood Exhaust Stack - Building 36		Lab Hood Exhaust Stack - Building 37		Total	
Building size (gsf)					[1]	169,768		138,545		165,490		173,790		199,630		193,275		209,615			
Modeling ID						LAB_B30		LAB_B32		LAB_B33		LAB_B34		LAB_B35		LAB_B36		LAB_B37			
TAC	CAS	Total Phase I Emissions [2] (tons/yr)	LBNL Chemical Emission Factor (tons/R&D gsf/yr)	UCB Chemical Emission Factor (tons/R&D gsf/yr)	Average Lab Chemical Emission Factor [a] (tons/R&D gsf/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [c] (tons/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [c] (tons/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [c] (tons/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [c] (tons/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [c] (tons/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [c] (tons/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [c] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average (tons/yr)
1,3-Butadiene	106-99-0	3.2E-04	6.3E-10 [d]	--	2.3E-10	1.6E-04	3.9E-05	1.3E-04	3.2E-05	1.5E-04	3.8E-05	1.6E-04	4.0E-05	1.8E-04	4.6E-05	1.8E-04	4.5E-05	1.9E-04	4.9E-05	4.0E-03	1.0E-03
1,4-Dioxane	123-91-1	3.4E-03	6.8E-09 [d]	--	2.5E-09	1.7E-03	4.3E-04	1.4E-03	3.5E-04	1.7E-03	4.2E-04	1.7E-03	4.4E-04	2.0E-03	5.0E-04	1.9E-03	4.9E-04	2.1E-03	5.3E-04	0.044	0.011
Acetaldehyde	75-07-0	1.6E-04	3.2E-10 [d]	--	1.2E-10	7.9E-05	2.0E-05	6.5E-05	1.6E-05	7.7E-05	1.9E-05	8.1E-05	2.0E-05	9.3E-05	2.3E-05	9.0E-05	2.3E-05	9.8E-05	2.5E-05	2.0E-03	5.1E-04
Acrolein	107-02-8	7.7E-05	1.5E-10 [d]	--	5.7E-11	3.9E-05	9.7E-06	3.1E-05	7.9E-06	3.8E-05	9.4E-06	3.9E-05	9.9E-06	4.5E-05	1.1E-05	4.4E-05	1.1E-05	4.8E-05	1.2E-05	9.9E-04	2.5E-04
Acrylic acid	79-10-7	1.1E-05	2.2E-11 [d]	--	8.1E-12	5.5E-06	1.4E-06	4.5E-06	1.1E-06	5.4E-06	1.3E-06	5.6E-06	1.4E-06	6.5E-06	1.6E-06	6.3E-06	1.6E-06	6.8E-06	1.7E-06	1.4E-04	3.6E-05
Aniline	62-53-3	2.7E-06	5.4E-12 [d]	--	2.0E-12	1.3E-06	3.4E-07	1.1E-06	2.7E-07	1.3E-06	3.3E-07	1.4E-06	3.4E-07	1.6E-06	4.0E-07	1.5E-06	3.8E-07	1.7E-06	4.2E-07	3.5E-05	8.7E-06
Benzene	71-43-2	2.1E-03	4.3E-09 [d]	--	1.6E-09	1.1E-03	2.7E-04	8.7E-04	2.2E-04	1.0E-03	2.6E-04	1.1E-03	2.7E-04	1.3E-03	3.1E-04	1.2E-03	3.0E-04	1.3E-03	3.3E-04	0.027	6.9E-03
Benzyl chloride	100-44-7	5.7E-06	1.1E-11 [d]	--	4.2E-12	2.8E-06	7.1E-07	2.3E-06	5.8E-07	2.8E-06	6.9E-07	2.9E-06	7.3E-07	3.3E-06	8.4E-07	3.2E-06	8.1E-07	3.5E-06	8.8E-07	7.3E-05	1.8E-05
Bromine	7726-95-6	1.2E-06	2.5E-12 [d]	1.8E-10 [e]	1.1E-10	7.6E-05	1.9E-05	6.2E-05	1.6E-05	7.4E-05	1.9E-05	7.8E-05	2.0E-05	9.0E-05	2.2E-05	8.7E-05	2.2E-05	9.4E-05	2.4E-05	2.0E-03	4.9E-04
Carbon tetrachloride	56-23-5	3.2E-04	6.5E-10 [d]	1.3E-08 [e]	8.4E-09	5.7E-03	1.4E-03	4.6E-03	1.2E-03	5.5E-03	1.4E-03	5.8E-03	1.5E-03	6.6E-03	1.7E-03	6.4E-03	1.6E-03	7.0E-03	1.8E-03	0.15	0.037
Chloroform	67-66-3	0.051	1.0E-07 [d]	1.7E-07 [e]	1.5E-07	0.099	0.025	0.081	0.020	0.097	0.024	0.10	0.025	0.12	0.029	0.11	0.028	0.12	0.031	2.55	0.64
Diethanolamine	111-42-2	3.3E-09	6.6E-15 [d]	--	2.5E-15	1.7E-09	4.2E-10	1.4E-09	3.4E-10	1.6E-09	4.1E-10	1.7E-09	4.3E-10	2.0E-09	4.9E-10	1.9E-09	4.7E-10	2.1E-09	5.1E-10	4.3E-08	1.1E-08
Dimethyl formamide	68-12-2	5.7E-04	1.1E-09 [d]	6.5E-09 [e]	4.5E-09	3.0E-03	7.6E-04	2.5E-03	6.2E-04	3.0E-03	7.5E-04	3.1E-03	7.8E-04	3.6E-03	9.0E-04	3.5E-03	8.7E-04	3.8E-03	9.4E-04	0.078	0.020
Epichlorohydrin	106-89-8	1.6E-05	3.2E-11 [d]	--	1.2E-11	8.1E-06	2.0E-06	6.6E-06	1.7E-06	7.9E-06	2.0E-06	8.3E-06	2.1E-06	9.6E-06	2.4E-06	9.3E-06	2.3E-06	1.0E-05	2.5E-06	2.1E-04	5.3E-05
Ethylbenzene	100-41-4	1.0E-04	2.0E-10 [d]	--	7.4E-11	5.0E-05	1.3E-05	4.1E-05	1.0E-05	4.9E-05	1.2E-05	5.1E-05	1.3E-05	5.9E-05	1.5E-05	5.7E-05	1.4E-05	6.2E-05	1.5E-05	1.3E-03	3.2E-04
Ethylene dichloride [EDC]	107-06-2	2.3E-03	4.6E-09 [d]	--	1.7E-09	1.1E-03	2.9E-04	9.4E-04	2.3E-04	1.1E-03	2.8E-04	1.2E-03	2.9E-04	1.3E-03	3.4E-04	1.3E-03	3.3E-04	1.4E-03	3.6E-04	0.030	7.4E-03
Ethylene glycol	107-21-1	6.0E-06	1.2E-11 [d]	--	4.4E-12	3.0E-06	7.5E-07	2.4E-06	6.1E-07	2.9E-06	7.3E-07	3.0E-06	7.7E-07	3.5E-06	8.8E-07	3.4E-06	8.5E-07	3.7E-06	9.2E-07	7.7E-05	1.9E-05
Ethylene glycol monomethyl ether	109-86-4	8.5E-05	1.7E-10 [d]	--	6.3E-11	4.2E-05	1.1E-05	3.5E-05	8.7E-06	4.1E-05	1.0E-05	4.3E-05	1.1E-05	5.0E-05	1.2E-05	4.8E-05	1.2E-05	5.2E-05	1.3E-05	1.1E-03	2.7E-04
Formaldehyde	50-00-0	0.014	2.7E-08 [d]	1.6E-07 [e]	1.1E-07	0.076	0.019	0.062	0.016	0.074	0.019	0.078	0.019	0.089	0.022	0.086	0.022	0.094	0.024	1.95	0.49
Glutaraldehyde	111-30-8	4.9E-05	9.8E-11 [d]	5.1E-09 [e]	3.2E-09	2.2E-03	5.5E-04	1.8E-03	4.5E-04	2.1E-03	5.4E-04	2.2E-03	5.6E-04	2.6E-03	6.5E-04	2.5E-03	6.3E-04	2.7E-03	6.8E-04	0.056	0.014
n-Hexane	110-54-3	0.044	8.8E-08 [d]	--	3.3E-08	0.022	5.5E-03	0.018	4.5E-03	0.021	5.4E-03	0.023	5.7E-03	0.026	6.5E-03	0.025	6.3E-03	0.027	6.8E-03	0.57	0.14
Hydrogen Chloride	7647-01-0	0.042	8.3E-08 [d]	4.2E-07 [e]	2.9E-07	0.20	0.050	0.16	0.041	0.19	0.049	0.20	0.051	0.23	0.059	0.23	0.057	0.24	0.061	5.11	1.28
Hydrogen fluoride	7664-39-3	4.1E-05	8.2E-11 [d]	3.1E-09 [e]	2.0E-09	1.4E-03	3.4E-04	1.1E-03	2.8E-04	1.3E-03	3.3E-04	1.4E-03	3.5E-04	1.6E-03	4.0E-04	1.5E-03	3.9E-04	1.7E-03	4.2E-04	0.035	8.8E-03
Isopropyl alcohol	67-63-0	0.039	7.8E-08 [d]	5.3E-07 [e]	3.6E-07	0.24	0.061	0.20	0.050	0.24	0.060	0.25	0.063	0.29	0.072	0.28	0.070	0.30	0.075	6.27	1.57
Lindane [gamma-Hexachlorocyclohexane]	58-89-9	1.3E-10	2.6E-16 [d]	--	9.7E-17	6.6E-11	1.6E-11	5.4E-11	1.3E-11	6.4E-11	1.6E-11	6.7E-11	1.7E-11	7.7E-11	1.9E-11	7.5E-11	1.9E-11	8.1E-11	2.0E-11	1.7E-09	4.2E-10
m-Cresol	108-39-4	1.3E-06	2.6E-12 [d]	--	9.6E-13	6.5E-07	1.6E-07	5.3E-07	1.3E-07	6.3E-07	1.6E-07	6.7E-07	1.7E-07	7.7E-07	1.9E-07	7.4E-07	1.9E-07	8.0E-07	2.0E-07	1.7E-05	4.2E-06
Methanol	67-56-1	0.050	1.0E-07 [d]	1.9E-06 [e]	1.2E-06	0.82	0.21	0.67	0.17	0.80	0.20	0.84	0.21	0.96	0.24	0.93	0.23	1.01	0.25	21.1	5.30
2-Butanone	78-93-3	1.1E-03	2.1E-09 [d]	--	7.9E-10	5.4E-04	1.3E-04	4.4E-04	1.1E-04	5.2E-04	1.3E-04	5.5E-04	1.4E-04	6.3E-04	1.6E-04	6.1E-04	1.5E-04	6.6E-04	1.7E-04	0.014	3.5E-03
Methyl tert-butyl ether	1634-04-4	7.5E-04	1.5E-09 [d]	--	5.6E-10	3.8E-04	9.4E-05	3.1E-04	7.7E-05	3.7E-04	9.2E-05	3.8E-04	9.6E-05	4.4E-04	1.1E-04	4.3E-04	1.1E-04	4.6E-04	1.2E-04	9.7E-03	2.4E-03
Methylene chloride [Dichloromethane]	75-09-2	0.056	1.1E-07 [d]	--	4.1E-08	0.028	7.0E-03	0.023	5.7E-03	0.027	6.8E-03	0.029	7.2E-03	0.033	8.2E-03	0.032	8.0E-03	0.034	8.6E-03	0.72	0.18
Nitric acid	7697-37-2	2.1E-03	4.1E-09 [d]	--	1.5E-09	1.0E-03	2.6E-04	8.4E-04	2.1E-04	1.0E-03	2.5E-04	1.1E-03	2.6E-04	1.2E-03	3.0E-04	1.2E-03	2.9E-04	1.3E-03	3.2E-04	0.026	6.6E-03
Tetrachloroehtene	127-18-4	2.6E-04	5.2E-10 [d]	--	1.9E-10	1.3E-04	3.3E-05	1.1E-04	2.7E-05	1.3E-04	3.2E-05	1.3E-04	3.3E-05	1.5E-04	3.8E-05	1.5E-04	3.7E-05	1.6E-04	4.0E-05	3.3E-03	8.4E-04
Phosphoric acid	7664-38-2	5.9E-06	1.2E-11 [d]	--	4.4E-12	3.0E-06	7.4E-07	2.4E-06	6.0E-07	2.9E-06	7.2E-07	3.0E-06	7.6E-07	3.5E-06	8.7E-07	3.4E-06	8.4E-07	3.6E-06	9.2E-07	7.6E-05	1.9E-05
Propylene glycol monomethyl ether	107-98-2	1.1E-05	2.1E-11 [d]	--	7.9E-12	5.3E-06	1.3E-06	4.4E-06	1.1E-06	5.2E-06	1.3E-06	5.5E-06	1.4E-06	6.3E-06	1.6E-06	6.1E-06	1.5E-06	6.6E-06	1.7E-06	1.4E-04	3.4E-05
Propylene oxide	75-56-9	4.7E-07	9.3E-13 [d]	--	3.4E-13	2.3E-07	5.8E-08	1.9E-07	4.8E-08	2.3E-07	5.7E-08	2.4E-07	6.0E-08	2.7E-07	6.9E-08	2.6E-07	6.6E-08	2.9E-07	7.2E-08	6.0E-06	1.5E-06
Styrene	100-42-5	3.0E-05	6.0E-11 [d]	--	2.2E-11	1.5E-05	3.8E-06	1.2E-05	3.1E-06	1.5E-05	3.7E-06	1.5E-05	3.9E-06	1.8E-05	4.4E-06	1.7E-05	4.3E-06	1.9E-05	4.6E-06	3.9E-04	9.7E-05
Sulfuric acid	7664-93-9	2.1E-04	4.1E-10 [d]	--	1.5E-10	1.0E-04	2.6E-05	8.4E-05	2.1E-05	1.0E-04	2.5E-05	1.1E-04	2.6E-05	1.2E-04	3.0E-05	1.2E-04	2.9E-05	1.3E-04	3.2E-05	2.7E-03	6.7E-04
Toluene	108-88-3	5.1E-03	1.0E-08 [d]	1.6E-08 [e]	1.4E-08	9.4E-03	2.4E-03	7.7E-03	1.9E-03	9.2E-03	2.3E-03	9.7E-03	2.4E-03	0.011	2.8E-03	0.011	2.7E-03	0.012	2.9E-03	0.24	0.061
Trichloroethylene	79-01-6	1.2E-03	2.3E-09 [d]	--	8.6E-10	5.8E-04	1.5E-04	4.8E-04	1.2E-04	5.7E-04	1.4E-04	6.0E-04	1.5E-04	6.9E-04	1.7E-04	6.6E-04	1.7E-04	7.2E-04	1.8E-04	0.015	3.8E-03
Triethylamine	121-44-8	1.4E-03	2.8E-09 [d]	--	1.0E-09	7.0E-04	1.8E-04	5.7E-04	1.4E-04	6.8E-04	1.7E-04	7.2E-04	1.8E-04	8.3E-04	2.1E-04	8.0E-04	2.0E-04	8.7E-04	2.2E-04	0.018	4.5E-03
Xylenes	1330-20-7	9.6E-04	1.9E-09 [d]	3.2E-08 [e]	2.1E-08	0.014	3.6E-03	0.012	2.9E-03	0.014	3.5E-03	0.015	3.6E-03	0.017	4.2E-03	0.016	4.1E-03	0.018	4.4E-03	0.37	0.092
Hydrazine	302-01-2	--	--	1.4E-10 [e]	8.9E-11	6.0E-05	1.5E-05	4.9E-05	1.2E-05	5.9E-05	1.5E-05	6.2E-05	1.5E-05	7.1E-05	1.8E-05	6.9E-05	1.7E-05	7.4E-05	1.9E-05	1.5E-03	3.9E-04
1,1,1-Trichloroethane	71-55-6	--	--	5.0E-10 [e]	3.1E-10	2.1E-04	5.3E-05	1.7E-04	4.3E-05	2.1E-04	5.2E-05	2.2E-04	5.4E-05	2.5E-04	6.2E-05	2.4E-04	6.0E-05	2.6E-04	6.5E-05	5.4E-03	1.4E-03
Total - All Chemicals Listed		**0.32**				**1.53**	**0.38**	**1.25**	**0.31**	**1.49**	**0.37**	**1.57**	**0.39**	**1.80**	**0.45**	**1.74**	**0.44**	**1.89**	**0.47**	**39.4**	**9.89**

Notes:

(a) Average lab chemical emission factor (tons/R&D gsf/yr) = (LBNL chemical emission factor [tons/R&D gsf/yr] x LBNL percentage of total lab space [%] / 100)
+ (UCB chemical emission factor [tons/R&D gsf/yr] x UCB percentage of total lab space [%] / 100)
LBNL percentage of total lab space (%) = 37 (2)
UCB percentage of total lab space (%) = 63 (2)

(b) Maximum hourly emissions estimate (lbs/hr) = (Annual average emissions [tons/year]) / (annual operation [days/year])
/ (daily operation [hrs/day]) x (2,000 lbs/ton) x (conversion factor)
Annual operation for all buildings (days/year) = 260 (1)
Daily operation for all buildings (hrs/day) = 10 (1)
Conversion factor = 5.18 (4)

(c) Annual average emissions estimate (tons/yr) = (Phase I emissions fraction [tons/gsf/yr]) x (building size [gsf])

(d) Lab chemical emission factor (tons/R&D gsf/yr) = (Phase I emissions [tons/yr]) / (total Phase I R&D building gsf)
Total Phase I building gsf = 501,915 (1)

(e) Lab chemical emission factor (tons/R&D gsf/yr) = (UCB emission factor [g/lab gsf/s]) x (lab fraction of R&D building gsf [lab gsf/R&D gsf]) x (lb/453.59 g) x (ton/2,000 lb) x (3,600 s/hr) x (8,760 hrs/yr)
Lab fraction of R&D building gsf (lab gsf/R&D gsf) = 0.60 (5)
UCB emission factor (g/lab gsf/s) = see (6)

References:

(1) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.
(2) Provided by the University.
(3) Phase 1 Laboratory emissions calculated as part of the Phase 1 assessment. See Appendix G.
(4) Based in studies comparing maximum to average emission rates for laboratories. See text for further information.
(5) Based on average of existing and planned laboratory sizes.
(6) Emission factors provided by UC Berkeley.

Table F-20
LRDP Operations TAC Emissions Summary

TAC	CAS	Natural Gas Boilers		Diesel Generators		Cooling Towers		Laboratory Buildings		Onsite Onroad Exhaust		Offsite Onroad Exhaust		Total	
		(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)
DPM [1]	9901	--	--	0.40	5.1E-03	--	--	--	--	9.4E-04	2.0E-03	6.8E-03	0.014	0.41	0.021
1,1,1-Trichloroethane	71-55-6	--	--	--	--	--	--	5.4E-03	1.4E-03	--	--	--	--	5.4E-03	1.4E-03
1,3-Butadiene	106-99-0	--	--	0.14	1.7E-03	--	--	4.0E-03	1.0E-03	1.7E-03	3.6E-03	5.1E-03	0.011	0.15	0.017
1,4-Dioxane	123-91-1	--	--	--	--	--	--	0.044	0.011	--	--	--	--	0.044	0.011
2-Butanone	78-93-3	--	--	--	--	--	--	0.014	3.5E-03	1.2E-04	2.6E-04	1.9E-04	3.9E-04	0.014	4.1E-03
7,12-Dimethylbenz(a)anthracene	57-97-6	7.3E-06	5.2E-06	--	--	--	--	--	--	--	--	--	--	7.3E-06	5.2E-06
Acetaldehyde	75-07-0	4.0E-03	2.9E-03	2.2E-03	2.8E-05	--	--	2.0E-03	5.1E-04	1.2E-03	2.4E-03	2.6E-03	5.4E-03	0.012	0.011
Acrolein	107-02-8	--	--	--	--	--	--	9.9E-04	2.5E-04	3.1E-04	6.4E-04	1.2E-03	2.5E-03	2.5E-03	3.4E-03
Acrylic acid	79-10-7	--	--	--	--	--	--	1.4E-04	3.6E-05	--	--	--	--	1.4E-04	3.6E-05
Aniline	62-53-3	--	--	--	--	--	--	3.5E-05	8.7E-06	--	--	--	--	3.5E-05	8.7E-06
Arsenic	7440-38-2	9.1E-05	6.5E-05	1.0E-03	1.3E-05	--	--	--	--	--	--	2.1E-05	4.4E-05	1.1E-03	1.2E-04
Benzene	71-43-2	2.0E-03	1.4E-03	0.12	1.5E-03	--	--	0.027	6.9E-03	0.013	0.027	0.023	0.048	0.19	0.084
Benzyl chloride	100-44-7	--	--	--	--	--	--	7.3E-05	1.8E-05	--	--	--	--	7.3E-05	1.8E-05
Beryllium	7440-41-7	5.4E-06	3.9E-06	--	--	--	--	--	--	--	--	--	--	5.4E-06	3.9E-06
Bromine	7726-95-6	--	--	--	--	3.7E-03	0.012	2.0E-03	4.9E-04	--	--	9.1E-05	1.9E-04	5.8E-03	0.013
Cadmium	7440-43-9	5.0E-04	3.6E-04	9.5E-04	1.2E-05	--	--	--	--	--	--	--	--	1.4E-03	3.7E-04
Carbon tetrachloride	56-23-5	--	--	--	--	--	--	0.15	0.037	--	--	--	--	0.15	0.037
Chlorine	7782-50-5	--	--	--	--	--	--	--	--	--	--	6.7E-03	0.014	6.7E-03	0.014
Chlorobenzene	108-90-7	--	--	1.3E-04	1.6E-06	--	--	--	--	--	--	--	--	1.3E-04	1.6E-06
Chloroform	67-66-3	--	--	--	--	--	--	2.55	0.64	--	--	--	--	2.55	0.64
Chromium VI	18540-29-9	1.1E-04	7.7E-05	6.3E-05	7.9E-07	--	--	--	--	--	--	--	--	1.7E-04	7.8E-05
Cobalt	7440-48-4	3.8E-05	2.7E-05	--	--	--	--	--	--	--	--	--	--	3.8E-05	2.7E-05
Copper	7440-50-8	3.9E-04	2.8E-04	2.6E-03	3.3E-05	--	--	--	--	--	--	0.024	0.050	0.027	0.051
Dichlorobenzene	25321-22-6	5.4E-04	3.9E-04	--	--	--	--	--	--	--	--	--	--	5.4E-04	3.9E-04
Diethanolamine	111-42-2	--	--	--	--	--	--	4.3E-08	1.1E-08	--	--	--	--	4.3E-08	1.1E-08
Dimethyl formamide	68-12-2	--	--	--	--	--	--	0.078	0.020	--	--	--	--	0.078	0.020
Epichlorohydrin	106-89-8	--	--	--	--	--	--	2.1E-04	5.3E-05	--	--	--	--	2.1E-04	5.3E-05
Ethylbenzene	100-41-4	3.1E-03	2.2E-03	4.3E-03	5.4E-05	--	--	1.3E-03	3.2E-04	0.014	0.029	9.8E-03	0.020	0.032	0.052
Ethylene dichloride [EDC]	107-06-2	--	--	--	--	--	--	0.030	7.4E-03	--	--	--	--	0.030	7.4E-03
Ethylene glycol	107-21-1	--	--	--	--	--	--	7.7E-05	1.9E-05	--	--	--	--	7.7E-05	1.9E-05
Ethylene glycol monomethyl ether	109-86-4	--	--	--	--	--	--	1.1E-03	2.7E-04	--	--	--	--	1.1E-03	2.7E-04
Fluoranthene	206-44-0	1.4E-06	9.7E-07	--	--	--	--	--	--	--	--	--	--	1.4E-06	9.7E-07
Formaldehyde	50-00-0	0.10	0.072	0.032	4.0E-04	--	--	1.95	0.49	3.6E-03	7.5E-03	0.015	0.031	2.10	0.60
Glutaraldehyde	111-30-8	--	--	--	--	--	--	0.056	0.014	--	--	--	--	0.056	0.014
Hydrazine	302-01-2	--	--	--	--	--	--	1.5E-03	3.9E-04	--	--	--	--	1.5E-03	3.9E-04
Hydrogen Chloride	7647-01-0	--	--	0.12	1.5E-03	--	--	5.11	1.28	--	--	--	--	5.23	1.28
Hydrogen fluoride	7664-39-3	--	--	--	--	--	--	0.035	8.8E-03	--	--	--	--	0.035	8.8E-03
Isopropyl alcohol	67-63-0	--	--	--	--	--	--	6.27	1.57	--	--	--	--	6.27	1.57
Lead	7439-92-1	2.3E-04	1.6E-04	5.2E-03	6.6E-05	--	--	--	--	--	--	1.8E-04	3.7E-04	5.6E-03	6.0E-04
Lindane [gamma-Hexachlorocyclohexane]	58-89-9	--	--	--	--	--	--	1.7E-09	4.2E-10	--	--	--	--	1.7E-09	4.2E-10
Manganese	7439-96-5	1.7E-04	1.2E-04	2.0E-03	2.5E-05	--	--	--	--	--	--	3.6E-03	7.5E-03	5.7E-03	7.6E-03
m-Cresol	108-39-4	--	--	--	--	--	--	1.7E-05	4.2E-06	--	--	--	--	1.7E-05	4.2E-06
Mercury	7439-97-6	1.2E-04	8.4E-05	1.3E-03	1.6E-05	--	--	--	--	--	--	--	--	1.4E-03	1.0E-04
Methanol	67-56-1	--	--	--	--	--	--	21.1	5.30	6.8E-04	1.4E-03	1.1E-03	2.3E-03	21.1	5.30
Methyl tert-butyl ether	1634-04-4	--	--	--	--	--	--	9.7E-03	2.4E-03	--	--	--	--	9.7E-03	2.4E-03
Methylene chloride [Dichloromethane]	75-09-2	--	--	--	--	--	--	0.72	0.18	--	--	--	--	0.72	0.18
Naphthalene	91-20-3	1.4E-04	9.7E-05	0.010	1.3E-04	--	--	--	--	1.0E-03	2.1E-03	4.7E-04	9.7E-04	0.012	3.3E-03
n-Hexane	110-54-3	2.1E-03	1.5E-03	8.8E-04	1.1E-05	--	--	0.57	0.14	0.010	0.022	0.015	0.031	0.60	0.20
Nickel	7440-02-0	9.5E-04	6.8E-04	2.5E-03	3.1E-05	--	--	--	--	--	--	1.4E-03	2.9E-03	4.8E-03	3.6E-03
Nitric acid	7697-37-2	--	--	--	--	--	--	0.026	6.6E-03	--	--	--	--	0.026	6.6E-03
Phosphoric acid	7664-38-2	--	--	--	--	--	--	7.6E-05	1.9E-05	--	--	--	--	7.6E-05	1.9E-05
Propylene	115-07-1	0.24	0.17	0.22	2.7E-03	--	--	--	--	8.6E-03	0.018	0.029	0.059	0.49	0.25
Propylene glycol monomethyl ether	107-98-2	--	--	--	--	--	--	1.4E-04	3.4E-05	--	--	--	--	1.4E-04	3.4E-05
Propylene oxide	75-56-9	--	--	--	--	--	--	6.0E-06	1.5E-06	--	--	--	--	6.0E-06	1.5E-06
Selenium	7782-49-2	1.1E-05	7.8E-06	1.4E-03	1.7E-05	--	--	--	--	--	--	5.1E-05	1.1E-04	1.5E-03	1.3E-04
Styrene	100-42-5	--	--	--	--	--	--	3.9E-04	9.7E-05	5.6E-04	1.2E-03	1.1E-03	2.3E-03	2.1E-03	3.6E-03
Sulfuric acid	7664-93-9	--	--	--	--	--	--	2.7E-03	6.7E-04	--	--	--	--	2.7E-03	6.7E-04
Tetrachloroehtene	127-18-4	--	--	--	--	--	--	3.3E-03	8.4E-04	--	--	--	--	3.3E-03	8.4E-04
Toluene	108-88-3	0.012	8.6E-03	0.039	4.9E-04	--	--	0.24	0.061	0.051	0.11	0.054	0.11	0.40	0.29
Trichloroethylene	79-01-6	--	--	--	--	--	--	0.015	3.8E-03	--	--	--	--	0.015	3.8E-03
Triethylamine	121-44-8	--	--	--	--	--	--	0.018	4.5E-03	--	--	--	--	0.018	4.5E-03
Vanadium	7440-62-2	--	--	--	--	--	--	--	--	--	--	1.4E-03	2.9E-03	1.4E-03	2.9E-03
m-Xylene	108-38-3	--	--	--	--	--	--	--	--	0.029	0.061	0.033	0.069	0.062	0.13
o-Xylene	95-47-6	--	--	--	--	--	--	--	--	0.014	0.029	0.012	0.024	0.026	0.054
p-Xylene	106-42-3	--	--	--	--	--	--	--	--	8.5E-03	0.018	--	--	8.5E-03	0.018
Xylenes	1330-20-7	8.9E-03	6.4E-03	0.027	3.4E-04	--	--	0.37	0.092	--	--	--	--	0.40	0.098
NO_2	10102-44-0	8.43	6.01	9.95	0.13	--	--	--	--	0.66	1.37	0.14	0.29	19.2	7.79
SO_2	7446-09-5	0.27	0.19	0.18	2.3E-03	--	--	--	--	2.2E-03	4.5E-03	6.9E-03	0.014	0.46	0.21
CO	630-08-0	37.8	27.0	61.3	0.77	--	--	--	--	6.91	14.4	1.02	2.13	107	44.2

References:

(1) On-site DPM emissions. Assumes all PM10 emissions from mobile source combustion equals diesel particulate matter (DPM). See Table F-11, Criteria Pollutant Emissions Summary, for DPM emissions from onsite onroad sources.

(2) NO_2 emissions are shown as NO_X emissions.

Appendix G

Laboratory Chemical Calculations

Table G-1
Total Estimated Air Emissions of Laboratory Non-Radionuclide Liquid Chemicals(1)
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California

CAS Number	Chemical Name	Estimated Emissions (grams/year)	Estimated Emissions (lbs/year)
106-99-0	1,3-Butadiene	285.77	0.63
123-91-1	1,4-Dioxane	3,095.08	6.82
75-07-0	Acetaldehyde	144.08	0.32
107-02-8	Acrolein	70.08	0.15
79-10-7	Acrylic acid	9.99	0.02
62-53-3	Aniline	2.44	0.01
71-43-2	Benzene	1,939.26	4.28
100-44-7	Benzyl chloride	5.16	0.01
7726-95-6	Bromine	1.13	0.00
56-23-5	Carbon tetrachloride	294.54	0.65
67-66-3	Chloroform	46,603.66	102.76
111-42-2	Diethanolamine	3.0E-03	6.7E-06
68-12-2	Dimethyl formamide	515.60	1.14
106-89-8	Epichlorohydrin	14.79	0.03
100-41-4	Ethyl benzene	90.75	0.20
107-06-2	Ethylene dichloride [EDC]	2,083.46	4.59
107-21-1	Ethylene glycol	5.41	0.01
109-86-4	Ethylene glycol monomethyl ether	76.91	0.17
50-00-0	Formaldehyde	12,391.31	27.32
111-30-8	Glutaraldehyde	44.5	0.10
110-54-3	Hexane	40,004.39	88.21
7647-01-0	Hydrochloric acid	37,991.59	83.77
7664-39-3	Hydrogen fluoride	37.50	0.08
67-63-0	Isopropyl alcohol	35,382.88	78.02
58-89-9	Lindane [gamma-Hexachlorocyclohexane]	1.2E-04	2.6E-07
108-39-4	m-Cresol	1.18	0.00
67-56-1	Methanol	45,342.02	99.98
78-93-3	Methyl ethyl ketone [2-Butanone]	974.22	2.15
1634-04-4	Methyl tert-butyl ether	682.39	1.50
75-09-2	Methylene chloride [Dichloromethane]	50,699.56	111.79
7697-37-2	Nitric acid	1,865.18	4.11
127-18-4	Perchloroethylene [Tetrachloroethene]	235.75	0.52
7664-38-2	Phosphoric acid	5.37	0.01
107-98-2	Propylene glycol monomethyl ether	9.70	0.02
75-56-9	Propylene oxide	0.42	0.00
100-42-5	Styrene	27.25	0.06
7664-93-9	Sulfuric acid	187.24	0.41
108-88-3	Toluene	4,636.09	10.22
79-01-6	Trichloroethylene	1,059.27	2.34
121-44-8	Triethylamine	1,276.26	2.81
1330-20-7	Xylenes (mixed isomers)	868.92	1.92
	Total - All Chemicals Listed	**288,961.03**	**637.16**

Notes:
(1) Estimation methods continued in Appendix G.

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Emission Estimation Approach for Liquids

Step 1: Pour Liquid Into Receiving Container (i.e. Beaker)

Emissions based on quantity poured.

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T From U.S. EPA AP-42 Section 5.2, converted from lbs/10^3 gal to gram/liter and VP in mmHg instead of psia.

where:
S = Saturation Factor (1.45 [unitless]) - From U.S. EPA AP-42 Table 5.2-1
VP = Vapor Pressure at room temperature (mmHg; assume 532 degrees Rankin)
MW = Molecular Weight (grams/mole)
T = Room Temperature (assume 532 degrees Rankin)

Assumptions: Liquid is poured when at room temperature.
Receiving vessel is an open beaker.

Step 2: Stir Liquid in Receiving Container (i.e. Beaker)

Emissions based on number of batches..

Loss (grams/30 min. batch) = $(0.002289*t*A*U^{0.78}*MW^{0.67}*VP)/(R*T)$ From: *Risk Management Program Guidance for Offsite Consequence Analysis*
United States Environmental Protection Agency
Emergency Response (Document 550-B-99-009)
April 1999

where:
t = Batch time in seconds (=1,800)
A = Surface Area (100 cm^2)
U = Surface Wind Speed (0.51 meters/second)
MW = Molecular Weight (grams/mole)
VP = Vapor Pressure at elevated temperature (mmHg)
R = Gas Constant (82.05 atm-cm^3/mole-deg K)
T = Temperature During Use (degrees Kelvin)

Assumptions: If VP(295 K) is > 100 mmHg, no heating is assumed.
*If VP(295 K) is < 100 mmHg, VP(as used) = 2 * VP(298 K), up to 100 mmHg maximum.*
Vessel used is an open beaker.
Diameter of beaker is such that A = 100 cm^2.
Assume that beaker contains pure chemical.
Assume that use occurs within a laboratory fume hood.
Assume fume hood face velocity of 100 ft/min (OSHA recommendation).
Assume batch (use) time of 30 minutes.
For calculation purposes, assume T = 295 deg K. Conservative because temperatures above room temperature would only decrease predicted emission rate.

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Calculation Constants

Name	Value	Comment
TempAmbC	21.85	Assumed room temperature in degrees C
TempAmbK	295	Assumed room temperature in degrees K
TempAmbR	532	Assumed room temperature in degrees R
MaxPressBar	0.133	Maximum adjusted vapor pressure in Bars
MaxPressHg	100	Maximum adjusted vapor pressure in mmHg
SatFactor	1.45	Saturation factor for pouring emissions
SurfaceArea	100	Vessel surface area in cm^2
WindSpeed	0.51	Surface Wind Speed (meters/second)
GasConstant	82.05	Gas constant R ($atm\text{-}cm^3$/mole-deg K)

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Chemical Inventory Data (Table G-2)

Conservatively assume specific gravity of 0.7 for laboratory liquids (0.649 liter/lb) when units are in pounds

Batch Assumptions:	Annual Usage	Assumed Annual Batches
	< 0.01 liter	*1*
	0.01-0.1 liter	*5*
	0.1-1.0 liter	*10*
	1.0-10 liter	*25*
	>10 liter	*100*

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data*		*Calculated*	*Recalculated*	*Calculated*	*Entered Data*		*Calculated*
		Inventory Amount		Inventory Amount (liters)	Inventory Amount (liters)	Annual Usage * (liters/yr)	Building	Room	Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
50-00-0	NORTHERNMAX DENATURING GEL BUFFER	250	ML	0.25000	--	0.29341	9	0446	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	9	0412	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	9	0446	10
50-00-0	FORMALDEHYDE SOLUTION	500	ML	0.50000	--	0.58682	9	0446	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	9	0412	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	9	0412	10
50-00-0	FORMALDEHYDE SOLUTION	25	ML	0.02500	--	0.02934	9	0459	5
50-00-0	FORMALDEHYDE	25	ML	0.02500	--	0.02934	9	0446	5
50-00-0	FORMALDEHYDE	25	ML	0.02500	--	0.02934	9	0459	5
50-00-0	FORMALDEHYDE	25	ML	0.02500	--	0.02934	9	0459	5
50-00-0	FORMALDEHYDE	25	ML	0.02500	--	0.02934	9	0459	5
50-00-0	FORMALDEHYDE	25	ML	0.02500	--	0.02934	9	0459	5
50-00-0	FORMALDEHYDE	25	ML	0.02500	--	0.02934	9	0459	5
50-00-0	FORMALDEHYDE	25	ML	0.02500	--	0.02934	9	0446	5
50-00-0	FORMALDEHYDE	25	ML	0.02500	--	0.02934	9	0446	5
50-00-0	FORMALDEHYDE	25	ML	0.02500	--	0.02934	9	0446	5
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50-00-0	FORMALDEHYDE	25	ML	0.02500	--	0.02934	9	0446	5
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	9	0412	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	9	0412	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	9	0412	10
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50-00-0	FORMALDEHYDE	25	ML	0.02500	--	0.02934	9	0459	5
50-00-0	FORMALDEHYDE SOLUTION	500	ML	0.50000	--	0.58682	9	0412	10
50-00-0	FORMALDEHYDE	25	ML	0.02500	--	0.02934	9	0446	5
50-00-0	FORMALDEHYDE	25	ML	0.02500	--	0.02934	9	0446	5
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50-00-0	FORMALDEHYDE	25	ML	0.02500	--	0.02934	9	0446	5
50-00-0	FORMALDEHYDE SOLUTION	25	ML	0.02500	--	0.02934	9	0459	5
50-00-0	FORMALDEHYDE	450	ML	0.45000	--	0.52814	8	4550	10
50-00-0	FORMALDEHYDE	450	ML	0.45000	--	0.52814	8	4524	10
50-00-0	FORMALDEHYDE	450	ML	0.45000	--	0.52814	8	4440	10
50-00-0	FORMALDEHYDE	450	ML	0.45000	--	0.52814	8	4440	10
50-00-0	FORMALDEHYDE SOLUTION	500	ML	0.50000	--	0.58682	8	4310	10
50-00-0	FORMALDEHYDE SOLUTION	500	ML	0.50000	--	0.58682	8	4310	10
50-00-0	FORMALDEHYDE SOLUTION	500	G	**Units**	0.45872	0.53836	8	4310	10
50-00-0	FORMALDEHYDE SOLUTION	500	G	**Units**	0.45872	0.53836	8	4310	10
50-00-0	FORMALDEHYDE	100	ML	0.10000	--	0.11736	6/7	0166	10
50-00-0	NORTHERNMAX DENATURING GEL BUFFER	250	ML	0.25000	--	0.29341	6/7	0166	10

* Equals inventory x (365 days per yr/311 days)
[311 days = 95th percentile lowest turnover rate for historic use]

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Chemical Inventory Data (Table G-2)

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Batch Assumptions:	Annual Usage	Assumed Annual Batches
	< 0.01 liter	1
	0.01-0.1 liter	5
	0.1-1.0 liter	10
	1.0-10 liter	25
	>10 liter	100

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data* Inventory Amount		*Calculated* Inventory Amount (liters)	*Recalculated* Inventory Amount (liters)	*Calculated* Annual Usage * (liters/yr)	*Entered Data* Building	Room	*Calculated* Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
50-00-0	FORMALDEHYDE	100	ML	0.10000	--	0.11736	6/7	0293	10
50-00-0	FORMALDEHYDE	100	ML	0.10000	--	0.11736	6/7	0293	10
50-00-0	FORMALDEHYDE	100	ML	0.10000	--	0.11736	6/7	0293	10
50-00-0	FORMALDEHYDE	100	ML	0.10000	--	0.11736	6/7	0293	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0293	10
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	1	GAL	3.78500	--	4.44220	6/7	0271	25
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	1	GAL	3.78500	--	4.44220	6/7	0271	25
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	1	GAL	3.78500	--	4.44220	6/7	0271	25
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0244	10
50-00-0	FORMALDEHYDE	450	ML	0.45000	--	0.52814	6/7	0239	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0239	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0204	10
50-00-0	FORMALIN	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	4	L	4.00000	--	4.69453	6/7	0128	25
50-00-0	FORMALDEHYDE	4	L	4.00000	--	4.69453	6/7	0128	25
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	15	ML	0.01500	--	0.01760	6/7	0128	5
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	15	ML	0.01500	--	0.01760	6/7	0128	5
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	15	ML	0.01500	--	0.01760	6/7	0128	5
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50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	15	ML	0.01500	--	0.01760	6/7	0128	5
50-00-0	FORMALINE SOLUTION ACCUSTAIN 10%	120	ML	0.12000	--	0.14084	6/7	0128	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0128	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0128	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0128	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0128	10
50-00-0	FORMALDEHYDE	25	ML	0.02500	--	0.02934	6/7	0128	5
50-00-0	FORMALINE SOLUTION ACCUSTAIN 10%	50	ML	0.05000	--	0.05868	6/7	0128	5
50-00-0	NORTHERNMAX DENATURING GEL BUFFER	250	ML	0.25000	--	0.29341	6/7	0196A	10
50-00-0	FORMALDEHYDE SOLUTION	500	ML	0.50000	--	0.58682	6/7	0196A	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0116	10
50-00-0	FORMALDEHYDE SOLUTION	500	ML	0.50000	--	0.58682	6/7	0177	10
50-00-0	FORMALDEHYDE SOLUTION	500	ML	0.50000	--	0.58682	6/7	0177	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0177	10
50-00-0	FORMALDEHYDE SOLUTION	500	ML	0.50000	--	0.58682	6/7	0177	10
50-00-0	FORMALDEHYDE	100	ML	0.10000	--	0.11736	6/7	0177	10
50-00-0	FORMALDEHYDE	100	ML	0.10000	--	0.11736	6/7	0177	10
50-00-0	FORMALDEHYDE	100	ML	0.10000	--	0.11736	6/7	0177	10

* Equals inventory x (365 days per yr/311 days)
[311 days = 95th percentile lowest turnover rate for historic use]

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Batch Assumptions:	Annual Usage	Assumed Annual Batches
	< 0.01 liter	1
	0.01-0.1 liter	5
	0.1-1.0 liter	10
	1.0-10 liter	25
	>10 liter	100

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data* Inventory Amount		*Calculated* Inventory Amount (liters)	*Recalculated* Inventory Amount (liters)	*Calculated* Annual Usage * (liters/yr)	*Entered Data* Building	Room	*Calculated* Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	1	GAL	3.78500	--	4.44220	6/7	0109	25
50-00-0	FORMALDEHYDE	80	ML	0.08000	--	0.09389	6/7	0196	5
50-00-0	BUFFERED NEUTRAL FORMALIN	4	L	4.00000	--	4.69453	6/7	0239	25
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0239	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0239	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0239	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0239	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0239	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0239	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0229	10
50-00-0	FORMALINE SOLUTION ACCUSTAIN 10%	4	L	4.00000	--	4.69453	6/7	0204	25
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0204	10
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	1	GAL	3.78500	--	4.44220	6/7	0188C	25
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	1	GAL	3.78500	--	4.44220	6/7	0188C	25
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	1	GAL	3.78500	--	4.44220	6/7	0188C	25
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	1	GAL	3.78500	--	4.44220	6/7	0188C	25
50-00-0	FORMALDEHYDE SOLUTION	500	ML	0.50000	--	0.58682	6/7	0188C	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0188C	10
50-00-0	FORMALDEHYDE	25	ML	0.02500	--	0.02934	6/7	0287	5
50-00-0	FORMALDEHYDE	10	ML	0.01000	--	0.01174	6/7	0287	5
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0287	10
50-00-0	FORMALIN SOLUTION	15	ML	0.01500	--	0.01760	6/7	0241	5
50-00-0	FORMALDEHYDE SOLUTION	500	ML	0.50000	--	0.58682	6/7	0240	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0239	10
50-00-0	FORMALDEHYDE	5	ML	0.00500	--	0.00587	6/7	0239	1
50-00-0	FORMALDEHYDE	150	ML	0.15000	--	0.17605	6/7	0295	10
50-00-0	FORMALDEHYDE	150	ML	0.15000	--	0.17605	6/7	0295	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0295	10
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	35	ML	0.03500	--	0.04108	6/7	0128	5
50-00-0	FORMALDEHYDE	1	L	1.00000	--	1.17363	6/7	0185	25
50-00-0	FORMALDEHYDE, 37 WT IN H2O	500	ML	0.50000	--	0.58682	6/7	0216	10
50-00-0	FORMALDEHYDE	1000	ML	1.00000	--	1.17363	6/7	0209	25
50-00-0	FORMALDEHYDE, 37 WT	500	ML	0.50000	--	0.58682	6/7	0220	10
50-00-0	FORMALDEHYDE 37 % IN WATER	500	ML	0.50000	--	0.58682	6/7	0220	10
50-00-0	FORMALDEHYDE	100	ML	0.10000	--	0.11736	6/7	0220	10
50-00-0	FORMALDEHYDE	100	ML	0.10000	--	0.11736	6/7	0220	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0220	10
50-00-0	FORMALDEHYDE	500	ML	0.50000	--	0.58682	6/7	0220	10
50-00-0	FORMALDEHYDE SOLUTION	500	ML	0.50000	--	0.58682	6/7	0220	10
50-00-0	FORMALIN	1	L	1.00000	--	1.17363	6/7	0255	25
56-23-5	CARBON TETRACHLORIDE	1	PT	0.47318	--	0.55534	6/7	0239	10
58-89-9	CYCLOHEXANE, 1,2,3,4,5,6-HEXACHLORO-, GAMMA-ISOMER	500	G	**Units**	0.31387	0.36837	6/7	0188C	10
58-89-9	CYCLOHEXANE, 1,2,3,4,5,6-HEXACHLORO-, GAMMA-ISOMER	500	G	**Units**	0.31387	0.36837	6/7	0188C	10
58-89-9	CYCLOHEXANE, 1,2,3,4,5,6-HEXACHLORO-, GAMMA-ISOMER	5	G	**Units**	0.00314	0.00368	6/7	0188C	1
58-89-9	CYCLOHEXANE, 1,2,3,4,5,6-HEXACHLORO-, GAMMA-ISOMER	5	G	**Units**	0.00314	0.00368	6/7	0188C	1
62-53-3	ANILINE OIL	500	G	**Units**	0.48924	0.57418	8	4310	10
62-53-3	BENZAMINE	5	G	**Units**	0.00489	0.00574	6/7	0230	1
67-56-1	METHANOL	1	GAL	3.78500	--	4.44220	9	0458	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	9	0459	25
67-56-1	METHANOL	2.5	L	2.50000	--	2.93408	9	0446	25
67-56-1	METHANOL	2.5	L	2.50000	--	2.93408	9	0446	25
67-56-1	METHANOL	1	ML	0.00100	--	0.00117	9	3219	1
67-56-1	METHANOL	4	L	4.00000	--	4.69453	9	3219	25

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	1.0-10 liter	25
	>10 liter	100

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data*		*Calculated*	*Recalculated*	*Calculated*	*Entered Data*		*Calculated*
		Inventory Amount		Inventory Amount (liters)	Inventory Amount (liters)	Annual Usage * (liters/yr)	Building	Room	Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
67-56-1	METHANOL	1	L	1.00000	--	1.17363	9	3219	25
67-56-1	COMBI METHANOL	1	L	1.00000	--	1.17363	9	3219	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8		25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4550	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4550	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4550	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4550	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4550	25
67-56-1	METHANOL	2	L	2.00000	--	2.34727	8	4550	25
67-56-1	METHANOL	2	L	2.00000	--	2.34727	8	4550	25
67-56-1	METHANOL	2	L	2.00000	--	2.34727	8	4550	25
67-56-1	METHANOL	2	L	2.00000	--	2.34727	8	4550	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4550	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4550	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4550	25
67-56-1	METHANOL	2	L	2.00000	--	2.34727	8	4550	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4524	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4524	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4524	25
67-56-1	METHANOL	1	GAL	3.78500	--	4.44220	8	4524	25
67-56-1	METHANOL	100	ML	0.10000	--	0.11736	8	4510	10
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4465R	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4440	25
67-56-1	METHANOL	250	ML	0.25000	--	0.29341	8	4440	10
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4440	25
67-56-1	METHANOL	1	GAL	3.78500	--	4.44220	8	4440	25
67-56-1	METHANOL	1	GAL	3.78500	--	4.44220	8	4440	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4440	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4440	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4410	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4410	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4410	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4410	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4410	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4410	25
67-56-1	METHANOL	1	GAL	3.78500	--	4.44220	8	4410	25
67-56-1	METHANOL	1	GAL	3.78500	--	4.44220	8	4410	25
67-56-1	METHANOL	1	GAL	3.78500	--	4.44220	8	4410	25
67-56-1	METHANOL	1	GAL	3.78500	--	4.44220	8	4410	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4410	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4410	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4410	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4410	25
67-56-1	METHANOL	19	L	19.00000	--	22.29904	8	4330M	100
67-56-1	METHANOL	19	L	19.00000	--	22.29904	8	4330M	100
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4330M	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4330M	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4330M	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4330M	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4316	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4316	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25

* Equals inventory x (365 days per yr/311 days)
[311 days = 95th percentile lowest turnover rate for historic use]

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Chemical Inventory Data (Table G-2)

Conservatively assume specific gravity of 0.7 for laboratory liquids (0.649 liter/lb) when units are in pounds

Batch Assumptions:	Annual Usage	Assumed Annual Batches
	< 0.01 liter	1
	0.01-0.1 liter	5
	0.1-1.0 liter	10
	1.0-10 liter	25
	>10 liter	100

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data* Inventory Amount		*Calculated* Inventory Amount (liters)	*Recalculated* Inventory Amount (liters)	*Calculated* Annual Usage * (liters/yr)	*Entered Data* Building	Room	*Calculated* Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4310	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4310	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4310	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4310	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4310	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	100	ML	0.10000	--	0.11736	8	4310	10
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	500	ML	0.50000	--	0.58682	8	4310	10
67-56-1	METHANOL	100	ML	0.10000	--	0.11736	8	4310	10
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4310	25
67-56-1	METHANOL	500	ML	0.50000	--	0.58682	8	4310	10
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	2.5	L	2.50000	--	2.93408	8	4310	25
67-56-1	METHANOL	2.5	L	2.50000	--	2.93408	8	4310	25
67-56-1	METHANOL	2.5	L	2.50000	--	2.93408	8	4310	25
67-56-1	METHANOL	2.5	L	2.50000	--	2.93408	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4310	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4308	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4308	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4308	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4308	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4308	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4308	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	4308	25
67-56-1	HYDRA-POINT METHANOL, DRY	1	L	1.00000	--	1.17363	8	4302	25
67-56-1	HYDRA-POINT METHANOL, DRY	1	L	1.00000	--	1.17363	8	4302	25
67-56-1	AMMONIA 7N SOLUTION IN METHANOL	100	ML	0.10000	--	0.11736	8	4302	10
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4302	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4302	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4302	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4302	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4302	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4302	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4302	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	4302	25

* Equals inventory x (365 days per yr/311 days)
[311 days = 95th percentile lowest turnover rate for historic use]

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
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Chemical Inventory Data (Table G-2)

Conservatively assume specific gravity of 0.7 for laboratory liquids (0.649 liter/lb) when units are in pounds

Batch Assumptions:	Annual Usage	Assumed Annual Batches
	< 0.01 liter	1
	0.01-0.1 liter	5
	0.1-1.0 liter	10
	1.0-10 liter	25
	>10 liter	100

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data*		*Calculated*	*Recalculated*	*Calculated*	*Entered Data*		*Calculated*
		Inventory Amount		Inventory Amount (liters)	Inventory Amount (liters)	Annual Usage * (liters/yr)	Building	Room	Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
67-56-1	METHANOL	100	ML	0.10000	--	0.11736	8	4240	10
67-56-1	METHANOL	1	ML	0.00100	--	0.00117	8	3219	1
67-56-1	METHANOL	4	L	4.00000	--	4.69453	8	3219	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	8	3219	25
67-56-1	COMBI METHANOL	1	L	1.00000	--	1.17363	8	3219	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	6/7	0293	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0286	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0286	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0286	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	6/7	0244	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	6/7	0244	25
67-56-1	METHYL ALCOHOL	1	L	1.00000	--	1.17363	6/7	0244	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0239	25
67-56-1	METHANOL	4	GAL	15.14000	--	17.76881	6/7	00196	100
67-56-1	METHANOL	1	L	1.00000	--	1.17363	6/7	0128	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0128	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0128	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0128	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0128	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0128	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0128	25
67-56-1	METHANOL	2	L	2.00000	--	2.34727	6/7	0116	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0116	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0116	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0106	25
67-56-1	METHANOL	5	L	5.00000	--	5.86817	6/7	0177	25
67-56-1	METHANOL	100	ML	0.10000	--	0.11736	6/7	0177	10
67-56-1	METHANOL	1	L	1.00000	--	1.17363	6/7	0177	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0196	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	6/7	0244	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	6/7	0239	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0204	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0204	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0204	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0204	25
67-56-1	METHANOL	500	ML	0.50000	--	0.58682	6/7	0188C	10
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0188C	25
67-56-1	METHANOL	1	L	1.00000	--	1.17363	6/7	0188C	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0293	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0271	25
67-56-1	METHANOL	100	ML	0.10000	--	0.11736	6/7	0240	10
67-56-1	METHANOL	500	ML	0.50000	--	0.58682	6/7	0295	10
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0295	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0187	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0187	25
67-56-1	METHANOL	1	GAL	3.78500	--	4.44220	6/7	0109	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0216	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0216	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0216	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0216	25
67-56-1	METHANOL	2	L	2.00000	--	2.34727	6/7	0209A	25
67-56-1	METHANOL	4	L	4.00000	--	4.69453	6/7	0209	25
67-56-1	METHANOL	1	GAL	3.78500	--	4.44220	6/7	0209	25

* Equals inventory x (365 days per yr/311 days)
[311 days = 95th percentile lowest turnover rate for historic use]

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Chemical Inventory Data (Table G-2)

Conservatively assume specific gravity of 0.7 for laboratory liquids (0.649 liter/lb) when units are in pounds

Batch Assumptions:	Annual Usage	Assumed Annual Batches
	< 0.01 liter	*1*
	0.01-0.1 liter	*5*
	0.1-1.0 liter	*10*
	1.0-10 liter	*25*
	>10 liter	*100*

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data*		*Calculated*	*Recalculated*	*Calculated*	*Entered Data*		*Calculated*
		Inventory Amount		Inventory Amount (liters)	Inventory Amount (liters)	Annual Usage * (liters/yr)	Building	Room	Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
67-56-1	METHANOL	1	L	1.00000	--	1.17363	6/7	0220	25
67-56-1	METHANOL	500	ML	0.50000	--	0.58682	6/7	0220	10
67-56-1	METHANOL	1	L	1.00000	--	1.17363	6/7	0220	25
67-63-0	ISOPROPYL ALCOHOL (2)	60	L	60.00000	--	70.41801	9	0120A	100
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	9	0139	25
67-63-0	ISOPROPANOL	4	L	4.00000	--	4.69453	9	0139	25
67-63-0	ISOPROPYL ALCOHOL	15	OZ	0.44360	--	0.52063	9	0355K	10
67-63-0	ISOPROPYL ALCOHOL	16	OZ	0.47318	--	0.55534	9	0355K	10
67-63-0	ISOPROPANOL	250	ML	0.25000	--	0.29341	9	0412	10
67-63-0	ISOPROPYL ALCOHOL	250	ML	0.25000	--	0.29341	9	0412	10
67-63-0	ISOPROPYL ALCOHOL	100	KG	**Units**	127.38854	149.50744	9	0458	100
67-63-0	ISOPROPANOL	15	L	15.00000	--	17.60450	9	0459	100
67-63-0	ISOPROPYL ALCOHOL	4	L	4.00000	--	4.69453	9	0458	25
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	9	0459	10
67-63-0	ISOPROPYL ALCOHOL	1	KG	**Units**	1.27389	1.49507	9	0459	25
67-63-0	ISOPROPANOL	500	ML	0.50000	--	0.58682	9	0412	10
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	9	0459	10
67-63-0	ISOPROPYL ALCOHOL	500	ML	0.50000	--	0.58682	9	0412	10
67-63-0	ISOPROPYL ALCOHOL	250	ML	0.25000	--	0.29341	9	0413	10
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	9	0412	10
67-63-0	ISOPROPANOL	1	L	1.00000	--	1.17363	9	0458	25
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	9	0413	10
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	9	0446	25
67-63-0	ISOPROPANOL	500	ML	0.50000	--	0.58682	9	0446	10
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	9	0446	10
67-63-0	ISOPROPYL ALCOHOL	500	ML	0.50000	--	0.58682	9	0413	10
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	9	0412	25
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	9	0412	5
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	9	0412	5
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	9	0412	10
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	9	0412	5
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	9	0412	5
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	9	0412	5
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	9	0412	5
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	9	0412	5
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	9	0412	5
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	9	0412	5
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	9	0415A	25
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	9	0412	10
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	9	0412	10
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	9	0412	10
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	9	3223	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	9	3223	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	9	3223	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	9	3223	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	9	3223	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	9	3223	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	9	3223	25
67-63-0	2-PROPANOL	1	L	1.00000	--	1.17363	9	3219	25
67-63-0	ISOPROPYL ALCOHOL	4	L	4.00000	--	4.69453	8	4550	25
67-63-0	ISOPROPYL ALCOHOL	25	ML	0.02500	--	0.02934	8	4550	5
67-63-0	ISOPROPYL	1	G	**Units**	1.27389	1.49507	8	4550	25
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	8	4550	10

* Equals inventory x (365 days per yr/311 days)
[311 days = 95th percentile lowest turnover rate for historic use]

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Chemical Inventory Data (Table G-2)

Conservatively assume specific gravity of 0.7 for laboratory liquids (0.649 liter/lb) when units are in pounds

Batch Assumptions:	Annual Usage	Assumed Annual Batches
	< 0.01 liter	1
	0.01-0.1 liter	5
	0.1-1.0 liter	10
	1.0-10 liter	25
	>10 liter	100

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data*		*Calculated*	*Recalculated*	*Calculated*	*Entered Data*		*Calculated*
		Inventory Amount		Inventory Amount (liters)	Inventory Amount (liters)	Annual Usage * (liters/yr)	Building	Room	Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	8	4550	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	8	4550	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	8	4550	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	8	4550	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	8	4550	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	8	4550	25
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	8	4524	10
67-63-0	ISOPROPYL ALCOHOL	2	L	2.00000	--	2.34727	8	4524	25
67-63-0	ISOPROPYL ALCOHOL	4	L	4.00000	--	4.69453	8	4440	25
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	8	4440	10
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	8	4440	5
67-63-0	2-PROPANOL	1	GAL	3.78500	--	4.44220	8	4440	25
67-63-0	2-PROPANOL	1	GAL	3.78500	--	4.44220	8	4440	25
67-63-0	ISOPROPANOL	1	L	1.00000	--	1.17363	8	4440	25
67-63-0	ISOPROPANOL	1	L	1.00000	--	1.17363	8	4440	25
67-63-0	ISOPROPANOL	4	L	4.00000	--	4.69453	8	4410	25
67-63-0	ISOPROPYL ALCOHOL	4	L	4.00000	--	4.69453	8	4340	25
67-63-0	ISOPROPYL ALCOHOL	4	L	4.00000	--	4.69453	8	4340	25
67-63-0	ISOPROPYL ALCOHOL	4	L	4.00000	--	4.69453	8	4340	25
67-63-0	ISOPROPYL ALCOHOL	4	L	4.00000	--	4.69453	8	4340	25
67-63-0	ISOPROPYL ALCOHOL	5	L	5.00000	--	5.86817	8	4310	25
67-63-0	ISOPROPANOL	4	L	4.00000	--	4.69453	8	4308	25
67-63-0	ISOPROPANOL	4	L	4.00000	--	4.69453	8	4308	25
67-63-0	2-PROPANOL	5	L	5.00000	--	5.86817	8	4308	25
67-63-0	ISOPROPANOL	4	L	4.00000	--	4.69453	8	4302	25
67-63-0	ISOPROPANOL	4	L	4.00000	--	4.69453	8	4302	25
67-63-0	2-PROPANOL	4	L	4.00000	--	4.69453	8	4302	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	8	3202D	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	8	3223	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	8	3223	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	8	3223	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	8	3223	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	8	3223	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	8	3223	25
67-63-0	2-PROPANOL	1	L	1.00000	--	1.17363	8	3219	25
67-63-0	2-PROPANOL	1	L	1.00000	--	1.17363	6/7	0166	25
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	6/7	0166	10
67-63-0	ISOPROPYL ALCOHOL	500	ML	0.50000	--	0.58682	6/7	0166	10
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	6/7	0166	10
67-63-0	ISOPROPYL ALCOHOL	4	L	4.00000	--	4.69453	6/7	0293	25
67-63-0	ISOPROPYL ALCOHOL	4	L	4.00000	--	4.69453	6/7	0293	25
67-63-0	ISOPROPYL ALCOHOL	500	ML	0.50000	--	0.58682	6/7	0293	10
67-63-0	ISOPROPYL ALCOHOL	4	L	4.00000	--	4.69453	6/7	0271	25
67-63-0	ISOPROPYL ALCOHOL	4	L	4.00000	--	4.69453	6/7	0271	25
67-63-0	ISOPROPYL ALCOHOL	4	L	4.00000	--	4.69453	6/7	0271	25
67-63-0	ISOPROPYL ALCOHOL	500	ML	0.50000	--	0.58682	6/7	0244	10
67-63-0	2-PROPANOL	1	L	1.00000	--	1.17363	6/7	0244	25
67-63-0	2-PROPANOL	1	L	1.00000	--	1.17363	6/7	0196A	25
67-63-0	ISOPROPANOL	1	L	1.00000	--	1.17363	6/7	0196A	25
67-63-0	ISOPROPANOL	1	L	1.00000	--	1.17363	6/7	0196A	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	6/7	0196	25
67-63-0	ISOPROPYL ALCOHOL	25	ML	0.02500	--	0.02934	6/7	0128	5

* Equals inventory x (365 days per yr/311 days)
[311 days = 95th percentile lowest turnover rate for historic use]

Golder Associates

Calculation of Liquid Chemical Emissions
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Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Chemical Inventory Data (Table G-2)

Conservatively assume specific gravity of 0.7 for laboratory liquids (0.649 liter/lb) when units are in pounds

Batch Assumptions:	Annual Usage	Assumed Annual Batches
	< 0.01 liter	1
	0.01-0.1 liter	5
	0.1-1.0 liter	10
	1.0-10 liter	25
	>10 liter	100

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data* Inventory Amount		*Calculated* Inventory Amount (liters)	*Recalculated* Inventory Amount (liters)	*Calculated* Annual Usage * (liters/yr)	*Entered Data* Building	Room	*Calculated* Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
67-63-0	ISOPROPYL ALCOHOL	25	ML	0.02500	--	0.02934	6/7	0128	5
67-63-0	ISOPROPYL ALCOHOL	25	ML	0.02500	--	0.02934	6/7	0128	5
67-63-0	ISOPROPYL ALCOHOL	25	ML	0.02500	--	0.02934	6/7	0128	5
67-63-0	ISOPROPYL ALCOHOL	25	ML	0.02500	--	0.02934	6/7	0128	5
67-63-0	ISOPROPYL ALCOHOL	25	ML	0.02500	--	0.02934	6/7	0128	5
67-63-0	ISOPROPYL ALCOHOL	25	ML	0.02500	--	0.02934	6/7	0128	5
67-63-0	ISOPROPANOL ALCOHOL	4	L	4.00000	--	4.69453	6/7	0128	25
67-63-0	ISOPROPANOL ALCOHOL	4	L	4.00000	--	4.69453	6/7	0128	25
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	6/7	0128	5
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	6/7	0128	5
67-63-0	2-PROPANOL	1	GAL	3.78500	--	4.44220	6/7	0128	25
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	6/7	0128	5
67-63-0	2-PROPANOL	1	GAL	3.78500	--	4.44220	6/7	0128	25
67-63-0	2-PROPANOL	4	L	4.00000	--	4.69453	6/7	0128	25
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	6/7	0128	5
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	6/7	0128	5
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	6/7	0128	5
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	6/7	0128	5
67-63-0	ISOPROPYL ALCOHOL	500	ML	0.50000	--	0.58682	6/7	0128	10
67-63-0	ISOPROPYL ALCOHOL	500	ML	0.50000	--	0.58682	6/7	0128	10
67-63-0	ISOPROPANOL	1	L	1.00000	--	1.17363	6/7	0196A	25
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	6/7	0116	10
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	6/7	0116	10
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	6/7	0116	10
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	6/7	0116	5
67-63-0	2-PROPANOL	2	L	2.00000	--	2.34727	6/7	0116	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	6/7	0177	25
67-63-0	ISOPROPANOL	250	ML	0.25000	--	0.29341	6/7	0177	10
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	6/7	0177	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	6/7	0177	25
67-63-0	2-PROPANOL	4	L	4.00000	--	4.69453	6/7	0196	25
67-63-0	ISOPROPYL ALCOHOL	500	ML	0.50000	--	0.58682	6/7	0239	10
67-63-0	MICROSHARP CLEANING FLUID	236	ML	0.23600	--	0.27698	6/7	0204	10
67-63-0	MICROSHARP CLEANING FLUID	236	ML	0.23600	--	0.27698	6/7	0204	10
67-63-0	MICROSHARP CLEANING FLUID	236	ML	0.23600	--	0.27698	6/7	0204	10
67-63-0	MICROSHARP CLEANING FLUID	236	ML	0.23600	--	0.27698	6/7	0204	10
67-63-0	MICROSHARP CLEANING FLUID	236	ML	0.23600	--	0.27698	6/7	0204	10
67-63-0	ISOPROPANOL	500	ML	0.50000	--	0.58682	6/7	0188C	10
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	6/7	0188C	10
67-63-0	ISOPROPANOL	25	ML	0.02500	--	0.02934	6/7	0188C	5
67-63-0	ISOPROPANOL	25	ML	0.02500	--	0.02934	6/7	0188C	5
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	6/7	0188C	10
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	6/7	0188C	10
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	6/7	0188C	10
67-63-0	2-PROPANOL	500	ML	0.50000	--	0.58682	6/7	0188C	10
67-63-0	ISOPROPANOL	500	ML	0.50000	--	0.58682	6/7	0293	10
67-63-0	N-HYDROXYSUCCINIMIDYL-ACTIVATED AGAROSE	5	ML	0.00500	--	0.00587	6/7	0287	1
67-63-0	2-PROPANOL	4	L	4.00000	--	4.69453	6/7	0287	25
67-63-0	ISOPROPYL ALCOHOL	4	L	4.00000	--	4.69453	6/7	0271	25
67-63-0	ISOPROPANOL	500	ML	0.50000	--	0.58682	6/7	0240	10
67-63-0	ISOPROPYL ALCOHOL	100	ML	0.10000	--	0.11736	6/7	0239	10
67-63-0	ISOPROPANOL	500	ML	0.50000	--	0.58682	6/7	0239	10
67-63-0	ISOPROPANOL	500	ML	0.50000	--	0.58682	6/7	0295	10

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Golder Associates

Calculation of Liquid Chemical Emissions
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Conservatively assume specific gravity of 0.7 for laboratory liquids (0.649 liter/lb) when units are in pounds

Batch Assumptions:	Annual Usage	Assumed Annual Batches
	< 0.01 liter	1
	0.01-0.1 liter	5
	0.1-1.0 liter	10
	1.0-10 liter	25
	>10 liter	100

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data*		*Calculated*	*Recalculated*	*Calculated*	*Entered Data*		*Calculated*
		Inventory Amount		Inventory Amount (liters)	Inventory Amount (liters)	Annual Usage * (liters/yr)	Building	Room	Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
67-63-0	2-PROPANOL	1	L	1.00000	--	1.17363	6/7	0295	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	6/7	0240	25
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	6/7	0106	5
67-63-0	ISOPROPYL ALCOHOL	25	ML	0.02500	--	0.02934	6/7	0128	5
67-63-0	ISOPROPYL ALCOHOL	25	ML	0.02500	--	0.02934	6/7	0128	5
67-63-0	ISOPROPYL ALCOHOL	25	ML	0.02500	--	0.02934	6/7	0128	5
67-63-0	ISOPROPYL ALCOHOL	25	ML	0.02500	--	0.02934	6/7	0128	5
67-63-0	ISOPROPYL ALCOHOL	25	ML	0.02500	--	0.02934	6/7	0128	5
67-63-0	ISOPROPANOL	1	L	1.00000	--	1.17363	6/7	0187	25
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	6/7	0166	25
67-63-0	2-PROPANOL	25	ML	0.02500	--	0.02934	6/7	0109	5
67-63-0	ISOPROPYL ALCOHOL	2.5	L	2.50000	--	2.93408	6/7	0217	25
67-63-0	ISOPROPYL ALCOHOL	8	L	8.00000	--	9.38907	6/7	0216	25
67-63-0	2-PROPANOL	1	L	1.00000	--	1.17363	6/7	0209	25
67-63-0	ISOPROPYL ALCOHOL	500	ML	0.50000	--	0.58682	6/7	0208	10
67-63-0	ISOPROPYL ALCOHOL	500	ML	0.50000	--	0.58682	6/7	0220	10
67-63-0	ISOPROPYL ALCOHOL	500	ML	0.50000	--	0.58682	6/7	0220	10
67-63-0	ISOPROPYL ALCOHOL	4	L	4.00000	--	4.69453	6/7	0220	25
67-63-0	ISOPROPYL ALCOHOL	4	L	4.00000	--	4.69453	6/7	0220	25
67-63-0	ISOPROPYL ALCOHOL	500	ML	0.50000	--	0.58682	6/7	0220	10
67-63-0	ISOPROPANOL	25	ML	0.02500	--	0.02934	6/7	0220	5
67-63-0	ISOPROPYL ALCOHOL	1	L	1.00000	--	1.17363	6/7	0220	25
67-63-0	ISOPROPYL ALCOHOL	2	L	2.00000	--	2.34727	6/7	0220	25
67-66-3	CHLOROFORM	100	ML	0.10000	--	0.11736	9	0139	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	9	0139	10
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL 24:1	500	ML	0.50000	--	0.58682	9	0412	10
67-66-3	CHLOROFORM ISOAMYL ALCOHOL	100	ML	0.10000	--	0.11736	9	0412	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	9	0459	10
67-66-3	CHLOROFORM ISOAMYL ALCOHOL	500	ML	0.50000	--	0.58682	9	0459	10
67-66-3	CHLOROFORM ISOAMYL ALCOHOL	500	ML	0.50000	--	0.58682	9	0459	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	9	0459	10
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL 24:1	100	ML	0.10000	--	0.11736	9	0459	10
67-66-3	CHLOROFORM	1	L	1.00000	--	1.17363	9	0446	25
67-66-3	CHLOROFORM	1	L	1.00000	--	1.17363	9	0446	25
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	9	0413	10
67-66-3	CHLOROFORM	1	L	1.00000	--	1.17363	9	0412	25
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	9	0413	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	9	0459	10
67-66-3	CHLOROFORM	25	ML	0.02500	--	0.02934	9	0459	5
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL 24:1	1	QT	0.94635	--	1.11067	9	0446	25
67-66-3	CHLOROFORM: ISOAMYL ALCOHOL MIXTURE	500	ML	0.50000	--	0.58682	9	0446	10
67-66-3	CHLOROFORM	25	ML	0.02500	--	0.02934	9	0412	5
67-66-3	CHLOROFORM	400	ML	0.40000	--	0.46945	9	0459	10
67-66-3	CHLOROFORM	400	ML	0.40000	--	0.46945	9	0459	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	9	0446	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	9	0446	10
67-66-3	CHLOROFORM	1	PT	0.47318	--	0.55534	9	0459	10
67-66-3	CHLOROFORM	1	PT	0.47318	--	0.55534	9	0459	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	9	0412	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	9	0412	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	9	0412	10
67-66-3	CHLOROFORM	4	L	4.00000	--	4.69453	9	3219	25
67-66-3	CHLOROFORM HPLC PURE	1	L	1.00000	--	1.17363	9	3219	25

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Batch Assumptions:	Annual Usage	Assumed Annual Batches
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	0.01-0.1 liter	5
	0.1-1.0 liter	10
	1.0-10 liter	25
	>10 liter	100

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data*		*Calculated*	*Recalculated*	*Calculated*	*Entered Data*		*Calculated*
		Inventory Amount		Inventory Amount (liters)	Inventory Amount (liters)	Annual Usage * (liters/yr)	Building	Room	Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
67-66-3	CHLOROFORM	4	L	4.00000	--	4.69453	8	4550	25
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL MIXTURE	100	ML	0.10000	--	0.11736	8	4550	10
67-66-3	CHLOROFORM	25	ML	0.02500	--	0.02934	8	4550	5
67-66-3	CHLOROFORM	100	ML	0.10000	--	0.11736	8	4550	10
67-66-3	CHLOROFORM	1	L	1.00000	--	1.17363	8	4550	25
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	8	4550	10
67-66-3	CHLOROFORM	1	L	1.00000	--	1.17363	8	4550	25
67-66-3	CHLOROFORM	50	G	**Units**	0.03372	0.03957	8	4525	5
67-66-3	CHLOROFORM	25	ML	0.02500	--	0.02934	8	4524	5
67-66-3	CHLOROFORM	25	ML	0.02500	--	0.02934	8	4524	5
67-66-3	CHLOROFORM	25	ML	0.02500	--	0.02934	8	4524	5
67-66-3	CHLOROFORM	4	L	4.00000	--	4.69453	8	4440	25
67-66-3	CHLOROFORM	2	L	2.00000	--	2.34727	8	4440	25
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	8	4440	10
67-66-3	CHLOROFORM: ISOAMYL ALCOHOL	500	ML	0.50000	--	0.58682	8	4440	10
67-66-3	CHLOROFORM: ISOAMYL ALCOHOL	500	ML	0.50000	--	0.58682	8	4440	10
67-66-3	CHLOROFORM	4	L	4.00000	--	4.69453	8	4440	25
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL	100	ML	0.10000	--	0.11736	8	4440	10
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL 24:1	500	ML	0.50000	--	0.58682	8	4440	10
67-66-3	CHLOROFORM	1	L	1.00000	--	1.17363	8	4440	25
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	8	4330P	10
67-66-3	CHLOROFORM	1	L	1.00000	--	1.17363	8	4310	25
67-66-3	CHLOROFORM	2	L	2.00000	--	2.34727	8	4310	25
67-66-3	CHLOROFORM	2.5	L	2.50000	--	2.93408	8	4310	25
67-66-3	CHLOROFORM	2.5	L	2.50000	--	2.93408	8	4310	25
67-66-3	CHLOROFORM	2.5	L	2.50000	--	2.93408	8	4302	25
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	8	4230M	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	8	4230M	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	8	4230M	10
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL	1	PT	0.47318	--	0.55534	8	3202D	10
67-66-3	CHLOROFORM	4	L	4.00000	--	4.69453	8	3219	25
67-66-3	CHLOROFORM HPLC PURE	1	L	1.00000	--	1.17363	8	3219	25
67-66-3	CHLOROFORM	100	ML	0.10000	--	0.11736	6/7	0166	10
67-66-3	TRICHLOROMETHANE	25	ML	0.02500	--	0.02934	6/7	0166	5
67-66-3	CHLOROFORM	25	ML	0.02500	--	0.02934	6/7	0166	5
67-66-3	CHLOROFORM	25	ML	0.02500	--	0.02934	6/7	0166	5
67-66-3	CHLOROFORM: ISOAMYL ALCOHOL MIXTURE	450	ML	0.45000	--	0.52814	6/7	0293	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0293	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0293	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0244	10
67-66-3	CHLOROFORM	100	G	**Units**	0.06743	0.07914	6/7	0244	5
67-66-3	CHLOROFORM	1	QT	0.94635	--	1.11067	6/7	0128	25
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0128	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0128	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0128	10
67-66-3	CHLOROFORM	4	L	4.00000	--	4.69453	6/7	0128	25
67-66-3	CHLOROFORM	4	L	4.00000	--	4.69453	6/7	0128	25
67-66-3	CHLOROFORM	4	L	4.00000	--	4.69453	6/7	0128	25
67-66-3	CHLOROFORM/ISOAMYL ALCOHOL	50	ML	0.05000	--	0.05868	6/7	0128	5
67-66-3	CHLOROFORM	1	L	1.00000	--	1.17363	6/7	0196A	25
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0196A	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0196A	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0196A	10

* Equals inventory x (365 days per yr/311 days)
[311 days = 95th percentile lowest turnover rate for historic use]

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Chemical Inventory Data (Table G-2)

Conservatively assume specific gravity of 0.7 for laboratory liquids (0.649 liter/lb) when units are in pounds

Batch Assumptions:	Annual Usage	Assumed Annual Batches
	< 0.01 liter	1
	0.01-0.1 liter	5
	0.1-1.0 liter	10
	1.0-10 liter	25
	>10 liter	100

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data*		*Calculated*	*Recalculated*	*Calculated*	*Entered Data*		*Calculated*
		Inventory Amount		Inventory Amount (liters)	Inventory Amount (liters)	Annual Usage * (liters/yr)	Building	Room	Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0116	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0116	10
67-66-3	CHLOROFORM	4	L	4.00000	--	4.69453	6/7	0177	25
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0177	10
67-66-3	CHLOROFORM	25	ML	0.02500	--	0.02934	6/7	0177	5
67-66-3	CHLOROFORM	25	ML	0.02500	--	0.02934	6/7	0177	5
67-66-3	CHLOROFORM	25	ML	0.02500	--	0.02934	6/7	0177	5
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0244	10
67-66-3	CHLOROFORM	4	L	4.00000	--	4.69453	6/7	0204	25
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0204	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0204	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0204	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0204	10
67-66-3	CHLOROFORM	25	ML	0.02500	--	0.02934	6/7	0188C	5
67-66-3	CHLOROFORM	1000	ML	1.00000	--	1.17363	6/7	0188C	25
67-66-3	CHLOROFORM	25	ML	0.02500	--	0.02934	6/7	0287	5
67-66-3	CHLOROFORM	100	ML	0.10000	--	0.11736	6/7	0287	10
67-66-3	CHLOROFORM	25	ML	0.02500	--	0.02934	6/7	0287	5
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0239	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0239	10
67-66-3	CHLOROFORM	950	ML	0.95000	--	1.11495	6/7	0295	25
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0295	10
67-66-3	CHLOROFORM	25	ML	0.02500	--	0.02934	6/7	0295	5
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0128	10
67-66-3	CHLOROFORM	25	ML	0.02500	--	0.02934	6/7	0109	5
67-66-3	CHLOROFORM	1	L	1.00000	--	1.17363	6/7	0217	25
67-66-3	CHLOROFORM	1	L	1.00000	--	1.17363	6/7	0216	25
67-66-3	CHLOROFORM	25	ML	0.02500	--	0.02934	6/7	0209	5
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0209	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0220	10
67-66-3	CHLOROFORM	500	ML	0.50000	--	0.58682	6/7	0220	10
68-12-2	N-N-DIMETHYLFOMAMIDE	100	ML	0.10000	--	0.11736	9	0446	10
68-12-2	N,N-DIMETHYLFORMAMIDE	500	ML	0.50000	--	0.58682	8	4550	10
68-12-2	N,N-DIMETHYLFORMAMIDE	1	L	1.00000	--	1.17363	8	4550	25
68-12-2	N,N-DIMETHYLFORMAMIDE	250	ML	0.25000	--	0.29341	8	4440	10
68-12-2	N,N-DIMETHYLFORMAMIDE	2	L	2.00000	--	2.34727	8	4440	25
68-12-2	N-N-DIMETHYL FORMAMIDE	4	L	4.00000	--	4.69453	8	4310	25
68-12-2	N,N-DIMETHYLFORMAMIDE	1	L	1.00000	--	1.17363	8	4310	25
68-12-2	N,N-DIMETHYLFORMAMIDE, ANHYDROUS	1	L	1.00000	--	1.17363	8	4310	25
68-12-2	DMF	500	ML	0.50000	--	0.58682	8	4208	10
68-12-2	DMF	500	ML	0.50000	--	0.58682	6/7	0166	10
68-12-2	DMF	1	L	1.00000	--	1.17363	6/7	0166	25
68-12-2	DMF	250	ML	0.25000	--	0.29341	6/7	0166	10
68-12-2	DIMETHYLFORMAMIDE	500	ML	0.50000	--	0.58682	6/7	0293	10
68-12-2	DMF	1	ML	0.00100	--	0.00117	6/7	0239	1
68-12-2	DMF	250	ML	0.25000	--	0.29341	6/7	0209	10
68-12-2	DMF	500	ML	0.50000	--	0.58682	6/7	0128	10
68-12-2	DIMETHYLFORMAMIDE	500	ML	0.50000	--	0.58682	6/7	0128	10
68-12-2	DIMETHYL-FORMAMIDE	250	ML	0.25000	--	0.29341	6/7	0196A	10
68-12-2	DIMETHYL-FORMAMIDE	250	ML	0.25000	--	0.29341	6/7	0116	10
68-12-2	DIMETHYLFORMAMIDE	250	ML	0.25000	--	0.29341	6/7	0116	10
68-12-2	DIMETHYLFORMAMIDE	1	L	1.00000	--	1.17363	6/7	0177	25
68-12-2	DMF	1	L	1.00000	--	1.17363	6/7	0177	25

* Equals inventory x (365 days per yr/311 days)
[311 days = 95th percentile lowest turnover rate for historic use]

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Chemical Inventory Data (Table G-2)

Conservatively assume specific gravity of 0.7 for laboratory liquids (0.649 liter/lb) when units are in pounds

Batch Assumptions:	Annual Usage	Assumed Annual Batches
	< 0.01 liter	*1*
	0.01-0.1 liter	*5*
	0.1-1.0 liter	*10*
	1.0-10 liter	*25*
	>10 liter	*100*

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data*		*Calculated*	*Recalculated*	*Calculated*	*Entered Data*		*Calculated*
		Inventory Amount		Inventory Amount (liters)	Inventory Amount (liters)	Annual Usage * (liters/yr)	Building	Room	Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
68-12-2	N, N-DIMETHYLFORMAMIDE, REAGENT GRADE	100	ML	0.10000	--	0.11736	6/7	0239	10
68-12-2	N,N-DIMETHYLFORMAMIDE	100	ML	0.10000	--	0.11736	6/7	0188F	10
68-12-2	DIMETHYLFORMAMIDE	100	ML	0.10000	--	0.11736	6/7	0188C	10
68-12-2	N,N-DIMETHYL FORMAMIDE	100	ML	0.10000	--	0.11736	6/7	0239	10
68-12-2	N,N'-DIMETHYL FORMAMIDE	1	L	1.00000	--	1.17363	6/7	0239	25
68-12-2	N,N-DIMETHYLFORMAMIDE	500	ML	0.50000	--	0.58682	6/7	0295	10
68-12-2	DMF	500	ML	0.50000	--	0.58682	6/7	0239	10
68-12-2	DMF	500	CC	**Units**	0.50000	0.58682	6/7	0220	10
68-12-2	DMF	500	ML	0.50000	--	0.58682	6/7	0220	10
68-12-2	N,N-DIMETHYLFORMAMIDE	250	ML	0.25000	--	0.29341	6/7	0220	10
71-43-2	BENZENE	1	L	1.00000	--	1.17363	9	0139	25
71-43-2	BENZENE(ANHYDROUS)	1	L	1.00000	--	1.17363	8	4310	25
71-43-2	BENZENE(ANHYDROUS)	2	L	2.00000	--	2.34727	8	4208	25
71-43-2	BENZENE	100	ML	0.10000	--	0.11736	8	4208	10
71-43-2	BENZENE	1	L	1.00000	--	1.17363	6/7	0244	25
75-07-0	ACETALDEHYDE	5	ML	0.00500	--	0.00587	8	4550	1
75-07-0	ACETALDEHYDE	100	ML	0.10000	--	0.11736	8	4550	10
75-07-0	ACETALDEHYDE	100	ML	0.10000	--	0.11736	8	4440	10
75-09-2	DICHLOROMETHANE	100	ML	0.10000	--	0.11736	9	0446	10
75-09-2	METHYLENE CHLORIDE	4	L	4.00000	--	4.69453	8	4550	25
75-09-2	DICHLOROMETHANE	19	L	19.00000	--	22.29904	8	4550	100
75-09-2	TO BE VALIDATED-DICHLOROME, ANHYDROUS	100	ML	0.10000	--	0.11736	8	4550	10
75-09-2	DICHLOROMETHANE	1	L	1.00000	--	1.17363	8	4524	25
75-09-2	METHYLENE CHLORIDE	19	L	19.00000	--	22.29904	8	4462	100
75-09-2	METHYLENE CHLORIDE	4	L	4.00000	--	4.69453	8	4450B	25
75-09-2	METHYLENE CHLORIDE	4	L	4.00000	--	4.69453	8	4450B	25
75-09-2	METHYLENE CHLORIDE	100	ML	0.10000	--	0.11736	8	4440	10
75-09-2	METHYLENE CHLORIDE	1	L	1.00000	--	1.17363	8	4440	25
75-09-2	METHYLENE CHLORIDE	100	ML	0.10000	--	0.11736	8	4410	10
75-09-2	DICHLOROMETHANE	4	L	4.00000	--	4.69453	8	4410	25
75-09-2	DICHLOROMETHANE	4	L	4.00000	--	4.69453	8	4410	25
75-09-2	DICHLOROMETHANE	1	L	1.00000	--	1.17363	8	4310	25
75-09-2	METHYLENE CHLORIDE	1	L	1.00000	--	1.17363	8	4310	25
75-09-2	METHYLENE CHLORIDE	1	L	1.00000	--	1.17363	8	4310	25
75-09-2	DICHLOROMETHANE	20	L	20.00000	--	23.47267	8	4310	100
75-09-2	METHYLENE CHLORIDE	1	L	1.00000	--	1.17363	8	4310	25
75-09-2	DICHLOROMETHANE	20	L	20.00000	--	23.47267	8	4310	100
75-09-2	METHYLENE CHLORIDE	4	L	4.00000	--	4.69453	8	4310	25
75-09-2	DICHLOROMETHANE	4	L	4.00000	--	4.69453	8	4310	25
75-09-2	DICHLOROMETHANE	4	L	4.00000	--	4.69453	8	4410	25
75-09-2	METHANE, DICHLORO-	500	ML	0.50000	--	0.58682	6/7	0204	10
75-09-2	METHYLENE CHLORIDE	1	L	1.00000	--	1.17363	6/7	0271	25
75-56-9	PROPYLENE OXIDE	250	MG	**Units**	0.00030	0.00035	6/7	0239	1
75-56-9	PROPYLENE OXIDE	250	MG	**Units**	0.00030	0.00035	6/7	0204	1
78-93-3	MEK	500	ML	0.50000	--	0.58682	8	4550	10
78-93-3	METHYL ETHYL KETONE	500	ML	0.50000	--	0.58682	8	4410	10
78-93-3	MEK	500	ML	0.50000	--	0.58682	8	4410	10
78-93-3	2-BUTANONE	1	L	1.00000	--	1.17363	8	4310	25
79-01-6	TRICHLOROETHYLENE	500	ML	0.50000	--	0.58682	8	4550	10
79-01-6	TRICHLOROETHYLENE	500	ML	0.50000	--	0.58682	8	4550	10
79-01-6	TRICHLOROETHYLENE	500	ML	0.50000	--	0.58682	8	4550	10
79-01-6	TRICHLOROETHYLENE	500	ML	0.50000	--	0.58682	6/7	0128	10
79-10-7	ACRYLIC ACID	5	G	**Units**	0.00476	0.00558	8	4550	1

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[311 days = 95th percentile lowest turnover rate for historic use]

Golder Associates

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Chemical Inventory Data (Table G-2)

Conservatively assume specific gravity of 0.7 for laboratory liquids (0.649 liter/lb) when units are in pounds

Batch Assumptions:	*Annual Usage*	*Assumed Annual Batches*
	< 0.01 liter	*1*
	0.01-0.1 liter	*5*
	0.1-1.0 liter	*10*
	1.0-10 liter	*25*
	>10 liter	*100*

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data*		*Calculated*	*Recalculated*	*Calculated*	*Entered Data*		*Calculated*
		Inventory Amount		**Inventory Amount (liters)**	**Inventory Amount (liters)**	**Annual Usage * (liters/yr)**	**Building**	**Room**	**Estimated No. of Batches (per year)**
CAS No.	**Compound Name**	**Quantity**	**Units**						
79-10-7	ACRYLIC ACID	5	G	**Units**	0.00476	0.00558	8	4550	1
79-10-7	ACRYLIC ACID	5	G	**Units**	0.00476	0.00558	8	4450	1
100-41-4	ETHYL BENZENE	1	L	1.00000	--	1.17363	8	4310	25
100-42-5	STYRENE	100	ML	0.10000	--	0.11736	8	4550	10
100-42-5	STYRENE	5	ML	0.00500	--	0.00587	8	4550	1
100-44-7	BENZYL CHLORIDE	250	ML	0.25000	--	0.29341	8	4440	10
106-89-8	4-METHYLUMBELLIFERONE	25	G	**Units**	0.02113	0.02480	8	4440	5
106-99-0	1,3-BUTADIENE IN TOLUENE	250	G	**Units**	0.40323	0.47324	8	4550	10
107-02-8	ACROLEIN	100	ML	0.10000	--	0.11736	6/7	0128	10
107-06-2	1,2-DICHLOROETHANE	2.38	L	2.38000	--	2.79325	8	4550	25
107-06-2	1,2-DICHLOROETHANE	500	ML	0.50000	--	0.58682	8	4410	10
107-06-2	1,2-DICHLOROETHANE	1	L	1.00000	--	1.17363	8	4310	25
107-06-2	1,2-DICHLOROETHANE	4	L	4.00000	--	4.69453	8	4310	25
107-06-2	1,2-DICHLOROETHANE	500	ML	0.50000	--	0.58682	8	4310	10
107-21-1	ETHYLENE GLYCOL	1	L	1.00000	--	1.17363	9	0459	25
107-21-1	ETHYLENE GLYCOL	1	L	1.00000	--	1.17363	9	0459	25
107-21-1	ETHYLENE GLYCOL	1	L	1.00000	--	1.17363	9	0459	25
107-21-1	ETHYLENE GLYCOL	4	L	4.00000	--	4.69453	8	4524	25
107-21-1	ETHYLENE GLYCOL	4	KG	**Units**	3.27869	3.84798	8	4310	25
107-21-1	ETHYLENE GLYCOL	1	KG	**Units**	0.81967	0.96199	6/7	0239	10
107-21-1	ETHYLENE GLYCOL	1	L	1.00000	--	1.17363	6/7	0196A	25
107-21-1	ETHYLENE GLYCOL	500	ML	0.50000	--	0.58682	6/7	0244	10
107-21-1	ETHYLENE GLYCOL	250	ML	0.25000	--	0.29341	6/7	0239	10
107-21-1	ETHYLENE GLYCOL	250	ML	0.25000	--	0.29341	6/7	0239	10
107-21-1	ETHYLENE GLYCOL	2.5	L	2.50000	--	2.93408	6/7	0188C	25
107-21-1	ETHYLENE GLYCOL	1	L	1.00000	--	1.17363	6/7	0239	25
107-21-1	ETHYLENE GLYCOL	250	ML	0.25000	--	0.29341	6/7	0295	10
107-21-1	ETHYLENE GLYCOL	25	ML	0.02500	--	0.02934	6/7	0185	5
107-98-2	1-METHOXY-2-PROPANOL	8	ML	0.00800	--	0.00939	9	3219	1
107-98-2	1-METHOXY-2-PROPANOL	8	ML	0.00800	--	0.00939	8	3219	1
108-39-4	M-CRESOL	500	ML	0.50000	--	0.58682	8	4410	10
108-39-4	M-CRESOL	100	ML	0.10000	--	0.11736	6/7	0239	10
108-88-3	TOLUENE	100	ML	0.10000	--	0.11736	9	0413	10
108-88-3	TOLUENE	1	L	1.00000	--	1.17363	8	4550	25
108-88-3	TOLUENE	500	ML	0.50000	--	0.58682	8	4440	10
108-88-3	TOLUENE	1	L	1.00000	--	1.17363	8	4440	25
108-88-3	TOLUENE	1	L	1.00000	--	1.17363	8	4410	25
108-88-3	TOLUENE	2	L	2.00000	--	2.34727	8	4310	25
108-88-3	TOLUENE	1	L	1.00000	--	1.17363	8	4310	25
108-88-3	TOLUENE	1	L	1.00000	--	1.17363	8	4310	25
108-88-3	TOLUENE	1	L	1.00000	--	1.17363	8	4302	25
108-88-3	TOLUENE	1	L	1.00000	--	1.17363	8	4302	25
108-88-3	TOLUENE	1	L	1.00000	--	1.17363	8	4302	25
108-88-3	TOLUENE	1	L	1.00000	--	1.17363	8	4302	25
108-88-3	TOLUENE	100	ML	0.10000	--	0.11736	8	4208	10
108-88-3	TOLUENE	1	L	1.00000	--	1.17363	6/7	0293	25
108-88-3	TOLUENE	1	L	1.00000	--	1.17363	6/7	0128	25
108-88-3	TOLUENE	500	ML	0.50000	--	0.58682	6/7	0128	10
108-88-3	TOLUENE	1	L	1.00000	--	1.17363	6/7	0196A	25
108-88-3	TOLUENE	1	L	1.00000	--	1.17363	6/7	0239	25
108-88-3	TOLUENE	1	L	1.00000	--	1.17363	6/7	0204	25
108-88-3	TOLUENE	100	ML	0.10000	--	0.11736	6/7	0204	10
108-88-3	TOLUENE	500	ML	0.50000	--	0.58682	6/7	0239	10

* Equals inventory x (365 days per yr/311 days)
[311 days = 95th percentile lowest turnover rate for historic use]

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Chemical Inventory Data (Table G-2)

Conservatively assume specific gravity of 0.7 for laboratory liquids (0.649 liter/lb) when units are in pounds

Batch Assumptions:	Annual Usage	Assumed Annual Batches
	< 0.01 liter	1
	0.01-0.1 liter	5
	0.1-1.0 liter	10
	1.0-10 liter	25
	>10 liter	100

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data*		*Calculated*	*Recalculated*	*Calculated*	*Entered Data*		*Calculated*
		Inventory Amount		Inventory Amount (liters)	Inventory Amount (liters)	Annual Usage * (liters/yr)	Building	Room	Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
108-88-3	TOLUENE	2000	ML	2.00000	--	2.34727	6/7	0109	25
108-88-3	TOLUENE	500	ML	0.50000	--	0.58682	6/7	0209	10
109-86-4	2-METHOXYETHANOL	1	L	1.00000	--	1.17363	8	4310	25
110-54-3	HEXANE	1	L	1.00000	--	1.17363	9	0459	25
110-54-3	HEXANE, CHROMASOLV PLUS	1	L	1.00000	--	1.17363	9	0446	25
110-54-3	HEXANE	1	L	1.00000	--	1.17363	9	3219	25
110-54-3	HEXANE	4	L	4.00000	--	4.69453	8		25
110-54-3	HEXANE	4	L	4.00000	--	4.69453	8	4550	25
110-54-3	HEXANE	19	L	19.00000	--	22.29904	8	4550	100
110-54-3	HEXANE	1	L	1.00000	--	1.17363	8	4550	25
110-54-3	HEXANE	19	L	19.00000	--	22.29904	8	4524	100
110-54-3	HEXANE	1	L	1.00000	--	1.17363	8	4524	25
110-54-3	ALKANE STANDARD SOLUTION C8-C20	1	ML	0.00100	--	0.00117	8	4524	1
110-54-3	HEXANE	4	L	4.00000	--	4.69453	8	4440	25
110-54-3	HEXANE	4	L	4.00000	--	4.69453	8	4440	25
110-54-3	HEXANE	4	L	4.00000	--	4.69453	8	4440	25
110-54-3	HEXANE	4	L	4.00000	--	4.69453	8	4440	25
110-54-3	HEXANE	4	L	4.00000	--	4.69453	8	4440	25
110-54-3	HEXANE	4	L	4.00000	--	4.69453	8	4410	25
110-54-3	HEXANE	20	L	20.00000	--	23.47267	8	4310	100
110-54-3	HEXANE	24	L	24.00000	--	28.16720	8	4310	100
110-54-3	HEXANE	4	L	4.00000	--	4.69453	8	4310	25
110-54-3	HEXANE	19	L	19.00000	--	22.29904	8	4310	100
110-54-3	HEXANE	1	L	1.00000	--	1.17363	8	4310	25
110-54-3	HEXANE	4	L	4.00000	--	4.69453	8	4308	25
110-54-3	HEXANE	4	L	4.00000	--	4.69453	8	4302	25
110-54-3	HEXANE	4	L	4.00000	--	4.69453	8	4302	25
110-54-3	HEXANE	20	L	20.00000	--	23.47267	8	4240	100
110-54-3	HEXANE	20	L	20.00000	--	23.47267	8	4110	100
110-54-3	ALKANE STANDARD SOLUTION C8-C20	1	ML	0.00100	--	0.00117	8	4102	1
110-54-3	HEXANE	20	L	20.00000	--	23.47267	8	0102	100
110-54-3	HEXANE	1	L	1.00000	--	1.17363	8	3219	25
110-54-3	HEXANE	1	L	1.00000	--	1.17363	6/7	0239	25
110-54-3	N-HEXANE	1	L	1.00000	--	1.17363	6/7	0128	25
110-54-3	HEXANE	1	L	1.00000	--	1.17363	6/7	0128	25
110-54-3	HEXANE	1	L	1.00000	--	1.17363	6/7	0177	25
110-54-3	N-HEXANE	100	ML	0.10000	--	0.11736	6/7	0287	10
110-54-3	HEXANE	500	ML	0.50000	--	0.58682	6/7	0271	10
110-54-3	HEXANE	1	L	1.00000	--	1.17363	6/7	0216	25
110-54-3	HEXANE	1	L	1.00000	--	1.17363	6/7	0220	25
110-54-3	HEXANE	1	L	1.00000	--	1.17363	6/7	0220	25
110-54-3	HEXANE, CHROMASOLV PLUS	1	L	1.00000	--	1.17363	6/7	0220	25
110-54-3	HEXANE	1	L	1.00000	--	1.17363	6/7	0220	25
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION	1	L	1.00000	--	1.17363	9	0446	25
111-30-8	GLUTARALDEHYDE SOLUTION	25	G	**Units**	0.02352	0.02760	9	0446	5
111-30-8	GLUTARALDEHYDE	10	ML	0.01000	--	0.01174	9	0446	5
111-30-8	GLUTARALDEHYDE SOLUTION	100	ML	0.10000	--	0.11736	9	0459	10
111-30-8	GLUTARALDEHYDE	20	ML	0.02000	--	0.02347	8	4550	5
111-30-8	GLUTARALDEHYDE	100	ML	0.10000	--	0.11736	8	4440	10
111-30-8	GLUTARALDEHYDE SOLUTION	10	ML	0.01000	--	0.01174	6/7	0293	5
111-30-8	GLUTARALDEHYDE SOLUTION	10	ML	0.01000	--	0.01174	6/7	0293	5
111-30-8	GLUTARALDEHYDE	10	ML	0.01000	--	0.01174	6/7	0229	5
111-30-8	GLUTARALDEHYDE	10	ML	0.01000	--	0.01174	6/7	0128	5

* Equals inventory x (365 days per yr/311 days)
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Golder Associates

Calculation of Liquid Chemical Emissions
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Chemical Inventory Data (Table G-2)

Conservatively assume specific gravity of 0.7 for laboratory liquids (0.649 liter/lb) when units are in pounds

Batch Assumptions:	Annual Usage	Assumed Annual Batches
	< 0.01 liter	1
	0.01-0.1 liter	5
	0.1-1.0 liter	10
	1.0-10 liter	25
	>10 liter	100

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data*		*Calculated*	*Recalculated*	*Calculated*	*Entered Data*		*Calculated*
		Inventory Amount		Inventory Amount (liters)	Inventory Amount (liters)	Annual Usage * (liters/yr)	Building	Room	Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
111-30-8	GLUTARALDEHYDE	10	ML	0.01000	--	0.01174	6/7	0196A	5
111-30-8	GLUTARALDEHYDE	90	ML	0.09000	--	0.10563	6/7	0196A	10
111-30-8	GLUTARALDEHYDE	90	ML	0.09000	--	0.10563	6/7	0196A	10
111-30-8	GLUTERALDEHYDE	2	ML	0.00200	--	0.00235	6/7	0196A	1
111-30-8	GLUTERALDEHYDE	10	ML	0.01000	--	0.01174	6/7	0196A	5
111-30-8	GLUTERALDEHYDE	10	ML	0.01000	--	0.01174	6/7	0106	5
111-30-8	GLUTARALDEHYDE	20	ML	0.02000	--	0.02347	6/7	0177	5
111-30-8	GLUTARALDEHYDE	2	ML	0.00200	--	0.00235	6/7	0177	1
111-30-8	GLUTARALDEHYDE	10	ML	0.01000	--	0.01174	6/7	0230	5
111-30-8	GLUTARALDEHYDE	100	ML	0.10000	--	0.11736	6/7	0204	10
111-30-8	GLUTARALDEHYDE	1	ML	0.00100	--	0.00117	6/7	0188C	1
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION	1	ML	0.00100	--	0.00117	6/7	0188C	1
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION	25	ML	0.02500	--	0.02934	6/7	0188C	5
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION	25	ML	0.02500	--	0.02934	6/7	0188C	5
111-30-8	GLUTARALDEHYDE	100	ML	0.10000	--	0.11736	6/7	0188C	10
111-30-8	GLUTARALDEHYDE	10	ML	0.01000	--	0.01174	6/7	0287	5
111-30-8	GLUTARIC DIALDEHYDE	1	L	1.00000	--	1.17363	6/7	0239	25
111-30-8	GLUTERALDEHYDE	100	ML	0.10000	--	0.11736	6/7	0294	10
111-30-8	GLUTARALDEHYDE	100	ML	0.10000	--	0.11736	6/7	0109	10
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION	100	ML	0.10000	--	0.11736	6/7	0209A	10
111-30-8	GLUTARALDEHYDE SOLUTION	25	ML	0.02500	--	0.02934	6/7	0220	5
111-42-2	DIETHANOLAMINE	500	G	**Units**	0.45579	0.53493	9	0446	10
111-42-2	DIETHANOLAMINE	30	ML	0.03000	--	0.03521	8	4302	5
111-42-2	DIETHANOLAMINE	100	G	**Units**	0.09116	0.10699	6/7	0288C	10
111-42-2	DIETHANOLAMINE	500	G	**Units**	0.45579	0.53493	6/7	0239	10
121-44-8	TRIETHYLAMINE	500	ML	0.50000	--	0.58682	8		10
121-44-8	TRIETHYLAMINE	100	ML	0.10000	--	0.11736	8	4550	10
121-44-8	TRIETHYLAMINE	10	ML	0.01000	--	0.01174	8	4450D	5
121-44-8	TRIETHYLAMINE	25	G	**Units**	0.03434	0.04030	8	4440	5
121-44-8	TRIETHYLAMINE	1	L	1.00000	--	1.17363	8	4310	25
121-44-8	TRIETHYLAMINE	100	ML	0.10000	--	0.11736	8	4310	10
121-44-8	TRIETHYLAMINE	100	ML	0.10000	--	0.11736	8	4121	10
121-44-8	TRIETHYLAMINE	100	ML	0.10000	--	0.11736	6/7	0271	10
121-44-8	TRIETHYLAMINE	500	ML	0.50000	--	0.58682	6/7	0295	10
123-91-1	1,4-DIOXANE	1	L	1.00000	--	1.17363	9	0446	25
123-91-1	DIOXANE	1	L	1.00000	--	1.17363	8	4550	25
123-91-1	1,4-DIOXANE	1	L	1.00000	--	1.17363	8	4450B	25
123-91-1	1,4 DIOXANE	2	L	2.00000	--	2.34727	8	4440	25
123-91-1	1,4 DIOXANE	2	L	2.00000	--	2.34727	8	4410	25
123-91-1	1,4-DIOXANE ANHYDROUS	500	G	**Units**	0.48370	0.56769	8	4410	10
123-91-1	DIOXANE	1	L	1.00000	--	1.17363	8	4310	25
123-91-1	DIOXANE	1	L	1.00000	--	1.17363	8	4310	25
123-91-1	DIOXANE	4	L	4.00000	--	4.69453	8	4310	25
123-91-1	DIOXANE	4	L	4.00000	--	4.69453	8	4310	25
123-91-1	1,4-DIOXANE ANHYDROUS	100	ML	0.10000	--	0.11736	8	4302	10
127-18-4	TETRACHLOROETHYLENE	1	L	1.00000	--	1.17363	8	4550	25
1330-20-7	XYLENE	1	L	1.00000	--	1.17363	6/7	0166	25
1330-20-7	XYLENE	500	ML	0.50000	--	0.58682	6/7	0166	10
1330-20-7	XYLENE	4	L	4.00000	--	4.69453	6/7	0286	25
1330-20-7	XYLENE	5	ML	0.00500	--	0.00587	6/7	0128	1
1330-20-7	XYLENE	500	ML	0.50000	--	0.58682	6/7	0177	10
1330-20-7	XYLENE	1	GAL	3.78500	--	4.44220	6/7	0204	25
1330-20-7	XYLENE	4	L	4.00000	--	4.69453	6/7	0204	25

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Chemical Inventory Data (Table G-2)

Conservatively assume specific gravity of 0.7 for laboratory liquids (0.649 liter/lb) when units are in pounds

Batch Assumptions:	Annual Usage	Assumed Annual Batches
	< 0.01 liter	1
	0.01-0.1 liter	5
	0.1-1.0 liter	10
	1.0-10 liter	25
	>10 liter	100

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data*		*Calculated*	*Recalculated*	*Calculated*	*Entered Data*		*Calculated*
		Inventory Amount		Inventory Amount (liters)	Inventory Amount (liters)	Annual Usage * (liters/yr)	Building	Room	Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
1330-20-7	XYLENE	4	L	4.00000	--	4.69453	6/7	0204	25
1330-20-7	XYLENE	500	ML	0.50000	--	0.58682	6/7	0188C	10
1330-20-7	XYLENE	500	ML	0.50000	--	0.58682	6/7	0188C	10
1330-20-7	XYLENE	500	ML	0.50000	--	0.58682	6/7	0239	10
1330-20-7	XYLENE	1	GAL	3.78500	--	4.44220	6/7	0239	25
1330-20-7	XYLENE	4	L	4.00000	--	4.69453	6/7	0239	25
1330-20-7	XYLENES	500	ML	0.50000	--	0.58682	6/7	0239	10
1330-20-7	XYLENE	1	G	**Units**	0.00116	0.00136	6/7	0109	1
1330-20-7	XYLENE	500	ML	0.50000	--	0.58682	6/7	0209	10
1330-20-7	XYLENE	4	L	4.00000	--	4.69453	6/7	0204	25
1330-20-7	DEPEX MOUNTING MEDIA	100	ML	0.10000	--	0.11736	6/7	0220	10
1634-04-4	METHYL TERT-BUTYL ETHER	4	L	4.00000	--	4.69453	8	4310	25
1634-04-4	METHYL TERT-BUTYL ETHER	100	ML	0.10000	--	0.11736	6/7	0216	10
7647-01-0	HYDROCHLORIC ACID STANDARD SOLUTION	1	L	1.00000	--	1.17363	9	0139	25
7647-01-0	HCL	50	ML	0.05000	--	0.05868	9	0459	5
7647-01-0	HYDROCHLORIC ACID	1	L	1.00000	--	1.17363	9	0412	25
7647-01-0	HYDROCHLORIC ACID	1	L	1.00000	--	1.17363	9	0412	25
7647-01-0	HYDROCHLORIC ACID	1	L	1.00000	--	1.17363	9	0412	25
7647-01-0	HYDROCHLORIC ACID	1	L	1.00000	--	1.17363	9	0412	25
7647-01-0	HYDROCHLORIC ACID	1	L	1.00000	--	1.17363	9	0459	25
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	9	0446	10
7647-01-0	HYDROCHLORIC ACID	4	L	4.00000	--	4.69453	9	3219	25
7647-01-0	HYDROCHLORIC ACID	4	L	4.00000	--	4.69453	9	3219	25
7647-01-0	HYDROCHLORIC ACID	4	L	4.00000	--	4.69453	9	3219	25
7647-01-0	HYDROCHLORIC ACID	4	L	4.00000	--	4.69453	9	3219	25
7647-01-0	HYDROCHLORIC ACID	4	L	4.00000	--	4.69453	9	3219	25
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	9	3219	10
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	8	4550	25
7647-01-0	HYDROCHLORIC ACID	1	L	1.00000	--	1.17363	8	4550	25
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	8	4550	10
7647-01-0	HYDROCHLORIC ACID	1	L	1.00000	--	1.17363	8	4550	25
7647-01-0	HYDROCHLORIC ACID	1	L	1.00000	--	1.17363	8	4550	25
7647-01-0	HYDROCHLORIC ACID	1	L	1.00000	--	1.17363	8	4550	25
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	8	4550	25
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	8	4524	25
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	8	4524	25
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	8	4524	25
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	8	4524	25
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	8	4524	25
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	8	4524	10
7647-01-0	HYDROCHLORIC ACID SOLUTION	100	ML	0.10000	--	0.11736	8	4440	10
7647-01-0	HYDROCHLORIC ACID	100	ML	0.10000	--	0.11736	8	4440	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	8	4410	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	8	4410	10
7647-01-0	HYDROCHLORIC ACID	100	ML	0.10000	--	0.11736	8	4310	10
7647-01-0	HYDROCHLORIC ACID	1	L	1.00000	--	1.17363	8	4310	25
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	8	4310	10
7647-01-0	HYDROCHLORIC ACID	1	L	1.00000	--	1.17363	8	4310	25
7647-01-0	HYDROCHLORIC ACID	4	L	4.00000	--	4.69453	8	3219	25
7647-01-0	HYDROCHLORIC ACID	4	L	4.00000	--	4.69453	8	3219	25
7647-01-0	HYDROCHLORIC ACID	4	L	4.00000	--	4.69453	8	3219	25
7647-01-0	HYDROCHLORIC ACID	4	L	4.00000	--	4.69453	8	3219	25
7647-01-0	HYDROCHLORIC ACID	4	L	4.00000	--	4.69453	8	3219	25

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	0.01-0.1 liter	5
	0.1-1.0 liter	10
	1.0-10 liter	25
	>10 liter	100

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data*		*Calculated*	*Recalculated*	*Calculated*	*Entered Data*		*Calculated*
		Inventory Amount		Inventory Amount (liters)	Inventory Amount (liters)	Annual Usage * (liters/yr)	Building	Room	Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	8	3219	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0166	10
7647-01-0	HYDROCHLORIC ACID SOLUTION	500	ML	0.50000	--	0.58682	6/7	0293	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0286	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0244	10
7647-01-0	HYDROCHLORIC ACID	1	L	1.00000	--	1.17363	6/7	0244	25
7647-01-0	HYDROCHLORIC ACID	1	ML	0.00100	--	0.00117	6/7	0239	1
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	6/7	0128	25
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	6/7	0128	25
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	6/7	0128	25
7647-01-0	IMIDAZOLERIC ACID	25	G	**Units**	20.83333	24.45070	6/7	0196A	100
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	6/7	0196A	25
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0196A	10
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	6/7	0177	25
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0177	10
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	6/7	0196	25
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	6/7	0294	25
7647-01-0	HCL	500	ML	0.50000	--	0.58682	6/7	0239	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0239	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0239	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0239	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0239	10
7647-01-0	(TRIDECAFLUORO-1,1,2,2-TERAHYDROOCTYL)TRICHLOROSILANE	50	G	**Units**	41.66667	48.90139	6/7	0239	100
7647-01-0	HCL	500	ML	0.50000	--	0.58682	6/7	0239	10
7647-01-0	HCL	500	ML	0.50000	--	0.58682	6/7	0239	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0188C	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0188C	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0293	10
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	6/7	0287	25
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	6/7	0271	25
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	6/7	0239	25
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0239	10
7647-01-0	HYDROCHLORIC ACID	6	GAL	22.71000	--	26.65322	6/7	0239	100
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0239	10
7647-01-0	HYDROCHLORIC ACID	1	GAL	3.78500	--	4.44220	6/7	0239	25
7647-01-0	HYDROCHLORIC ACID	100	ML	0.10000	--	0.11736	6/7	0295	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0295	10
7647-01-0	HYDROCHLORIC ACID	100	ML	0.10000	--	0.11736	6/7	0116	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0187	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0187	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0187	10
7647-01-0	HYDROCHLORIC ACID	3	ML	0.00300	--	0.00352	6/7	0216	1
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	6/7	0216	25
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0208	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0208	10
7647-01-0	HYDROCHLORIC ACID	2.5	L	2.50000	--	2.93408	6/7	0208	25
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0208	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0220	10
7647-01-0	HYDROCHLORIC ACID	500	CC	**Units**	0.50000	0.58682	6/7	0220	10
7647-01-0	HYDROCHLORIC ACID	500	ML	0.50000	--	0.58682	6/7	0220	10
7647-01-0	HYDROCHLORIC ACID	4	L	4.00000	--	4.69453	6/7	0255	25
7664-38-2	BIO-SAFE COOMASSIE	1	L	1.00000	--	1.17363	9	0451	25
7664-38-2	BIO-SAFE COOMASSIE	1	L	1.00000	--	1.17363	9	0459	25

* Equals inventory x (365 days per yr/311 days)
[311 days = 95th percentile lowest turnover rate for historic use]

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Chemical Inventory Data (Table G-2)

Conservatively assume specific gravity of 0.7 for laboratory liquids (0.649 liter/lb) when units are in pounds

Batch Assumptions:	Annual Usage	Assumed Annual Batches
	< 0.01 liter	1
	0.01-0.1 liter	5
	0.1-1.0 liter	10
	1.0-10 liter	25
	>10 liter	100

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data*		*Calculated*	*Recalculated*	*Calculated*	*Entered Data*		*Calculated*
		Inventory Amount		Inventory Amount (liters)	Inventory Amount (liters)	Annual Usage * (liters/yr)	Building	Room	Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
7664-38-2	BIO-SAFE COOMASSIE	1	L	1.00000	--	1.17363	9	0459	25
7664-38-2	BIO-SAFE COOMASSIE	1	L	1.00000	--	1.17363	9	0459	25
7664-38-2	PHOSPHORIC ACID	100	G	**Units**	0.05935	0.06965	9	3219	5
7664-38-2	PHOSPHORIC ACID	450	ML	0.45000	--	0.52814	8	4550	10
7664-38-2	PHOSPHORIC ACID	500	ML	0.50000	--	0.58682	8	4550	10
7664-38-2	LPH SE GERMICIDAL DETERGENT	1	GAL	3.78500	--	4.44220	8	4543	25
7664-38-2	PHOSPHORIC ACID	500	ML	0.50000	--	0.58682	8	4524	10
7664-38-2	PHOSPHORIC ACID	500	ML	0.50000	--	0.58682	8	4524	10
7664-38-2	PHOSPHORIC ACID	500	ML	0.50000	--	0.58682	8	4468	10
7664-38-2	PHOSPHORIC ACID	10	KG	**Units**	5.93472	6.96518	8	4450	25
7664-38-2	PHOSPHORIC ACID	500	ML	0.50000	--	0.58682	8	4440	10
7664-38-2	PHOSPHORIC ACID	2.5	L	2.50000	--	2.93408	8	4440	25
7664-38-2	PHOSPHORIC ACID	10	KG	**Units**	5.93472	6.96518	8	4310	25
7664-38-2	PHOSPHORIC ACID	500	ML	0.50000	--	0.58682	8	4310	10
7664-38-2	PHOSPHORIC ACID	100	G	**Units**	0.05935	0.06965	8	3219	5
7664-38-2	PHOSPHORIC ACID	500	ML	0.50000	--	0.58682	6/7	0166	10
7664-38-2	PHOSPHORIC ACID	500	ML	0.50000	--	0.58682	6/7	0239	10
7664-38-2	PHOSPHORIC ACID	450	ML	0.45000	--	0.52814	6/7	0128	10
7664-38-2	O-PHOSPHORIC ACID	1	L	1.00000	--	1.17363	6/7	0128	25
7664-38-2	PHOSPHORIC ACID	500	ML	0.50000	--	0.58682	6/7	0196A	10
7664-38-2	DYE REAGENT CONCENTRATE (PHOSPHAIC ACID/METHANOL)	450	ML	0.45000	--	0.52814	6/7	0177	10
7664-38-2	PHOSPHORIC ACID	500	ML	0.50000	--	0.58682	6/7	0287	10
7664-38-2	5'-MONOPHOSPHORIC ACID	500	MG	**Units**	0.00030	0.00035	6/7	0239	1
7664-38-2	PHOSPHORIC ACID	500	ML	0.50000	--	0.58682	6/7	0239	10
7664-38-2	PHOSPHORIC ACID	100	G	**Units**	0.05935	0.06965	6/7	0220	5
7664-38-2	PHOSPHORIC ACID	100	G	**Units**	0.05935	0.06965	6/7	0220	5
7664-38-2	PHOSPHORIC ACID	500	G	**Units**	0.29674	0.34826	6/7	0220	10
7664-38-2	PHOSPORIC ACID	50	ML	0.05000	--	0.05868	6/7	0220	5
7664-38-2	PHOSPHORIC ACID	500	ML	0.50000	--	0.58682	6/7	0255	10
7664-39-3	HYDROFLUORIC ACID	500	ML	0.50000	--	0.58682	6/7	0216	10
7664-93-9	SULFURIC ACID	100	ML	0.10000	--	0.11736	9	3219	10
7664-93-9	SULFURIC ACID	1	L	1.00000	--	1.17363	9	3219	25
7664-93-9	SULFURIC ACID	1	L	1.00000	--	1.17363	8		25
7664-93-9	SULFURIC ACID	1	L	1.00000	--	1.17363	8	4440	25
7664-93-9	SULFURIC ACID	500	ML	0.50000	--	0.58682	8	4410	10
7664-93-9	SULFURIC ACID	500	ML	0.50000	--	0.58682	8	4410	10
7664-93-9	SULFURIC ACID	500	ML	0.50000	--	0.58682	8	4410	10
7664-93-9	SULFURIC ACID	500	ML	0.50000	--	0.58682	8	4410	10
7664-93-9	SULFURIC ACID	500	ML	0.50000	--	0.58682	8	4410	10
7664-93-9	SULFURIC ACID	500	ML	0.50000	--	0.58682	8	4310	10
7664-93-9	SULFURIC ACID	4	L	4.00000	--	4.69453	8	4310	25
7664-93-9	FISHER CLEANING SOLUTION	500	ML	0.50000	--	0.58682	8	4302	10
7664-93-9	SULFURIC ACID	1	L	1.00000	--	1.17363	8	4208	25
7664-93-9	SULFURIC ACID	100	ML	0.10000	--	0.11736	8	3219	10
7664-93-9	SULFURIC ACID	1	L	1.00000	--	1.17363	8	3219	25
7664-93-9	SULFURIC ACID	500	ML	0.50000	--	0.58682	6/7	0166	10
7664-93-9	SULFURIC ACID	50	ML	0.05000	--	0.05868	6/7	0128	5
7664-93-9	SULFURIC ACID	2.5	L	2.50000	--	2.93408	6/7	0177	25
7664-93-9	SULFURIC ACID	100	ML	0.10000	--	0.11736	6/7	0239	10
7664-93-9	SULFURIC ACID	100	ML	0.10000	--	0.11736	6/7	0188C	10
7664-93-9	SULFURIC ACID	2.5	L	2.50000	--	2.93408	6/7	0188C	25
7664-93-9	SULFURIC ACID	500	ML	0.50000	--	0.58682	6/7	0287	10

* Equals inventory x (365 days per yr/311 days)
[311 days = 95th percentile lowest turnover rate for historic use]

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Chemical Inventory Data (Table G-2)

Conservatively assume specific gravity of 0.7 for laboratory liquids (0.649 liter/lb) when units are in pounds

Batch Assumptions:	Annual Usage	Assumed Annual Batches
	< 0.01 liter	*1*
	0.01-0.1 liter	*5*
	0.1-1.0 liter	*10*
	1.0-10 liter	*25*
	>10 liter	*100*

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data* Inventory Amount		*Calculated* Inventory Amount (liters)	*Recalculated* Inventory Amount (liters)	*Calculated* Annual Usage * (liters/yr)	*Entered Data* Building	Room	*Calculated* Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
7664-93-9	SULFURIC ACID	500	ML	0.50000	--	0.58682	6/7	0287	10
7664-93-9	SULFURIC ACID	5	L	5.00000	--	5.86817	6/7	0271	25
7664-93-9	SULFURIC ACID	5	LB	3.24500	--	3.80844	6/7	0239	25
7664-93-9	SULFURIC ACID	2.5	L	2.50000	--	2.93408	6/7	0295	25
7697-37-2	NITRIC ACID	2.5	L	2.50000	--	2.93408	9	3219	25
7697-37-2	NITRIC ACID	2.5	L	2.50000	--	2.93408	8	4550	25
7697-37-2	NITRIC ACID	2.5	L	2.50000	--	2.93408	8	4550	25
7697-37-2	NITRIC ACID	2.5	L	2.50000	--	2.93408	8	4550	25
7697-37-2	NITRIC ACID	500	ML	0.50000	--	0.58682	8	4550	10
7697-37-2	NITRIC ACID	500	ML	0.50000	--	0.58682	8	3219	10
7726-95-6	BROMINE	5	G	**Units**	0.00160	0.00188	8	4310	1

* Equals inventory x (365 days per yr/311 days)
[311 days = 95th percentile lowest turnover rate for historic use]

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Vapor Pressure Data (Table G-3)

Antoine Equation: $VP = 10^{[A - (B/(T+C))]}$

where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually*				or *Entered manually*		*Entered manually*	*Calculated values*		*Calculated*
		For Antoine Eq. @ 295 K				Literature					
CAS No.	**Compound Name**	**Antoine Coefficients A**	**B**	**C**	**VP Units**	**VP @ Ref Temp (mmHg)**	**Ref Temp (K)**	**Vapor Pressure Reference**	**Vapor Pressure at Ref**	**Vapor Pressure at Ref (VP Units)**	**Adjusted Vapor Pressure[a] (mmHg)**
50-00-0	NORTHERNMAX DENATURING GEL BUFFER					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE SOLUTION					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE SOLUTION					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE SOLUTION					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE SOLUTION					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE SOLUTION					87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
If VP (@ ref temp) >= 100 mmHg, then not adjusted

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Vapor Pressure Data (Table G-3)

Antoine Equation: $VP = 10^{[A - (B/(T+C))]}$

where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	**Compound Name**	**A**	**B**	**C**	**VP Units**		**VP @ Ref Temp (mmHg)**	**Ref Temp (K)**	**Vapor Pressure Reference**	**Vapor Pressure at Ref**	**Vapor Pressure at Ref (VP Units)**	**Adjusted Vapor Pressure [a] (mmHg)**
50-00-0	FORMALDEHYDE SOLUTION						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE SOLUTION						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE SOLUTION						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	NORTHERNMAX DENATURING GEL BUFFER						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALIN						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALINE SOLUTION ACCUSTAIN 10%						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
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Golder Associates

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Vapor Pressure Data (Table G-3)

Antoine Equation: $VP = 10^{[A - (B/(T+C))]}$

where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	**Compound Name**	**A**	**B**	**C**	**VP Units**		**VP @ Ref Temp (mmHg)**	**Ref Temp (K)**	**Vapor Pressure Reference**	**Vapor Pressure at Ref**	**Vapor Pressure at Ref (VP Units)**	**Adjusted Vapor Pressure [a] (mmHg)**
50-00-0	FORMALINE SOLUTION ACCUSTAIN 10%						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	NORTHERNMAX DENATURING GEL BUFFER						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE SOLUTION						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE SOLUTION						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE SOLUTION						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE SOLUTION						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	BUFFERED NEUTRAL FORMALIN						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALINE SOLUTION ACCUSTAIN 10%						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE SOLUTION						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALIN SOLUTION						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE SOLUTION						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE, 37 WT IN H2O						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE, 37 WT						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE 37 % IN WATER						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
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Antoine Equation: $VP = 10^{[A - (B/(T+C))]}$

where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	Compound Name	A	B	C	VP Units		VP @ Ref Temp (mmHg)	Ref Temp (K)	Vapor Pressure Reference	Vapor Pressure at Ref	Vapor Pressure at Ref (VP Units)	Adjusted Vapor Pressure [a] (mmHg)
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE SOLUTION						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALIN						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
56-23-5	CARBON TETRACHLORIDE	6.87926	1212.021	226.41	mmHg				LBNL Data File	99.357	mmHg	100.00
58-89-9	CYCLOHEXANE, 1,2,3,4,5,6-HEXACHLORO-, GAMMA-ISOMER						0.000006	293	MSDS	0.000	mmHg	0.00
58-89-9	CYCLOHEXANE, 1,2,3,4,5,6-HEXACHLORO-, GAMMA-ISOMER						0.000006	293	MSDS	0.000	mmHg	0.00
58-89-9	CYCLOHEXANE, 1,2,3,4,5,6-HEXACHLORO-, GAMMA-ISOMER						0.000006	293	MSDS	0.000	mmHg	0.00
58-89-9	CYCLOHEXANE, 1,2,3,4,5,6-HEXACHLORO-, GAMMA-ISOMER						0.000006	293	MSDS	0.000	mmHg	0.00
62-53-3	ANILINE OIL	7.3201	1731.515	206.049	mmHg				LBNL Data File	0.528	mmHg	1.06
62-53-3	BENZAMINE	7.3201	1731.515	206.049	mmHg				LBNL Data File	0.528	mmHg	1.06
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	COMBI METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
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A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually*				or *Entered manually*		*Entered manually*	*Calculated values*		*Calculated*
		For Antoine Eq. @ 295 K				**Literature**					**Adjusted**
		Antoine Coefficients				**VP @ Ref Temp (mmHg)**	**Ref Temp (K)**	**Vapor Pressure Reference**	**Vapor Pressure at Ref**	**Vapor Pressure at Ref (VP Units)**	**Vapor Pressure[a] (mmHg)**
CAS No.	**Compound Name**	**A**	**B**	**C**	**VP Units**						
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
If VP (@ ref temp) >= 100 mmHg, then not adjusted

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California

Vapor Pressure Data (Table G-3)

Antoine Equation: $VP = 10^{[A - (B/(T+C))]}$

where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually*				*or Entered manually*		*Entered manually*	*Calculated values*		*Calculated*
		For Antoine Eq. @ 295 K				Literature					
		Antoine Coefficients									
CAS No.	Compound Name	A	B	C	VP Units	VP @ Ref Temp (mmHg)	Ref Temp (K)	Vapor Pressure Reference	Vapor Pressure at Ref	Vapor Pressure at Ref (VP Units)	Adjusted Vapor Pressure [a] (mmHg)
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	HYDRA-POINT METHANOL, DRY	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	HYDRA-POINT METHANOL, DRY	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	AMMONIA 7N SOLUTION IN METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	COMBI METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHYL ALCOHOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg			LBNL Data File	105.731	mmHg	105.73

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Vapor Pressure Data (Table G-3)

Antoine Equation: $VP = 10^{[A - (B/(T+C))]}$

where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	**Compound Name**	**A**	**B**	**C**	**VP Units**		**VP @ Ref Temp (mmHg)**	**Ref Temp (K)**	**Vapor Pressure Reference**	**Vapor Pressure at Ref**	**Vapor Pressure at Ref (VP Units)**	**Adjusted Vapor Pressure [a] (mmHg)**
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-63-0	ISOPROPYL ALCOHOL (2)	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
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Golder Associates

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Vapor Pressure Data (Table G-3)

Antoine Equation: $VP = 10^{[A - (B/(T+C))]}$

where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	Compound Name	A	B	C	VP Units		VP @ Ref Temp (mmHg)	Ref Temp (K)	Vapor Pressure Reference	Vapor Pressure at Ref	Vapor Pressure at Ref (VP Units)	Adjusted Vapor Pressure [a] (mmHg)
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
If VP (@ ref temp) >= 100 mmHg, then not adjusted

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Vapor Pressure Data (Table G-3)

Antoine Equation: $VP = 10^{[A - (B/(T+C))]}$

where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	Compound Name	A	B	C	VP Units		VP @ Ref Temp (mmHg)	Ref Temp (K)	Vapor Pressure Reference	Vapor Pressure at Ref	Vapor Pressure at Ref (VP Units)	Adjusted Vapor Pressure [a] (mmHg)
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
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67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
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67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
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where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	Compound Name	A	B	C	VP Units		VP @ Ref Temp (mmHg)	Ref Temp (K)	Vapor Pressure Reference	Vapor Pressure at Ref	Vapor Pressure at Ref (VP Units)	Adjusted Vapor Pressure [a] (mmHg)
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	MICROSHARP CLEANING FLUID	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	MICROSHARP CLEANING FLUID	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	MICROSHARP CLEANING FLUID	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	MICROSHARP CLEANING FLUID	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	MICROSHARP CLEANING FLUID	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38

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A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	Compound Name	A	B	C	VP Units		VP @ Ref Temp (mmHg)	Ref Temp (K)	Vapor Pressure Reference	Vapor Pressure at Ref	Vapor Pressure at Ref (VP Units)	Adjusted Vapor Pressure [a] (mmHg)
67-63-0	N-HYDROXYSUCCINIMIDYL-ACTIVATED AGAROSE	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	2-PROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPANOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL 24:1	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM ISOAMYL ALCOHOL	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM ISOAMYL ALCOHOL	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM ISOAMYL ALCOHOL	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL 24:1	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL 24:1	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
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Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Vapor Pressure Data (Table G-3)

Antoine Equation: $VP = 10^{[A - (B/(T+C))]}$

where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	**Compound Name**	**A**	**B**	**C**	**VP Units**		**VP @ Ref Temp (mmHg)**	**Ref Temp (K)**	**Vapor Pressure Reference**	**Vapor Pressure at Ref**	**Vapor Pressure at Ref (VP Units)**	**Adjusted Vapor Pressure [a] (mmHg)**
67-66-3	CHLOROFORM: ISOAMYL ALCOHOL MIXTURE	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM HPLC PURE	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL MIXTURE	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM: ISOAMYL ALCOHOL	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM: ISOAMYL ALCOHOL	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL 24:1	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM HPLC PURE	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	TRICHLOROMETHANE	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
If VP (@ ref temp) >= 100 mmHg, then not adjusted

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Vapor Pressure Data (Table G-3)

Antoine Equation: $VP = 10^{[A - (B/(T+C))]}$

where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*Must be entered manually*				*or* *Entered manually*		*Entered manually*	*Calculated values*		*Calculated*
		For Antoine Eq. @ 295 K				Literature					
		Antoine Coefficients				VP @ Ref Temp (mmHg)	Ref Temp (K)	Vapor Pressure Reference	Vapor Pressure at Ref	Vapor Pressure at Ref (VP Units)	Adjusted Vapor Pressure [a] (mmHg)
CAS No.	Compound Name	A	B	C	VP Units						
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM: ISOAMYL ALCOHOL MIXTURE	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM/ISOAMYL ALCOHOL	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg			LBNL Data File	168.875	mmHg	168.88

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
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Calculation of Liquid Chemical Emissions
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Vapor Pressure Data (Table G-3)

Antoine Equation: $VP = 10^{[A - (B/(T+C))]}$

where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	Compound Name	A	B	C	VP Units		VP @ Ref Temp (mmHg)	Ref Temp (K)	Vapor Pressure Reference	Vapor Pressure at Ref	Vapor Pressure at Ref (VP Units)	Adjusted Vapor Pressure [a] (mmHg)
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
68-12-2	N,N-DIMETHYLFORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	N-N-DIMETHYLFOMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	N,N-DIMETHYLFORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	N,N-DIMETHYLFORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	N,N-DIMETHYLFORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	N,N-DIMETHYLFORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	N-N-DIMETHYL FORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	N,N-DIMETHYLFORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	N,N-DIMETHYLFORMAMIDE, ANHYDROUS	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	DMF	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	DMF	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	DMF	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	DMF	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	DIMETHYLFORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	DMF	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	DMF	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	DMF	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	DIMETHYLFORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	DIMETHYL-FORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	DIMETHYL-FORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	DIMETHYLFORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	DIMETHYLFORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	DMF	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	N, N-DIMETHYLFORMAMIDE, REAGENT GRADE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	N,N-DIMETHYLFORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	DIMETHYLFORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	N,N-DIMETHYL FORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	N,N'-DIMETHYL FORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	N,N-DIMETHYLFORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	DMF	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	DMF	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
68-12-2	DMF	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
71-43-2	BENZENE	6.90565	1211.033	220.79	mmHg				LBNL Data File	82.145	mmHg	100.00
71-43-2	BENZENE	6.90565	1211.033	220.79	mmHg				LBNL Data File	82.145	mmHg	100.00
71-43-2	BENZENE(ANHYDROUS)	6.90565	1211.033	220.79	mmHg				LBNL Data File	82.145	mmHg	100.00
71-43-2	BENZENE(ANHYDROUS)	6.90565	1211.033	220.79	mmHg				LBNL Data File	82.145	mmHg	100.00
71-43-2	BENZENE	6.90565	1211.033	220.79	mmHg				LBNL Data File	82.145	mmHg	100.00
75-07-0	ACETALDEHYDE	8.00552	1600.017	291.809	mmHg				LBNL Data File	802.388	mmHg	802.39
75-07-0	ACETALDEHYDE	8.00552	1600.017	291.809	mmHg				LBNL Data File	802.388	mmHg	802.39
75-07-0	ACETALDEHYDE	8.00552	1600.017	291.809	mmHg				LBNL Data File	802.388	mmHg	802.39
75-09-2	DICHLOROMETHANE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	METHYLENE CHLORIDE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	METHYLENE CHLORIDE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	DICHLOROMETHANE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
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Golder Associates

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Antoine Equation: $VP = 10^{[A - (B/(T+C))]}$

where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	**Compound Name**	**A**	**B**	**C**	**VP Units**		**VP @ Ref Temp (mmHg)**	**Ref Temp (K)**	**Vapor Pressure Reference**	**Vapor Pressure at Ref**	**Vapor Pressure at Ref (VP Units)**	**Adjusted Vapor Pressure [a] (mmHg)**
75-09-2	TO BE VALIDATED-DICHLOROME, ANHYDROUS	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	DICHLOROMETHANE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	METHYLENE CHLORIDE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	METHYLENE CHLORIDE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	METHYLENE CHLORIDE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	METHYLENE CHLORIDE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	METHYLENE CHLORIDE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	METHYLENE CHLORIDE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	DICHLOROMETHANE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	DICHLOROMETHANE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	DICHLOROMETHANE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	METHYLENE CHLORIDE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	METHYLENE CHLORIDE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	DICHLOROMETHANE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	METHYLENE CHLORIDE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	DICHLOROMETHANE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	METHYLENE CHLORIDE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	DICHLOROMETHANE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	METHYLENE CHLORIDE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	DICHLOROMETHANE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	METHANE, DICHLORO-	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	METHYLENE CHLORIDE	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-56-9	PROPYLENE OXIDE	3.55046	802.487	-81.348	bar				NIST	0.623	bar	468.34
75-56-9	PROPYLENE OXIDE	3.55046	802.487	-81.348	bar				NIST	0.623	bar	468.34
78-93-3	MEK	7.06356	1261.34	221.97	mmHg				LBNL Data File	77.681	mmHg	100.00
78-93-3	METHYL ETHYL KETONE	7.06356	1261.34	221.97	mmHg				LBNL Data File	77.681	mmHg	100.00
78-93-3	MEK	7.06356	1261.34	221.97	mmHg				LBNL Data File	77.681	mmHg	100.00
78-93-3	2-BUTANONE	7.06356	1261.34	221.97	mmHg				LBNL Data File	77.681	mmHg	100.00
79-01-6	TRICHLOROETHYLENE	6.5183	1018.6	192.7	mmHg				LBNL Data File	58.978	mmHg	100.00
79-01-6	TRICHLOROETHYLENE	6.5183	1018.6	192.7	mmHg				LBNL Data File	58.978	mmHg	100.00
79-01-6	TRICHLOROETHYLENE	6.5183	1018.6	192.7	mmHg				LBNL Data File	58.978	mmHg	100.00
79-01-6	TRICHLOROETHYLENE	6.5183	1018.6	192.7	mmHg				LBNL Data File	58.978	mmHg	100.00
79-10-7	ACRYLIC ACID	5.65204	648.629	154.683	mmHg				LBNL Data File	95.011	mmHg	100.00
79-10-7	ACRYLIC ACID	5.65204	648.629	154.683	mmHg				LBNL Data File	95.011	mmHg	100.00
79-10-7	ACRYLIC ACID	5.65204	648.629	154.683	mmHg				LBNL Data File	95.011	mmHg	100.00
100-41-4	ETHYL BENZENE	6.95719	1424.255	213.21	mmHg				LBNL Data File	7.908	mmHg	15.82
100-42-5	STYRENE	7.14016	1574.51	224.09	mmHg				LBNL Data File	5.472	mmHg	10.94
100-42-5	STYRENE	7.14016	1574.51	224.09	mmHg				LBNL Data File	5.472	mmHg	10.94
100-44-7	BENZYL CHLORIDE	4.68263	1932.142	-39.396	bar				NIST	0.001	bar	2.00
106-89-8	4-METHYLUMBELLIFERONE						13	293	MSDS	13.000	mmHg	26.00
106-99-0	1,3-BUTADIENE IN TOLUENE						1838	293	NIST	1838.000	mmHg	1838.00
107-02-8	ACROLEIN	4.11586	1167.888	-41.56	bar				NIST	0.322	bar	242.03
107-06-2	1,2-DICHLOROETHANE	7.0253	1271.3	222.9	mmHg				LBNL Data File	67.767	mmHg	100.00
107-06-2	1,2-DICHLOROETHANE	7.0253	1271.3	222.9	mmHg				LBNL Data File	67.767	mmHg	100.00
107-06-2	1,2-DICHLOROETHANE	7.0253	1271.3	222.9	mmHg				LBNL Data File	67.767	mmHg	100.00
107-06-2	1,2-DICHLOROETHANE	7.0253	1271.3	222.9	mmHg				LBNL Data File	67.767	mmHg	100.00
107-06-2	1,2-DICHLOROETHANE	7.0253	1271.3	222.9	mmHg				LBNL Data File	67.767	mmHg	100.00

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
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where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	Compound Name	A	B	C	VP Units		VP @ Ref Temp (mmHg)	Ref Temp (K)	Vapor Pressure Reference	Vapor Pressure at Ref	Vapor Pressure at Ref (VP Units)	Adjusted Vapor Pressure [a] (mmHg)
107-21-1	ETHYLENE GLYCOL	8.0908	2088.9	203.5	mmHg				LBNL Data File	0.066	mmHg	0.13
107-21-1	ETHYLENE GLYCOL	8.0908	2088.9	203.5	mmHg				LBNL Data File	0.066	mmHg	0.13
107-21-1	ETHYLENE GLYCOL	8.0908	2088.9	203.5	mmHg				LBNL Data File	0.066	mmHg	0.13
107-21-1	ETHYLENE GLYCOL	8.0908	2088.9	203.5	mmHg				LBNL Data File	0.066	mmHg	0.13
107-21-1	ETHYLENE GLYCOL	8.0908	2088.9	203.5	mmHg				LBNL Data File	0.066	mmHg	0.13
107-21-1	ETHYLENE GLYCOL	8.0908	2088.9	203.5	mmHg				LBNL Data File	0.066	mmHg	0.13
107-21-1	ETHYLENE GLYCOL	8.0908	2088.9	203.5	mmHg				LBNL Data File	0.066	mmHg	0.13
107-21-1	ETHYLENE GLYCOL	8.0908	2088.9	203.5	mmHg				LBNL Data File	0.066	mmHg	0.13
107-21-1	ETHYLENE GLYCOL	8.0908	2088.9	203.5	mmHg				LBNL Data File	0.066	mmHg	0.13
107-21-1	ETHYLENE GLYCOL	8.0908	2088.9	203.5	mmHg				LBNL Data File	0.066	mmHg	0.13
107-21-1	ETHYLENE GLYCOL	8.0908	2088.9	203.5	mmHg				LBNL Data File	0.066	mmHg	0.13
107-21-1	ETHYLENE GLYCOL	8.0908	2088.9	203.5	mmHg				LBNL Data File	0.066	mmHg	0.13
107-21-1	ETHYLENE GLYCOL	8.0908	2088.9	203.5	mmHg				LBNL Data File	0.066	mmHg	0.13
107-21-1	ETHYLENE GLYCOL	8.0908	2088.9	203.5	mmHg				LBNL Data File	0.066	mmHg	0.13
107-98-2	1-METHOXY-2-PROPANOL						11.8	298	MSDS	11.800	mmHg	23.60
107-98-2	1-METHOXY-2-PROPANOL						11.8	298	MSDS	11.800	mmHg	23.60
108-39-4	M-CRESOL	7.508	1856.36	199.07	mmHg				LBNL Data File	0.127	mmHg	0.25
108-39-4	M-CRESOL	7.508	1856.36	199.07	mmHg				LBNL Data File	0.127	mmHg	0.25
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
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108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
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108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
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108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
109-86-4	2-METHOXYETHANOL	5.06386	1853.556	-30.838	bar				NIST	0.011	bar	16.76
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE, CHROMASOLV PLUS	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88

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T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	**Compound Name**	**A**	**B**	**C**	**VP Units**		**VP @ Ref Temp (mmHg)**	**Ref Temp (K)**	**Vapor Pressure Reference**	**Vapor Pressure at Ref**	**Vapor Pressure at Ref (VP Units)**	**Adjusted Vapor Pressure [a] (mmHg)**
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	ALKANE STANDARD SOLUTION C8-C20	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
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110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
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110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	ALKANE STANDARD SOLUTION C8-C20	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	N-HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	N-HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE, CHROMASOLV PLUS	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE SOLUTION						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE SOLUTION						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE SOLUTION						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE SOLUTION						0.45	293	MSDS	0.450	mmHg	0.90

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
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Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Vapor Pressure Data (Table G-3)

Antoine Equation: $VP = 10^{[A - (B/(T+C))]}$

where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	Compound Name	A	B	C	VP Units		VP @ Ref Temp (mmHg)	Ref Temp (K)	Vapor Pressure Reference	Vapor Pressure at Ref	Vapor Pressure at Ref (VP Units)	Adjusted Vapor Pressure [a] (mmHg)
111-30-8	GLUTARALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTERALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTERALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTERALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARIC DIALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTERALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION						0.45	293	MSDS	0.450	mmHg	0.90
111-30-8	GLUTARALDEHYDE SOLUTION						0.45	293	MSDS	0.450	mmHg	0.90
111-42-2	DIETHANOLAMINE	8.1388	2327.9	174.4	mmHg				LBNL Data File	0.000	mmHg	0.00
111-42-2	DIETHANOLAMINE	8.1388	2327.9	174.4	mmHg				LBNL Data File	0.000	mmHg	0.00
111-42-2	DIETHANOLAMINE	8.1388	2327.9	174.4	mmHg				LBNL Data File	0.000	mmHg	0.00
111-42-2	DIETHANOLAMINE	8.1388	2327.9	174.4	mmHg				LBNL Data File	0.000	mmHg	0.00
121-44-8	TRIETHYLAMINE	5.8588	695.7	144.8	mmHg				LBNL Data File	48.326	mmHg	96.65
121-44-8	TRIETHYLAMINE	5.8588	695.7	144.8	mmHg				LBNL Data File	48.326	mmHg	96.65
121-44-8	TRIETHYLAMINE	5.8588	695.7	144.8	mmHg				LBNL Data File	48.326	mmHg	96.65
121-44-8	TRIETHYLAMINE	5.8588	695.7	144.8	mmHg				LBNL Data File	48.326	mmHg	96.65
121-44-8	TRIETHYLAMINE	5.8588	695.7	144.8	mmHg				LBNL Data File	48.326	mmHg	96.65
121-44-8	TRIETHYLAMINE	5.8588	695.7	144.8	mmHg				LBNL Data File	48.326	mmHg	96.65
121-44-8	TRIETHYLAMINE	5.8588	695.7	144.8	mmHg				LBNL Data File	48.326	mmHg	96.65
121-44-8	TRIETHYLAMINE	5.8588	695.7	144.8	mmHg				LBNL Data File	48.326	mmHg	96.65
121-44-8	TRIETHYLAMINE	5.8588	695.7	144.8	mmHg				LBNL Data File	48.326	mmHg	96.65
123-91-1	1,4-DIOXANE ANHYDROUS	7.43155	1554.68	240.34	mmHg				LBNL Data File	31.766	mmHg	63.53
123-91-1	1,4-DIOXANE	7.43155	1554.68	240.34	mmHg				LBNL Data File	31.766	mmHg	63.53
123-91-1	DIOXANE	7.43155	1554.68	240.34	mmHg				LBNL Data File	31.766	mmHg	63.53
123-91-1	1,4-DIOXANE	7.43155	1554.68	240.34	mmHg				LBNL Data File	31.766	mmHg	63.53
123-91-1	1,4 DIOXANE	7.43155	1554.68	240.34	mmHg				LBNL Data File	31.766	mmHg	63.53
123-91-1	1,4 DIOXANE	7.43155	1554.68	240.34	mmHg				LBNL Data File	31.766	mmHg	63.53
123-91-1	1,4-DIOXANE ANHYDROUS	7.43155	1554.68	240.34	mmHg				LBNL Data File	31.766	mmHg	63.53
123-91-1	DIOXANE	7.43155	1554.68	240.34	mmHg				LBNL Data File	31.766	mmHg	63.53
123-91-1	DIOXANE	7.43155	1554.68	240.34	mmHg				LBNL Data File	31.766	mmHg	63.53
123-91-1	DIOXANE	7.43155	1554.68	240.34	mmHg				LBNL Data File	31.766	mmHg	63.53
123-91-1	DIOXANE	7.43155	1554.68	240.34	mmHg				LBNL Data File	31.766	mmHg	63.53

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Vapor Pressure Data (Table G-3)

Antoine Equation: $VP = 10^{[A - (B/(T+C))]}$

where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	**Compound Name**	**A**	**B**	**C**	**VP Units**		**VP @ Ref Temp (mmHg)**	**Ref Temp (K)**	**Vapor Pressure Reference**	**Vapor Pressure at Ref**	**Vapor Pressure at Ref (VP Units)**	**Adjusted Vapor Pressure [a] (mmHg)**
127-18-4	TETRACHLOROETHYLENE	6.97683	1386.92	217.53	mmHg				LBNL Data File	15.242	mmHg	30.48
1330-20-7	XYLENE						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	XYLENE						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	XYLENE						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	XYLENE						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	XYLENE						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	XYLENE						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	XYLENE						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	XYLENE						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	XYLENE						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	XYLENE						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	XYLENE						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	XYLENE						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	XYLENE						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	XYLENE						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	XYLENE						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	XYLENES						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	XYLENE						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	XYLENE						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	XYLENE						6.72	294	MSDS	6.720	mmHg	13.44
1330-20-7	DEPEX MOUNTING MEDIA						6.72	294	MSDS	6.720	mmHg	13.44
1634-04-4	METHYL TERT-BUTYL ETHER	6.8871	1162.1	219.9	mmHg				LBNL Data File	120.245	mmHg	120.25
1634-04-4	METHYL TERT-BUTYL ETHER	6.8871	1162.1	219.9	mmHg				LBNL Data File	120.245	mmHg	120.25
7647-01-0	HYDROCHLORIC ACID STANDARD SOLUTION						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HCL						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
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Antoine Equation: $VP = 10^{[A - (B/(T+C))]}$

where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
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A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	**Compound Name**	**A**	**B**	**C**	**VP Units**		**VP @ Ref Temp (mmHg)**	**Ref Temp (K)**	**Vapor Pressure Reference**	**Vapor Pressure at Ref**	**Vapor Pressure at Ref (VP Units)**	**Adjusted Vapor Pressure [a] (mmHg)**
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID SOLUTION						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID SOLUTION						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	IMIDAZOLERIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HCL						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	(TRIDECAFLUORO-1,1,2,2-TERAHYDROOCTYL)TRICHLOROSILANE						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HCL						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HCL						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00

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A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	**Compound Name**	**A**	**B**	**C**	**VP Units**		**VP @ Ref Temp (mmHg)**	**Ref Temp (K)**	**Vapor Pressure Reference**	**Vapor Pressure at Ref**	**Vapor Pressure at Ref (VP Units)**	**Adjusted Vapor Pressure [a] (mmHg)**
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID						190	298	MSDS	190.000	mmHg	190.00
7664-38-2	BIO-SAFE COOMASSIE						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	BIO-SAFE COOMASSIE						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	BIO-SAFE COOMASSIE						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	BIO-SAFE COOMASSIE						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	LPH SE GERMICIDAL DETERGENT						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	O-PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	DYE REAGENT CONCENTRATE (PHOSPHAIC ACID/METHANOL)						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	5'-MONOPHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
If VP (@ ref temp) >= 100 mmHg, then not adjusted

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Vapor Pressure Data (Table G-3)

Antoine Equation: $VP = 10^{[A - (B/(T+C))]}$

where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients

(Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	**Compound Name**	**A**	**B**	**C**	**VP Units**		**VP @ Ref Temp (mmHg)**	**Ref Temp (K)**	**Vapor Pressure Reference**	**Vapor Pressure at Ref**	**Vapor Pressure at Ref (VP Units)**	**Adjusted Vapor Pressure [a] (mmHg)**
7664-38-2	PHOSPORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-38-2	PHOSPHORIC ACID						0.03	293	MSDS	0.030	mmHg	0.06
7664-39-3	HYDROFLUORIC ACID						25	293	MSDS	25.000	mmHg	50.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	FISHER CLEANING SOLUTION						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID						1	419	MSDS	1.000	mmHg	2.00
7697-37-2	NITRIC ACID						48	293	MSDS	48.000	mmHg	96.00
7697-37-2	NITRIC ACID						48	293	MSDS	48.000	mmHg	96.00
7697-37-2	NITRIC ACID						48	293	MSDS	48.000	mmHg	96.00
7697-37-2	NITRIC ACID						48	293	MSDS	48.000	mmHg	96.00
7697-37-2	NITRIC ACID						48	293	MSDS	48.000	mmHg	96.00
7697-37-2	NITRIC ACID						48	293	MSDS	48.000	mmHg	96.00
7726-95-6	BROMINE	6.8778	1119.68	221.38	mmHg				LBNL Data File	188.114	mmHg	188.11

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
If VP (@ ref temp) >= 100 mmHg, then not adjusted

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
50-00-0	NORTHERNMAX DENATURING GEL BUFFER	30.03	LBNL Data File	87.9	0.20771	0.29341	0.06094
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.52814	0.10970
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.52814	0.10970
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.52814	0.10970
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.52814	0.10970
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	87.9	0.20771	0.53836	0.11182
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	87.9	0.20771	0.53836	0.11182
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.11736	0.02438
50-00-0	NORTHERNMAX DENATURING GEL BUFFER	30.03	LBNL Data File	87.9	0.20771	0.29341	0.06094
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.11736	0.02438
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.11736	0.02438
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.11736	0.02438
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.11736	0.02438
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	87.9	0.20771	4.44220	0.92267
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	87.9	0.20771	4.44220	0.92267
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	87.9	0.20771	4.44220	0.92267
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.52814	0.10970
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALIN	30.03	LBNL Data File	87.9	0.20771	0.14084	0.02925
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.14084	0.02925
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.14084	0.02925
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.14084	0.02925

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.14084	0.02925
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.14084	0.02925
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.14084	0.02925
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.14084	0.02925
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.14084	0.02925
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.14084	0.02925
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.14084	0.02925
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.14084	0.02925
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.14084	0.02925
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.14084	0.02925
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.14084	0.02925
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.14084	0.02925
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	4.69453	0.97508
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	4.69453	0.97508
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	87.9	0.20771	0.01760	0.00366
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	87.9	0.20771	0.01760	0.00366
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	87.9	0.20771	0.01760	0.00366
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	87.9	0.20771	0.01760	0.00366
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	87.9	0.20771	0.01760	0.00366
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	87.9	0.20771	0.01760	0.00366
50-00-0	FORMALINE SOLUTION ACCUSTAIN 10%	30.03	LBNL Data File	87.9	0.20771	0.14084	0.02925
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALINE SOLUTION ACCUSTAIN 10%	30.03	LBNL Data File	87.9	0.20771	0.05868	0.01219
50-00-0	NORTHERNMAX DENATURING GEL BUFFER	30.03	LBNL Data File	87.9	0.20771	0.29341	0.06094
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.11736	0.02438
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.11736	0.02438
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.11736	0.02438
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	87.9	0.20771	4.44220	0.92267
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.09389	0.01950
50-00-0	BUFFERED NEUTRAL FORMALIN	30.03	LBNL Data File	87.9	0.20771	4.69453	0.97508
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALINE SOLUTION ACCUSTAIN 10%	30.03	LBNL Data File	87.9	0.20771	4.69453	0.97508
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	87.9	0.20771	4.44220	0.92267
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	87.9	0.20771	4.44220	0.92267
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	87.9	0.20771	4.44220	0.92267
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	87.9	0.20771	4.44220	0.92267
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02934	0.00609
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.01174	0.00244
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALIN SOLUTION	30.03	LBNL Data File	87.9	0.20771	0.01760	0.00366
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.00587	0.00122
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.17605	0.03657
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.17605	0.03657
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	87.9	0.20771	0.04108	0.00853
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	1.17363	0.24377
50-00-0	FORMALDEHYDE, 37 WT IN H2O	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	1.17363	0.24377
50-00-0	FORMALDEHYDE, 37 WT	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE 37 % IN WATER	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.11736	0.02438
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.11736	0.02438
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	87.9	0.20771	0.58682	0.12188
50-00-0	FORMALIN	30.03	LBNL Data File	87.9	0.20771	1.17363	0.24377
56-23-5	CARBON TETRACHLORIDE	153.8	LBNL Data File	99.4	1.20242	0.55534	0.66775
58-89-9	YCLOHEXANE, 1,2,3,4,5,6-HEXACHLORO-, GAMMA-ISOME	290.9	LBNL Data File	0.0	0.00000	0.36837	0.00000
58-89-9	YCLOHEXANE, 1,2,3,4,5,6-HEXACHLORO-, GAMMA-ISOME	291.9	LBNL Data File	0.0	0.00000	0.36837	0.00000
58-89-9	YCLOHEXANE, 1,2,3,4,5,6-HEXACHLORO-, GAMMA-ISOME	292.9	LBNL Data File	0.0	0.00000	0.00368	0.00000
58-89-9	YCLOHEXANE, 1,2,3,4,5,6-HEXACHLORO-, GAMMA-ISOME	293.9	LBNL Data File	0.0	0.00000	0.00368	0.00000
62-53-3	ANILINE OIL	93	LBNL Data File	0.5	0.00386	0.57418	0.00222
62-53-3	BENZAMINE	93	LBNL Data File	0.5	0.00386	0.00574	0.00002
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.44220	1.18634
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	2.93408	0.78358
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	2.93408	0.78358
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	0.00117	0.00031
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	COMBI METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	2.34727	0.62686
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	2.34727	0.62686
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	2.34727	0.62686
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	2.34727	0.62686

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	2.34727	0.62686
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.44220	1.18634
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	0.11736	0.03134
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	0.29341	0.07836
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.44220	1.18634
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.44220	1.18634
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.44220	1.18634
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.44220	1.18634
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.44220	1.18634
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.44220	1.18634
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	22.29904	5.95522
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	22.29904	5.95522
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	0.00000	0.00000
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	0.11736	0.03134
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	0.58682	0.15672
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	0.11736	0.03134
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	0.58682	0.15672

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	2.93408	0.78358
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	2.93408	0.78358
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	2.93408	0.78358
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	2.93408	0.78358
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	HYDRA-POINT METHANOL, DRY	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	HYDRA-POINT METHANOL, DRY	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	AMMONIA 7N SOLUTION IN METHANOL	32.1	LBNL Data File	105.7	0.26706	0.11736	0.03134
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	0.11736	0.03134
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	0.00117	0.00031
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	COMBI METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHYL ALCOHOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	17.76881	4.74537
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	2.34727	0.62686
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	5.86817	1.56716
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	0.11736	0.03134
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	0.58682	0.15672
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	0.11736	0.03134

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	0.58682	0.15672
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.44220	1.18634
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	2.34727	0.62686
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.69453	1.25373
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	4.44220	1.18634
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	0.58682	0.15672
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-63-0	ISOPROPYL ALCOHOL (2)	60.1	LBNL Data File	37.2	0.17588	70.41801	12.38524
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.52063	0.09157
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.55534	0.09767
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	0.29341	0.05161
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.29341	0.05161
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	149.50744	26.29562
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	17.60450	3.09631
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.49507	0.26296
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.29341	0.05161
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	ISOPROPYL	60.1	LBNL Data File	37.2	0.17588	1.49507	0.26296
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	2.34727	0.41284
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	4.44220	0.78130
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	4.44220	0.78130
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	5.86817	1.03210
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	5.86817	1.03210
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	ISOPROPANOL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPANOL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	4.44220	0.78130
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	4.44220	0.78130
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	2.34727	0.41284
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	0.29341	0.05161
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	MICROSHARP CLEANING FLUID	60.1	LBNL Data File	37.2	0.17588	0.27698	0.04872
67-63-0	MICROSHARP CLEANING FLUID	60.1	LBNL Data File	37.2	0.17588	0.27698	0.04872
67-63-0	MICROSHARP CLEANING FLUID	60.1	LBNL Data File	37.2	0.17588	0.27698	0.04872
67-63-0	MICROSHARP CLEANING FLUID	60.1	LBNL Data File	37.2	0.17588	0.27698	0.04872
67-63-0	MICROSHARP CLEANING FLUID	60.1	LBNL Data File	37.2	0.17588	0.27698	0.04872
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	N-HYDROXYSUCCINIMIDYL-ACTIVATED AGAROSE	60.1	LBNL Data File	37.2	0.17588	0.00587	0.00103
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.11736	0.02064
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	2.93408	0.51605
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	9.38907	1.65136
67-63-0	2-PROPANOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	4.69453	0.82568
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	0.58682	0.10321
67-63-0	ISOPROPANOL	60.1	LBNL Data File	37.2	0.17588	0.02934	0.00516
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	1.17363	0.20642
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	37.2	0.17588	2.34727	0.41284
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.11736	0.18621
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL 24:1	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM ISOAMYL ALCOHOL	119.4	LBNL Data File	168.9	1.58662	0.11736	0.18621
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM ISOAMYL ALCOHOL	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM ISOAMYL ALCOHOL	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL 24:1	119.4	LBNL Data File	168.9	1.58662	0.11736	0.18621
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	1.17363	1.86211

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	1.17363	1.86211
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	1.17363	1.86211
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.02934	0.04655
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL 24:1	119.4	LBNL Data File	168.9	1.58662	1.11067	1.76221
67-66-3	CHLOROFORM: ISOAMYL ALCOHOL MIXTURE	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.02934	0.04655
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.46945	0.74484
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.46945	0.74484
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.55534	0.88111
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.55534	0.88111
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	4.69453	7.44844
67-66-3	CHLOROFORM HPLC PURE	119.4	LBNL Data File	168.9	1.58662	1.17363	1.86211
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	4.69453	7.44844
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL MIXTURE	119.4	LBNL Data File	168.9	1.58662	0.11736	0.18621
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.02934	0.04655
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.11736	0.18621
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	1.17363	1.86211
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	1.17363	1.86211
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.03957	0.06278
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.02934	0.04655
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.02934	0.04655
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.02934	0.04655
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	4.69453	7.44844
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	2.34727	3.72422
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
67-66-3	CHLOROFORM: ISOAMYL ALCOHOL	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM: ISOAMYL ALCOHOL	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	4.69453	7.44844
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL	119.4	LBNL Data File	168.9	1.58662	0.11736	0.18621
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL 24:1	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	1.17363	1.86211
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	1.17363	1.86211
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	2.34727	3.72422
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	2.93408	4.65528
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	2.93408	4.65528
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	2.93408	4.65528
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL	119.4	LBNL Data File	168.9	1.58662	0.55534	0.88111
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	4.69453	7.44844
67-66-3	CHLOROFORM HPLC PURE	119.4	LBNL Data File	168.9	1.58662	1.17363	1.86211
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.11736	0.18621
67-66-3	TRICHLOROMETHANE	119.4	LBNL Data File	168.9	1.58662	0.02934	0.04655
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.02934	0.04655
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.02934	0.04655
67-66-3	CHLOROFORM: ISOAMYL ALCOHOL MIXTURE	119.4	LBNL Data File	168.9	1.58662	0.52814	0.83795
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.07914	0.12556
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	1.11067	1.76221
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	4.69453	7.44844
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	4.69453	7.44844
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	4.69453	7.44844

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
67-66-3	CHLOROFORM/ISOAMYL ALCOHOL	119.4	LBNL Data File	168.9	1.58662	0.05868	0.09311
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	1.17363	1.86211
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	4.69453	7.44844
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.02934	0.04655
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.02934	0.04655
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.02934	0.04655
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	4.69453	7.44844
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.02934	0.04655
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	1.17363	1.86211
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.02934	0.04655
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.11736	0.18621
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.02934	0.04655
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	1.11495	1.76901
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.02934	0.04655
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.02934	0.04655
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	1.17363	1.86211
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	1.17363	1.86211
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.02934	0.04655
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	0.58682	0.93106
68-12-2	N,N-DIMETHYLFORMAMIDE	73.1	LBNL Data File	3.2	0.01862	0.11736	0.00219
68-12-2	N-N-DIMETHYLFOMAMIDE	73.1	LBNL Data File	3.2	0.01862	0.58682	0.01093
68-12-2	N,N-DIMETHYLFORMAMIDE	73.1	LBNL Data File	3.2	0.01862	1.17363	0.02186
68-12-2	N,N-DIMETHYLFORMAMIDE	73.1	LBNL Data File	3.2	0.01862	0.29341	0.00546
68-12-2	N,N-DIMETHYLFORMAMIDE	73.1	LBNL Data File	3.2	0.01862	2.34727	0.04371
68-12-2	N,N-DIMETHYLFORMAMIDE	73.1	LBNL Data File	3.2	0.01862	4.69453	0.08743
68-12-2	N-N-DIMETHYL FORMAMIDE	73.1	LBNL Data File	3.2	0.01862	1.17363	0.02186
68-12-2	N,N-DIMETHYLFORMAMIDE	73.1	LBNL Data File	3.2	0.01862	1.17363	0.02186
68-12-2	N,N-DIMETHYLFORMAMIDE, ANHYDROUS	73.1	LBNL Data File	3.2	0.01862	0.58682	0.01093
68-12-2	DMF	73.1	LBNL Data File	3.2	0.01862	0.58682	0.01093
68-12-2	DMF	73.1	LBNL Data File	3.2	0.01862	1.17363	0.02186
68-12-2	DMF	73.1	LBNL Data File	3.2	0.01862	0.29341	0.00546
68-12-2	DMF	73.1	LBNL Data File	3.2	0.01862	0.58682	0.01093
68-12-2	DIMETHYLFORMAMIDE	73.1	LBNL Data File	3.2	0.01862	0.00117	0.00002
68-12-2	DMF	73.1	LBNL Data File	3.2	0.01862	0.29341	0.00546
68-12-2	DMF	73.1	LBNL Data File	3.2	0.01862	0.58682	0.01093
68-12-2	DMF	73.1	LBNL Data File	3.2	0.01862	0.58682	0.01093
68-12-2	DIMETHYLFORMAMIDE	73.1	LBNL Data File	3.2	0.01862	0.29341	0.00546
68-12-2	DIMETHYL-FORMAMIDE	73.1	LBNL Data File	3.2	0.01862	0.29341	0.00546
68-12-2	DIMETHYL-FORMAMIDE	73.1	LBNL Data File	3.2	0.01862	0.29341	0.00546
68-12-2	DIMETHYLFORMAMIDE	73.1	LBNL Data File	3.2	0.01862	1.17363	0.02186
68-12-2	DIMETHYLFORMAMIDE	73.1	LBNL Data File	3.2	0.01862	1.17363	0.02186
68-12-2	DMF	73.1	LBNL Data File	3.2	0.01862	0.11736	0.00219
68-12-2	N, N-DIMETHYLFORMAMIDE, REAGENT GRADE	73.1	LBNL Data File	3.2	0.01862	0.11736	0.00219
68-12-2	N,N-DIMETHYLFORMAMIDE	73.1	LBNL Data File	3.2	0.01862	0.11736	0.00219
68-12-2	DIMETHYLFORMAMIDE	73.1	LBNL Data File	3.2	0.01862	0.11736	0.00219
68-12-2	N,N-DIMETHYL FORMAMIDE	73.1	LBNL Data File	3.2	0.01862	1.17363	0.02186
68-12-2	N,N'-DIMETHYL FORMAMIDE	73.1	LBNL Data File	3.2	0.01862	0.58682	0.01093
68-12-2	N,N-DIMETHYLFORMAMIDE	73.1	LBNL Data File	3.2	0.01862	0.58682	0.01093
68-12-2	DMF	73.1	LBNL Data File	3.2	0.01862	0.58682	0.01093
68-12-2	DMF	73.1	LBNL Data File	3.2	0.01862	0.58682	0.01093
68-12-2	DMF	73.1	LBNL Data File	3.2	0.01862	0.29341	0.00546

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
71-43-2	BENZENE	78.1	LBNL Data File	82.1	0.50482	1.17363	0.59247
71-43-2	BENZENE	78.1	LBNL Data File	82.1	0.50482	1.17363	0.59247
71-43-2	BENZENE(ANHYDROUS)	78.1	LBNL Data File	82.1	0.50482	2.34727	1.18494
71-43-2	BENZENE(ANHYDROUS)	78.1	LBNL Data File	82.1	0.50482	0.11736	0.05925
71-43-2	BENZENE	78.1	LBNL Data File	82.1	0.50482	1.17363	0.59247
75-07-0	ACETALDEHYDE	44.1	LBNL Data File	802.4	2.78437	0.00587	0.01634
75-07-0	ACETALDEHYDE	44.1	LBNL Data File	802.4	2.78437	0.11736	0.32678
75-07-0	ACETALDEHYDE	44.1	LBNL Data File	802.4	2.78437	0.11736	0.32678
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	378.5	2.52868	0.11736	0.29677
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	378.5	2.52868	0.00000	0.00000
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	378.5	2.52868	4.69453	11.87098
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	378.5	2.52868	22.29904	56.38715
75-09-2	TO BE VALIDATED-DICHLOROME, ANHYDROUS	84.9	LBNL Data File	378.5	2.52868	0.11736	0.29677
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	378.5	2.52868	1.17363	2.96774
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	378.5	2.52868	22.29904	56.38715
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	378.5	2.52868	4.69453	11.87098
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	378.5	2.52868	4.69453	11.87098
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	378.5	2.52868	0.11736	0.29677
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	378.5	2.52868	1.17363	2.96774
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	378.5	2.52868	0.11736	0.29677
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	378.5	2.52868	4.69453	11.87098
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	378.5	2.52868	4.69453	11.87098
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	378.5	2.52868	1.17363	2.96774
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	378.5	2.52868	1.17363	2.96774
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	378.5	2.52868	1.17363	2.96774
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	378.5	2.52868	23.47267	59.35489
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	378.5	2.52868	1.17363	2.96774
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	378.5	2.52868	23.47267	59.35489
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	378.5	2.52868	4.69453	11.87098
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	378.5	2.52868	4.69453	11.87098
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	378.5	2.52868	0.00000	0.00000
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	378.5	2.52868	4.69453	11.87098
75-09-2	METHANE, DICHLORO-	84.9	LBNL Data File	378.5	2.52868	0.58682	1.48387
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	378.5	2.52868	1.17363	2.96774

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
75-56-9	PROPYLENE OXIDE	58.08	LBNL Data File	468.3	2.14038	0.00035	0.00076
75-56-9	PROPYLENE OXIDE	58.08	LBNL Data File	468.3	2.14038	0.00035	0.00076
78-93-3	MEK	72.1	LBNL Data File	77.7	0.44071	0.58682	0.25862
78-93-3	METHYL ETHYL KETONE	72.1	LBNL Data File	77.7	0.44071	0.58682	0.25862
78-93-3	MEK	72.1	LBNL Data File	77.7	0.44071	0.58682	0.25862
78-93-3	2-BUTANONE	72.1	LBNL Data File	77.7	0.44071	1.17363	0.51724
79-01-6	TRICHLOROETHYLENE	131.4	LBNL Data File	59.0	0.60980	0.58682	0.35784
79-01-6	TRICHLOROETHYLENE	131.4	LBNL Data File	59.0	0.60980	0.58682	0.35784
79-01-6	TRICHLOROETHYLENE	131.4	LBNL Data File	59.0	0.60980	0.58682	0.35784
79-01-6	TRICHLOROETHYLENE	131.4	LBNL Data File	59.0	0.60980	0.58682	0.35784
79-10-7	ACRYLIC ACID	72.06	LBNL Data File	95.0	0.53873	0.00558	0.00301
79-10-7	ACRYLIC ACID	72.06	LBNL Data File	95.0	0.53873	0.00558	0.00301
79-10-7	ACRYLIC ACID	72.06	LBNL Data File	95.0	0.53873	0.00558	0.00301
100-41-4	ETHYL BENZENE	106.2	LBNL Data File	7.9	0.06609	1.17363	0.07756
100-42-5	STYRENE	104.14	LBNL Data File	5.5	0.04484	0.11736	0.00526
100-42-5	STYRENE	104.14	LBNL Data File	5.5	0.04484	0.00587	0.00026
100-44-7	BENZYL CHLORIDE	126.58	LBNL Data File	1.0	0.00995	0.29341	0.00292
106-89-8	4-METHYLUMBELLIFERONE	92.5	LBNL Data File	13.0	0.09462	0.02480	0.00235
106-99-0	1,3-BUTADIENE IN TOLUENE	54.1	LBNL Data File	1838.0	7.82431	0.47324	3.70277
107-02-8	ACROLEIN	56.1	LBNL Data File	242.0	1.06839	0.11736	0.12539
107-06-2	1,2-DICHLOROETHANE	99	LBNL Data File	67.8	0.52791	2.79325	1.47458
107-06-2	1,2-DICHLOROETHANE	99	LBNL Data File	67.8	0.52791	0.58682	0.30979
107-06-2	1,2-DICHLOROETHANE	99	LBNL Data File	67.8	0.52791	1.17363	0.61957
107-06-2	1,2-DICHLOROETHANE	99	LBNL Data File	67.8	0.52791	4.69453	2.47828
107-06-2	1,2-DICHLOROETHANE	99	LBNL Data File	67.8	0.52791	0.58682	0.30979
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0.1	0.00032	1.17363	0.00038
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0.1	0.00032	1.17363	0.00038
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0.1	0.00032	1.17363	0.00038
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0.1	0.00032	4.69453	0.00152
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0.1	0.00032	3.84798	0.00125
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0.1	0.00032	0.96199	0.00031
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0.1	0.00032	1.17363	0.00038
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0.1	0.00032	0.58682	0.00019
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0.1	0.00032	0.29341	0.00009

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0.1	0.00032	0.29341	0.00009
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0.1	0.00032	2.93408	0.00095
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0.1	0.00032	1.17363	0.00038
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0.1	0.00032	0.29341	0.00009
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0.1	0.00032	0.02934	0.00001
107-98-2	1-METHOXY-2-PROPANOL	90.12	NIST	11.8	0.08368	0.00939	0.00079
107-98-2	1-METHOXY-2-PROPANOL	90.12	NIST	11.8	0.08368	0.00939	0.00079
108-39-4	M-CRESOL	108.1	LBNL Data File	0.1	0.00108	0.58682	0.00064
108-39-4	M-CRESOL	108.1	LBNL Data File	0.1	0.00108	0.11736	0.00013
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	0.11736	0.02051
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	1.17363	0.20506
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	0.58682	0.10253
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	1.17363	0.20506
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	1.17363	0.20506
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	2.34727	0.41012
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	1.17363	0.20506
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	1.17363	0.20506
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	1.17363	0.20506
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	1.17363	0.20506
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	1.17363	0.20506
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	0.11736	0.02051
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	1.17363	0.20506
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	1.17363	0.20506
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	0.58682	0.10253
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	1.17363	0.20506
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	1.17363	0.20506
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	1.17363	0.20506
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	0.11736	0.02051
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	0.58682	0.10253
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	2.34727	0.41012
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	0.58682	0.10253
109-86-4	2-METHOXYETHANOL	76.09	NIST	8.4	0.05018	1.17363	0.05889
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	1.17363	1.04948

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
110-54-3	HEXANE, CHROMASOLV PLUS	86.17	LBNL Data File	131.9	0.89422	1.17363	1.04948
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	1.17363	1.04948
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	0.00000	0.00000
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	4.69453	4.19792
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	4.69453	4.19792
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	22.29904	19.94014
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	1.17363	1.04948
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	0.00000	0.00000
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	22.29904	19.94014
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	1.17363	1.04948
110-54-3	ALKANE STANDARD SOLUTION C8-C20	86.17	LBNL Data File	131.9	0.89422	0.00117	0.00105
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	0.00000	0.00000
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	4.69453	4.19792
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	4.69453	4.19792
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	4.69453	4.19792
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	4.69453	4.19792
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	4.69453	4.19792
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	4.69453	4.19792
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	23.47267	20.98962
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	28.16720	25.18754
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	4.69453	4.19792
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	22.29904	19.94014
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	1.17363	1.04948
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	4.69453	4.19792
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	4.69453	4.19792
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	4.69453	4.19792
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	23.47267	20.98962
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	23.47267	20.98962
110-54-3	ALKANE STANDARD SOLUTION C8-C20	86.17	LBNL Data File	131.9	0.89422	0.00117	0.00105
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	23.47267	20.98962
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	1.17363	1.04948
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	0.00000	0.00000
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	1.17363	1.04948
110-54-3	N-HEXANE	86.17	LBNL Data File	131.9	0.89422	1.17363	1.04948

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	1.17363	1.04948
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	1.17363	1.04948
110-54-3	N-HEXANE	86.17	LBNL Data File	131.9	0.89422	0.11736	0.10495
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	0.58682	0.52474
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	1.17363	1.04948
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	1.17363	1.04948
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	1.17363	1.04948
110-54-3	HEXANE, CHROMASOLV PLUS	86.17	LBNL Data File	131.9	0.89422	1.17363	1.04948
110-54-3	HEXANE	86.17	LBNL Data File	131.9	0.89422	1.17363	1.04948
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION	100.12	NIST	0.5	0.00355	1.17363	0.00416
111-30-8	GLUTARALDEHYDE SOLUTION	100.12	NIST	0.5	0.00355	0.02760	0.00010
111-30-8	GLUTARALDEHYDE	100.12	NIST	0.5	0.00355	0.01174	0.00004
111-30-8	GLUTARALDEHYDE SOLUTION	100.12	NIST	0.5	0.00355	0.11736	0.00042
111-30-8	GLUTARALDEHYDE	100.12	NIST	0.5	0.00355	0.02347	0.00008
111-30-8	GLUTARALDEHYDE	100.12	NIST	0.5	0.00355	0.11736	0.00042
111-30-8	GLUTARALDEHYDE SOLUTION	100.12	NIST	0.5	0.00355	0.01174	0.00004
111-30-8	GLUTARALDEHYDE SOLUTION	100.12	NIST	0.5	0.00355	0.01174	0.00004
111-30-8	GLUTARALDEHYDE	100.12	NIST	0.5	0.00355	0.01174	0.00004
111-30-8	GLUTARALDEHYDE	100.12	NIST	0.5	0.00355	0.01174	0.00004
111-30-8	GLUTARALDEHYDE	100.12	NIST	0.5	0.00355	0.01174	0.00004
111-30-8	GLUTARALDEHYDE	100.12	NIST	0.5	0.00355	0.10563	0.00037
111-30-8	GLUTARALDEHYDE	100.12	NIST	0.5	0.00355	0.10563	0.00037
111-30-8	GLUTERALDEHYDE	100.12	NIST	0.5	0.00355	0.00235	0.00001
111-30-8	GLUTERALDEHYDE	100.12	NIST	0.5	0.00355	0.01174	0.00004
111-30-8	GLUTERALDEHYDE	100.12	NIST	0.5	0.00355	0.01174	0.00004
111-30-8	GLUTARALDEHYDE	100.12	NIST	0.5	0.00355	0.02347	0.00008
111-30-8	GLUTARALDEHYDE	100.12	NIST	0.5	0.00355	0.00235	0.00001
111-30-8	GLUTARALDEHYDE	100.12	NIST	0.5	0.00355	0.01174	0.00004
111-30-8	GLUTARALDEHYDE	100.12	NIST	0.5	0.00355	0.11736	0.00042
111-30-8	GLUTARALDEHYDE	100.12	NIST	0.5	0.00355	0.00117	0.00000
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION	100.12	NIST	0.5	0.00355	0.00117	0.00000
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION	100.12	NIST	0.5	0.00355	0.02934	0.00010
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION	100.12	NIST	0.5	0.00355	0.02934	0.00010
111-30-8	GLUTARALDEHYDE	100.12	NIST	0.5	0.00355	0.11736	0.00042

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
111-30-8	GLUTARALDEHYDE	100.12	NIST	0.5	0.00355	0.01174	0.00004
111-30-8	GLUTARIC DIALDEHYDE	100.12	NIST	0.5	0.00355	1.17363	0.00416
111-30-8	GLUTERALDEHYDE	100.12	NIST	0.5	0.00355	0.11736	0.00042
111-30-8	GLUTARALDEHYDE	100.12	NIST	0.5	0.00355	0.11736	0.00042
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION	100.12	NIST	0.5	0.00355	0.11736	0.00042
111-30-8	GLUTARALDEHYDE SOLUTION	100.12	NIST	0.5	0.00355	0.02934	0.00010
111-42-2	DIETHANOLAMINE	105.1	LBNL Data File	0.0	0.00000	0.53493	0.00000
111-42-2	DIETHANOLAMINE	105.1	LBNL Data File	0.0	0.00000	0.03521	0.00000
111-42-2	DIETHANOLAMINE	105.1	LBNL Data File	0.0	0.00000	0.10699	0.00000
111-42-2	DIETHANOLAMINE	105.1	LBNL Data File	0.0	0.00000	0.53493	0.00000
121-44-8	TRIETHYLAMINE	101	LBNL Data File	48.3	0.38407	0.58682	0.22538
121-44-8	TRIETHYLAMINE	101	LBNL Data File	48.3	0.38407	0.11736	0.04508
121-44-8	TRIETHYLAMINE	101	LBNL Data File	48.3	0.38407	0.01174	0.00451
121-44-8	TRIETHYLAMINE	101	LBNL Data File	48.3	0.38407	0.04030	0.01548
121-44-8	TRIETHYLAMINE	101	LBNL Data File	48.3	0.38407	1.17363	0.45075
121-44-8	TRIETHYLAMINE	101	LBNL Data File	48.3	0.38407	0.11736	0.04508
121-44-8	TRIETHYLAMINE	101	LBNL Data File	48.3	0.38407	0.11736	0.04508
121-44-8	TRIETHYLAMINE	101	LBNL Data File	48.3	0.38407	0.11736	0.04508
121-44-8	TRIETHYLAMINE	101	LBNL Data File	48.3	0.38407	0.58682	0.22538
123-91-1	1,4-DIOXANE ANHYDROUS	88.1	LBNL Data File	31.8	0.22021	1.17363	0.25845
123-91-1	1,4-DIOXANE	88.1	LBNL Data File	31.8	0.22021	1.17363	0.25845
123-91-1	DIOXANE	88.1	LBNL Data File	31.8	0.22021	1.17363	0.25845
123-91-1	1,4-DIOXANE	88.1	LBNL Data File	31.8	0.22021	2.34727	0.51689
123-91-1	1,4 DIOXANE	88.1	LBNL Data File	31.8	0.22021	2.34727	0.51689
123-91-1	1,4 DIOXANE	88.1	LBNL Data File	31.8	0.22021	0.56769	0.12501
123-91-1	1,4-DIOXANE ANHYDROUS	88.1	LBNL Data File	31.8	0.22021	1.17363	0.25845
123-91-1	DIOXANE	88.1	LBNL Data File	31.8	0.22021	1.17363	0.25845
123-91-1	DIOXANE	88.1	LBNL Data File	31.8	0.22021	4.69453	1.03378
123-91-1	DIOXANE	88.1	LBNL Data File	31.8	0.22021	4.69453	1.03378
123-91-1	DIOXANE	88.1	LBNL Data File	31.8	0.22021	0.11736	0.02584
127-18-4	TETRACHLOROETHYLENE	165.8	LBNL Data File	15.2	0.19885	1.17363	0.23337
1330-20-7	XYLENE	106.2	LBNL Data File	6.7	0.05616	1.17363	0.06591
1330-20-7	XYLENE	106.2	LBNL Data File	6.7	0.05616	0.58682	0.03295
1330-20-7	XYLENE	106.2	LBNL Data File	6.7	0.05616	4.69453	0.26363

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
1330-20-7	XYLENE	106.2	LBNL Data File	6.7	0.05616	0.00587	0.00033
1330-20-7	XYLENE	106.2	LBNL Data File	6.7	0.05616	0.58682	0.03295
1330-20-7	XYLENE	106.2	LBNL Data File	6.7	0.05616	4.44220	0.24946
1330-20-7	XYLENE	106.2	LBNL Data File	6.7	0.05616	4.69453	0.26363
1330-20-7	XYLENE	106.2	LBNL Data File	6.7	0.05616	4.69453	0.26363
1330-20-7	XYLENE	106.2	LBNL Data File	6.7	0.05616	0.58682	0.03295
1330-20-7	XYLENE	106.2	LBNL Data File	6.7	0.05616	0.58682	0.03295
1330-20-7	XYLENE	106.2	LBNL Data File	6.7	0.05616	0.58682	0.03295
1330-20-7	XYLENE	106.2	LBNL Data File	6.7	0.05616	4.44220	0.24946
1330-20-7	XYLENE	106.2	LBNL Data File	6.7	0.05616	4.69453	0.26363
1330-20-7	XYLENES	106.2	LBNL Data File	6.7	0.05616	0.58682	0.03295
1330-20-7	XYLENE	106.2	LBNL Data File	6.7	0.05616	0.00136	0.00008
1330-20-7	XYLENE	106.2	LBNL Data File	6.7	0.05616	0.58682	0.03295
1330-20-7	XYLENE	106.2	LBNL Data File	6.7	0.05616	4.69453	0.26363
1330-20-7	DEPEX MOUNTING MEDIA	106.2	LBNL Data File	6.7	0.05616	0.11736	0.00659
1634-04-4	METHYL TERT-BUTYL ETHER	88.15	LBNL Data File	120.2	0.83405	4.69453	3.91549
1634-04-4	METHYL TERT-BUTYL ETHER	88.15	LBNL Data File	120.2	0.83405	0.11736	0.09789
7647-01-0	HYDROCHLORIC ACID STANDARD SOLUTION	36.47	LBNL Data File	190.0	0.54525	1.17363	0.63992
7647-01-0	HCL	36.47	LBNL Data File	190.0	0.54525	0.05868	0.03200
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	1.17363	0.63992
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	1.17363	0.63992
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	1.17363	0.63992
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	1.17363	0.63992
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	1.17363	0.63992
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	4.69453	2.55968
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	4.69453	2.55968
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	4.69453	2.55968
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	4.69453	2.55968
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	4.69453	2.55968
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	1.17363	0.63992
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	1.17363	0.63992
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	1.17363	0.63992
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	1.17363	0.63992
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID SOLUTION	36.47	LBNL Data File	190.0	0.54525	0.11736	0.06399
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.11736	0.06399
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.11736	0.06399
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	1.17363	0.63992
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	1.17363	0.63992
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	4.69453	2.55968
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	4.69453	2.55968
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	4.69453	2.55968
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	4.69453	2.55968
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	4.69453	2.55968
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID SOLUTION	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	1.17363	0.63992
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.00117	0.00064
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	IMIDAZOLERIC ACID	36.47	LBNL Data File	190.0	0.54525	24.45070	13.33165

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HCL	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	)ECAFLUORO-1,1,2,2-TERAHYDROOCTYL)TRICHLOROSI	36.47	LBNL Data File	190.0	0.54525	48.90139	26.66329
7647-01-0	HCL	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HCL	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	26.65322	14.53256
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	4.44220	2.42209
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.11736	0.06399
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.11736	0.06399
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.00352	0.00192
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190.0	0.54525	4.69453	2.55968
7664-38-2	BIO-SAFE COOMASSIE	98.04	LBNL Data File	0.0	0.00023	1.17363	0.00027
7664-38-2	BIO-SAFE COOMASSIE	98.04	LBNL Data File	0.0	0.00023	1.17363	0.00027
7664-38-2	BIO-SAFE COOMASSIE	98.04	LBNL Data File	0.0	0.00023	1.17363	0.00027
7664-38-2	BIO-SAFE COOMASSIE	98.04	LBNL Data File	0.0	0.00023	1.17363	0.00027
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.06965	0.00002
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.52814	0.00012
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.58682	0.00014
7664-38-2	LPH SE GERMICIDAL DETERGENT	98.04	LBNL Data File	0.0	0.00023	4.44220	0.00103
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.58682	0.00014
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.58682	0.00014
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.58682	0.00014
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	6.96518	0.00161
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.58682	0.00014
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	2.93408	0.00068
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	6.96518	0.00161
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.58682	0.00014
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.06965	0.00002
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.58682	0.00014
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.58682	0.00014
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.52814	0.00012
7664-38-2	O-PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	1.17363	0.00027
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.58682	0.00014
7664-38-2	E REAGENT CONCENTRATE (PHOSPHAIC ACID/METHAN	98.04	LBNL Data File	0.0	0.00023	0.52814	0.00012
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.58682	0.00014
7664-38-2	5'-MONOPHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.00035	0.00000
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.58682	0.00014
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.06965	0.00002
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.06965	0.00002

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.34826	0.00008
7664-38-2	PHOSPORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.05868	0.00001
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0.0	0.00023	0.58682	0.00014
7664-39-3	HYDROFLUORIC ACID	20.01	LBNL Data File	25.0	0.03936	0.58682	0.02310
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	0.11736	0.00091
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	1.17363	0.00906
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	1.17363	0.00906
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	1.17363	0.00906
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	0.58682	0.00453
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	0.58682	0.00453
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	0.58682	0.00453
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	0.58682	0.00453
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	0.58682	0.00453
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	0.58682	0.00453
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	0.58682	0.00453
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	4.69453	0.03623
7664-93-9	FISHER CLEANING SOLUTION	98.08	NIST	1.0	0.00772	0.58682	0.00453
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	1.17363	0.00906
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	0.11736	0.00091
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	1.17363	0.00906
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	0.58682	0.00453
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	0.05868	0.00045
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	2.93408	0.02264
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	0.11736	0.00091
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	0.11736	0.00091
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	2.93408	0.02264
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	0.58682	0.00453
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	0.58682	0.00453
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	5.86817	0.04529
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	3.80844	0.02939
7664-93-9	SULFURIC ACID	98.08	NIST	1.0	0.00772	2.93408	0.02264
7697-37-2	NITRIC ACID	63.02	LBNL Data File	48.0	0.23803	2.93408	0.69839
7697-37-2	NITRIC ACID	63.02	LBNL Data File	48.0	0.23803	2.93408	0.69839
7697-37-2	NITRIC ACID	63.02	LBNL Data File	48.0	0.23803	2.93408	0.69839

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table G-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
7697-37-2	NITRIC ACID	63.02	LBNL Data File	48.0	0.23803	2.93408	0.69839
7697-37-2	NITRIC ACID	63.02	LBNL Data File	48.0	0.23803	0.58682	0.13968
7697-37-2	NITRIC ACID	63.02	LBNL Data File	48.0	0.23803	0.58682	0.13968
7726-95-6	BROMINE	159.8	LBNL Data File	188.1	2.36538	0.00188	0.00445

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Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Emissions from Evaporation During Use (Table G-5)

A = Surface Area (cm^2) = 100
U = Wind Speed (m/s) = 0.51
MW = Molecular Weight (g/mole) = Chemical-specific
VP = Vapor Pressure (mmHg) = Chemical-specific
R = Gas Constant ($atm\text{-}cm^3/mole\text{-}deg\ K$) = 82.05
T = Ambient Temperature (K) = 295

Loss (grams/batch) = $(4.120*A*U^{0.78}*MW^{0.67}*VP)/(R*T)$

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet		*MW entered manually*		*From previous worksheet*	*From previous worksheet*	*Calculated*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**Adjusted Vapor Pressure (mmHg)**	**Assumed No. of Batches (per yr)**	**Estimated Loss Emission Factor (grams/batch)**	**Estimated Emissions (grams/yr)**
50-00-0	NORTHERNMAX DENATURING GEL BUFFER	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	69.95
50-00-0	NORTHERNMAX DENATURING GEL BUFFER	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	69.95
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	69.95
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	69.95
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	69.95
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	100	25	9.837	245.93
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	100	25	9.837	245.93
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	100	25	9.837	245.93
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALIN	30.03	LBNL Data File	100	10	9.837	83.94
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	83.94
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	83.94
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	83.94
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	83.94
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	83.94
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	83.94
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	83.94
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	83.94
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	83.94

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Emissions from Evaporation During Use (Table G-5)

A = Surface Area (cm^2) = 100
U = Wind Speed (m/s) = 0.51
MW = Molecular Weight (g/mole) = Chemical-specific
VP = Vapor Pressure (mmHg) = Chemical-specific
R = Gas Constant ($atm\text{-}cm^3/mole\text{-}deg\ K$) = 82.05
T = Ambient Temperature (K) = 295

Loss (grams/batch) = $(4.120*A*U^{0.78}*MW^{0.67}*VP)/(R*T)$

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet		*MW entered manually*		*From previous worksheet*	*From previous worksheet*	*Calculated*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**Adjusted Vapor Pressure (mmHg)**	**Assumed No. of Batches (per yr)**	**Estimated Loss Emission Factor (grams/batch)**	**Estimated Emissions (grams/yr)**
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	83.94
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	83.94
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	83.94
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	83.94
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	83.94
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	25	9.837	245.93
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	25	9.837	245.93
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	100	5	9.837	10.49
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	100	5	9.837	10.49
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	100	5	9.837	10.49
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	100	5	9.837	10.49
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	100	5	9.837	10.49
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	100	5	9.837	10.49
50-00-0	FORMALINE SOLUTION ACCUSTAIN 10%	30.03	LBNL Data File	100	10	9.837	83.94
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALINE SOLUTION ACCUSTAIN 10%	30.03	LBNL Data File	100	5	9.837	34.98
50-00-0	NORTHERNMAX DENATURING GEL BUFFER	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	69.95
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	69.95
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	69.95
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	100	25	9.837	245.93
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	49.19
50-00-0	BUFFERED NEUTRAL FORMALIN	30.03	LBNL Data File	100	25	9.837	245.93
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALINE SOLUTION ACCUSTAIN 10%	30.03	LBNL Data File	100	25	9.837	245.93
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	100	25	9.837	245.93
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	100	25	9.837	245.93
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	100	25	9.837	245.93
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	100	25	9.837	245.93
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	17.49
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	7.00
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALIN SOLUTION	30.03	LBNL Data File	100	5	9.837	10.49
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	1	9.837	3.50
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALIN SOLUTION 10%, NEUTRAL BUFFERED	30.03	LBNL Data File	100	5	9.837	24.48
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	25	9.837	245.93
50-00-0	FORMALDEHYDE, 37 WT IN H2O	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	25	9.837	245.93
50-00-0	FORMALDEHYDE, 37 WT	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE 37 % IN WATER	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	69.95
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	69.95
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALDEHYDE SOLUTION	30.03	LBNL Data File	100	10	9.837	98.37
50-00-0	FORMALIN	30.03	LBNL Data File	100	25	9.837	245.93
56-23-5	CARBON TETRACHLORIDE	153.8	LBNL Data File	100	10	29.387	293.87
58-89-9	YCLOHEXANE, 1,2,3,4,5,6-HEXACHLORO-, GAMMA-ISOME	290.9	LBNL Data File	0	10	0.000	0.00
58-89-9	YCLOHEXANE, 1,2,3,4,5,6-HEXACHLORO-, GAMMA-ISOME	291.9	LBNL Data File	0	10	0.000	0.00
58-89-9	YCLOHEXANE, 1,2,3,4,5,6-HEXACHLORO-, GAMMA-ISOME	292.9	LBNL Data File	0	1	0.000	0.00
58-89-9	YCLOHEXANE, 1,2,3,4,5,6-HEXACHLORO-, GAMMA-ISOME	293.9	LBNL Data File	0	1	0.000	0.00

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Emissions from Evaporation During Use (Table G-5)

A = Surface Area (cm^2) = 100
U = Wind Speed (m/s) = 0.51
MW = Molecular Weight (g/mole) = Chemical-specific
VP = Vapor Pressure (mmHg) = Chemical-specific
R = Gas Constant (atm-cm^3/mole-deg K) = 82.05
T = Ambient Temperature (K) = 295

Loss (grams/batch) = $(4.120 \cdot A \cdot U^{0.78} \cdot MW^{0.67} \cdot VP)/(R \cdot T)$

CAS No.	*This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet* Compound Name	*MW entered manually* MW (g/mole)	MW Reference	*From previous worksheet* Adjusted Vapor Pressure (mmHg)	*From previous worksheet* Assumed No. of Batches (per yr)	*Calculated* Estimated Loss Emission Factor (grams/batch)	*Calculated* Estimated Emissions (grams/yr)
62-53-3	ANILINE OIL	93	LBNL Data File	1	10	0.221	2.21
62-53-3	BENZAMINE	93	LBNL Data File	1	1	0.221	0.22
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	1	10.876	0.70
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	COMBI METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	10	10.876	69.95
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	10	10.876	108.76
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	100	10.876	1087.58
67-56-1	METHANOL	32.1	LBNL Data File	106	100	10.876	1087.58
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	0	10.876	0.00
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Emissions from Evaporation During Use (Table G-5)

A = Surface Area (cm^2) = 100
U = Wind Speed (m/s) = 0.51
MW = Molecular Weight (g/mole) = Chemical-specific
VP = Vapor Pressure (mmHg) = Chemical-specific
R = Gas Constant ($atm\text{-}cm^3/mole\text{-}deg\ K$) = 82.05
T = Ambient Temperature (K) = 295

Loss (grams/batch) = $(4.120*A*U^{0.78}*MW^{0.67}*VP)/(R*T)$

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet		*MW entered manually*		*From previous worksheet*	*From previous worksheet*	*Calculated*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**Adjusted Vapor Pressure (mmHg)**	**Assumed No. of Batches (per yr)**	**Estimated Loss Emission Factor (grams/batch)**	**Estimated Emissions (grams/yr)**
67-56-1	METHANOL	32.1	LBNL Data File	106	10	10.876	69.95
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	10	10.876	108.76
67-56-1	METHANOL	32.1	LBNL Data File	106	10	10.876	69.95
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	10	10.876	108.76
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	HYDRA-POINT METHANOL, DRY	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	HYDRA-POINT METHANOL, DRY	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	AMMONIA 7N SOLUTION IN METHANOL	32.1	LBNL Data File	106	10	10.876	69.95
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	10	10.876	69.95
67-56-1	METHANOL	32.1	LBNL Data File	106	1	10.876	0.70
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	COMBI METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHYL ALCOHOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	100	10.876	1087.58
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	10	10.876	69.95
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Emissions from Evaporation During Use (Table G-5)

A = Surface Area (cm^2) = 100
U = Wind Speed (m/s) = 0.51
MW = Molecular Weight (g/mole) = Chemical-specific
VP = Vapor Pressure (mmHg) = Chemical-specific
R = Gas Constant ($atm\text{-}cm^3/mole\text{-}deg\ K$) = 82.05
T = Ambient Temperature (K) = 295

Loss (grams/batch) = $(4.120*A*U^{0.78}*MW^{0.67}*VP)/(R*T)$

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet		*MW entered manually*		*From previous worksheet*	*From previous worksheet*	*Calculated*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**Adjusted Vapor Pressure (mmHg)**	**Assumed No. of Batches (per yr)**	**Estimated Loss Emission Factor (grams/batch)**	**Estimated Emissions (grams/yr)**
67-56-1	METHANOL	32.1	LBNL Data File	106	10	10.876	108.76
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	10	10.876	69.95
67-56-1	METHANOL	32.1	LBNL Data File	106	10	10.876	108.76
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	10	10.876	108.76
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-63-0	ISOPROPYL ALCOHOL (2)	60.1	LBNL Data File	74	100	11.647	1164.72
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	100	11.647	1164.72
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	100	11.647	1164.72
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	ISOPROPYL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Emissions from Evaporation During Use (Table G-5)

A = Surface Area (cm^2) = 100
U = Wind Speed (m/s) = 0.51
MW = Molecular Weight (g/mole) = Chemical-specific
VP = Vapor Pressure (mmHg) = Chemical-specific
R = Gas Constant ($atm\text{-}cm^3/mole\text{-}deg\ K$) = 82.05
T = Ambient Temperature (K) = 295

Loss (grams/batch) = $(4.120*A*U^{0.78}*MW^{0.67}*VP)/(R*T)$

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet		*MW entered manually*		*From previous worksheet*	*From previous worksheet*	*Calculated*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**Adjusted Vapor Pressure (mmHg)**	**Assumed No. of Batches (per yr)**	**Estimated Loss Emission Factor (grams/batch)**	**Estimated Emissions (grams/yr)**
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	ISOPROPANOL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPANOL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	25	11.647	291.18

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Emissions from Evaporation During Use (Table G-5)

A = Surface Area (cm^2) = 100
U = Wind Speed (m/s) = 0.51
MW = Molecular Weight (g/mole) = Chemical-specific
VP = Vapor Pressure (mmHg) = Chemical-specific
R = Gas Constant ($atm\text{-}cm^3$/mole-deg K) = 82.05
T = Ambient Temperature (K) = 295

Loss (grams/batch) = $(4.120*A*U^{0.78}*MW^{0.67}*VP)/(R*T)$

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet		*MW entered manually*		*From previous worksheet*	*From previous worksheet*	*Calculated*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**Adjusted Vapor Pressure (mmHg)**	**Assumed No. of Batches (per yr)**	**Estimated Loss Emission Factor (grams/batch)**	**Estimated Emissions (grams/yr)**
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	MICROSHARP CLEANING FLUID	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	MICROSHARP CLEANING FLUID	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	MICROSHARP CLEANING FLUID	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	MICROSHARP CLEANING FLUID	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	MICROSHARP CLEANING FLUID	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	N-HYDROXYSUCCINIMIDYL-ACTIVATED AGAROSE	60.1	LBNL Data File	74	1	11.647	3.50
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	10	11.647	69.95
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	2-PROPANOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPANOL	60.1	LBNL Data File	74	5	11.647	17.49
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL	60.1	LBNL Data File	74	25	11.647	291.18
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	69.95
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL 24:1	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM ISOAMYL ALCOHOL	119.4	LBNL Data File	169	10	41.885	69.95
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM ISOAMYL ALCOHOL	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM ISOAMYL ALCOHOL	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL 24:1	119.4	LBNL Data File	169	10	41.885	69.95
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	699.54
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	699.54
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	699.54
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	17.49
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL 24:1	119.4	LBNL Data File	169	25	41.885	662.01
67-66-3	CHLOROFORM: ISOAMYL ALCOHOL MIXTURE	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	17.49
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	279.82
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	279.82
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	331.00
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	331.00

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Emissions from Evaporation During Use (Table G-5)

A = Surface Area (cm^2) = 100
U = Wind Speed (m/s) = 0.51
MW = Molecular Weight (g/mole) = Chemical-specific
VP = Vapor Pressure (mmHg) = Chemical-specific
R = Gas Constant (atm-cm^3/mole-deg K) = 82.05
T = Ambient Temperature (K) = 295

Loss (grams/batch) = $(4.120*A*U^{0.78}*MW^{0.67}*VP)/(R*T)$

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet		*MW entered manually*		*From previous worksheet*	*From previous worksheet*	*Calculated*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**Adjusted Vapor Pressure (mmHg)**	**Assumed No. of Batches (per yr)**	**Estimated Loss Emission Factor (grams/batch)**	**Estimated Emissions (grams/yr)**
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	1047.13
67-66-3	CHLOROFORM HPLC PURE	119.4	LBNL Data File	169	25	41.885	699.54
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	1047.13
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL MIXTURE	119.4	LBNL Data File	169	10	41.885	69.95
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	17.49
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	69.95
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	699.54
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	699.54
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	23.59
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	17.49
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	17.49
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	17.49
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	1047.13
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	1047.13
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM: ISOAMYL ALCOHOL	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM: ISOAMYL ALCOHOL	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	1047.13
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL	119.4	LBNL Data File	169	10	41.885	69.95
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL 24:1	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	699.54
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	699.54
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	1047.13
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	1047.13
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	1047.13
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	1047.13
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM:ISOAMYL ALCOHOL	119.4	LBNL Data File	169	10	41.885	331.00
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	1047.13
67-66-3	CHLOROFORM HPLC PURE	119.4	LBNL Data File	169	25	41.885	699.54
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	69.95
67-66-3	TRICHLOROMETHANE	119.4	LBNL Data File	169	5	41.885	17.49
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	17.49
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	17.49
67-66-3	CHLOROFORM: ISOAMYL ALCOHOL MIXTURE	119.4	LBNL Data File	169	10	41.885	314.79
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	47.17
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	662.01
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	1047.13
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	1047.13
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	1047.13
67-66-3	CHLOROFORM/ISOAMYL ALCOHOL	119.4	LBNL Data File	169	5	41.885	34.98
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	699.54
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	1047.13
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	17.49
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	17.49
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	17.49
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	1047.13
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	17.49
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	699.54
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	17.49
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	69.95

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Emissions from Evaporation During Use (Table G-5)

A = Surface Area (cm^2) = 100
U = Wind Speed (m/s) = 0.51
MW = Molecular Weight (g/mole) = Chemical-specific
VP = Vapor Pressure (mmHg) = Chemical-specific
R = Gas Constant ($atm\text{-}cm^3$/mole-deg K) = 82.05
T = Ambient Temperature (K) = 295

Loss (grams/batch) = $(4.120*A*U^{0.78}*MW^{0.67}*VP)/(R*T)$

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet		*MW entered manually*		*From previous worksheet*	*From previous worksheet*	*Calculated*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**Adjusted Vapor Pressure (mmHg)**	**Assumed No. of Batches (per yr)**	**Estimated Loss Emission Factor (grams/batch)**	**Estimated Emissions (grams/yr)**
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	17.49
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	664.56
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	17.49
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	17.49
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	699.54
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	699.54
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	5	41.885	17.49
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	10	41.885	349.77
68-12-2	N,N-DIMETHYLFORMAMIDE	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	N-N-DIMETHYLFOMAMIDE	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	N,N-DIMETHYLFORMAMIDE	73.1	LBNL Data File	6	25	1.156	28.90
68-12-2	N,N-DIMETHYLFORMAMIDE	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	N,N-DIMETHYLFORMAMIDE	73.1	LBNL Data File	6	25	1.156	28.90
68-12-2	N,N-DIMETHYLFORMAMIDE	73.1	LBNL Data File	6	25	1.156	28.90
68-12-2	N-N-DIMETHYL FORMAMIDE	73.1	LBNL Data File	6	25	1.156	28.90
68-12-2	N,N-DIMETHYLFORMAMIDE	73.1	LBNL Data File	6	25	1.156	28.90
68-12-2	N,N-DIMETHYLFORMAMIDE, ANHYDROUS	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	DMF	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	DMF	73.1	LBNL Data File	6	25	1.156	28.90
68-12-2	DMF	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	DMF	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	DIMETHYLFORMAMIDE	73.1	LBNL Data File	6	1	1.156	0.70
68-12-2	DMF	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	DMF	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	DMF	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	DIMETHYLFORMAMIDE	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	DIMETHYL-FORMAMIDE	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	DIMETHYL-FORMAMIDE	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	DIMETHYLFORMAMIDE	73.1	LBNL Data File	6	25	1.156	28.90
68-12-2	DIMETHYLFORMAMIDE	73.1	LBNL Data File	6	25	1.156	28.90
68-12-2	DMF	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	N, N-DIMETHYLFORMAMIDE, REAGENT GRADE	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	N,N-DIMETHYLFORMAMIDE	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	DIMETHYLFORMAMIDE	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	N,N-DIMETHYL FORMAMIDE	73.1	LBNL Data File	6	25	1.156	28.90
68-12-2	N,N'-DIMETHYL FORMAMIDE	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	N,N-DIMETHYLFORMAMIDE	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	DMF	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	DMF	73.1	LBNL Data File	6	10	1.156	11.56
68-12-2	DMF	73.1	LBNL Data File	6	10	1.156	11.56
71-43-2	BENZENE	78.1	LBNL Data File	100	25	18.663	466.57
71-43-2	BENZENE	78.1	LBNL Data File	100	25	18.663	466.57
71-43-2	BENZENE(ANHYDROUS)	78.1	LBNL Data File	100	25	18.663	466.57
71-43-2	BENZENE(ANHYDROUS)	78.1	LBNL Data File	100	10	18.663	69.95
71-43-2	BENZENE	78.1	LBNL Data File	100	25	18.663	466.57
75-07-0	ACETALDEHYDE	44.1	LBNL Data File	802	1	102.108	3.50
75-07-0	ACETALDEHYDE	44.1	LBNL Data File	802	10	102.108	69.95
75-07-0	ACETALDEHYDE	44.1	LBNL Data File	802	10	102.108	69.95
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	379	10	74.706	69.95
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	379	0	74.706	0.00
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	379	25	74.706	1867.64
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	379	100	74.706	7470.55
75-09-2	TO BE VALIDATED-DICHLOROME, ANHYDROUS	84.9	LBNL Data File	379	10	74.706	69.95
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	379	25	74.706	699.54
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	379	100	74.706	7470.55
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	379	25	74.706	1867.64
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	379	25	74.706	1867.64
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	379	10	74.706	69.95
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	379	25	74.706	699.54
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	379	10	74.706	69.95
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	379	25	74.706	1867.64
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	379	25	74.706	1867.64
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	379	25	74.706	699.54
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	379	25	74.706	699.54
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	379	25	74.706	699.54
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	379	100	74.706	7470.55
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	379	25	74.706	699.54
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	379	100	74.706	7470.55
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	379	25	74.706	1867.64

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Emissions from Evaporation During Use (Table G-5)

A = Surface Area (cm^2) = 100
U = Wind Speed (m/s) = 0.51
MW = Molecular Weight (g/mole) = Chemical-specific
VP = Vapor Pressure (mmHg) = Chemical-specific
R = Gas Constant ($atm\text{-}cm^3$/mole-deg K) = 82.05
T = Ambient Temperature (K) = 295

Loss (grams/batch) = $(4.120*A*U^{0.78}*MW^{0.67}*VP)/(R*T)$

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet		*MW entered manually*		*From previous worksheet*	*From previous worksheet*	*Calculated*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**Adjusted Vapor Pressure (mmHg)**	**Assumed No. of Batches (per yr)**	**Estimated Loss Emission Factor (grams/batch)**	**Estimated Emissions (grams/yr)**
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	379	25	74.706	1867.64
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	379	0	74.706	0.00
75-09-2	DICHLOROMETHANE	84.9	LBNL Data File	379	25	74.706	1867.64
75-09-2	METHANE, DICHLORO-	84.9	LBNL Data File	379	10	74.706	349.77
75-09-2	METHYLENE CHLORIDE	84.9	LBNL Data File	379	25	74.706	699.54
75-56-9	PROPYLENE OXIDE	58.08	LBNL Data File	468	1	71.674	0.21
75-56-9	PROPYLENE OXIDE	58.08	LBNL Data File	468	1	71.674	0.21
78-93-3	MEK	72.1	LBNL Data File	100	10	17.690	176.90
78-93-3	METHYL ETHYL KETONE	72.1	LBNL Data File	100	10	17.690	176.90
78-93-3	MEK	72.1	LBNL Data File	100	10	17.690	176.90
78-93-3	2-BUTANONE	72.1	LBNL Data File	100	25	17.690	442.24
79-01-6	TRICHLOROETHYLENE	131.4	LBNL Data File	100	10	26.446	264.46
79-01-6	TRICHLOROETHYLENE	131.4	LBNL Data File	100	10	26.446	264.46
79-01-6	TRICHLOROETHYLENE	131.4	LBNL Data File	100	10	26.446	264.46
79-01-6	TRICHLOROETHYLENE	131.4	LBNL Data File	100	10	26.446	264.46
79-10-7	ACRYLIC ACID	72.06	LBNL Data File	100	1	17.683	3.33
79-10-7	ACRYLIC ACID	72.06	LBNL Data File	100	1	17.683	3.33
79-10-7	ACRYLIC ACID	72.06	LBNL Data File	100	1	17.683	3.33
100-41-4	ETHYL BENZENE	106.2	LBNL Data File	16	25	3.627	90.67
100-42-5	STYRENE	104.14	LBNL Data File	11	10	2.477	24.77
100-42-5	STYRENE	104.14	LBNL Data File	11	1	2.477	2.48
100-44-7	BENZYL CHLORIDE	126.58	LBNL Data File	2	10	0.515	5.15
106-89-8	4-METHYLUMBELLIFERONE	92.5	LBNL Data File	26	5	5.435	14.78
106-99-0	1,3-BUTADIENE IN TOLUENE	54.1	LBNL Data File	1838	10	268.219	282.07
107-02-8	ACROLEIN	56.1	LBNL Data File	242	10	36.189	69.95
107-06-2	1,2-DICHLOROETHANE	99	LBNL Data File	100	25	21.876	546.91
107-06-2	1,2-DICHLOROETHANE	99	LBNL Data File	100	10	21.876	218.76
107-06-2	1,2-DICHLOROETHANE	99	LBNL Data File	100	25	21.876	546.91
107-06-2	1,2-DICHLOROETHANE	99	LBNL Data File	100	25	21.876	546.91
107-06-2	1,2-DICHLOROETHANE	99	LBNL Data File	100	10	21.876	218.76
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0	25	0.021	0.53
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0	25	0.021	0.53
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0	25	0.021	0.53
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0	25	0.021	0.53
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0	25	0.021	0.53
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0	10	0.021	0.21
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0	25	0.021	0.53
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0	10	0.021	0.21
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0	10	0.021	0.21
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0	10	0.021	0.21
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0	25	0.021	0.53
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0	25	0.021	0.53
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0	10	0.021	0.21
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0	5	0.021	0.11
107-98-2	1-METHOXY-2-PROPANOL	90.12	NIST	24	1	4.848	4.85
107-98-2	1-METHOXY-2-PROPANOL	90.12	NIST	24	1	4.848	4.85
108-39-4	M-CRESOL	108.1	LBNL Data File	0	10	0.059	0.59
108-39-4	M-CRESOL	108.1	LBNL Data File	0	10	0.059	0.59
108-88-3	TOLUENE	92.1	LBNL Data File	48	10	10.050	69.95
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	10	10.050	100.50
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	10	10.050	69.95
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	10	10.050	100.50
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	10	10.050	69.95
108-88-3	TOLUENE	92.1	LBNL Data File	48	10	10.050	100.50
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
109-86-4	2-METHOXYETHANOL	76.09	NIST	17	25	3.074	76.85
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE, CHROMASOLV PLUS	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Emissions from Evaporation During Use (Table G-5)

A = Surface Area (cm^2) = 100
U = Wind Speed (m/s) = 0.51
MW = Molecular Weight (g/mole) = Chemical-specific
VP = Vapor Pressure (mmHg) = Chemical-specific
R = Gas Constant (atm-cm^3/mole-deg K) = 82.05
T = Ambient Temperature (K) = 295

Loss (grams/batch) = $(4.120*A*U^{0.78}*MW^{0.67}*VP)/(R*T)$

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet		*MW entered manually*		*From previous worksheet*	*From previous worksheet*	*Calculated*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**Adjusted Vapor Pressure (mmHg)**	**Assumed No. of Batches (per yr)**	**Estimated Loss Emission Factor (grams/batch)**	**Estimated Emissions (grams/yr)**
110-54-3	HEXANE	86.17	LBNL Data File	132	0	26.289	0.00
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	100	26.289	2628.89
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	0	26.289	0.00
110-54-3	HEXANE	86.17	LBNL Data File	132	100	26.289	2628.89
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	ALKANE STANDARD SOLUTION C8-C20	86.17	LBNL Data File	132	1	26.289	0.70
110-54-3	HEXANE	86.17	LBNL Data File	132	0	26.289	0.00
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	100	26.289	2628.89
110-54-3	HEXANE	86.17	LBNL Data File	132	100	26.289	2628.89
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	100	26.289	2628.89
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	100	26.289	2628.89
110-54-3	HEXANE	86.17	LBNL Data File	132	100	26.289	2628.89
110-54-3	ALKANE STANDARD SOLUTION C8-C20	86.17	LBNL Data File	132	1	26.289	0.70
110-54-3	HEXANE	86.17	LBNL Data File	132	100	26.289	2628.89
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	0	26.289	0.00
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	N-HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	N-HEXANE	86.17	LBNL Data File	132	10	26.289	69.95
110-54-3	HEXANE	86.17	LBNL Data File	132	10	26.289	262.89
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE, CHROMASOLV PLUS	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION	100.12	NIST	1	25	0.198	4.96
111-30-8	GLUTARALDEHYDE SOLUTION	100.12	NIST	1	5	0.198	0.99
111-30-8	GLUTARALDEHYDE	100.12	NIST	1	5	0.198	0.99
111-30-8	GLUTARALDEHYDE SOLUTION	100.12	NIST	1	10	0.198	1.98
111-30-8	GLUTARALDEHYDE	100.12	NIST	1	5	0.198	0.99
111-30-8	GLUTARALDEHYDE	100.12	NIST	1	10	0.198	1.98
111-30-8	GLUTARALDEHYDE SOLUTION	100.12	NIST	1	5	0.198	0.99
111-30-8	GLUTARALDEHYDE SOLUTION	100.12	NIST	1	5	0.198	0.99
111-30-8	GLUTARALDEHYDE	100.12	NIST	1	5	0.198	0.99
111-30-8	GLUTARALDEHYDE	100.12	NIST	1	5	0.198	0.99
111-30-8	GLUTARALDEHYDE	100.12	NIST	1	5	0.198	0.99
111-30-8	GLUTARALDEHYDE	100.12	NIST	1	10	0.198	1.98
111-30-8	GLUTARALDEHYDE	100.12	NIST	1	10	0.198	1.98
111-30-8	GLUTERALDEHYDE	100.12	NIST	1	1	0.198	0.20
111-30-8	GLUTERALDEHYDE	100.12	NIST	1	5	0.198	0.99
111-30-8	GLUTERALDEHYDE	100.12	NIST	1	5	0.198	0.99
111-30-8	GLUTARALDEHYDE	100.12	NIST	1	5	0.198	0.99
111-30-8	GLUTARALDEHYDE	100.12	NIST	1	1	0.198	0.20
111-30-8	GLUTARALDEHYDE	100.12	NIST	1	5	0.198	0.99
111-30-8	GLUTARALDEHYDE	100.12	NIST	1	10	0.198	1.98
111-30-8	GLUTARALDEHYDE	100.12	NIST	1	1	0.198	0.20
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION	100.12	NIST	1	1	0.198	0.20
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION	100.12	NIST	1	5	0.198	0.99
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION	100.12	NIST	1	5	0.198	0.99
111-30-8	GLUTARALDEHYDE	100.12	NIST	1	10	0.198	1.98
111-30-8	GLUTARALDEHYDE	100.12	NIST	1	5	0.198	0.99
111-30-8	GLUTARIC DIALDEHYDE	100.12	NIST	1	25	0.198	4.96
111-30-8	GLUTERALDEHYDE	100.12	NIST	1	10	0.198	1.98
111-30-8	GLUTARALDEHYDE	100.12	NIST	1	10	0.198	1.98
111-30-8	GLUTARALDEHYDE 25% AQUEOUS SOLUTION	100.12	NIST	1	10	0.198	1.98
111-30-8	GLUTARALDEHYDE SOLUTION	100.12	NIST	1	5	0.198	0.99
111-42-2	DIETHANOLAMINE	105.1	LBNL Data File	0	10	0.000	0.00
111-42-2	DIETHANOLAMINE	105.1	LBNL Data File	0	5	0.000	0.00
111-42-2	DIETHANOLAMINE	105.1	LBNL Data File	0	10	0.000	0.00

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Emissions from Evaporation During Use (Table G-5)

A = Surface Area (cm^2) = 100
U = Wind Speed (m/s) = 0.51
MW = Molecular Weight (g/mole) = Chemical-specific
VP = Vapor Pressure (mmHg) = Chemical-specific
R = Gas Constant (atm-cm^3/mole-deg K) = 82.05
T = Ambient Temperature (K) = 295

Loss (grams/batch) = $(4.120*A*U^{0.78}*MW^{0.67}*VP)/(R*T)$

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet		*MW entered manually*		*From previous worksheet*	*From previous worksheet*	*Calculated*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**Adjusted Vapor Pressure (mmHg)**	**Assumed No. of Batches (per yr)**	**Estimated Loss Emission Factor (grams/batch)**	**Estimated Emissions (grams/yr)**
111-42-2	DIETHANOLAMINE	105.1	LBNL Data File	0	10	0.000	0.00
121-44-8	TRIETHYLAMINE	101	LBNL Data File	97	10	21.429	214.29
121-44-8	TRIETHYLAMINE	101	LBNL Data File	97	10	21.429	69.95
121-44-8	TRIETHYLAMINE	101	LBNL Data File	97	5	21.429	7.00
121-44-8	TRIETHYLAMINE	101	LBNL Data File	97	5	21.429	24.02
121-44-8	TRIETHYLAMINE	101	LBNL Data File	97	25	21.429	535.73
121-44-8	TRIETHYLAMINE	101	LBNL Data File	97	10	21.429	69.95
121-44-8	TRIETHYLAMINE	101	LBNL Data File	97	10	21.429	69.95
121-44-8	TRIETHYLAMINE	101	LBNL Data File	97	10	21.429	69.95
121-44-8	TRIETHYLAMINE	101	LBNL Data File	97	10	21.429	214.29
123-91-1	1,4-DIOXANE ANHYDROUS	88.1	LBNL Data File	64	25	12.854	321.34
123-91-1	1,4-DIOXANE	88.1	LBNL Data File	64	25	12.854	321.34
123-91-1	DIOXANE	88.1	LBNL Data File	64	25	12.854	321.34
123-91-1	1,4-DIOXANE	88.1	LBNL Data File	64	25	12.854	321.34
123-91-1	1,4 DIOXANE	88.1	LBNL Data File	64	25	12.854	321.34
123-91-1	1,4 DIOXANE	88.1	LBNL Data File	64	10	12.854	128.54
123-91-1	1,4-DIOXANE ANHYDROUS	88.1	LBNL Data File	64	25	12.854	321.34
123-91-1	DIOXANE	88.1	LBNL Data File	64	25	12.854	321.34
123-91-1	DIOXANE	88.1	LBNL Data File	64	25	12.854	321.34
123-91-1	DIOXANE	88.1	LBNL Data File	64	25	12.854	321.34
123-91-1	DIOXANE	88.1	LBNL Data File	64	10	12.854	69.95
127-18-4	TETRACHLOROETHYLENE	165.8	LBNL Data File	30	25	9.421	235.52
1330-20-7	XYLENE	106.2	LBNL Data File	13	25	3.082	77.04
1330-20-7	XYLENE	106.2	LBNL Data File	13	10	3.082	30.82
1330-20-7	XYLENE	106.2	LBNL Data File	13	25	3.082	77.04
1330-20-7	XYLENE	106.2	LBNL Data File	13	1	3.082	3.08
1330-20-7	XYLENE	106.2	LBNL Data File	13	10	3.082	30.82
1330-20-7	XYLENE	106.2	LBNL Data File	13	25	3.082	77.04
1330-20-7	XYLENE	106.2	LBNL Data File	13	25	3.082	77.04
1330-20-7	XYLENE	106.2	LBNL Data File	13	25	3.082	77.04
1330-20-7	XYLENE	106.2	LBNL Data File	13	10	3.082	30.82
1330-20-7	XYLENE	106.2	LBNL Data File	13	10	3.082	30.82
1330-20-7	XYLENE	106.2	LBNL Data File	13	10	3.082	30.82
1330-20-7	XYLENE	106.2	LBNL Data File	13	25	3.082	77.04
1330-20-7	XYLENE	106.2	LBNL Data File	13	25	3.082	77.04
1330-20-7	XYLENES	106.2	LBNL Data File	13	10	3.082	30.82
1330-20-7	XYLENE	106.2	LBNL Data File	13	1	3.082	0.81
1330-20-7	XYLENE	106.2	LBNL Data File	13	10	3.082	30.82
1330-20-7	XYLENE	106.2	LBNL Data File	13	25	3.082	77.04
1330-20-7	DEPEX MOUNTING MEDIA	106.2	LBNL Data File	13	10	3.082	30.82
1634-04-4	METHYL TERT-BUTYL ETHER	88.15	LBNL Data File	120	25	24.337	608.43
1634-04-4	METHYL TERT-BUTYL ETHER	88.15	LBNL Data File	120	10	24.337	69.95
7647-01-0	HYDROCHLORIC ACID STANDARD SOLUTION	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HCL	36.47	LBNL Data File	190	5	21.289	34.98
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID SOLUTION	36.47	LBNL Data File	190	10	21.289	69.95
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	69.95
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	69.95
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Emissions from Evaporation During Use (Table G-5)

A = Surface Area (cm^2) = 100
U = Wind Speed (m/s) = 0.51
MW = Molecular Weight (g/mole) = Chemical-specific
VP = Vapor Pressure (mmHg) = Chemical-specific
R = Gas Constant ($atm\text{-}cm^3/mole\text{-}deg\ K$) = 82.05
T = Ambient Temperature (K) = 295

Loss (grams/batch) = $(4.120*A*U^{0.78}*MW^{0.67}*VP)/(R*T)$

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet		*MW entered manually*		*From previous worksheet*	*From previous worksheet*	*Calculated*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**Adjusted Vapor Pressure (mmHg)**	**Assumed No. of Batches (per yr)**	**Estimated Loss Emission Factor (grams/batch)**	**Estimated Emissions (grams/yr)**
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID SOLUTION	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	1	21.289	0.70
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	IMIDAZOLERIC ACID	36.47	LBNL Data File	190	100	21.289	2128.88
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HCL	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	DECAFLUORO-1,1,2,2-TERAHYDROOCTYL)TRICHLOROSIL	36.47	LBNL Data File	190	100	21.289	2128.88
7647-01-0	HCL	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HCL	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	100	21.289	2128.88
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	69.95
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	69.95
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	1	21.289	2.10

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Emissions from Evaporation During Use (Table G-5)

A = Surface Area (cm^2) = 100
U = Wind Speed (m/s) = 0.51
MW = Molecular Weight (g/mole) = Chemical-specific
VP = Vapor Pressure (mmHg) = Chemical-specific
R = Gas Constant (atm-cm^3/mole-deg K) = 82.05
T = Ambient Temperature (K) = 295

Loss (grams/batch) = $(4.120*A*U^{0.78}*MW^{0.67}*VP)/(R*T)$

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet		*MW entered manually*		*From previous worksheet*	*From previous worksheet*	*Calculated*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**Adjusted Vapor Pressure (mmHg)**	**Assumed No. of Batches (per yr)**	**Estimated Loss Emission Factor (grams/batch)**	**Estimated Emissions (grams/yr)**
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID	36.47	LBNL Data File	190	25	21.289	532.22
7664-38-2	BIO-SAFE COOMASSIE	98.04	LBNL Data File	0	25	0.013	0.33
7664-38-2	BIO-SAFE COOMASSIE	98.04	LBNL Data File	0	25	0.013	0.33
7664-38-2	BIO-SAFE COOMASSIE	98.04	LBNL Data File	0	25	0.013	0.33
7664-38-2	BIO-SAFE COOMASSIE	98.04	LBNL Data File	0	25	0.013	0.33
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	5	0.013	0.07
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	10	0.013	0.13
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	10	0.013	0.13
7664-38-2	LPH SE GERMICIDAL DETERGENT	98.04	LBNL Data File	0	25	0.013	0.33
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	10	0.013	0.13
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	10	0.013	0.13
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	10	0.013	0.13
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	25	0.013	0.33
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	10	0.013	0.13
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	25	0.013	0.33
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	25	0.013	0.33
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	10	0.013	0.13
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	5	0.013	0.07
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	10	0.013	0.13
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	10	0.013	0.13
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	10	0.013	0.13
7664-38-2	O-PHOSPHORIC ACID	98.04	LBNL Data File	0	25	0.013	0.33
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	10	0.013	0.13
7664-38-2	E REAGENT CONCENTRATE (PHOSPHAIC ACID/METHAN	98.04	LBNL Data File	0	10	0.013	0.13
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	10	0.013	0.13
7664-38-2	5'-MONOPHOSPHORIC ACID	98.04	LBNL Data File	0	1	0.013	0.01
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	10	0.013	0.13
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	5	0.013	0.07
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	5	0.013	0.07
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	10	0.013	0.13
7664-38-2	PHOSPORIC ACID	98.04	LBNL Data File	0	5	0.013	0.07
7664-38-2	PHOSPHORIC ACID	98.04	LBNL Data File	0	10	0.013	0.13
7664-39-3	HYDROFLUORIC ACID	20.01	LBNL Data File	50	10	3.747	37.47
7664-93-9	SULFURIC ACID	98.08	NIST	2	10	0.435	4.35
7664-93-9	SULFURIC ACID	98.08	NIST	2	25	0.435	10.87
7664-93-9	SULFURIC ACID	98.08	NIST	2	25	0.435	10.87
7664-93-9	SULFURIC ACID	98.08	NIST	2	25	0.435	10.87
7664-93-9	SULFURIC ACID	98.08	NIST	2	10	0.435	4.35
7664-93-9	SULFURIC ACID	98.08	NIST	2	10	0.435	4.35
7664-93-9	SULFURIC ACID	98.08	NIST	2	10	0.435	4.35
7664-93-9	SULFURIC ACID	98.08	NIST	2	10	0.435	4.35
7664-93-9	SULFURIC ACID	98.08	NIST	2	10	0.435	4.35
7664-93-9	SULFURIC ACID	98.08	NIST	2	10	0.435	4.35
7664-93-9	SULFURIC ACID	98.08	NIST	2	25	0.435	10.87
7664-93-9	FISHER CLEANING SOLUTION	98.08	NIST	2	10	0.435	4.35
7664-93-9	SULFURIC ACID	98.08	NIST	2	25	0.435	10.87
7664-93-9	SULFURIC ACID	98.08	NIST	2	10	0.435	4.35
7664-93-9	SULFURIC ACID	98.08	NIST	2	25	0.435	10.87
7664-93-9	SULFURIC ACID	98.08	NIST	2	10	0.435	4.35
7664-93-9	SULFURIC ACID	98.08	NIST	2	5	0.435	2.17
7664-93-9	SULFURIC ACID	98.08	NIST	2	25	0.435	10.87
7664-93-9	SULFURIC ACID	98.08	NIST	2	10	0.435	4.35
7664-93-9	SULFURIC ACID	98.08	NIST	2	10	0.435	4.35
7664-93-9	SULFURIC ACID	98.08	NIST	2	25	0.435	10.87
7664-93-9	SULFURIC ACID	98.08	NIST	2	10	0.435	4.35
7664-93-9	SULFURIC ACID	98.08	NIST	2	10	0.435	4.35
7664-93-9	SULFURIC ACID	98.08	NIST	2	25	0.435	10.87
7664-93-9	SULFURIC ACID	98.08	NIST	2	25	0.435	10.87
7664-93-9	SULFURIC ACID	98.08	NIST	2	25	0.435	10.87
7697-37-2	NITRIC ACID	63.02	LBNL Data File	96	25	15.518	387.94
7697-37-2	NITRIC ACID	63.02	LBNL Data File	96	25	15.518	387.94
7697-37-2	NITRIC ACID	63.02	LBNL Data File	96	25	15.518	387.94
7697-37-2	NITRIC ACID	63.02	LBNL Data File	96	25	15.518	387.94
7697-37-2	NITRIC ACID	63.02	LBNL Data File	96	10	15.518	155.18
7697-37-2	NITRIC ACID	63.02	LBNL Data File	96	10	15.518	155.18
7726-95-6	BROMINE	159.8	LBNL Data File	188	1	56.718	1.12

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Total Estimated Emissions (Table G-6)

Limit total annual emissions to inventory usage quantity. Assume 1,000 grams/liter when converting liters used to grams.

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet			*From previous worksheet (A3)*	*From previous worksheet (A4)*	*Chemical Often Used For Cleaning or Drying?*	*Calculated - Sum of Pouring & Stirring Emissions*
CAS No.		**Compound Name**	**Pouring Annual Emissions (grams/yr)**	**Stirring Annual Emissions (grams/yr)**	**(Yes/No) ***	**Total Annual Emissions * (grams/yr)**
50-00-0	50000	Formaldehyde	0.061	98.37	No	98.43
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.110	98.37	No	98.48
50-00-0	50000	Formaldehyde	0.110	98.37	No	98.48
50-00-0	50000	Formaldehyde	0.110	98.37	No	98.48
50-00-0	50000	Formaldehyde	0.110	98.37	No	98.48
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.112	98.37	No	98.48
50-00-0	50000	Formaldehyde	0.112	98.37	No	98.48
50-00-0	50000	Formaldehyde	0.024	69.95	No	69.98
50-00-0	50000	Formaldehyde	0.061	98.37	No	98.43
50-00-0	50000	Formaldehyde	0.024	69.95	No	69.98
50-00-0	50000	Formaldehyde	0.024	69.95	No	69.98
50-00-0	50000	Formaldehyde	0.024	69.95	No	69.98
50-00-0	50000	Formaldehyde	0.024	69.95	No	69.98
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.923	245.93	No	246.85
50-00-0	50000	Formaldehyde	0.923	245.93	No	246.85
50-00-0	50000	Formaldehyde	0.923	245.93	No	246.85
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.110	98.37	No	98.48
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.029	83.94	No	83.97
50-00-0	50000	Formaldehyde	0.029	83.94	No	83.97
50-00-0	50000	Formaldehyde	0.029	83.94	No	83.97
50-00-0	50000	Formaldehyde	0.029	83.94	No	83.97

* Chemicals identified as being frequently used to clean, dry, or sterilize glassware and surfaces assigned emissions of at least 50% of usage.

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Total Estimated Emissions (Table G-6)

Limit total annual emissions to inventory usage quantity. Assume 1,000 grams/liter when converting liters used to grams.

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet			*From previous worksheet (A3)*	*From previous worksheet (A4)*	*Chemical Often Used For Cleaning or Drying?*	*Calculated - Sum of Pouring & Stirring Emissions*
CAS No.		**Compound Name**	**Pouring Annual Emissions (grams/yr)**	**Stirring Annual Emissions (grams/yr)**	**(Yes/No) ***	**Total Annual Emissions * (grams/yr)**
50-00-0	50000	Formaldehyde	0.029	83.94	No	83.97
50-00-0	50000	Formaldehyde	0.029	83.94	No	83.97
50-00-0	50000	Formaldehyde	0.029	83.94	No	83.97
50-00-0	50000	Formaldehyde	0.029	83.94	No	83.97
50-00-0	50000	Formaldehyde	0.029	83.94	No	83.97
50-00-0	50000	Formaldehyde	0.029	83.94	No	83.97
50-00-0	50000	Formaldehyde	0.029	83.94	No	83.97
50-00-0	50000	Formaldehyde	0.029	83.94	No	83.97
50-00-0	50000	Formaldehyde	0.029	83.94	No	83.97
50-00-0	50000	Formaldehyde	0.029	83.94	No	83.97
50-00-0	50000	Formaldehyde	0.029	83.94	No	83.97
50-00-0	50000	Formaldehyde	0.029	83.94	No	83.97
50-00-0	50000	Formaldehyde	0.975	245.93	No	246.90
50-00-0	50000	Formaldehyde	0.975	245.93	No	246.90
50-00-0	50000	Formaldehyde	0.004	10.49	No	10.50
50-00-0	50000	Formaldehyde	0.004	10.49	No	10.50
50-00-0	50000	Formaldehyde	0.004	10.49	No	10.50
50-00-0	50000	Formaldehyde	0.004	10.49	No	10.50
50-00-0	50000	Formaldehyde	0.004	10.49	No	10.50
50-00-0	50000	Formaldehyde	0.004	10.49	No	10.50
50-00-0	50000	Formaldehyde	0.029	83.94	No	83.97
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.012	34.98	No	34.99
50-00-0	50000	Formaldehyde	0.061	98.37	No	98.43
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.024	69.95	No	69.98
50-00-0	50000	Formaldehyde	0.024	69.95	No	69.98
50-00-0	50000	Formaldehyde	0.024	69.95	No	69.98
50-00-0	50000	Formaldehyde	0.923	245.93	No	246.85
50-00-0	50000	Formaldehyde	0.020	49.19	No	49.20
50-00-0	50000	Formaldehyde	0.975	245.93	No	246.90
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.975	245.93	No	246.90
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.923	245.93	No	246.85
50-00-0	50000	Formaldehyde	0.923	245.93	No	246.85
50-00-0	50000	Formaldehyde	0.923	245.93	No	246.85
50-00-0	50000	Formaldehyde	0.923	245.93	No	246.85
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.006	17.49	No	17.49
50-00-0	50000	Formaldehyde	0.002	7.00	No	7.00
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.004	10.49	No	10.50
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.001	3.50	No	3.50
50-00-0	50000	Formaldehyde	0.037	98.37	No	98.41
50-00-0	50000	Formaldehyde	0.037	98.37	No	98.41
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.009	24.48	No	24.49
50-00-0	50000	Formaldehyde	0.244	245.93	No	246.17
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49

* Chemicals identified as being frequently used to clean, dry, or sterilize glassware and surfaces assigned emissions of at least 50% of usage.

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Total Estimated Emissions (Table G-6)

Limit total annual emissions to inventory usage quantity. Assume 1,000 grams/liter when converting liters used to grams.

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet			*From previous worksheet (A3)*	*From previous worksheet (A4)*	*Chemical Often Used For Cleaning or Drying?*	*Calculated - Sum of Pouring & Stirring Emissions*
CAS No.		**Compound Name**	**Pouring Annual Emissions (grams/yr)**	**Stirring Annual Emissions (grams/yr)**	**(Yes/No) ***	**Total Annual Emissions * (grams/yr)**
50-00-0	50000	Formaldehyde	0.244	245.93	No	246.17
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.024	69.95	No	69.98
50-00-0	50000	Formaldehyde	0.024	69.95	No	69.98
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.122	98.37	No	98.49
50-00-0	50000	Formaldehyde	0.244	245.93	No	246.17
56-23-5	56236	Carbon tetrachloride	0.668	293.87	No	294.54
58-89-9	58899	Lindane [gamma-Hexachlorocyclohexane]	0.000	0.00	No	5.41E-05
58-89-9	58899	Lindane [gamma-Hexachlorocyclohexane]	0.000	0.00	No	5.42E-05
58-89-9	58899	Lindane [gamma-Hexachlorocyclohexane]	0.000	0.00	No	5.43E-06
58-89-9	58899	Lindane [gamma-Hexachlorocyclohexane]	0.000	0.00	No	5.44E-06
62-53-3	62534	Aniline	0.002	2.21	No	2.22
62-53-3	62534	Aniline	0.000	0.22	No	0.22
67-56-1	67561	Benzamine	1.186	271.90	No	273.08
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.784	271.90	No	272.68
67-56-1	67561	Methanol	0.784	271.90	No	272.68
67-56-1	67561	Methanol	0.000	0.70	No	0.70
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.627	271.90	No	272.52
67-56-1	67561	Methanol	0.627	271.90	No	272.52
67-56-1	67561	Methanol	0.627	271.90	No	272.52
67-56-1	67561	Methanol	0.627	271.90	No	272.52
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.627	271.90	No	272.52
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	1.186	271.90	No	273.08
67-56-1	67561	Methanol	0.031	69.95	No	69.99
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.078	108.76	No	108.84
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	1.186	271.90	No	273.08
67-56-1	67561	Methanol	1.186	271.90	No	273.08
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.186	271.90	No	273.08
67-56-1	67561	Methanol	1.186	271.90	No	273.08
67-56-1	67561	Methanol	1.186	271.90	No	273.08
67-56-1	67561	Methanol	1.186	271.90	No	273.08
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	5.955	1087.58	No	1093.54
67-56-1	67561	Methanol	5.955	1087.58	No	1093.54
67-56-1	67561	Methanol	0.313	271.90	No	272.21

* Chemicals identified as being frequently used to clean, dry, or sterilize glassware and surfaces assigned emissions of at least 50% of usage.

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Total Estimated Emissions (Table G-6)

Limit total annual emissions to inventory usage quantity. Assume 1,000 grams/liter when converting liters used to grams.

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet			*From previous worksheet (A3)*	*From previous worksheet (A4)*	*Chemical Often Used For Cleaning or Drying?*	*Calculated - Sum of Pouring & Stirring Emissions*
CAS No.		**Compound Name**	**Pouring Annual Emissions (grams/yr)**	**Stirring Annual Emissions (grams/yr)**	**(Yes/No) ***	**Total Annual Emissions * (grams/yr)**
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.031	69.95	No	69.99
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.157	108.76	No	108.92
67-56-1	67561	Methanol	0.031	69.95	No	69.99
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.157	108.76	No	108.92
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.784	271.90	No	272.68
67-56-1	67561	Methanol	0.784	271.90	No	272.68
67-56-1	67561	Methanol	0.784	271.90	No	272.68
67-56-1	67561	Methanol	0.784	271.90	No	272.68
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.031	69.95	No	69.99
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.031	69.95	No	69.99
67-56-1	67561	Methanol	0.000	0.70	No	0.70
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	1.254	271.90	No	273.15

* Chemicals identified as being frequently used to clean, dry, or sterilize glassware and surfaces assigned emissions of at least 50% of usage.

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Total Estimated Emissions (Table G-6)

Limit total annual emissions to inventory usage quantity. Assume 1,000 grams/liter when converting liters used to grams.

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet			*From previous worksheet (A3)*	*From previous worksheet (A4)*	*Chemical Often Used For Cleaning or Drying?*	*Calculated - Sum of Pouring & Stirring Emissions*
CAS No.		**Compound Name**	**Pouring Annual Emissions (grams/yr)**	**Stirring Annual Emissions (grams/yr)**	**(Yes/No) ***	**Total Annual Emissions * (grams/yr)**
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	4.745	1087.58	No	1092.33
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.627	271.90	No	272.52
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.567	271.90	No	273.46
67-56-1	67561	Methanol	0.031	69.95	No	69.99
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.157	108.76	No	108.92
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.031	69.95	No	69.99
67-56-1	67561	Methanol	0.157	108.76	No	108.92
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.186	271.90	No	273.08
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	0.627	271.90	No	272.52
67-56-1	67561	Methanol	1.254	271.90	No	273.15
67-56-1	67561	Methanol	1.186	271.90	No	273.08
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-56-1	67561	Methanol	0.157	108.76	No	108.92
67-56-1	67561	Methanol	0.313	271.90	No	272.21
67-63-0	67630	Isopropyl alcohol	12.385	1164.72	No	1177.10
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.092	116.47	No	116.56
67-63-0	67630	Isopropyl alcohol	0.098	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.052	116.47	No	116.52
67-63-0	67630	Isopropyl alcohol	0.052	116.47	No	116.52
67-63-0	67630	Isopropyl alcohol	26.296	1164.72	No	1191.01
67-63-0	67630	Isopropyl alcohol	3.096	1164.72	No	1167.81
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.263	291.18	No	291.44
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.052	116.47	No	116.52
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39

* Chemicals identified as being frequently used to clean, dry, or sterilize glassware and surfaces assigned emissions of at least 50% of usage.

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Total Estimated Emissions (Table G-6)

Limit total annual emissions to inventory usage quantity. Assume 1,000 grams/liter when converting liters used to grams.

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet			*From previous worksheet (A3)*	*From previous worksheet (A4)*	*Chemical Often Used For Cleaning or Drying?*	*Calculated - Sum of Pouring & Stirring Emissions*
CAS No.		**Compound Name**	**Pouring Annual Emissions (grams/yr)**	**Stirring Annual Emissions (grams/yr)**	**(Yes/No) ***	**Total Annual Emissions * (grams/yr)**
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.263	291.18	No	291.44
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.413	291.18	No	291.59
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.781	291.18	No	291.96
67-63-0	67630	Isopropyl alcohol	0.781	291.18	No	291.96
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	1.032	291.18	No	292.21
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	1.032	291.18	No	292.21
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57

* Chemicals identified as being frequently used to clean, dry, or sterilize glassware and surfaces assigned emissions of at least 50% of usage.

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Total Estimated Emissions (Table G-6)

Limit total annual emissions to inventory usage quantity. Assume 1,000 grams/liter when converting liters used to grams.

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet			*From previous worksheet (A3)*	*From previous worksheet (A4)*	*Chemical Often Used For Cleaning or Drying?*	*Calculated - Sum of Pouring & Stirring Emissions*
CAS No.		**Compound Name**	**Pouring Annual Emissions (grams/yr)**	**Stirring Annual Emissions (grams/yr)**	**(Yes/No) ***	**Total Annual Emissions * (grams/yr)**
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.781	291.18	No	291.96
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.781	291.18	No	291.96
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.413	291.18	No	291.59
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.052	116.47	No	116.52
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.049	116.47	No	116.52
67-63-0	67630	Isopropyl alcohol	0.049	116.47	No	116.52
67-63-0	67630	Isopropyl alcohol	0.049	116.47	No	116.52
67-63-0	67630	Isopropyl alcohol	0.049	116.47	No	116.52
67-63-0	67630	Isopropyl alcohol	0.049	116.47	No	116.52
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.001	3.50	No	3.50
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.021	69.95	No	69.97
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57

* Chemicals identified as being frequently used to clean, dry, or sterilize glassware and surfaces assigned emissions of at least 50% of usage.

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Total Estimated Emissions (Table G-6)

Limit total annual emissions to inventory usage quantity. Assume 1,000 grams/liter when converting liters used to grams.

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet			*From previous worksheet (A3)*	*From previous worksheet (A4)*	*Chemical Often Used For Cleaning or Drying?*	*Calculated - Sum of Pouring & Stirring Emissions*
CAS No.		**Compound Name**	**Pouring Annual Emissions (grams/yr)**	**Stirring Annual Emissions (grams/yr)**	**(Yes/No) ***	**Total Annual Emissions * (grams/yr)**
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.516	291.18	No	291.70
67-63-0	67630	Isopropyl alcohol	1.651	291.18	No	292.83
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.826	291.18	No	292.00
67-63-0	67630	Isopropyl alcohol	0.103	116.47	No	116.57
67-63-0	67630	Isopropyl alcohol	0.005	17.49	No	17.49
67-63-0	67630	Isopropyl alcohol	0.206	291.18	No	291.39
67-63-0	67630	Isopropyl alcohol	0.413	291.18	No	291.59
67-66-3	67663	Chloroform	0.186	69.95	No	70.14
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.186	69.95	No	70.14
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.186	69.95	No	70.14
67-66-3	67663	Chloroform	1.862	699.54	No	701.40
67-66-3	67663	Chloroform	1.862	699.54	No	701.40
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	1.862	699.54	No	701.40
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.047	17.49	No	17.53
67-66-3	67663	Chloroform	1.762	662.01	No	663.77
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.047	17.49	No	17.53
67-66-3	67663	Chloroform	0.745	279.82	No	280.56
67-66-3	67663	Chloroform	0.745	279.82	No	280.56
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.881	331.00	No	331.89
67-66-3	67663	Chloroform	0.881	331.00	No	331.89
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	7.448	1047.13	No	1054.58
67-66-3	67663	Chloroform	1.862	699.54	No	701.40
67-66-3	67663	Chloroform	7.448	1047.13	No	1054.58
67-66-3	67663	Chloroform	0.186	69.95	No	70.14
67-66-3	67663	Chloroform	0.047	17.49	No	17.53
67-66-3	67663	Chloroform	0.186	69.95	No	70.14
67-66-3	67663	Chloroform	1.862	699.54	No	701.40
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	1.862	699.54	No	701.40
67-66-3	67663	Chloroform	0.063	23.59	No	23.65
67-66-3	67663	Chloroform	0.047	17.49	No	17.53
67-66-3	67663	Chloroform	0.047	17.49	No	17.53
67-66-3	67663	Chloroform	0.047	17.49	No	17.53
67-66-3	67663	Chloroform	7.448	1047.13	No	1054.58
67-66-3	67663	Chloroform	3.724	1047.13	No	1050.85
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70

* Chemicals identified as being frequently used to clean, dry, or sterilize glassware and surfaces assigned emissions of at least 50% of usage.

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Total Estimated Emissions (Table G-6)

Limit total annual emissions to inventory usage quantity. Assume 1,000 grams/liter when converting liters used to grams.

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet			*From previous worksheet (A3)*	*From previous worksheet (A4)*	*Chemical Often Used For Cleaning or Drying?*	*Calculated - Sum of Pouring & Stirring Emissions*
CAS No.		**Compound Name**	**Pouring Annual Emissions (grams/yr)**	**Stirring Annual Emissions (grams/yr)**	**(Yes/No) ***	**Total Annual Emissions * (grams/yr)**
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	7.448	1047.13	No	1054.58
67-66-3	67663	Chloroform	0.186	69.95	No	70.14
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	1.862	699.54	No	701.40
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	1.862	699.54	No	701.40
67-66-3	67663	Chloroform	3.724	1047.13	No	1050.85
67-66-3	67663	Chloroform	4.655	1047.13	No	1051.78
67-66-3	67663	Chloroform	4.655	1047.13	No	1051.78
67-66-3	67663	Chloroform	4.655	1047.13	No	1051.78
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.881	331.00	No	331.89
67-66-3	67663	Chloroform	7.448	1047.13	No	1054.58
67-66-3	67663	Chloroform	1.862	699.54	No	701.40
67-66-3	67663	Chloroform	0.186	69.95	No	70.14
67-66-3	67663	Chloroform	0.047	17.49	No	17.53
67-66-3	67663	Chloroform	0.047	17.49	No	17.53
67-66-3	67663	Chloroform	0.047	17.49	No	17.53
67-66-3	67663	Chloroform	0.838	314.79	No	315.63
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.126	47.17	No	47.30
67-66-3	67663	Chloroform	1.762	662.01	No	663.77
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	7.448	1047.13	No	1054.58
67-66-3	67663	Chloroform	7.448	1047.13	No	1054.58
67-66-3	67663	Chloroform	7.448	1047.13	No	1054.58
67-66-3	67663	Chloroform	0.093	34.98	No	35.07
67-66-3	67663	Chloroform	1.862	699.54	No	701.40
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	7.448	1047.13	No	1054.58
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.047	17.49	No	17.53
67-66-3	67663	Chloroform	0.047	17.49	No	17.53
67-66-3	67663	Chloroform	0.047	17.49	No	17.53
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	7.448	1047.13	No	1054.58
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.047	17.49	No	17.53
67-66-3	67663	Chloroform	1.862	699.54	No	701.40
67-66-3	67663	Chloroform	0.047	17.49	No	17.53
67-66-3	67663	Chloroform	0.186	69.95	No	70.14
67-66-3	67663	Chloroform	0.047	17.49	No	17.53
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	1.769	664.56	No	666.33
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.047	17.49	No	17.53
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.047	17.49	No	17.53
67-66-3	67663	Chloroform	1.862	699.54	No	701.40
67-66-3	67663	Chloroform	1.862	699.54	No	701.40
67-66-3	67663	Chloroform	0.047	17.49	No	17.53
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
67-66-3	67663	Chloroform	0.931	349.77	No	350.70

* Chemicals identified as being frequently used to clean, dry, or sterilize glassware and surfaces assigned emissions of at least 50% of usage.

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Total Estimated Emissions (Table G-6)

Limit total annual emissions to inventory usage quantity. Assume 1,000 grams/liter when converting liters used to grams.

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet			*From previous worksheet (A3)*	*From previous worksheet (A4)*	*Chemical Often Used For Cleaning or Drying?*	*Calculated - Sum of Pouring & Stirring Emissions*
CAS No.		**Compound Name**	**Pouring Annual Emissions (grams/yr)**	**Stirring Annual Emissions (grams/yr)**	**(Yes/No) ***	**Total Annual Emissions * (grams/yr)**
67-66-3	67663	Chloroform	0.931	349.77	No	350.70
68-12-2	68122	Dimethyl formamide	0.002	11.56	No	11.56
68-12-2	68122	Dimethyl formamide	0.011	11.56	No	11.57
68-12-2	68122	Dimethyl formamide	0.022	28.90	No	28.92
68-12-2	68122	Dimethyl formamide	0.005	11.56	No	11.57
68-12-2	68122	Dimethyl formamide	0.044	28.90	No	28.95
68-12-2	68122	Dimethyl formamide	0.087	28.90	No	28.99
68-12-2	68122	Dimethyl formamide	0.022	28.90	No	28.92
68-12-2	68122	Dimethyl formamide	0.022	28.90	No	28.92
68-12-2	68122	Dimethyl formamide	0.011	11.56	No	11.57
68-12-2	68122	Dimethyl formamide	0.011	11.56	No	11.57
68-12-2	68122	Dimethyl formamide	0.022	28.90	No	28.92
68-12-2	68122	Dimethyl formamide	0.005	11.56	No	11.57
68-12-2	68122	Dimethyl formamide	0.011	11.56	No	11.57
68-12-2	68122	Dimethyl formamide	0.000	0.70	No	0.70
68-12-2	68122	Dimethyl formamide	0.005	11.56	No	11.57
68-12-2	68122	Dimethyl formamide	0.011	11.56	No	11.57
68-12-2	68122	Dimethyl formamide	0.011	11.56	No	11.57
68-12-2	68122	Dimethyl formamide	0.005	11.56	No	11.57
68-12-2	68122	Dimethyl formamide	0.005	11.56	No	11.57
68-12-2	68122	Dimethyl formamide	0.005	11.56	No	11.57
68-12-2	68122	Dimethyl formamide	0.022	28.90	No	28.92
68-12-2	68122	Dimethyl formamide	0.022	28.90	No	28.92
68-12-2	68122	Dimethyl formamide	0.002	11.56	No	11.56
68-12-2	68122	Dimethyl formamide	0.002	11.56	No	11.56
68-12-2	68122	Dimethyl formamide	0.002	11.56	No	11.56
68-12-2	68122	Dimethyl formamide	0.002	11.56	No	11.56
68-12-2	68122	Dimethyl formamide	0.022	28.90	No	28.92
68-12-2	68122	Dimethyl formamide	0.011	11.56	No	11.57
68-12-2	68122	Dimethyl formamide	0.011	11.56	No	11.57
68-12-2	68122	Dimethyl formamide	0.011	11.56	No	11.57
68-12-2	68122	Dimethyl formamide	0.011	11.56	No	11.57
68-12-2	68123	Dimethyl formamide	0.005	11.56	No	11.57
71-43-2	71432	Benzene	0.592	466.57	No	467.16
71-43-2	71432	Benzene	0.592	466.57	No	467.16
71-43-2	71432	Benzene	1.185	466.57	No	467.76
71-43-2	71433	Benzene	0.059	69.95	No	70.01
71-43-2	71433	Benzene	0.592	466.57	No	467.16
75-07-0	75070	Acetaldhyde	0.016	3.50	No	3.51
75-07-0	75070	Acetaldhyde	0.327	69.95	No	70.28
75-07-0	75070	Acetaldhyde	0.327	69.95	No	70.28
75-09-2	75092	Methylene chloride [Dichloromethane]	0.297	69.95	No	70.25
75-09-2	75092	Methylene chloride [Dichloromethane]	11.871	1867.64	No	1879.51
75-09-2	75092	Methylene chloride [Dichloromethane]	56.387	7470.55	No	7526.94
75-09-2	75092	Methylene chloride [Dichloromethane]	0.297	69.95	No	70.25
75-09-2	75092	Methylene chloride [Dichloromethane]	2.968	699.54	No	702.51
75-09-2	75092	Methylene chloride [Dichloromethane]	56.387	7470.55	No	7526.94
75-09-2	75092	Methylene chloride [Dichloromethane]	11.871	1867.64	No	1879.51
75-09-2	75092	Methylene chloride [Dichloromethane]	11.871	1867.64	No	1879.51
75-09-2	75092	Methylene chloride [Dichloromethane]	0.297	69.95	No	70.25
75-09-2	75092	Methylene chloride [Dichloromethane]	2.968	699.54	No	702.51
75-09-2	75092	Methylene chloride [Dichloromethane]	0.297	69.95	No	70.25
75-09-2	75092	Methylene chloride [Dichloromethane]	11.871	1867.64	No	1879.51
75-09-2	75092	Methylene chloride [Dichloromethane]	11.871	1867.64	No	1879.51
75-09-2	75092	Methylene chloride [Dichloromethane]	2.968	699.54	No	702.51
75-09-2	75092	Methylene chloride [Dichloromethane]	2.968	699.54	No	702.51
75-09-2	75092	Methylene chloride [Dichloromethane]	2.968	699.54	No	702.51
75-09-2	75092	Methylene chloride [Dichloromethane]	59.355	7470.55	No	7529.91
75-09-2	75092	Methylene chloride [Dichloromethane]	2.968	699.54	No	702.51
75-09-2	75092	Methylene chloride [Dichloromethane]	59.355	7470.55	No	7529.91
75-09-2	75092	Methylene chloride [Dichloromethane]	11.871	1867.64	No	1879.51
75-09-2	75092	Methylene chloride [Dichloromethane]	11.871	1867.64	No	1879.51
75-09-2	75092	Methylene chloride [Dichloromethane]	11.871	1867.64	No	1879.51
75-09-2	75092	Methylene chloride [Dichloromethane]	1.484	349.77	No	351.25
75-09-2	75092	Methylene chloride [Dichloromethane]	2.968	699.54	No	702.51
75-56-9	75569	Propylene oxide	0.001	0.21	No	0.21
75-56-9	75569	Propylene oxide	0.001	0.21	No	0.21
78-93-3	78933	Methyl ethyl ketone [2-Butanone]	0.259	176.90	No	177.15

* Chemicals identified as being frequently used to clean, dry, or sterilize glassware and surfaces assigned emissions of at least 50% of usage.

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Total Estimated Emissions (Table G-6)

Limit total annual emissions to inventory usage quantity. Assume 1,000 grams/liter when converting liters used to grams.

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet			*From previous worksheet (A3)*	*From previous worksheet (A4)*	*Chemical Often Used For Cleaning or Drying?*	*Calculated - Sum of Pouring & Stirring Emissions*
CAS No.		**Compound Name**	**Pouring Annual Emissions (grams/yr)**	**Stirring Annual Emissions (grams/yr)**	**(Yes/No) ***	**Total Annual Emissions * (grams/yr)**
78-93-3	78933	Methyl ethyl ketone [2-Butanone]	0.259	176.90	No	177.15
78-93-3	78933	Methyl ethyl ketone [2-Butanone]	0.259	176.90	No	177.15
78-93-3	78933	Methyl ethyl ketone [2-Butanone]	0.517	442.24	No	442.76
79-01-6	79016	Trichloroethylene	0.358	264.46	No	264.82
79-01-6	79016	Trichloroethylene	0.358	264.46	No	264.82
79-01-6	79016	Trichloroethylene	0.358	264.46	No	264.82
79-01-6	79017	Trichloroethylene	0.358	264.46	No	264.82
79-10-7	79107	Acrylic Acid	0.003	3.33	No	3.33
79-10-7	79107	Acrylic Acid	0.003	3.33	No	3.33
79-10-7	79107	Acrylic Acid	0.003	3.33	No	3.33
100-41-4	100415	Ethyl benzene	0.078	90.67	No	90.75
100-42-5	100425	Styrene	0.005	24.77	No	24.77
100-42-5	100425	Styrene	0.000	2.48	No	2.48
100-44-7	100448	Benzyl chloride	0.003	5.15	No	5.16
106-89-8	106899	Epichlorohydrin	0.002	14.78	No	14.79
106-99-0	106991	1,3-Butadiene	3.703	282.07	No	285.77
107-02-8	107029	Acrolein	0.125	69.95	No	70.08
107-06-2	107062	Ethylene dichloride [EDC]	1.475	546.91	No	548.39
107-06-2	107062	Ethylene dichloride [EDC]	0.310	218.76	No	219.07
107-06-2	107062	Ethylene dichloride [EDC]	0.620	546.91	No	547.53
107-06-2	107062	Ethylene dichloride [EDC]	2.478	546.91	No	549.39
107-06-2	107062	Ethylene dichloride [EDC]	0.310	218.76	No	219.07
107-21-1	107211	Ethylene glycol	0.000	0.53	No	0.53
107-21-1	107211	Ethylene glycol	0.000	0.53	No	0.53
107-21-1	107211	Ethylene glycol	0.000	0.53	No	0.53
107-21-1	107211	Ethylene glycol	0.002	0.53	No	0.53
107-21-1	107211	Ethylene glycol	0.001	0.53	No	0.53
107-21-1	107211	Ethylene glycol	0.000	0.21	No	0.21
107-21-1	107211	Ethylene glycol	0.000	0.53	No	0.53
107-21-1	107211	Ethylene glycol	0.000	0.21	No	0.21
107-21-1	107211	Ethylene glycol	0.000	0.21	No	0.21
107-21-1	107211	Ethylene glycol	0.000	0.21	No	0.21
107-21-1	107211	Ethylene glycol	0.001	0.53	No	0.53
107-21-1	107211	Ethylene glycol	0.000	0.53	No	0.53
107-21-1	107211	Ethylene glycol	0.000	0.21	No	0.21
107-21-1	107211	Ethylene glycol	0.000	0.11	No	0.11
107-98-2	107983	Propylene glycol monomethyl ether	0.001	4.85	No	4.85
107-98-2	107983	Propylene glycol monomethyl ether	0.001	4.85	No	4.85
108-39-4	108395	m-Cresol	0.001	0.59	No	0.59
108-39-4	108395	m-Cresol	0.000	0.59	No	0.59
108-88-3	108883	Toluene	0.021	69.95	No	69.97
108-88-3	108883	Toluene	0.205	251.25	No	251.46
108-88-3	108883	Toluene	0.103	100.50	No	100.60
108-88-3	108883	Toluene	0.205	251.25	No	251.46
108-88-3	108883	Toluene	0.205	251.25	No	251.46
108-88-3	108883	Toluene	0.410	251.25	No	251.66
108-88-3	108883	Toluene	0.205	251.25	No	251.46
108-88-3	108883	Toluene	0.205	251.25	No	251.46
108-88-3	108883	Toluene	0.205	251.25	No	251.46
108-88-3	108883	Toluene	0.205	251.25	No	251.46
108-88-3	108883	Toluene	0.205	251.25	No	251.46
108-88-3	108883	Toluene	0.205	251.25	No	251.46
108-88-3	108883	Toluene	0.021	69.95	No	69.97
108-88-3	108883	Toluene	0.205	251.25	No	251.46
108-88-3	108883	Toluene	0.205	251.25	No	251.46
108-88-3	108883	Toluene	0.103	100.50	No	100.60
108-88-3	108883	Toluene	0.205	251.25	No	251.46
108-88-3	108883	Toluene	0.205	251.25	No	251.46
108-88-3	108883	Toluene	0.205	251.25	No	251.46
108-88-3	108883	Toluene	0.021	69.95	No	69.97
108-88-3	108883	Toluene	0.103	100.50	No	100.60
108-88-3	108883	Toluene	0.410	251.25	No	251.66
108-88-3	108884	Toluene	0.103	100.50	No	100.60
109-86-4	109865	Ethylene glycol monomethyl ether	0.059	76.85	No	76.91
110-54-3	110543	Hexane	1.049	657.22	No	658.27
110-54-3	110543	Hexane	1.049	657.22	No	658.27
110-54-3	110543	Hexane	1.049	657.22	No	658.27
110-54-3	110543	Hexane	4.198	657.22	No	661.42

* Chemicals identified as being frequently used to clean, dry, or sterilize glassware and surfaces assigned emissions of at least 50% of usage.

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Total Estimated Emissions (Table G-6)

Limit total annual emissions to inventory usage quantity. Assume 1,000 grams/liter when converting liters used to grams.

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet			*From previous worksheet (A3)*	*From previous worksheet (A4)*	*Chemical Often Used For Cleaning or Drying?*	*Calculated - Sum of Pouring & Stirring Emissions*
CAS No.		**Compound Name**	**Pouring Annual Emissions (grams/yr)**	**Stirring Annual Emissions (grams/yr)**	**(Yes/No) ***	**Total Annual Emissions * (grams/yr)**
110-54-3	110543	Hexane	4.198	657.22	No	661.42
110-54-3	110543	Hexane	19.940	2628.89	No	2648.83
110-54-3	110543	Hexane	1.049	657.22	No	658.27
110-54-3	110543	Hexane	19.940	2628.89	No	2648.83
110-54-3	110543	Hexane	1.049	657.22	No	658.27
110-54-3	110543	Hexane	0.001	0.70	No	0.70
110-54-3	110543	Hexane	4.198	657.22	No	661.42
110-54-3	110543	Hexane	4.198	657.22	No	661.42
110-54-3	110543	Hexane	4.198	657.22	No	661.42
110-54-3	110543	Hexane	4.198	657.22	No	661.42
110-54-3	110543	Hexane	4.198	657.22	No	661.42
110-54-3	110543	Hexane	4.198	657.22	No	661.42
110-54-3	110543	Hexane	20.990	2628.89	No	2649.88
110-54-3	110543	Hexane	25.188	2628.89	No	2654.08
110-54-3	110543	Hexane	4.198	657.22	No	661.42
110-54-3	110543	Hexane	19.940	2628.89	No	2648.83
110-54-3	110543	Hexane	1.049	657.22	No	658.27
110-54-3	110543	Hexane	4.198	657.22	No	661.42
110-54-3	110543	Hexane	4.198	657.22	No	661.42
110-54-3	110543	Hexane	4.198	657.22	No	661.42
110-54-3	110543	Hexane	20.990	2628.89	No	2649.88
110-54-3	110543	Hexane	20.990	2628.89	No	2649.88
110-54-3	110543	Hexane	0.001	0.70	No	0.70
110-54-3	110543	Hexane	20.990	2628.89	No	2649.88
110-54-3	110543	Hexane	1.049	657.22	No	658.27
110-54-3	110543	Hexane	1.049	657.22	No	658.27
110-54-3	110543	Hexane	1.049	657.22	No	658.27
110-54-3	110543	Hexane	1.049	657.22	No	658.27
110-54-3	110543	Hexane	1.049	657.22	No	658.27
110-54-3	110543	Hexane	0.105	69.95	No	70.06
110-54-3	110543	Hexane	0.525	262.89	No	263.41
110-54-3	110543	Hexane	1.049	657.22	No	658.27
110-54-3	110543	Hexane	1.049	657.22	No	658.27
110-54-3	110543	Hexane	1.049	657.22	No	658.27
110-54-3	110543	Hexane	1.049	657.22	No	658.27
111-30-8	111308	Glutaraldehyde	0.004	4.96	No	4.96
111-30-8	111308	Glutaraldehyde	0.0001	0.99	No	0.99
111-30-8	111308	Glutaraldehyde	0.000	0.99	No	0.99
111-30-8	111308	Glutaraldehyde	0.000	1.98	No	1.98
111-30-8	111308	Glutaraldehyde	0.000	0.99	No	0.99
111-30-8	111308	Glutaraldehyde	0.000	1.98	No	1.98
111-30-8	111308	Glutaraldehyde	0.000	0.99	No	0.99
111-30-8	111308	Glutaraldehyde	0.000	0.99	No	0.99
111-30-8	111308	Glutaraldehyde	0.000	0.99	No	0.99
111-30-8	111308	Glutaraldehyde	0.000	0.99	No	0.99
111-30-8	111308	Glutaraldehyde	0.000	0.99	No	0.99
111-30-8	111308	Glutaraldehyde	0.000	1.98	No	1.98
111-30-8	111308	Glutaraldehyde	0.000	1.98	No	1.98
111-30-8	111308	Glutaraldehyde	0.000	0.20	No	0.20
111-30-8	111308	Glutaraldehyde	0.000	0.99	No	0.99
111-30-8	111308	Glutaraldehyde	0.000	0.99	No	0.99
111-30-8	111308	Glutaraldehyde	0.000	0.99	No	0.99
111-30-8	111308	Glutaraldehyde	0.000	0.20	No	0.20
111-30-8	111308	Glutaraldehyde	0.000	0.99	No	0.99
111-30-8	111308	Glutaraldehyde	0.000	1.98	No	1.98
111-30-8	111308	Glutaraldehyde	0.000	0.20	No	0.20
111-30-8	111308	Glutaraldehyde	0.000	0.20	No	0.20
111-30-8	111308	Glutaraldehyde	0.000	0.99	No	0.99
111-30-8	111308	Glutaraldehyde	0.000	0.99	No	0.99
111-30-8	111308	Glutaraldehyde	0.000	1.98	No	1.98
111-30-8	111308	Glutaraldehyde	0.000	0.99	No	0.99
111-30-8	111308	Glutaraldehyde	0.004	4.96	No	4.96
111-30-8	111308	Glutaraldehyde	0.000	1.98	No	1.98
111-30-8	111308	Glutaraldehyde	0.000	1.98	No	1.98
111-30-8	111308	Glutaraldehyde	0.000	1.98	No	1.98
111-30-8	111308	Glutaraldehyde	0.000	0.99	No	0.99
111-42-2	111422	Diethanolamine	0.000	0.00	No	0.00

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Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Total Estimated Emissions (Table G-6)

Limit total annual emissions to inventory usage quantity. Assume 1,000 grams/liter when converting liters used to grams.

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet			*From previous worksheet (A3)*	*From previous worksheet (A4)*	*Chemical Often Used For Cleaning or Drying?*	*Calculated - Sum of Pouring & Stirring Emissions*
CAS No.		**Compound Name**	**Pouring Annual Emissions (grams/yr)**	**Stirring Annual Emissions (grams/yr)**	**(Yes/No) ***	**Total Annual Emissions * (grams/yr)**
111-42-2	111422	Diethanolamine	0.000	0.00	No	0.00
111-42-2	111423	Diethanolamine	0.000	0.00	No	0.00
111-42-2	111423	Diethanolamine	0.000	0.00	No	0.00
121-44-8	121448	Triethylamine	0.225	214.29	No	214.52
121-44-8	121448	Triethylamine	0.045	69.95	No	70.00
121-44-8	121448	Triethylamine	0.005	7.00	No	7.00
121-44-8	121448	Triethylamine	0.015	24.02	No	24.04
121-44-8	121448	Triethylamine	0.451	535.73	No	536.18
121-44-8	121448	Triethylamine	0.045	69.95	No	70.00
121-44-8	121448	Triethylamine	0.045	69.95	No	70.00
121-44-8	121448	Triethylamine	0.045	69.95	No	70.00
121-44-8	121448	Triethylamine	0.225	214.29	No	214.52
123-91-1	123911	1,4-Dioxane	0.258	321.34	No	321.60
123-91-1	123911	1,4-Dioxane	0.258	321.34	No	321.60
123-91-1	123911	1,4-Dioxane	0.258	321.34	No	321.60
123-91-1	123911	1,4-Dioxane	0.517	321.34	No	321.85
123-91-1	123911	1,4-Dioxane	0.517	321.34	No	321.85
123-91-1	123911	1,4-Dioxane	0.125	128.54	No	128.66
123-91-1	123911	1,4-Dioxane	0.258	321.34	No	321.60
123-91-1	123911	1,4-Dioxane	0.258	321.34	No	321.60
123-91-1	123911	1,4-Dioxane	1.034	321.34	No	322.37
123-91-1	123911	1,4-Dioxane	1.034	321.34	No	322.37
123-91-1	123912	1,4-Dioxane	0.026	69.95	No	69.98
127-18-4	127185	Perchloroethylene [Tetrachloroethene]	0.233	235.52	No	235.75
1330-20-7	1330207	Xylenes (mixed isomers)	0.066	77.04	No	77.11
1330-20-7	1330207	Xylenes (mixed isomers)	0.033	30.82	No	30.85
1330-20-7	1330207	Xylenes (mixed isomers)	0.264	77.04	No	77.31
1330-20-7	1330207	Xylenes (mixed isomers)	0.000	3.08	No	3.08
1330-20-7	1330207	Xylenes (mixed isomers)	0.033	30.82	No	30.85
1330-20-7	1330207	Xylenes (mixed isomers)	0.249	77.04	No	77.29
1330-20-7	1330207	Xylenes (mixed isomers)	0.264	77.04	No	77.31
1330-20-7	1330207	Xylenes (mixed isomers)	0.264	77.04	No	77.31
1330-20-7	1330207	Xylenes (mixed isomers)	0.033	30.82	No	30.85
1330-20-7	1330207	Xylenes (mixed isomers)	0.033	30.82	No	30.85
1330-20-7	1330207	Xylenes (mixed isomers)	0.033	30.82	No	30.85
1330-20-7	1330207	Xylenes (mixed isomers)	0.249	77.04	No	77.29
1330-20-7	1330207	Xylenes (mixed isomers)	0.264	77.04	No	77.31
1330-20-7	1330207	Xylenes (mixed isomers)	0.033	30.82	No	30.85
1330-20-7	1330207	Xylenes (mixed isomers)	0.000	0.81	No	0.81
1330-20-7	1330207	Xylenes (mixed isomers)	0.033	30.82	No	30.85
1330-20-7	1330207	Xylenes (mixed isomers)	0.264	77.04	No	77.31
1330-20-7	1330207	Xylenes (mixed isomers)	0.007	30.82	No	30.82
1634-04-4	1634045	Methyl tert-butyl ether	3.915	608.43	No	612.34
1634-04-4	1634045	Methyl tert-butyl ether	0.098	69.95	No	70.05
7647-01-0	7647010	Hydrochloric acid	0.640	532.22	No	532.86
7647-01-0	7647010	Hydrochloric acid	0.032	34.98	No	35.01
7647-01-0	7647010	Hydrochloric acid	0.640	532.22	No	532.86
7647-01-0	7647010	Hydrochloric acid	0.640	532.22	No	532.86
7647-01-0	7647010	Hydrochloric acid	0.640	532.22	No	532.86
7647-01-0	7647010	Hydrochloric acid	0.640	532.22	No	532.86
7647-01-0	7647010	Hydrochloric acid	0.640	532.22	No	532.86
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	2.560	532.22	No	534.78
7647-01-0	7647010	Hydrochloric acid	2.560	532.22	No	534.78
7647-01-0	7647010	Hydrochloric acid	2.560	532.22	No	534.78
7647-01-0	7647010	Hydrochloric acid	2.560	532.22	No	534.78
7647-01-0	7647010	Hydrochloric acid	2.560	532.22	No	534.78
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82
7647-01-0	7647010	Hydrochloric acid	0.640	532.22	No	532.86
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.640	532.22	No	532.86
7647-01-0	7647010	Hydrochloric acid	0.640	532.22	No	532.86
7647-01-0	7647010	Hydrochloric acid	0.640	532.22	No	532.86
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82

* Chemicals identified as being frequently used to clean, dry, or sterilize glassware and surfaces assigned emissions of at least 50% of usage.

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Total Estimated Emissions (Table G-6)

Limit total annual emissions to inventory usage quantity. Assume 1,000 grams/liter when converting liters used to grams.

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet			*From previous worksheet (A3)*	*From previous worksheet (A4)*	*Chemical Often Used For Cleaning or Drying?*	*Calculated - Sum of Pouring & Stirring Emissions*
CAS No.		**Compound Name**	**Pouring Annual Emissions (grams/yr)**	**Stirring Annual Emissions (grams/yr)**	**(Yes/No) ***	**Total Annual Emissions * (grams/yr)**
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.064	69.95	No	70.02
7647-01-0	7647010	Hydrochloric acid	0.064	69.95	No	70.02
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.064	69.95	No	70.02
7647-01-0	7647010	Hydrochloric acid	0.640	532.22	No	532.86
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.640	532.22	No	532.86
7647-01-0	7647010	Hydrochloric acid	2.560	532.22	No	534.78
7647-01-0	7647010	Hydrochloric acid	2.560	532.22	No	534.78
7647-01-0	7647010	Hydrochloric acid	2.560	532.22	No	534.78
7647-01-0	7647010	Hydrochloric acid	2.560	532.22	No	534.78
7647-01-0	7647010	Hydrochloric acid	2.560	532.22	No	534.78
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.640	532.22	No	532.86
7647-01-0	7647010	Hydrochloric acid	0.001	0.70	No	0.70
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82
7647-01-0	7647010	Hydrochloric acid	13.332	2128.88	No	2142.22
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	26.663	2128.88	No	2155.55
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	14.533	2128.88	No	2143.42
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	2.422	532.22	No	534.64
7647-01-0	7647010	Hydrochloric acid	0.064	69.95	No	70.02
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.064	69.95	No	70.02
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.002	2.10	No	2.10
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	1.600	532.22	No	533.82
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	0.320	212.89	No	213.21
7647-01-0	7647010	Hydrochloric acid	2.560	532.22	No	534.78
7664-38-2	7664382	Phosphoric acid	0.000	0.33	No	0.33

* Chemicals identified as being frequently used to clean, dry, or sterilize glassware and surfaces assigned emissions of at least 50% of usage.

Golder Associates

Calculation of Liquid Chemical Emissions
Phase 1 Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Total Estimated Emissions (Table G-6)

Limit total annual emissions to inventory usage quantity. Assume 1,000 grams/liter when converting liters used to grams.

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet			*From previous worksheet (A3)*	*From previous worksheet (A4)*	*Chemical Often Used For Cleaning or Drying?*	*Calculated - Sum of Pouring & Stirring Emissions*
CAS No.		**Compound Name**	**Pouring Annual Emissions (grams/yr)**	**Stirring Annual Emissions (grams/yr)**	**(Yes/No) ***	**Total Annual Emissions * (grams/yr)**
7664-38-2	7664382	Phosphoric acid	0.000	0.33	No	0.33
7664-38-2	7664382	Phosphoric acid	0.000	0.33	No	0.33
7664-38-2	7664382	Phosphoric acid	0.000	0.33	No	0.33
7664-38-2	7664382	Phosphoric acid	0.000	0.07	No	0.07
7664-38-2	7664382	Phosphoric acid	0.000	0.13	No	0.13
7664-38-2	7664382	Phosphoric acid	0.000	0.13	No	0.13
7664-38-2	7664382	Phosphoric acid	0.001	0.33	No	0.33
7664-38-2	7664382	Phosphoric acid	0.000	0.13	No	0.13
7664-38-2	7664382	Phosphoric acid	0.000	0.13	No	0.13
7664-38-2	7664382	Phosphoric acid	0.000	0.13	No	0.13
7664-38-2	7664382	Phosphoric acid	0.002	0.33	No	0.33
7664-38-2	7664382	Phosphoric acid	0.000	0.13	No	0.13
7664-38-2	7664382	Phosphoric acid	0.001	0.33	No	0.33
7664-38-2	7664382	Phosphoric acid	0.002	0.33	No	0.33
7664-38-2	7664382	Phosphoric acid	0.000	0.13	No	0.13
7664-38-2	7664382	Phosphoric acid	0.000	0.07	No	0.07
7664-38-2	7664382	Phosphoric acid	0.000	0.13	No	0.13
7664-38-2	7664382	Phosphoric acid	0.000	0.13	No	0.13
7664-38-2	7664382	Phosphoric acid	0.000	0.13	No	0.13
7664-38-2	7664382	Phosphoric acid	0.000	0.33	No	0.33
7664-38-2	7664382	Phosphoric acid	0.000	0.13	No	0.13
7664-38-2	7664382	Phosphoric acid	0.000	0.13	No	0.13
7664-38-2	7664382	Phosphoric acid	0.000	0.13	No	0.13
7664-38-2	7664382	Phosphoric acid	0.000	0.01	No	0.01
7664-38-2	7664382	Phosphoric acid	0.000	0.13	No	0.13
7664-38-2	7664382	Phosphoric acid	0.000	0.07	No	0.07
7664-38-2	7664382	Phosphoric acid	0.000	0.07	No	0.07
7664-38-2	7664382	Phosphoric acid	0.000	0.13	No	0.13
7664-38-2	7664382	Phosphoric acid	0.000	0.07	No	0.07
7664-38-2	7664382	Phosphoric acid	0.000	0.13	No	0.13
7664-39-3	7664394	Hydrogen fluoride	0.023	37.47	No	37.50
7664-93-9	7664939	Sulfuric acid	0.001	4.35	No	4.35
7664-93-9	7664939	Sulfuric acid	0.009	10.87	No	10.88
7664-93-9	7664939	Sulfuric acid	0.009	10.87	No	10.88
7664-93-9	7664939	Sulfuric acid	0.009	10.87	No	10.88
7664-93-9	7664939	Sulfuric acid	0.005	4.35	No	4.35
7664-93-9	7664939	Sulfuric acid	0.005	4.35	No	4.35
7664-93-9	7664939	Sulfuric acid	0.005	4.35	No	4.35
7664-93-9	7664939	Sulfuric acid	0.005	4.35	No	4.35
7664-93-9	7664939	Sulfuric acid	0.005	4.35	No	4.35
7664-93-9	7664939	Sulfuric acid	0.005	4.35	No	4.35
7664-93-9	7664939	Sulfuric acid	0.005	4.35	No	4.35
7664-93-9	7664939	Sulfuric acid	0.036	10.87	No	10.91
7664-93-9	7664939	Sulfuric acid	0.005	4.35	No	4.35
7664-93-9	7664939	Sulfuric acid	0.009	10.87	No	10.88
7664-93-9	7664939	Sulfuric acid	0.001	4.35	No	4.35
7664-93-9	7664939	Sulfuric acid	0.009	10.87	No	10.88
7664-93-9	7664939	Sulfuric acid	0.005	4.35	No	4.35
7664-93-9	7664939	Sulfuric acid	0.000	2.17	No	2.17
7664-93-9	7664939	Sulfuric acid	0.023	10.87	No	10.89
7664-93-9	7664939	Sulfuric acid	0.001	4.35	No	4.35
7664-93-9	7664939	Sulfuric acid	0.001	4.35	No	4.35
7664-93-9	7664939	Sulfuric acid	0.023	10.87	No	10.89
7664-93-9	7664939	Sulfuric acid	0.005	4.35	No	4.35
7664-93-9	7664939	Sulfuric acid	0.005	4.35	No	4.35
7664-93-9	7664939	Sulfuric acid	0.045	10.87	No	10.92
7664-93-9	7664939	Sulfuric acid	0.029	10.87	No	10.90
7664-93-9	7664939	Sulfuric acid	0.023	10.87	No	10.89
7697-37-2	7697372	Nitric acid	0.698	387.94	No	388.64
7697-37-2	7697372	Nitric acid	0.698	387.94	No	388.64
7697-37-2	7697372	Nitric acid	0.698	387.94	No	388.64
7697-37-2	7697372	Nitric acid	0.698	387.94	No	388.64
7697-37-2	7697372	Nitric acid	0.140	155.18	No	155.32
7697-37-2	7697373	Nitric acid	0.140	155.18	No	155.32
7726-95-6	7726957	Bromine	0.004	1.12	No	1.13

* Chemicals identified as being frequently used to clean, dry, or sterilize glassware and surfaces assigned emissions of at least 50% of usage.

Golder Associates

Appendix H

Phase 1 Operations Indirect Greenhouse Gas Summary and CalEEMod Output

Table H-1
CalEEMod Indirect Greenhouse Gas Emissions Summary - Phase 1

Operation	Indirect Greenhouse Gas Emissions [(a)] (tons/yr)			
	Total CO_2	CH_4	N_2O	CO_2e
Electricity	2,595	0.23	0.23	2,671
Water	34.2	1.28	3.3E-02	71.9
Solid Waste	10.2	0.61	0	22.9
Total Indirect Emissions	**2,639**	**2.12**	**0.26**	**2,765**

Notes:

(a) Pollutant (tons/yr) = (CalEEMod GHG emission [MT/yr]) x (conversion factor [short ton/metric ton])

Conversion factor [short ton/metric ton] = 1.10231 (1)

References:

(1) CalEEMod greenhouse gas emission results are provided in metric tons/yr.

Phase 1 Development - GHG - 03/29/2012
Bay Area AQMD Air District, Annual

1.0 Project Characteristics

1.1 Land Usage

Land Uses	Size	Metric
Research & Development	600	1000sqft
Parking Lot	600	Space

1.2 Other Project Characteristics

		Utility Company	Pacific Gas & Electric Company
Urbanization	Urban	**Wind Speed (m/s)**	
Climate Zone	5		2.2
		Precipitation Freq (Days)	
			64

1.3 User Entered Comments

Project Characteristics - LBNL estimates for indirect GHG emissions
Land Use - For GHG emissions, the full Phase 1 construction gsf is used (600,000). Updated: 3/22/13
Construction Phase -
Off-road Equipment - Pumps = 307 hp. Updated: 3/22/13
Off-road Equipment -
Trips and VMT -
Demolition -
Grading - Blank - Updated: 3/29/13
Energy Use - LBNL provided: (15,820 MWhr/yr) / (600,000 gsf) x (1,000 kWhr/1 MWhr) / (3 columns) = 8.79 kWhr/size/yr - Updated: 3/29/13
Water And Wastewater - 38,000,000 gallons/yr - LBNL provided estimate - 3/29/13
Construction Off-road Equipment Mitigation -

2.0 Emissions Summary

2.2 Overall Operational

Unmitigated Operational

	ROG	NOx	CO	SO2	Fugitive	Exhaust	PM10 Total	Fugitive	Exhaust	PM2.5	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Area	4.25	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy	0.08	0.76	0.63	0.00		0.00	0.06		0.00	0.06	0.00	3,176.20	3,176.20	0.22	0.22	3,250.09
Mobile	2.68	5.05	23.51	0.05	4.49	0.22	4.71	0.08	0.21	0.29	0.00	3,878.34	3,878.34	0.17	0.00	3,881.89
Waste						0.00	0.00		0.00	0.00	9.26	0.00	9.26	0.55	0.00	20.74
Water						0.00	0.00		0.00	0.00	0.00	31.02	31.02	1.16	0.03	65.19
Total	**7.01**	**5.81**	**24.14**	**0.05**	**4.49**	**0.22**	**4.77**	**0.08**	**0.21**	**0.35**	**9.26**	**7,085.56**	**7,094.82**	**2.10**	**0.25**	**7,217.91**

Mitigated Operational

	ROG	NOx	CO	SO2	Fugitive	Exhaust	PM10 Total	Fugitive	Exhaust	PM2.5	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Area	4.25	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy	0.08	0.76	0.63	0.00		0.00	0.06		0.00	0.06	0.00	3,176.20	3,176.20	0.22	0.22	3,250.09
Mobile	2.68	5.05	23.51	0.05	4.49	0.22	4.71	0.08	0.21	0.29	0.00	3,878.34	3,878.34	0.17	0.00	3,881.89
Waste						0.00	0.00		0.00	0.00	9.26	0.00	9.26	0.55	0.00	20.74
Water						0.00	0.00		0.00	0.00	0.00	31.02	31.02	1.16	0.03	65.19
Total	**7.01**	**5.81**	**24.14**	**0.05**	**4.49**	**0.22**	**4.77**	**0.08**	**0.21**	**0.35**	**9.26**	**7,085.56**	**7,094.82**	**2.10**	**0.25**	**7,217.91**

3.0 Construction Detail

3.1 Mitigation Measures Construction

4.0 Mobile Detail

4.1 Mitigation Measures Mobile

	ROG	NOx	CO	SO2	Fugitive	Exhaust	PM10 Total	Fugitive	Exhaust	PM2.5	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Mitigated	2.68	5.05	23.51	0.05	4.49	0.22	4.71	0.08	0.21	0.29	0.00	3,878.34	3,878.34	0.17	0.00	3,881.89
Unmitigated	2.68	5.05	23.51	0.05	4.49	0.22	4.71	0.08	0.21	0.29	0.00	3,878.34	3,878.34	0.17	0.00	3,881.89
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

4.2 Trip Summary Information

	Average Daily Trip Rate			Unmitigated	Mitigated
Land Use	Weekday	Saturday	Sunday	Annual VMT	Annual VMT
Parking Lot	0.00	0.00	0.00		
Research & Development	4,866.00	1,140.00	666.00	9,357,612	9,357,612
Total	4,866.00	1,140.00	666.00	9,357,612	9,357,612

4.3 Trip Type Information

	Miles			Trip %		
Land Use	H-W or C-W	H-S or C-C	H-O or C-NW	H-W or C-W	H-S or C-C	H-O or C-NW
Parking Lot	9.50	7.30	7.30	0.00	0.00	0.00
Research & Development	9.50	7.30	7.30	33.00	48.00	19.00

5.0 Energy Detail

5.1 Mitigation Measures Energy

	ROG	NOx	CO	SO2	Fugitive	Exhaust	PM10 Total	Fugitive	Exhaust	PM2.5	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Electricity Mitigated						0.00	0.00		0.00	0.00	0.00	2,353.97	2,353.97	0.21	0.21	2,422.86
Electricity						0.00	0.00		0.00	0.00	0.00	2,353.97	2,353.97	0.21	0.21	2,422.86
NaturalGas	0.08	0.76	0.63	0.00		0.00	0.06		0.00	0.06	0.00	822.23	822.23	0.02	0.02	827.23
NaturalGas	0.08	0.76	0.63	0.00		0.00	0.06		0.00	0.06	0.00	822.23	822.23	0.02	0.02	827.23
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

5.2 Energy by Land Use - NaturalGas

Unmitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive	Exhaust	PM10 Total	Fugitive	Exhaust	PM2.5	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU	tons/yr										MT/yr					
Parking Lot	0	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Research &	1.5408e+007	0.08	0.76	0.63	0.00		0.00	0.06		0.00	0.06	0.00	822.23	822.23	0.02	0.02	827.23
Total		**0.08**	**0.76**	**0.63**	**0.00**		**0.00**	**0.06**		**0.00**	**0.06**	**0.00**	**822.23**	**822.23**	**0.02**	**0.02**	**827.23**

Mitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive	Exhaust	PM10 Total	Fugitive	Exhaust	PM2.5	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU	tons/yr										MT/yr					
Parking Lot	0	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Research &	1.5408e+007	0.08	0.76	0.63	0.00		0.00	0.06		0.00	0.06	0.00	822.23	822.23	0.02	0.02	827.23
Total		**0.08**	**0.76**	**0.63**	**0.00**		**0.00**	**0.06**		**0.00**	**0.06**	**0.00**	**822.23**	**822.23**	**0.02**	**0.02**	**827.23**

5.3 Energy by Land Use - Electricity

Unmitigated

	Electricity Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	kWh	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research &	1.5822e+007					2,353.97	0.21	0.21	2,422.86
Total						**2,353.97**	**0.21**	**0.21**	**2,422.86**

Mitigated

	Electricity Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	kWh	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research &	1.5822e+007					2,353.97	0.21	0.21	2,422.86
Total						**2,353.97**	**0.21**	**0.21**	**2,422.86**

6.0 Area Detail

6.1 Mitigation Measures Area

	ROG	NOx	CO	SO2	Fugitive	Exhaust	PM10 Total	Fugitive	Exhaust	PM2.5	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Mitigated	4.25	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unmitigated	4.25	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

6.2 Area by SubCategory

Unmitigated

	ROG	NOx	CO	SO2	Fugitive	Exhaust	PM10 Total	Fugitive	Exhaust	PM2.5	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
SubCategory	tons/yr										MT/yr					
Architectural	0.97					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumer Products	3.28					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landscaping	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**4.25**	**0.00**	**0.00**	**0.00**		**0.00**	**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Mitigated

	ROG	NOx	CO	SO2	Fugitive	Exhaust	PM10 Total	Fugitive	Exhaust	PM2.5	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
SubCategory	tons/yr										MT/yr					
Architectural	0.97					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumer Products	3.28					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landscaping	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**4.25**	**0.00**	**0.00**	**0.00**		**0.00**	**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

7.0 Water Detail

7.1 Mitigation Measures Water

	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr				MT/yr			
Mitigated					31.02	1.16	0.03	65.19
Unmitigated					31.02	1.16	0.03	65.19
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

7.2 Water by Land Use

Unmitigated

	Indoor/Outdoor Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	Mgal	tons/yr				MT/yr			
Parking Lot	0 / 0					0.00	0.00	0.00	0.00
Research & Development	38 / 0					31.02	1.16	0.03	65.19
Total						**31.02**	**1.16**	**0.03**	**65.19**

Mitigated

	Indoor/Outdoor Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	Mgal	tons/yr				MT/yr			
Parking Lot	0 / 0					0.00	0.00	0.00	0.00
Research & Development	38 / 0					31.02	1.16	0.03	65.19
Total						**31.02**	**1.16**	**0.03**	**65.19**

8.0 Waste Detail

8.1 Mitigation Measures Waste

Category/Year

	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
	tons/yr				MT/yr			
Mitigated					9.26	0.55	0.00	20.74
Unmitigated					9.26	0.55	0.00	20.74
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

8.2 Waste by Land Use

Unmitigated

	Waste Disposed	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	tons	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research &	45.6					9.26	0.55	0.00	20.74
Total						**9.26**	**0.55**	**0.00**	**20.74**

Mitigated

	Waste Disposed	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	tons	tons/yr				MT/yr			
Parking Lot	0					0.00	0.00	0.00	0.00
Research &	45.6					9.26	0.55	0.00	20.74
Total						**9.26**	**0.55**	**0.00**	**20.74**

Appendix I

Full LRDP Operations Indirect Greenhouse Gas Summary and CalEEMod Output

Table I-1
Indirect Electricity Usage Greenhouse Gas Emissions Summary - Full LRDP

Greenhouse Gas	Emission Factor			Indirect Electricity Usage Greenhouse Gas Emissions (tons/yr)	
CO_2	0.149	(tonnes/MWhr)	(1)	23,339	(a)
CH_4	0.029	(lbs/MWhr)	(3)	2.06	(b)
N_2O	0.011	(lbs/MWhr)	(3)	0.78	(b)
CO_2e	--			23,626	(c)

Notes:

(a) Indirect electricity CO_2 emissions (tons/yr) = (Electricity usage [MW-hr/yr]) x (GHG intensity factor [tonnes CO_2/MW-hr]) x (projected electricity demand [MWhr/yr]) x (1.1 ton/tonne)

Projected electricity demand (MWhr/yr) = 142,400 (2)

(b) Indirect electricity greenhouse gas emissions (lbs/yr) = (Emission factor [lbs/MWhr]) x (projected electricity demand [MWhr/yr]) x (ton/2,000 lbs) x (global warming potential)

Projected electricity demand (MWhr/yr) = 142,400 (2)

(c) CO_2e emissions (tons/yr) = (CO_2 emissions [tons/yr]) + (CH_4 emissions [tons/yr] x CH_4 global warming potential) + (N_2O emissions [tons/yr] x N_2O global warming potential)

CH_4 global warming potential = 21 (4)

N_2O global warming potential = 310 (4)

References:

(1) PG&E GHG emission factor for 2018, from CPUC GHG Calculator.

(2) Projected electricity demand provided by LBNL.

(3) CalEEMod Appendix D, Table 1.2, "Electrical Utility Emission Factors of Greenhouse Gases".

(4) 40 CFR Part 98 Subpart A, Table A-1, Global Warming Potentials.

Golder Associates

Table I-2
CalEEMod Indirect Greenhouse Gas Emissions Summary - Full LRDP

Operation	Indirect Greenhouse Gas Emissions (tons/yr)			
	Total CO_2 [(a)]	CH_4 [(a)]	N_2O [(a)]	CO_2e
Electricity	--	--	--	23,626 (2)
Water	594	11.5	0.30	926 (a)
Solid Waste	86.7	5.13	0	194 (a)
Total Indirect Emissions	**681**	**16.6**	**0.30**	**24,746**

Notes:

(a) Pollutant (tons/yr) = (CalEEMod GHG emission [MT/yr]) x (conversion factor [short ton/metric ton])
Conversion factor [short ton/metric ton] = 1.10231 (1)

References:

(1) CalEEMod greenhouse gas emission results are provided in metric tons/yr.

(2) See Table I-1, Indirect Electricity Usage Greenhouse Gas Emissions Summary - Full LRDP.

CalEEMod Version: CalEEMod.2011.1.1 Date: 3/26/2013

LRDP - GHG - 03/26/2013

Bay Area AQMD Air District, Annual

1.0 Project Characteristics

1.1 Land Usage

Land Uses	Size	Metric
Research & Development	5100	1000sqft
Parking Structure	1900	1000sqft

1.2 Other Project Characteristics

Urbanization	Urban	**Wind Speed (m/s)**		**Utility Company**	Pacific Gas & Electric Company
Climate Zone	5		2.2		
		Precipitation Freq (Days)			
			64		

1.3 User Entered Comments

Project Characteristics -

Land Use - Average construction of 5,100,000 gsf for R&D and 1,900,000 gsf for Parking structure with a 10,000 campus population. Updated: 3/26/2013

Construction Phase - One year full run (1/1/2018 - 12/31/2018). Updated: 3/26/2013

Trips and VMT - Blanked -Updated: 3/26/13

Demolition - Blanked - Updated: 3/26/2013

Grading - Blanked - Updated: 3/26/13

Energy Use - Blanked - Updated: 3/26/13

Construction Off-road Equipment Mitigation - Watering 2 times per day at 55%. -Updated: 3/26/13

Water And Wastewater - 340,000,000 gallons/year potable water - project description, table 3 - Updated: 3/26/13

Off-road Equipment -

Off-road Equipment -

2.0 Emissions Summary

2.1 Overall Construction

Unmitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2018	67.84				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**67.84**				**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Mitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2018	67.84				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**67.84**				**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

2.2 Overall Operational

Unmitigated Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Area	29.67	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy	0.71	6.42	5.39	0.04		0.00	0.49		0.00	0.49	0.00	19,258.72	19,258.72	0.69	0.34	19,378.15
Mobile	22.80	42.88	199.84	0.41	38.16	1.90	40.06	0.67	1.76	2.43	0.00	32,965.89	32,965.89	1.44	0.00	32,996.09
Waste						0.00	0.00		0.00	0.00	78.67	0.00	78.67	4.65	0.00	176.31
Water						0.00	0.00		0.00	0.00	0.00	539.01	539.01	10.40	0.27	840.10
Total	**53.18**	**49.30**	**205.23**	**0.45**	**38.16**	**1.90**	**40.55**	**0.67**	**1.76**	**2.92**	**78.67**	**52,763.62**	**52,842.29**	**17.18**	**0.61**	**53,390.65**

Mitigated Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Area	29.67	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy	0.71	6.42	5.39	0.04		0.00	0.49		0.00	0.49	0.00	19,258.72	19,258.72	0.69	0.34	19,378.15
Mobile	22.80	42.88	199.84	0.41	38.16	1.90	40.06	0.67	1.76	2.43	0.00	32,965.89	32,965.89	1.44	0.00	32,996.09
Waste						0.00	0.00		0.00	0.00	78.67	0.00	78.67	4.65	0.00	176.31
Water						0.00	0.00		0.00	0.00	0.00	539.01	539.01	10.40	0.27	840.10
Total	**53.18**	**49.30**	**205.23**	**0.45**	**38.16**	**1.90**	**40.55**	**0.67**	**1.76**	**2.92**	**78.67**	**52,763.62**	**52,842.29**	**17.18**	**0.61**	**53,390.65**

3.0 Construction Detail

3.1 Mitigation Measures Construction

Water Exposed Area

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worker					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total					**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

3.2 Demolition - 2018

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total					**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total					**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

3.6 Paving - 2018

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Paving	0.00					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**0.00**					**0.00**	**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Paving	0.00					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**0.00**					**0.00**	**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

3.7 Architectural Coating - 2018

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Archit. Coating	67.84					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**67.84**					**0.00**	**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Archit. Coating	67.84					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**67.84**					**0.00**	**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

4.0 Mobile Detail

4.1 Mitigation Measures Mobile

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Mitigated	22.80	42.88	199.84	0.41	38.16	1.90	40.06	0.67	1.76	2.43	0.00	32,965.89	32,965.89	1.44	0.00	32,996.09
Unmitigated	22.80	42.88	199.84	0.41	38.16	1.90	40.06	0.67	1.76	2.43	0.00	32,965.89	32,965.89	1.44	0.00	32,996.09
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

4.2 Trip Summary Information

	Average Daily Trip Rate			Unmitigated	Mitigated
Land Use	Weekday	Saturday	Sunday	Annual VMT	Annual VMT
Parking Structure	0.00	0.00	0.00		
Research & Development	41,361.00	9,690.00	5661.00	79,539,699	79,539,699
Total	41,361.00	9,690.00	5,661.00	79,539,699	79,539,699

4.3 Trip Type Information

	Miles			Trip %		
Land Use	H-W or C-W	H-S or C-C	H-O or C-NW	H-W or C-W	H-S or C-C	H-O or C-NW
Parking Structure	9.50	7.30	7.30	0.00	0.00	0.00
Research & Development	9.50	7.30	7.30	33.00	48.00	19.00

5.0 Energy Detail

5.1 Mitigation Measures Energy

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Electricity Mitigated						0.00	0.00		0.00	0.00	0.00	12,269.77	12,269.77	0.55	0.21	12,346.66
Electricity Unmitigated						0.00	0.00		0.00	0.00	0.00	12,269.77	12,269.77	0.55	0.21	12,346.66
NaturalGas Mitigated	0.71	6.42	5.39	0.04		0.00	0.49		0.00	0.49	0.00	6,988.95	6,988.95	0.13	0.13	7,031.48
NaturalGas Unmitigated	0.71	6.42	5.39	0.04		0.00	0.49		0.00	0.49	0.00	6,988.95	6,988.95	0.13	0.13	7,031.48
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

5.2 Energy by Land Use - NaturalGas

Unmitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU	tons/yr										MT/yr					
Parking Structure	0	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Research & Development	1.30968e+008	0.71	6.42	5.39	0.04		0.00	0.49		0.00	0.49	0.00	6,988.95	6,988.95	0.13	0.13	7,031.48
Total		**0.71**	**6.42**	**5.39**	**0.04**		**0.00**	**0.49**		**0.00**	**0.49**	**0.00**	**6,988.95**	**6,988.95**	**0.13**	**0.13**	**7,031.48**

Mitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU	tons/yr										MT/yr					
Parking Structure	0	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Research & Development	1.30968e+008	0.71	6.42	5.39	0.04		0.00	0.49		0.00	0.49	0.00	6,988.95	6,988.95	0.13	0.13	7,031.48
Total		**0.71**	**6.42**	**5.39**	**0.04**		**0.00**	**0.49**		**0.00**	**0.49**	**0.00**	**6,988.95**	**6,988.95**	**0.13**	**0.13**	**7,031.48**

5.3 Energy by Land Use - Electricity

Unmitigated

	Electricity Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	kWh	tons/yr				MT/yr			
Parking Structure	0					0.00	0.00	0.00	0.00
Research & Development	4.2177e+007					12,269.77	0.55	0.21	12,346.66
Total						**12,269.77**	**0.55**	**0.21**	**12,346.66**

Mitigated

	Electricity Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	kWh	tons/yr				MT/yr			
Parking Structure	0					0.00	0.00	0.00	0.00
Research & Development	4.2177e+007					12,269.77	0.55	0.21	12,346.66
Total						**12,269.77**	**0.55**	**0.21**	**12,346.66**

6.0 Area Detail

6.1 Mitigation Measures Area

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Mitigated	29.67	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unmitigated	29.67	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

6.2 Area by SubCategory

Unmitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
SubCategory	tons/yr										MT/yr					
Architectural Coating	6.78					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumer Products	22.89					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landscaping	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**29.67**	**0.00**	**0.00**	**0.00**		**0.00**	**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Mitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
SubCategory	tons/yr										MT/yr					
Architectural Coating	6.78					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumer Products	22.89					0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landscaping	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**29.67**	**0.00**	**0.00**	**0.00**		**0.00**	**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

7.0 Water Detail

7.1 Mitigation Measures Water

	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr				MT/yr			
Mitigated					539.01	10.40	0.27	840.10
Unmitigated					539.01	10.40	0.27	840.10
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

7.2 Water by Land Use

Unmitigated

	Indoor/Outdoor Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	Mgal	tons/yr				MT/yr			
Parking Structure	0 / 0					0.00	0.00	0.00	0.00
Research & Development	340 / 0					539.01	10.40	0.27	840.10
Total						**539.01**	**10.40**	**0.27**	**840.10**

Mitigated

	Indoor/Outdoor Use	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	Mgal	tons/yr				MT/yr			
Parking Structure	0 / 0					0.00	0.00	0.00	0.00
Research & Development	340 / 0					539.01	10.40	0.27	840.10
Total						**539.01**	**10.40**	**0.27**	**840.10**

8.0 Waste Detail

8.1 Mitigation Measures Waste

Category/Year

	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
	tons/yr				MT/yr			
Mitigated					78.67	4.65	0.00	176.31
Unmitigated					78.67	4.65	0.00	176.31
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

8.2 Waste by Land Use

Unmitigated

	Waste Disposed	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	tons	tons/yr				MT/yr			
Parking Structure	0					0.00	0.00	0.00	0.00
Research & Development	387.56					78.67	4.65	0.00	176.31
Total						**78.67**	**4.65**	**0.00**	**176.31**

Mitigated

	Waste Disposed	ROG	NOx	CO	SO2	Total CO2	CH4	N2O	CO2e
Land Use	tons	tons/yr				MT/yr			
Parking Structure	0					0.00	0.00	0.00	0.00
Research & Development	387.56					78.67	4.65	0.00	176.31
Total						**78.67**	**4.65**	**0.00**	**176.31**

Appendix J

Operations Greenhouse Gas Offsets

Table J-1

Phase 1 Greenhouse Gas Emissions Offsets

Parameter [1]		Phase 1 Total		Existing Offsite Employee "Offset" [2]		Net Increase [a]
Number of Vehicle Trips	(trips/day)	2,031	(3)	1,334		697
Employee Vehicle GHG Emissions	(tons/yr)	3,352	(4)	2,202	(b)	1,150
Delivery Vehicle GHG Emissions	(tons/yr)	49.5	(4)	0		49.5
Shuttle GHG Emissions	(tons/yr)	73.4	(4)	0		73.4
Total Vehicle GHG Emissions	(tons/yr)	3,475		2,202		1,273
Electricity Usage	(MW-hr/yr)	15,820	(5)	13,892	(6)	1,928
Electricity Indirect GHG Emissions	(tons/yr)	2,593	(c)	2,277	(c)	316
Natural Gas Usage	(therms/yr)	840,000	(3)	626,123	(6)	213,877
Natural Gas GHG Emissions	(tons/yr)	4,953	(4)	3,692	(d)	1,261

Notes:

(a) Net increase = (Phase 1 total) - (existing offsite employee "offset")

(b) Existing offsite employee "offset" vehicle GHG emissions (tons/yr) = (Phase 1 total employee vehicle GHG emissions [tons/yr]) x ("offset" employee vehicle trips [trips/day]) / (phase 1 total employee vehicle trips [trips/day])

(c) Electricity indirect GHG emissions (tons/yr) = (Electricity usage [MW-hr/yr]) x (GHG intensity factor [tonnes CO2/MW-hr]) x (1.1 ton/tonne)
GHG intensity factor (tonnes CO2/MW-hr) = 0.149 (7)

(d) Existing offsite employee "offset" natural gas GHG emissions (tons/yr) = (Phase 1 total employee natural gas GHG emissions [tons/yr]) x ("offset" employee natural gas usage [therms/yr]) / (phase 1 total employee natural gas usage [therms/yr])

References:

(1) Indirect GHG emissions from water usage and water treatment are not included in this analysis because the offset usages are higher than the Phase 1 Total usages.

(2) Based on information provided by LBNL, approximately two-thirds of the employees (667) currently working at the Hill Campus will transfer to RBC. The Hill Campus will not be re-occupied once the employees transfer to RBC. Thus, emissions associated with the transfers act as an emissions "offset". Traffic estimates result in approximately 2 trips per employee per day (1,000 employees, 2,031 total trips), so 1,334 trips are "offset".

(3) See Table E-1, Phase 1 Operations Input Assumptions for Emission Rate Calculations.

(4) See Table E-11, Phase 1 Operations Criteria Pollutant Emissions Summary.

(5) Provided by LBNL.

(6) Utility usage attributable to the transfer employees at the Hill Campus.

(7) PG&E GHG emission factor for 2018, from CPUC GHG Calculator.

Golder Associates

Table J-2

LRDP Greenhouse Gas Emissions Offsets

Parameter [1]		LRDP Total		Existing Offsite Employee "Offset" [2]		Net Increase [a]
Number of Vehicle Trips	(trips/day)	20,081	(3)	1,334	(2)	18,747
Employee Vehicle GHG Emissions	(tons/yr)	29,148	(4)	1,936	(b)	27,212
Delivery Vehicle GHG Emissions	(tons/yr)	506	(4)	0		506
Shuttle GHG Emissions	(tons/yr)	61.9	(4)	0		61.9
Total Vehicle GHG Emissions	(tons/yr)	29,716		1,936		27,780
Electricity Usage	(MW-hr/yr)	142,400	(5)	13,892	(6)	128,508
Electricity Indirect GHG Emissions	(tons/yr)	23,339	(c)	2,277	(c)	21,063
Natural Gas Usage	(therms/yr)	6,600,000	(3)	626,123	(6)	5,973,877
Natural Gas GHG Emissions	(tons/yr)	38,611	(4)	3,663	(d)	34,948

Notes:

(a) Net increase = (LRDP total) - (existing offsite employee "offset")

(b) Existing offsite employee "offset" vehicle GHG emissions (tons/yr) = (Phase 1 total employee vehicle GHG emissions [tons/yr]) x ("offset" employee vehicle trips [trips/day]) / (phase 1 total employee vehicle trips [trips/day])

(c) Electricity indirect GHG emissions (tons/yr) = (Electricity usage [MW-hr/yr]) x (GHG intensity factor [tonnes CO2/MW-hr]) x (1.1 ton/tonne)
GHG intensity factor (tonnes CO2/MW-hr) = 0.149 (7)

(d) Existing offsite employee "offset" natural gas GHG emissions (tons/yr) = (Phase 1 total employee natural gas GHG emissions [tons/yr]) x ("offset" employee natural gas usage [therms/yr]) / (phase 1 total employee natural gas usage [therms/yr])

References:

(1) Indirect GHG emissions from water usage and water treatment are not included in this analysis because the offset usages are higher than the Phase 1 Phase 1 Total usages.

(2) Based on information provided by LBNL, approximately two-thirds of the employees (667) currently working at the Hill Campus will transfer to RBC. The Hill Campus will not be re-occupied once the employees transfer to RBC. Thus, emissions associated with the transfers act as an emissions "offset". Traffic estimates result in approximately 2 trips per employee per day (1,000 employees, 2,031 total trips), so 1,334 trips are "offset".

(3) See Table F-1, LRDP Operations Input Assumptions for Emission Rate Calculations.

(4) See Table F-11, LRDP Operations Criteria Pollutant Emissions Summary - Annual Average Daily Emission Rates.

(5) Provided by LBNL.

(6) Utility usage attributable to the transfer employees at the Hill Campus.

(7) PG&E GHG emission factor for 2018, from CPUC GHG Calculator.

Appendix K

Emissions Estimates – Existing Richmond Field Station Sources – Phase 1

Table K-1
Existing Richmond Field Station Phase 1 Source Operation Input Assumptions for Emission Rate Calculations

Source		*Diesel Emergency Engines*		*Natural Gas Boilers*		
		Engine Size [1] (BHP)	Fuel Usage (gal/hr)	Maximum Heat Input [1] (MMBtu/hr)	Daily Operation (hrs/day)	Annual Fuel Usage [2] (MMBtu/yr)
Building 112 [3]		87.5	4.4 [a]	1.75	24	875
Building 194 [3]		87.5	4.4 [a]	--	--	--
Building 275		--	--	0.3	24	150
Building 400a	(PH1 - BR1)	--	--	1.35	24	675
Building 400b	(PH2 - BR17)	--	--	1.46	24	730
Building 400c	(PH2 - BR18)	--	--	1.46	24	730
Building 400d	(PH2 - B/3-3)	--	--	1.5	24	750
Building 451		--	--	0.65	24	325
Building 452		--	--	0.399	24	199
Building 454		--	--	0.45	24	225
Building 472		--	--	0.375	24	187
Building 477		--	--	0.6	24	300
Building 478a	(122 - BR1)	--	--	0.502	24	251
Building 478b	(122 - BR2)	--	--	0.502	24	251
Building 478c	(122A - LCE13)	--	--	1.966	24	983
Building 480		--	--	0.45	24	225
Building 484		--	--	1.008	24	504
Building 400	(emergency engine)	87.5	4.4 [a]	--	--	--
Building 400f	(fire pump engine)	87.5	4.4 [a]	--	--	--
Total		350	17.8	14.722	--	7,360 [1]

Facility Data			
Source	**Source Parameter**	**Short Term Input (units)**	**Annual Input (units)**
	Facility Operation (Laboratory)	10 (hrs/day) [5]	260 (days/yr) [6]
	Emergency Engine Usage	2 (hrs/day) [7]	25.15 (hrs/yr) [7]
	Gasoline Tank Throughput	0.011 (Mgal/day)	4 (Mgal/yr)
	Diesel Tank Throughput	0.003 (Mgal/day)	1.2 (Mgal/yr)
	Offroad Vehicle Usage	10 (hrs/day)	200 (hrs/yr)

Notes:

(a) Engine fuel consumption (gal/hr) = (Engine size [hp]) x (average brake-specific fuel consumption [Btu/hp-hr]) / (liquid fuel higher heating value [Btu/gal])

Average brake-specific fuel consumption (Btu/hp-hr) = 7,000 (1)

Liquid fuel higher heating value (Btu/gal) = 138,000 (4)

References:

(1) Provided by the University.
(2) Total annual RFS natural gas usage apportioned to individual buildings based on the maximum hourly heat input.
(3) Buildings only included to properly apportion annual natural gas usage to individual buildings. Buildings assumed to be removed during Phase 1.
(4) ULSD higher heating value.
(5) Conservatively assumes laboratory work and offroad equipment usage is conducted over 10 hours per day.
(6) Assumes employee-based operations will generally be active 5 days per week, 52 weeks per year.
(7) Hourly value conservatively assumes a maximum of 2 hours per day of operation for maintenance and testing. Annual value is based on the average historical emergency engine usage from the LBNL LRDP.

Table K-2
Summary of Existing Onsite Off-Road Exhaust Criteria Pollutant Emission Estimates

Pollutant	Vehicle Type	Quantity	Horsepower [1]	Load Factor [2]	Daily hours of operation [3]	Annual hours of operation [3]	Emission Factor [4] (g/hp-hr)	Maximum Daily Emissions Estimate [a] (lbs/day)	Annual Average Emissions Estimate [b] (tons/yr)
ROG	Aerial Lifts	1.0	48	0.31	10	200	1.5	0.50	5.0E-03
	Tractors/Loaders/Backhoes	2.0	39	0.37	10	200	1.5	0.94	9.4E-03
	Sweepers/Scrubbers	1.0	37	0.46	10	200	1.6	0.61	6.1E-03
	Lawnmowers	3.0	28	1.0	10	200	8.4	15	0.15
	Total ROG Emissions							**17**	**0.17**
NO_X	Aerial Lifts	1.0	48	0.31	10	200	5.1	1.7	1.7E-02
	Tractors/Loaders/Backhoes	2.0	39	0.37	10	200	5.2	3.3	3.3E-02
	Sweepers/Scrubbers	1.0	37	0.46	10	200	5.3	2.0	2.0E-02
	Lawnmowers	3.0	28	1.0	10	200	5.7	10	0.10
	Total NO_X Emissions							**17**	**0.17**
CO	Aerial Lifts	1.0	48	0.31	10	200	4.9	1.6	1.6E-02
	Tractors/Loaders/Backhoes	2.0	39	0.37	10	200	5.8	3.7	3.7E-02
	Sweepers/Scrubbers	1.0	37	0.46	10	200	5.9	2.2	2.2E-02
	Lawnmowers	3.0	28	1.0	10	200	545	992	9.9
	Total CO Emissions							**1,000**	**10.0**
SO_2	Aerial Lifts	1.0	48	0.31	10	200	7.0E-03	2.3E-03	2.3E-05
	Tractors/Loaders/Backhoes	2.0	39	0.37	10	200	7.0E-03	4.5E-03	4.5E-05
	Sweepers/Scrubbers	1.0	37	0.46	10	200	7.0E-03	2.6E-03	2.6E-05
	Lawnmowers	3.0	28	1.0	10	200	2.1E-02	3.8E-02	3.8E-04
	Total SO_2 Emissions							**4.8E-02**	**4.8E-04**
PM_{10}	Aerial Lifts	1.0	48	0.31	10	200	0.40	0.13	1.3E-03
	Tractors/Loaders/Backhoes	2.0	39	0.37	10	200	0.40	0.25	2.5E-03
	Sweepers/Scrubbers	1.0	37	0.46	10	200	0.43	0.16	1.6E-03
	Lawnmowers	3.0	28	1.0	10	200	0.37	0.67	6.7E-03
	Total PM_{10} Emissions							**1.2**	**1.2E-02**
$PM_{2.5}$	Aerial Lifts	1.0	48	0.31	10	200	0.40	0.13	1.3E-03
	Tractors/Loaders/Backhoes	2.0	39	0.37	10	200	0.40	0.25	2.5E-03
	Sweepers/Scrubbers	1.0	37	0.46	10	200	0.43	0.16	1.6E-03
	Lawnmowers	3.0	28	1.0	10	200	0.37	0.67	6.7E-03
	Total $PM_{2.5}$ Emissions							**1.2**	**1.2E-02**
CO_2	Aerial Lifts	1.0	48	0.31	10	200	568	186	1.9
	Tractors/Loaders/Backhoes	2.0	39	0.37	10	200	568	362	3.6
	Sweepers/Scrubbers	1.0	37	0.46	10	200	568	213	2.1
	Lawnmowers	3.0	28	1.0	10	200	859	1,562	16
	Total CO_2 Emissions							**2,323**	**23**
CH_4	Aerial Lifts	1.0	48	0.31	10	200	0.14	4.5E-02	4.5E-04
	Tractors/Loaders/Backhoes	2.0	39	0.37	10	200	0.13	8.5E-02	8.5E-04
	Sweepers/Scrubbers	1.0	37	0.46	10	200	0.15	5.4E-02	5.4E-04
	Lawnmowers	3.0	28	1.0	10	200	0.47	0.85	8.5E-03
	Total CH_4 Emissions							**1.0**	**1.0E-02**

Notes:
(a) Maximum daily emissions estimate (lbs/day) = (Equipment horsepower [hp]) x (load factor) x (daily hours of operation [hrs/day]) x (emission factor [g/hp-hr]) x (lb/453.59 g)
(b) Annual average emissions estimate (tons/yr) = (Equipment horsepower [hp]) x (load factor) x (annual hours of operation [hrs/yr]) x (emission factor [g/hp-hr]) x (lb/453.59 g) x (ton/2,000 lbs)

References:
(1) Provided by LBNL. Assumes 2 tractor/loader/backhoes at 28 hp and 50 hp (average 39 hp), 1 aerial lift, 1 sweeper/scrubber, and 3 lawnmowers between 26 hp and 29 hp (average 27.5 hp).
(2) Load factors taken from Table D-7: Original OFFROAD and New Load Factors (LF) by Equipment Type.
(3) See Table K-1, Existing Richmond Field Station Phase 1 Source Operation Input Assumptions for Emission Rate Calculations.
(4) Emission factors from CalEEMod Appendix D tables for the year 2014.

Table K-3
Natural Gas Boiler Criteria Emission Estimates

Pollutant					PM		PM_{10}		$PM_{2.5}$		NO_x		CO		SO_2		VOC		CO_2		CH_4		N_2O		CO_2e	
Emission Factor (lbs/MMscf)					7.60 (1)		7.60 (2)		7.60 (2)		18.72 (a)		84 (4)		0.6 (1)		5.5 (1)		120,162 (b)		2.27 (c)		0.23 (c)		120,280 (d)	
					Emission Estimates																					
Source	Modeling ID	Maximum Hourly Fuel Usage (8) (MMBtu/hr)	Daily Operation (8) (hrs/day)	Annual Fuel Usage (8) (MMBtu/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)
Natural Gas Boiler - Building 400a	NGB_400a	1.35	24	675	0.24	2.5E-03	0.24	2.5E-03	0.24	2.5E-03	0.59	6.2E-03	2.67	0.028	0.019	2.0E-04	0.17	1.8E-03	3,817	39.8	0.072	7.5E-04	7.2E-03	7.5E-05	3,821	39.8
Natural Gas Boiler - Building 400b	NGB_400b	1.46	24	730	0.26	2.7E-03	0.26	2.7E-03	0.26	2.7E-03	0.64	6.7E-03	2.89	0.030	0.021	2.1E-04	0.19	2.0E-03	4,128	43.0	0.078	8.1E-04	7.8E-03	8.1E-05	4,132	43.0
Natural Gas Boiler - Building 400c	NGB_400c	1.46	24	730	0.26	2.7E-03	0.26	2.7E-03	0.26	2.7E-03	0.64	6.7E-03	2.89	0.030	0.021	2.1E-04	0.19	2.0E-03	4,128	43.0	0.078	8.1E-04	7.8E-03	8.1E-05	4,132	43.0
Natural Gas Boiler - Building 400d	NGB_400d	1.5	24	750	0.27	2.8E-03	0.27	2.8E-03	0.27	2.8E-03	0.66	6.9E-03	2.96	0.031	0.021	2.2E-04	0.19	2.0E-03	4,241	44.2	0.080	8.3E-04	8.0E-03	8.3E-05	4,245	44.2
Natural Gas Boiler - Building 451	NGB_451	0.65	24	325	0.12	1.2E-03	0.12	1.2E-03	0.12	1.2E-03	0.29	3.0E-03	1.28	0.013	9.2E-03	9.6E-05	0.084	8.8E-04	1,838	19.1	0.035	3.6E-04	3.5E-03	3.6E-05	1,840	19.2
Natural Gas Boiler - Building 452	NGB_452	0.399	24	199	0.071	7.4E-04	0.071	7.4E-04	0.071	7.4E-04	0.18	1.8E-03	0.79	8.2E-03	5.6E-03	5.9E-05	0.052	5.4E-04	1,128	11.7	0.021	2.2E-04	2.1E-03	2.2E-05	1,129	11.8
Natural Gas Boiler - Building 454	NGB_454	0.45	24	225	0.080	8.4E-04	0.080	8.4E-04	0.080	8.4E-04	0.20	2.1E-03	0.89	9.3E-03	6.4E-03	6.6E-05	0.058	6.1E-04	1,272	13.3	0.024	2.5E-04	2.4E-03	2.5E-05	1,274	13.3
Natural Gas Boiler - Building 472	NGB_472	0.375	24	187	0.067	7.0E-04	0.067	7.0E-04	0.067	7.0E-04	0.17	1.7E-03	0.74	7.7E-03	5.3E-03	5.5E-05	0.049	5.1E-04	1,060	11.0	0.020	2.1E-04	2.0E-03	2.1E-05	1,061	11.1
Natural Gas Boiler - Building 477	NGB_477	0.6	24	300	0.11	1.1E-03	0.11	1.1E-03	0.11	1.1E-03	0.26	2.8E-03	1.19	0.012	8.5E-03	8.8E-05	0.078	8.1E-04	1,696	17.7	0.032	3.3E-04	3.2E-03	3.3E-05	1,698	17.7
Natural Gas Boiler - Building 478a	NGB_478a	0.502	24	251	0.090	9.3E-04	0.090	9.3E-04	0.090	9.3E-04	0.22	2.3E-03	0.99	0.010	7.1E-03	7.4E-05	0.065	6.8E-04	1,419	14.8	0.027	2.8E-04	2.7E-03	2.8E-05	1,421	14.8
Natural Gas Boiler - Building 478b	NGB_478b	0.502	24	251	0.090	9.3E-04	0.090	9.3E-04	0.090	9.3E-04	0.22	2.3E-03	0.99	0.010	7.1E-03	7.4E-05	0.065	6.8E-04	1,419	14.8	0.027	2.8E-04	2.7E-03	2.8E-05	1,421	14.8
Natural Gas Boiler - Building 478c	NGB_478c	1.966	24	983	0.35	3.7E-03	0.35	3.7E-03	0.35	3.7E-03	0.87	9.0E-03	3.89	0.040	0.028	2.9E-04	0.25	2.6E-03	5,559	57.9	0.10	1.1E-03	0.010	1.1E-04	5,564	58.0
Natural Gas Boiler - Building 480	NGB_480	0.45	24	225	0.080	8.4E-04	0.080	8.4E-04	0.080	8.4E-04	0.20	2.1E-03	0.89	9.3E-03	6.4E-03	6.6E-05	0.058	6.1E-04	1,272	13.3	0.024	2.5E-04	2.4E-03	2.5E-05	1,274	13.3
Natural Gas Boiler - Building 484	NGB_484	1.008	24	504	0.18	1.9E-03	0.18	1.9E-03	0.18	1.9E-03	0.44	4.6E-03	1.99	0.021	0.014	1.5E-04	0.13	1.4E-03	2,850	29.7	0.054	5.6E-04	5.4E-03	5.6E-05	2,853	29.7
Total					**0.24**	**2.5E-03**	**0.24**	**2.5E-03**	**0.24**	**2.5E-03**	**0.59**	**6.2E-03**	**2.67**	**0.028**	**0.019**	**2.0E-04**	**0.17**	**1.8E-03**	**3,817**	**39.8**	**0.072**	**7.5E-04**	**7.2E-03**	**7.5E-05**	**3,821**	**39.8**

Notes:

(a) Emission factor (lbs/MMscf) = (NO_2 or CO emission limit [ppmv @ 3% O_2]) x (10^{-6}) x (NO_2 or CO molecular weight [lbs/lb-mol]) x (lb-mol/385.44 ft^3) x (natural gas f-factor [8,710 dscf/MMBtu]) x (20.9% O_2/[20.9% O_2 - 3% O_2]) x (heat content [Btu/scf])

BAAQMD NO_x emission limit (ppmv @ 3% O_2) =	15	(3)
BAAQMD CO emission limit (ppmv @ 3% O_2) =	400	(3)
NO_2 molecular weight (lbs/lb-mol) =	46	
CO molecular weight (lbs/lb-mol) =	28.01	
Natural gas heat content (Btu/scf) =	1,028	(5)

(b) CO_2 emission factor (lbs/MMscf) = (CO_2 emission factor [kg CO_2/MMBtu]) x (default high heat value (MMBtu/scf)) x (10^6 scf/MMscf) x (lb/0.453592 kg)

CO_2 emission factor (kg/MMBtu) =	53.02	(5)
Default high heat value (MMBtu/scf) =	1.028E-03	(5)

(c) CH_4 or N_2O emission factor (lbs/MMscf) = (CH_4 or N_2O emission factor [kg/MMBtu]) x (lb/0.453592 kg) x (natural gas heat content [Btu/scf])

CH_4 emission factor (kg/MMBtu) =	1.0E-03	(6)
N_2O emission factor (kg/MMBtu) =	1.0E-04	(6)
Natural gas heat content (Btu/scf) =	1,028	(5)

(d) CO_2e emission factor (lbs/MMscf) = (CO_2 emission factor [lbs/MMscf]) + (CH_4 emission factor [lbs/MMscf] x CH_4 global warming potential)
+ (N_2O emission factor [lbs/MMscf] x N_2O global warming potential)

Global warming potential of CH_4 =	21	(7)
Global warming potential of N_2O =	310	(7)

(e) Daily emissions estimate (lbs/day) = (Emission factor [lbs/MMscf]) x (maximum hourly heat input [MMBtu/hr]) x (daily hours of operation [hrs/day]) / (natural gas heat content [Btu/scf])

Natural gas heat content (Btu/scf) =	1,020	(5)

(f) Annual emissions estimate (tons/yr) = (emission factor [lbs/MMscf]) x (annual heat input [MMBtu/yr]) / (natural gas heat content [Btu/scf]) x (tons/2,000 lbs)

Natural gas heat content (Btu/scf) =	1,020	(5)

References:

(1) AP-42 Chapter 1.4 (July 1998), Table 1.4-2 "Emission Factors for Criteria Pollutants and Greenhouse Gases from Natural Gas Combustion".
(2) Assumes that 100% of PM is $PM_{2.5}$. Therefore, 100% of PM_{10} is $PM_{2.5}$.
(3) BAAQMD Emission Limits 307.2, 307.3, and 307.4 from Section 9-7-307..
(4) AP-42 Chapter 1.4 (July 1998), Table 1.4-1 "Emission Factors for NO_x and CO from Natural Gas Combustion".
(5) 40 CFR Part 98 Subpart C, Table C-1, Default CO_2 Emission Factors and High Heat Values for Various Types of Fuel.
(6) 40 CFR Part 98 Subpart C, Table C-2, Default CH_4 and N_2O Emission Factors for Various Types of Fuel.
(7) 40 CFR Part 98 Subpart A, Table A-1, Global Warming Potentials.
(8) See Table K-1, Existing Richmond Field Station Phase 1 Source Operation Input Assumptions for Emission Rate Calculations.

Table K-4
Emergency Diesel Generator Criteria Emission Estimates

Pollutant				Min HP	Max HP	PM		PM_{10}		$PM_{2.5}$		NO_X		CO		SO_2		VOC		CO_2		CH_4		CO_2e	
Emission Factor - Tier 4 Interim (g/hp-hr) [1]				75	99	0.015 [1]		0.015 [1]		0.015 [1]		2.5 [2]		3.7 [2]		-- [3]		0.14 [2]		-- [4]		--		--	
Source	Modeling ID	Generator Power Rating [5] (BHP)	Diesel Fuel Usage [5] (gal/hr)	Load Factor [6]	Annual Operation [5] (hrs/yr)	Emission Estimates																			
						Maximum Daily [a] (lbs/day)	Annual Average [b] (tons/yr)	Maximum Daily [a] (lbs/day)	Annual Average [b] (tons/yr)	Maximum Daily [a] (lbs/day)	Annual Average [b] (tons/yr)	Maximum Daily [a] (lbs/day)	Annual Average [b] (tons/yr)	Maximum Daily [a] (lbs/day)	Annual Average [b] (tons/yr)	Maximum Daily [c] (lbs/day)	Annual Average [b] (tons/yr)	Maximum Daily [a] (lbs/day)	Annual Average [b] (tons/yr)	Maximum Daily [d] (lbs/day)	Annual Average [b] (tons/yr)	Maximum Daily [9] (lbs/day)	Annual Average [b] (tons/yr)	Maximum Daily [e] (lbs/day)	Annual Average [b] (tons/yr)
Existing standby generator - B194	DG_B194	88	4.4	0.74	25.15	4.3E-03	2.7E-05	4.3E-03	2.7E-05	4.3E-03	2.7E-05	0.71	4.5E-03	1.06	6.6E-03	1.9E-03	1.2E-05	0.040	2.5E-04	198	1.25	3.6E-03	2.3E-05	198	1.25
Existing standby generator - NRLF	DG_NRLF2	88	4.4	0.74	25.15	4.3E-03	2.7E-05	4.3E-03	2.7E-05	4.3E-03	2.7E-05	0.71	4.5E-03	1.06	6.6E-03	1.9E-03	1.2E-05	0.040	2.5E-04	198	1.25	3.6E-03	2.3E-05	198	1.25
Existing Fire Pump NRLF	FP_NRLF2	88	4.4	0.74	25.15	4.3E-03	2.7E-05	4.3E-03	2.7E-05	4.3E-03	2.7E-05	0.71	4.5E-03	1.06	6.6E-03	1.9E-03	1.2E-05	0.040	2.5E-04	198	1.25	3.6E-03	2.3E-05	198	1.25
Total						**0.013**	**8.1E-05**	**0.013**	**8.1E-05**	**0.013**	**8.1E-05**	**2.14**	**0.013**	**3.17**	**0.020**	**5.6E-03**	**3.5E-05**	**0.12**	**7.5E-04**	**594**	**3.74**	**0.011**	**6.8E-05**	**594**	**3.74**

Notes:

(a) Maximum daily emission estimate (lbs/day) = (Emission factor [g/hp-hr]) x (generator power [hp]) x (load factor) x (maximum hours per day [hrs/day]) x (lb/453.59g)

Daily hours of operation (hrs/day) = 2 (5)

(b) Annual average emission estimate (tons/yr) = (Daily emissions [lbs/day]) / (daily hours of operation [hrs/day]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)

Daily hours of operation (hrs/day) = 2 (5)

(c) Maximum daily emissions estimate (lbs/day) = (Fuel sulfur content [ppmw] / 1,000,000) x (generator fuel consumption [gal/hr]) x (daily hours of operation [hrs/day]) x (diesel density [lbs/gal]) x ([SO_2 molecular weight {lbs/lb-mol}] / [sulfur molecular weight {lbs/lb-mol}])

Fuel sulfur content (ppmw) = 15 (7)
Daily hours of operation (hrs/day) = 2 (5)
Diesel density (lbs/gal) = 7
SO_2 molecular weight (lbs/lb-mol) = 64
Sulfur molecular weight (lbs/lb-mol) = 32

(d) Maximum daily emissions estimate (lbs/day) = (Fuel carbon content [%] / 100) x (generator fuel consumption [gal/hr]) x (daily hours of operation [hrs/day]) x (diesel density [lbs/gal]) x ([CO_2 molecular weight {lbs/lb-mol}] / [carbon molecular weight {lbs/lb-mol}])

Fuel carbon content (%) = 87 (8)
Daily hours of operation (hrs/day) = 2 (5)
Diesel density (lbs/gal) = 7
CO_2 molecular weight (lbs/lb-mol) = 44.0
Carbon molecular weight (lbs/lb-mol) = 12.0

(e) CO_2e emissions (lbs/day) = (CO_2 emissions [lbs/day]) + (CH_4 emissions [lbs/day] x CH_4 global warming potential) + (N_2O emissions [lbs/day] x N_2O global warming potential)

CH_4 Global Warming Potential (GWP) = 21 (10)
N_2O Global Warming Potential (GWP) = 310 (10)

References:

(1) Interim Tier IV emission factors are assumed.
(2) CalEEMod Appendix D, Default Data Tables. Table 3.5, OFFROAD Emission Factor Based on Engine Tier. Assumes Tier 4 Final for LBNL-owned small engines (Buildings 9 and 8), and Tier 4 Interim for the Building 6&7 engine.
(3) Sulfur dioxide emissions calculated on a sulfur mass balance basis, assuming 100% of the fuel sulfur content is emitted as SO_2.
(4) Carbon dioxide emissions calculated on a carbon mass balance basis, conservatively assuming 100% of the fuel carbon content is emitted as CO_2.
(5) See Table K-1, Existing Richmond Field Station Phase 1 Source Operation Input Assumptions for Emission Rate Calculations.
(6) Default load factor for generators in URBEMIS emissions model.
(7) California Code of Regulations Title 13, Division 3, Chapter 5, Article 2, Standards for Diesel Fuel.
(8) AP-42 Chapter 3.3 (October 1996) and 3.4 (October 1996), Footnote to criteria emission factor table.
(9) Assumes methane is 9% of VOC, based on footnote f of Table 3.4-1 in AP-42, Chapter 3.4. VOC emission factor is shown as ROG/TOG in CalEEMod Appendix D ,Table 3.5.
(10) 40 CFR Part 98 Subpart A, Table A-1, Global Warming Potentials.

Table K-5

Gasoline Fueling Emission Estimates

Source		Gasoline Fueling	Diesel Fueling
Annual Gasoline Throughput (Mgal/yr)	(1)	4.0	1.2
Daily Gasoline Throughput (Mgal/day)	(1)	0.011	0.003
Tank height (ft)	(2)	4.0	20.0
Tank equivalent diameter (ft)	(a)	5.7	10.0
Small tank standing loss factor a	(4)	1.379	1.379
Small tank standing loss factor b	(4)	0.152	0.152
Small tank working loss factor f	(4)	9.099	9.099

VOC Source		Emission Factor (lbs/Mgal)	Maximum Daily Emissions Estimate [(b)] (lbs/day)	Annual Average Emissions Estimate [(c)] (tons/yr)	Emission Factor (lbs/Mgal)	Maximum Daily Emissions Estimate [(a)] (lbs/day)	Annual Average Emissions Estimate [(b)] (tons/yr)
Storage Tank Loss VOC [(a)]	(b)	37.10	0.41	0.074	577.99	8.1E-04	1.5E-04
Vehicle Refueling Displacement	(4)	1.1	0.012	2.2E-03	1.1	2.4E-05	4.4E-06
Vehicle Refueling Spillage	(4)	0.7	7.7E-03	1.4E-03	0.7	1.5E-05	2.8E-06
Total VOC		38.9	0.43	0.078	579.8	8.5E-04	1.6E-04

Notes:

(a) Equivalent diameter = 2 x Side 1 of rectangular tank (L_1, ft) x Side 2 of rectangular tank (L_2, ft) / (Side 1 of rectangular tank [L_1, ft]+ Side 2 of rectangular tank [L_2, ft]) (3)

Side 1 of rectangular tank L_1 (ft) = 4 (2)

Side 2 of rectangular tank L_2 (ft) = 10 (2)

(b) VOC Emission Factor (lbs/Mgal) =(a x [tank height {ft} x tank diameter {ft}^{2} / annual gasoline throughput {Mgal/yr}] / [1 + {b x tank height {ft}]) + f (4)

(c) Daily emissions estimate (lbs/day) =(Emission factor [lbs/trip]) x (number of vehicle trips per day)

(d) Annual emissions estimate (lbs/day) =(Emission factor [lbs/trip]) x (number of vehicle trips per year) x (ton/2,000 lbs)

References:

(1) See Table K-1, Existing Richmond Field Station Phase 1 Source Operation Input Assumptions for Emission Rate Calculations.

(2) Provided by the University.

(3) Taken from http://www.aqmd.gov/aer/Updates/SuppInstruforLiqdOrgStgeTanks.pdf. Loss factors are for Gasoline RVP 10.

(4) Taken from http://www.aqmd.gov/aer/Updates/GuideExManuallyRptTankEmis.pdf.

Table K-6
Existing Richmond Field Station Phase 1 Source Operations Criteria Pollutant Emissions Summary - Annual Average Daily Emission Rates (1)

Source	Annual Operation (days/yr)	TAC		Criteria												Greenhouse Gases							
		DPM		PM_{10}		$PM_{2.5}$		NO_X		CO		SO_2		VOC		CO_2		CH_4		N_2O		CO_2e	
		(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)
Stationary Sources																							
Diesel generators	260	6.2E-04	8.1E-05	6.2E-04	8.1E-05	6.2E-04	8.1E-05	0.10	1.3E-02	0.15	2.0E-02	2.7E-04	3.5E-05	5.8E-03	7.5E-04	28.7	3.74	5.2E-04	6.8E-05	0	0	28.8	3.74
Natural Gas Boilers	260	--	--	1.9E-02	2.5E-03	1.9E-02	2.5E-03	4.8E-02	6.2E-03	0.21	2.8E-02	1.5E-03	2.0E-04	1.4E-02	1.8E-03	306	39.8	5.8E-03	7.5E-04	5.8E-04	7.5E-05	306	39.8
Laboratory Chemicals	260	--	--	--	--	--	--	--	--	1.7E-03	2.2E-04	--	--	0.32	4.1E-02	--	--	--	--	--	--	--	--
Gasoline filling	260	--	--	--	--	--	--	--	--	--	--	--	--	0.60	7.8E-02	--	--	--	--	--	--	--	--
Total Onsite Stationary Source Emissions	**--**	**6.2E-04**	**8.1E-05**	**2.0E-02**	**2.6E-03**	**2.0E-02**	**2.6E-03**	**0.15**	**2.0E-02**	**0.37**	**4.8E-02**	**1.8E-03**	**2.3E-04**	**0.94**	**0.12**	**335**	**43.5**	**6.3E-03**	**8.2E-04**	**5.8E-04**	**7.5E-05**	**335**	**43.5**
Onsite Offroad Vehicle Emission Sources																							
Aerial Lifts	260	1.0E-02	1.3E-03	1.0E-02	1.3E-03	1.0E-02	1.3E-03	0.13	1.7E-02	0.12	1.6E-02	1.8E-04	2.3E-05	3.8E-02	5.0E-03	14.3	1.86	--	--	--	--	14.3	1.86
Tractors/Loaders/Backhoes	260	1.9E-02	2.5E-03	1.9E-02	2.5E-03	1.9E-02	2.5E-03	0.25	3.3E-02	0.28	3.7E-02	3.4E-04	4.5E-05	7.3E-02	9.4E-03	27.8	3.62	--	--	--	--	27.8	3.62
Sweepers/Scrubbers	260	1.2E-02	1.6E-03	1.2E-02	1.6E-03	1.2E-02	1.6E-03	0.15	2.0E-02	0.17	2.2E-02	2.0E-04	2.6E-05	4.7E-02	6.1E-03	16.4	2.13	--	--	--	--	16.4	2.13
Lawnmowers	260	5.2E-02	6.7E-03	5.2E-02	6.7E-03	5.2E-02	6.7E-03	0.79	0.10	76.3	9.92	2.9E-03	3.8E-04	1.17	0.15	120	15.6	--	--	--	--	120	15.6
Onsite Offroad Equipment	**--**	**9.4E-02**	**1.2E-02**	**9.4E-02**	**1.2E-02**	**9.4E-02**	**1.2E-02**	**1.33**	**0.17**	**76.9**	**10.00**	**3.7E-03**	**4.8E-04**	**1.33**	**0.17**	**179**	**23.2**	**0**	**0**	**0**	**0**	**179**	**23.2**
Total Phase 1 Project Summary	**--**	**9.4E-02**	**1.2E-02**	**0.11**	**1.5E-02**	**0.11**	**1.5E-02**	**1.48**	**0.19**	**77.3**	**10.0**	**5.5E-03**	**7.1E-04**	**2.27**	**0.29**	**513**	**66.7**	**6.3E-03**	**8.2E-04**	**5.8E-04**	**7.5E-05**	**514**	**66.8**
Onsite Stationary Exhaust	**--**	**6.2E-04**	**8.1E-05**	**2.0E-02**	**2.6E-03**	**2.0E-02**	**2.6E-03**	**0.15**	**2.0E-02**	**0.37**	**4.8E-02**	**1.8E-03**	**2.3E-04**	**0.94**	**0.12**	**335**	**43.5**	**6.3E-03**	**8.2E-04**	**5.8E-04**	**7.5E-05**	**335**	**43.5**
Onsite Offroad Exhaust	**--**	**9.4E-02**	**1.2E-02**	**9.4E-02**	**1.2E-02**	**9.4E-02**	**1.2E-02**	**1.33**	**0.17**	**76.9**	**10.00**	**3.7E-03**	**4.8E-04**	**1.33**	**0.17**	**179**	**23.2**	**0**	**0**	**0**	**0**	**179**	**23.2**

References:

(1) Daily emission rates are annual average daily emission rates, which are calculated by dividing the annual emission rate by the annual days of operation, and converting form tons to pounds. Annual days of operation is set to 5 days per week, 52 weeks per year.

Table K-7
Onsite Employee Vehicle TAC Emission Estimates

Parameter		Value	Total
Gasoline Refueling VOC Emission Factor (lbs/Mgal)	(2)	38.9	
Annual Gasoline Throughput (Mgal/yr)	(3)	4.0	
Daily Gasoline Throughput (Mgal/day)	(3)	0.011	

TAC	CAS	TAC Percent of Gasoline VOC (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	Maximum Daily Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)
Benzene	71-43-2	1.80	7.7E-04	1.4E-03	7.7E-04	1.4E-03
Ethylbenzene	100-41-4	1.40	6.0E-04	1.1E-03	6.0E-04	1.1E-03
n-Hexane	110-54-3	1.00	4.3E-04	7.8E-04	4.3E-04	7.8E-04
Toluene	108-88-3	7.00	3.0E-03	5.4E-03	3.0E-03	5.4E-03
m-Xylene	108-38-3	7.00	3.0E-03	5.4E-03	3.0E-03	5.4E-03

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (TAC percent of gasoline VOC [%] / 100) x (gasoline refueling VOC emission factor [lbs/Mgal]) x (daily gasoline throughput [Mgal/day]) / (daily hours of operation [hrs/day])

Daily hours of operation (hrs/day) = 10 (3)

(b) Annual emissions estimate (tons/yr) = (TAC percent of gasoline VOC [%] / 100) x (gasoline refueling VOC emission factor [lbs/Mgal]) x (annual gasoline throughput [Mgal/day])

References:

(1) California Air Resources Board Speciation Database. TAC emission fractions are derived from the individual speciation profiles listed. Profiles chosen to best represent the project vehicle fleet and existing gasoline formulation.

(2) Emission Factors source: EMFAC 2011 (Model Years to 2034). Onsite speed set to 15 mile per hour to conservatively estimate onsite emissions. No tire and brake wear emission factors are provided at 15 miles per hour.

(3) See Table K-1, Existing Richmond Field Station Phase 1 Source Operation Input Assumptions for Emission Rate Calculations.

Table K-8
Natural Gas Boiler TAC Emission Estimates

Source			Natural Gas Boiler - Building 400a	Natural Gas Boiler - Building 400b	Natural Gas Boiler - Building 400c	Natural Gas Boiler - Building 400d	Natural Gas Boiler - Building 451	Natural Gas Boiler - Building 452	Natural Gas Boiler - Building 454
Maximum Hourly Fuel Usage (MMBtu/hr)	(1)		1.35	1.46	1.46	1.5	0.65	0.399	0.45
Daily Hours of Operation (hrs/day)	(1)		24	24	24	24	24	24	24
Annual Fuel Usage (MMBtu/yr)	(1)		675	730	730	750	325	199	225
Modeling ID			NGB_400a	NGB_400b	NGB_400c	NGB_400d	NGB_451	NGB_452	NGB_454

TAC	CAS	Emission Factor (lbs/MMscf)	Maximum Hourly [(a)] (lbs/hr)	Annual Average [(b)] (tons/yr)	Maximum Hourly [(a)] (lbs/hr)	Annual Average [(b)] (tons/yr)	Maximum Hourly [(a)] (lbs/hr)	Annual Average [(b)] (tons/yr)	Maximum Hourly [(a)] (lbs/hr)	Annual Average [(b)] (tons/yr)	Maximum Hourly [(a)] (lbs/hr)	Annual Average [(b)] (tons/yr)	Maximum Hourly [(a)] (lbs/hr)	Annual Average [(b)] (tons/yr)	Maximum Hourly [(a)] (lbs/hr)	Annual Average [(b)] (tons/yr)
7,12-Dimethylbenz(a)anthracene	57-97-6	1.6E-05 [(2)]	2.1E-08	5.3E-09	2.3E-08	5.7E-09	2.3E-08	5.7E-09	2.4E-08	5.9E-09	1.0E-08	2.5E-09	6.3E-09	1.6E-09	7.1E-09	1.8E-09
Acetaldehyde	75-07-0	8.9E-03 [(3)]	1.2E-05	2.9E-06	1.3E-05	3.2E-06	1.3E-05	3.2E-06	1.3E-05	3.3E-06	5.7E-06	1.4E-06	3.5E-06	8.7E-07	3.9E-06	9.8E-07
Benzene	71-43-2	4.3E-03 [(3)]	5.7E-06	1.4E-06	6.2E-06	1.5E-06	6.2E-06	1.5E-06	6.3E-06	1.6E-06	2.7E-06	6.9E-07	1.7E-06	4.2E-07	1.9E-06	4.8E-07
Dichlorobenzene	25321-22-6	1.2E-03 [(4)]	1.6E-06	4.0E-07	1.7E-06	4.3E-07	1.7E-06	4.3E-07	1.8E-06	4.4E-07	7.6E-07	1.9E-07	4.7E-07	1.2E-07	5.3E-07	1.3E-07
Ethylbenzene	100-41-4	6.9E-03 [(5)]	9.1E-06	2.3E-06	9.9E-06	2.5E-06	9.9E-06	2.5E-06	1.0E-05	2.5E-06	4.4E-06	1.1E-06	2.7E-06	6.7E-07	3.0E-06	7.6E-07
Fluoranthene	206-44-0	3.0E-06 [(2)]	4.0E-09	9.9E-10	4.3E-09	1.1E-09	4.3E-09	1.1E-09	4.4E-09	1.1E-09	1.9E-09	4.8E-10	1.2E-09	2.9E-10	1.3E-09	3.3E-10
Formaldehyde	50-00-0	2.2E-01 [(3)]	2.9E-04	7.3E-05	3.2E-04	7.9E-05	3.2E-04	7.9E-05	3.3E-04	8.1E-05	1.4E-04	3.5E-05	8.6E-05	2.2E-05	9.8E-05	2.4E-05
n-Hexane	110-54-3	4.6E-03 [(5)]	6.1E-06	1.5E-06	6.6E-06	1.6E-06	6.6E-06	1.6E-06	6.8E-06	1.7E-06	2.9E-06	7.3E-07	1.8E-06	4.5E-07	2.0E-06	5.1E-07
Naphthalene	91-20-3	3.0E-04 [(5)]	4.0E-07	9.9E-08	4.3E-07	1.1E-07	4.3E-07	1.1E-07	4.4E-07	1.1E-07	1.9E-07	4.8E-08	1.2E-07	2.9E-08	1.3E-07	3.3E-08
Propylene	115-07-1	5.3E-01 [(5)]	7.0E-04	1.8E-04	7.6E-04	1.9E-04	7.6E-04	1.9E-04	7.8E-04	1.9E-04	3.4E-04	8.4E-05	2.1E-04	5.2E-05	2.3E-04	5.8E-05
Toluene	108-88-3	2.7E-02 [(5)]	3.5E-05	8.8E-06	3.8E-05	9.5E-06	3.8E-05	9.5E-06	3.9E-05	9.7E-06	1.7E-05	4.2E-06	1.0E-05	2.6E-06	1.2E-05	2.9E-06
Xylenes	1330-20-7	2.0E-02 [(5)]	2.6E-05	6.5E-06	2.8E-05	7.0E-06	2.8E-05	7.0E-06	2.9E-05	7.2E-06	1.3E-05	3.1E-06	7.7E-06	1.9E-06	8.7E-06	2.2E-06
Arsenic	7440-38-2	2.0E-04 [(4)]	2.6E-07	6.6E-08	2.9E-07	7.2E-08	2.9E-07	7.2E-08	2.9E-07	7.4E-08	1.3E-07	3.2E-08	7.8E-08	2.0E-08	8.8E-08	2.2E-08
Beryllium	7440-41-7	1.2E-05 [(4)]	1.6E-08	4.0E-09	1.7E-08	4.3E-09	1.7E-08	4.3E-09	1.8E-08	4.4E-09	7.6E-09	1.9E-09	4.7E-09	1.2E-09	5.3E-09	1.3E-09
Cadmium	7440-43-9	1.1E-03 [(4)]	1.5E-06	3.6E-07	1.6E-06	3.9E-07	1.6E-06	3.9E-07	1.6E-06	4.0E-07	7.0E-07	1.8E-07	4.3E-07	1.1E-07	4.9E-07	1.2E-07
Chromium VI	18540-29-9	2.4E-04 [(6)]	3.2E-07	7.9E-08	3.4E-07	8.5E-08	3.4E-07	8.5E-08	3.5E-07	8.7E-08	1.5E-07	3.8E-08	9.3E-08	2.3E-08	1.1E-07	2.6E-08
Cobalt	7440-48-4	8.4E-05 [(4)]	1.1E-07	2.8E-08	1.2E-07	3.0E-08	1.2E-07	3.0E-08	1.2E-07	3.1E-08	5.4E-08	1.3E-08	3.3E-08	8.2E-09	3.7E-08	9.3E-09
Copper	7440-50-8	8.5E-04 [(4)]	1.1E-06	2.8E-07	1.2E-06	3.0E-07	1.2E-06	3.0E-07	1.3E-06	3.1E-07	5.4E-07	1.4E-07	3.3E-07	8.3E-08	3.8E-07	9.4E-08
Lead	7439-92-1	5.0E-04 [(4)]	6.6E-07	1.7E-07	7.2E-07	1.8E-07	7.2E-07	1.8E-07	7.4E-07	1.8E-07	3.2E-07	8.0E-08	2.0E-07	4.9E-08	2.2E-07	5.5E-08
Manganese	7439-96-5	3.8E-04 [(4)]	5.0E-07	1.3E-07	5.4E-07	1.4E-07	5.4E-07	1.4E-07	5.6E-07	1.4E-07	2.4E-07	6.1E-08	1.5E-07	3.7E-08	1.7E-07	4.2E-08
Mercury	7439-97-6	2.6E-04 [(4)]	3.4E-07	8.6E-08	3.7E-07	9.3E-08	3.7E-07	9.3E-08	3.8E-07	9.6E-08	1.7E-07	4.1E-08	1.0E-07	2.5E-08	1.1E-07	2.9E-08
Nickel	7440-02-0	2.1E-03 [(4)]	2.8E-06	6.9E-07	3.0E-06	7.5E-07	3.0E-06	7.5E-07	3.1E-06	7.7E-07	1.3E-06	3.3E-07	8.2E-07	2.1E-07	9.3E-07	2.3E-07
Selenium	7782-49-2	2.4E-05 [(4)]	3.2E-08	7.9E-09	3.4E-08	8.6E-09	3.4E-08	8.6E-09	3.5E-08	8.8E-09	1.5E-08	3.8E-09	9.4E-09	2.3E-09	1.1E-08	2.6E-09

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/MMscf]) x (maximum hourly heat input [MMBtu/hr])/ (natural gas heat content [Btu/scf])
Natural gas heat content (Btu/scf) = 1,020 (2)

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/MMscf]) x (annual heat input [MMBtu/yr]) / (natural gas heat content [Btu/scf]) x (tons/2,000 lbs)
Natural gas heat content (Btu/scf) = 1,020 (2)

References:

(1) See Table K-1, Existing Richmond Field Station Phase 1 Source Operation Input Assumptions for Emission Rate Calculations.
(2) AP-42 Chapter 1.4 (July 1998), Table 1.4-3 "Emission Factors For Speciated Organic Compounds from Natural Gas Combustion".
(3) California Air Toxics Emission Factor (CATEF) Database under Natural Gas Boilers.
(4) AP-42 Chapter 1.4 (July 1998), Table 1.4-4 "Emission Factors For Metals from Natural Gas Combustion".
(5) Ventura Air Quality Management District emission factor database.
(6) The AP-42 total chromium emission factor was multiplied by 17% to correct for emissions of hexavalent chromium per EPA assumptions when regulating combustion sources under 40 CFR Part 63 Subpart DDDD.

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Table K-8
Natural Gas Boiler TAC Emission Estimates

Source	Natural Gas Boiler - Building 472	Natural Gas Boiler - Building 477	Natural Gas Boiler - Building 478a	Natural Gas Boiler - Building 478b	Natural Gas Boiler - Building 478c	Natural Gas Boiler - Building 480	Natural Gas Boiler - Building 484	Total
Maximum Hourly Fuel Usage (MMBtu/hr) (1)	0.375	0.6	0.502	0.502	1.966	0.45	1.008	
Daily Hours of Operation (hrs/day) (1)	24	24	24	24	24	24	24	
Annual Fuel Usage (MMBtu/yr) (1)	187	300	251	251	983	225	504	
Modeling ID	NGB_472	NGB_477	NGB_478a	NGB_478b	NGB_478c	NGB_480	NGB_484	

TAC	CAS	Emission Factor (lbs/MMscf)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)
7,12-Dimethylbenz(a)anthracene	57-97-6	1.6E-05 (2)	5.9E-09	1.5E-09	9.4E-09	2.4E-09	7.9E-09	2.0E-09	7.9E-09	2.0E-09	3.1E-08	7.7E-09	7.1E-09	1.8E-09	1.6E-08	4.0E-09	2.0E-07	5.0E-08
Acetaldehyde	75-07-0	8.9E-03 (3)	3.3E-06	8.2E-07	5.2E-06	1.3E-06	4.4E-06	1.1E-06	4.4E-06	1.1E-06	1.7E-05	4.3E-06	3.9E-06	9.8E-07	8.8E-06	2.2E-06	1.1E-04	2.8E-05
Benzene	71-43-2	4.3E-03 (3)	1.6E-06	4.0E-07	2.5E-06	6.3E-07	2.1E-06	5.3E-07	2.1E-06	5.3E-07	8.3E-06	2.1E-06	1.9E-06	4.8E-07	4.3E-06	1.1E-06	5.4E-05	1.3E-05
Dichlorobenzene	25321-22-6	1.2E-03 (4)	4.4E-07	1.1E-07	7.1E-07	1.8E-07	5.9E-07	1.5E-07	5.9E-07	1.5E-07	2.3E-06	5.8E-07	5.3E-07	1.3E-07	1.2E-06	3.0E-07	1.5E-05	3.7E-06
Ethylbenzene	100-41-4	6.9E-03 (5)	2.5E-06	6.3E-07	4.1E-06	1.0E-06	3.4E-06	8.5E-07	3.4E-06	8.5E-07	1.3E-05	3.3E-06	3.0E-06	7.6E-07	6.8E-06	1.7E-06	8.6E-05	2.1E-05
Fluoranthene	206-44-0	3.0E-06 (2)	1.1E-09	2.8E-10	1.8E-09	4.4E-10	1.5E-09	3.7E-10	1.5E-09	3.7E-10	5.8E-09	1.4E-09	1.3E-09	3.3E-10	3.0E-09	7.4E-10	3.7E-08	9.3E-09
Formaldehyde	50-00-0	2.2E-01 (3)	8.1E-05	2.0E-05	1.3E-04	3.2E-05	1.1E-04	2.7E-05	1.1E-04	2.7E-05	4.3E-04	1.1E-04	9.8E-05	2.4E-05	2.2E-04	5.5E-05	2.7E-03	6.9E-04
n-Hexane	110-54-3	4.6E-03 (5)	1.7E-06	4.2E-07	2.7E-06	6.8E-07	2.3E-06	5.7E-07	2.3E-06	5.7E-07	8.9E-06	2.2E-06	2.0E-06	5.1E-07	4.5E-06	1.1E-06	5.7E-05	1.4E-05
Naphthalene	91-20-3	3.0E-04 (5)	1.1E-07	2.8E-08	1.8E-07	4.4E-08	1.5E-07	3.7E-08	1.5E-07	3.7E-08	5.8E-07	1.4E-07	1.3E-07	3.3E-08	3.0E-07	7.4E-08	3.7E-06	9.3E-07
Propylene	115-07-1	5.3E-01 (5)	1.9E-04	4.9E-05	3.1E-04	7.8E-05	2.6E-04	6.5E-05	2.6E-04	6.5E-05	1.0E-03	2.6E-04	2.3E-04	5.8E-05	5.2E-04	1.3E-04	6.6E-03	1.6E-03
Toluene	108-88-3	2.7E-02 (5)	9.7E-06	2.4E-06	1.6E-05	3.9E-06	1.3E-05	3.3E-06	1.3E-05	3.3E-06	5.1E-05	1.3E-05	1.2E-05	2.9E-06	2.6E-05	6.5E-06	3.3E-04	8.2E-05
Xylenes	1330-20-7	2.0E-02 (5)	7.2E-06	1.8E-06	1.2E-05	2.9E-06	9.7E-06	2.4E-06	9.7E-06	2.4E-06	3.8E-05	9.5E-06	8.7E-06	2.2E-06	1.9E-05	4.9E-06	2.4E-04	6.1E-05
Arsenic	7440-38-2	2.0E-04 (4)	7.4E-08	1.8E-08	1.2E-07	2.9E-08	9.8E-08	2.5E-08	9.8E-08	2.5E-08	3.9E-07	9.6E-08	8.8E-08	2.2E-08	2.0E-07	4.9E-08	2.5E-06	6.2E-07
Beryllium	7440-41-7	1.2E-05 (4)	4.4E-09	1.1E-09	7.1E-09	1.8E-09	5.9E-09	1.5E-09	5.9E-09	1.5E-09	2.3E-08	5.8E-09	5.3E-09	1.3E-09	1.2E-08	3.0E-09	1.5E-07	3.7E-08
Cadmium	7440-43-9	1.1E-03 (4)	4.0E-07	1.0E-07	6.5E-07	1.6E-07	5.4E-07	1.4E-07	5.4E-07	1.4E-07	2.1E-06	5.3E-07	4.9E-07	1.2E-07	1.1E-06	2.7E-07	1.4E-05	3.4E-06
Chromium VI	18540-29-9	2.4E-04 (6)	8.8E-08	2.2E-08	1.4E-07	3.5E-08	1.2E-07	2.9E-08	1.2E-07	2.9E-08	4.6E-07	1.1E-07	1.1E-07	2.6E-08	2.4E-07	5.9E-08	3.0E-06	7.4E-07
Cobalt	7440-48-4	8.4E-05 (4)	3.1E-08	7.7E-09	4.9E-08	1.2E-08	4.1E-08	1.0E-08	4.1E-08	1.0E-08	1.6E-07	4.0E-08	3.7E-08	9.3E-09	8.3E-08	2.1E-08	1.0E-06	2.6E-07
Copper	7440-50-8	8.5E-04 (4)	3.1E-07	7.8E-08	5.0E-07	1.2E-07	4.2E-07	1.0E-07	4.2E-07	1.0E-07	1.6E-06	4.1E-07	3.8E-07	9.4E-08	8.4E-07	2.1E-07	1.1E-05	2.6E-06
Lead	7439-92-1	5.0E-04 (4)	1.8E-07	4.6E-08	2.9E-07	7.4E-08	2.5E-07	6.2E-08	2.5E-07	6.2E-08	9.6E-07	2.4E-07	2.2E-07	5.5E-08	4.9E-07	1.2E-07	6.2E-06	1.6E-06
Manganese	7439-96-5	3.8E-04 (4)	1.4E-07	3.5E-08	2.2E-07	5.6E-08	1.9E-07	4.7E-08	1.9E-07	4.7E-08	7.3E-07	1.8E-07	1.7E-07	4.2E-08	3.8E-07	9.4E-08	4.7E-06	1.2E-06
Mercury	7439-97-6	2.6E-04 (4)	9.6E-08	2.4E-08	1.5E-07	3.8E-08	1.3E-07	3.2E-08	1.3E-07	3.2E-08	5.0E-07	1.3E-07	1.1E-07	2.9E-08	2.6E-07	6.4E-08	3.2E-06	8.1E-07
Nickel	7440-02-0	2.1E-03 (4)	7.7E-07	1.9E-07	1.2E-06	3.1E-07	1.0E-06	2.6E-07	1.0E-06	2.6E-07	4.0E-06	1.0E-06	9.3E-07	2.3E-07	2.1E-06	5.2E-07	2.6E-05	6.5E-06
Selenium	7782-49-2	2.4E-05 (4)	8.8E-09	2.2E-09	1.4E-08	3.5E-09	1.2E-08	3.0E-09	1.2E-08	3.0E-09	4.6E-08	1.2E-08	1.1E-08	2.6E-09	2.4E-08	5.9E-09	3.0E-07	7.5E-08

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/MMscf]) x (maximum hourly heat input [MMBtu/hr])/ (natural gas heat content [Btu/scf])
Natural gas heat content (Btu/scf) = 1020 (2)

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/MMscf]) x (annual heat input [MMBtu/yr]) / (natural gas heat content [Btu/scf]) x (tons/2,000 lbs)
Natural gas heat content (Btu/scf) = 1020 (2)

References:

(1) See Table K-1, Existing Richmond Field Station Phase 1 Source Operation Input Assumptions for Emission Rate Calculations.
(2) AP-42 Chapter 1.4 (July 1998), Table 1.4-3 "Emission Factors For Speciated Organic Compounds from Natural Gas Combustion".
(3) California Air Toxics Emission Factor (CATEF) Database under Natural Gas Boilers.
(4) AP-42 Chapter 1.4 (July 1998), Table 1.4-4 "Emission Factors For Metals from Natural Gas Combustion".
(5) Ventura Air Quality Management District emission factor database.
The AP-42 total chromium emission factor was multiplied by 17% to correct for emissions of hexavalent chromium per EPA assumptions when regulating combustion sources under 40 CFR Part 63 Subpart DDDD.

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Table K-9
Emergency Diesel Generator TAC Emission Estimates

Source		Existing standby generator - B194	Existing standby generator - NRLF	Existing Fire Pump - NRLF	Total
BHP	(1)	88	88	88	
Diesel Fuel Combustion (gal/hr)	(1)	4.4	4.4	4.4	
Load Factor	(2)	0.74	0.74	0.74	
Annual Operation (hrs/yr)	(1)	25.15	25.15	25.15	
Modeling ID		DG_B194	DG_NRLF2	FP_NRLF2	

TAC	CAS	Emission Factor (lbs/10^3 gal)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Daily Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)
DPM	9901	-- [3]	2.1E-03 [b]	2.7E-05	2.1E-03 [b]	2.7E-05	2.1E-03 [b]	2.7E-05	6.4E-03	8.1E-05
1,3-Butadiene	106-99-0	2.17E-01 [4]	7.1E-04 [c]	9.0E-06	7.1E-04 [c]	9.0E-06	7.1E-04 [c]	9.0E-06	2.1E-03	2.7E-05
Acetaldehyde	75-07-0	3.47E-03 [5]	1.1E-05 [c]	1.4E-07	1.1E-05 [c]	1.4E-07	1.1E-05 [c]	1.4E-07	3.4E-05	4.3E-07
Benzene	71-43-2	1.93E-01 [5]	6.3E-04 [c]	8.0E-06	6.3E-04 [c]	8.0E-06	6.3E-04 [c]	8.0E-06	1.9E-03	2.4E-05
Benzo(a)anthracene	56-55-3	-- [6]	--	--	--	--	--	--	0	0
Benzo(b)fluoranthene	205-99-2	-- [6]	--	--	--	--	--	--	0	0
Benzo(k)fluoranthene	207-08-9	-- [6]	--	--	--	--	--	--	0	0
Chlorobenzene	108-90-7	2.00E-04 [4]	6.6E-07 [c]	8.3E-09	6.6E-07 [c]	8.3E-09	6.6E-07 [c]	8.3E-09	2.0E-06	2.5E-08
Chrysene	218-01-9	-- [6]	--	--	--	--	--	--	0	0
Dibenz(a,h)anthracene	53-70-3	-- [6]	--	--	--	--	--	--	0	0
Ethylbenzene	100-41-4	6.76E-03 [5]	2.2E-05 [c]	2.8E-07	2.2E-05 [c]	2.8E-07	2.2E-05 [c]	2.8E-07	6.7E-05	8.4E-07
Formaldehyde	50-00-0	5.06E-02 [5]	1.7E-04 [c]	2.1E-06	1.7E-04 [c]	2.1E-06	1.7E-04 [c]	2.1E-06	5.0E-04	6.3E-06
n-Hexane	110-54-3	1.39E-03 [5]	4.6E-06 [c]	5.7E-08	4.6E-06 [c]	5.7E-08	4.6E-06 [c]	5.7E-08	1.4E-05	1.7E-07
Hydrogen Chloride	7647-01-0	1.86E-01 [4]	6.1E-04 [c]	7.7E-06	6.1E-04 [c]	7.7E-06	6.1E-04 [c]	7.7E-06	1.8E-03	2.3E-05
Indeno(1,2,3-cd)pyrene	193-39-5	-- [6]	--	--	--	--	--	--	0	0
Naphthalene	91-20-3	1.60E-02 [5]	5.2E-05 [c]	6.6E-07	5.2E-05 [c]	6.6E-07	5.2E-05 [c]	6.6E-07	1.6E-04	2.0E-06
Propylene	115-07-1	3.41E-01 [5]	1.1E-03 [c]	1.4E-05	1.1E-03 [c]	1.4E-05	1.1E-03 [c]	1.4E-05	3.4E-03	4.2E-05
Toluene	108-88-3	6.12E-02 [5]	2.0E-04 [c]	2.5E-06	2.0E-04 [c]	2.5E-06	2.0E-04 [c]	2.5E-06	6.0E-04	7.6E-06
Xylenes	1330-20-7	4.24E-02 [4]	1.4E-04 [c]	1.8E-06	1.4E-04 [c]	1.8E-06	1.4E-04 [c]	1.8E-06	4.2E-04	5.3E-06
Arsenic	7440-38-2	1.60E-03 [4]	5.3E-06 [c]	6.6E-08	5.3E-06 [c]	6.6E-08	5.3E-06 [c]	6.6E-08	1.6E-05	2.0E-07
Cadmium	7440-43-9	1.50E-03 [4]	4.9E-06 [c]	6.2E-08	4.9E-06 [c]	6.2E-08	4.9E-06 [c]	6.2E-08	1.5E-05	1.9E-07
Chromium VI	18540-29-9	1.00E-04 [7]	3.3E-07 [c]	4.1E-09	3.3E-07 [c]	4.1E-09	3.3E-07 [c]	4.1E-09	9.9E-07	1.2E-08
Copper	7440-50-8	4.10E-03 [4]	1.3E-05 [c]	1.7E-07	1.3E-05 [c]	1.7E-07	1.3E-05 [c]	1.7E-07	4.0E-05	5.1E-07
Lead	7439-92-1	8.30E-03 [4]	2.7E-05 [c]	3.4E-07	2.7E-05 [c]	3.4E-07	2.7E-05 [c]	3.4E-07	8.2E-05	1.0E-06
Manganese	7439-96-5	3.10E-03 [4]	1.0E-05 [c]	1.3E-07	1.0E-05 [c]	1.3E-07	1.0E-05 [c]	1.3E-07	3.1E-05	3.8E-07
Mercury	7439-97-6	2.00E-03 [4]	6.6E-06 [c]	8.3E-08	6.6E-06 [c]	8.3E-08	6.6E-06 [c]	8.3E-08	2.0E-05	2.5E-07
Nickel	7440-02-0	3.90E-03 [4]	1.3E-05 [c]	1.6E-07	1.3E-05 [c]	1.6E-07	1.3E-05 [c]	1.6E-07	3.8E-05	4.8E-07
Selenium	7782-49-2	2.20E-03 [4]	7.2E-06 [c]	9.1E-08	7.2E-06 [c]	9.1E-08	7.2E-06 [c]	9.1E-08	2.2E-05	2.7E-07

Modeling ID		DG_B194	DG_NRLF2	FP_NRLF2
Diesel Particulate Emission factor (g/hp-hr)	(6)	0.015	0.015	0.015

Notes:

(a) Annual average emission estimate (tons/yr) = (Maximum hourly emissions estimate [lbs/hr]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)

(b) Maximum hourly diesel particulate emissions estimate (lbs/hr) = (Emission factor [g/hp-hr]) x (engine horsepower [hp]) x (load factor) / (453.59 [g/lb])

(c) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/10^3 gal]) x (load factor) x (fuel usage [gal/hr]) x (0.001 gal/10^3 gal)

References:

(1) See Table K-1, Existing Richmond Field Station Phase 1 Source Operation Input Assumptions for Emission Rate Calculations.

(2) Default load factor for generators in URBEMIS emission model.

(3) See diesel particulate matter emission factors at the bottom of the table.

(4) Ventura County Air Pollution Control District AB 2588 Combustion Emission Factors Database, May 2001.

(5) California Toxic Emission Factor (CATEF) Database, except for Diesel PM. The emission factors for each TAC are averaged for diesel internal combustion engines operating at less than 13% oxygen in the exhaust. Per vendor information, the percent oxygen in the exhaust is less than 13% at loads greater than 50%. It is assumed that the generator would be run at 50% load or greater.

(6) Polycyclic Aromatic Hydrocarbons (PAHs) are assumed to be included in the particulate matter emission factor. PAHs that are not specifically listed in this table, but may be included in the particulate matter emission factor, include Acenaphthylene, Anthracene, Acenaphthene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(g,h,i)perylene, Chrysene, Dibenz(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene. For purposes of this inventory, it is assumed that all particulate is represented as Diesel Particulate Matter (DPM).

(7) The AP-42 total chromium emission factor was multiplied by 17% to correct for emissions of hexavalent chromium per EPA assumptions when regulating combustion sources under 40 CFR Part 63 Subpart DDDD.

Table K-10
Total Estimated Air Emissions of Laboratory Non-Radionuclide Liquid Chemicals

Source		Lab Hood Exhaust Stack - Building 154		Lab Hood Exhaust Stack - Building 158		Lab Hood Exhaust Stack - Building 167		Lab Hood Exhaust Stack - Building 450		Lab Hood Exhaust Stack - Building 473		Lab Hood Exhaust Stack - Building 474		Lab Hood Exhaust Stack - Building 478		Lab Hood Exhaust Stack - Building 480		Total	
Modeling ID		LAB_B154		LAB_B158		LAB_B167		LAB_B450		LAB_B473		LAB_B474		LAB_B478		LAB_B480			
TAC	CAS	Maximum Hourly [(b)] (lbs/hr)	Annual Average [(2)] (tons/yr)	Maximum Hourly [(b)] (lbs/hr)	Annual Average [(2)] (tons/yr)	Maximum Hourly [(b)] (lbs/hr)	Annual Average [(2)] (tons/yr)	Maximum Hourly [(b)] (lbs/hr)	Annual Average [(2)] (tons/yr)	Maximum Hourly [(b)] (lbs/hr)	Annual Average [(2)] (tons/yr)	Maximum Hourly [(b)] (lbs/hr)	Annual Average [(2)] (tons/yr)	Maximum Hourly [(b)] (lbs/hr)	Annual Average [(2)] (tons/yr)	Maximum Hourly [(b)] (lbs/hr)	Annual Average [(2)] (tons/yr)	Maximum Daily (lbs/hr)	Annual Average (tons/yr)
1,2-Epoxybutane	106-88-7	2.4E-08	6.1E-09	2.4E-08	6.1E-09	2.4E-08	6.1E-09	2.4E-08	6.1E-09	2.4E-08	6.1E-09	2.4E-08	6.1E-09	2.4E-08	6.1E-09	2.4E-08	6.1E-09	1.9E-07	4.8E-08
Acrylic acid	79-10-7	--	--	--	--	2.0E-03	4.9E-04	--	--	--	--	--	--	--	--	--	--	2.0E-03	4.9E-04
Benzene	71-43-2	2.6E-04	6.5E-05	2.6E-04	6.5E-05	2.6E-04	6.5E-05	2.6E-04	6.5E-05	2.6E-04	6.5E-05	2.6E-04	6.5E-05	2.6E-04	6.5E-05	2.6E-04	6.5E-05	2.1E-03	5.2E-04
Chloroform	67-66-3	9.6E-04	2.4E-04	9.6E-04	2.4E-04	9.6E-04	2.4E-04	9.6E-04	2.4E-04	9.6E-04	2.4E-04	4.0E-03	1.0E-03	9.6E-04	2.4E-04	9.6E-04	2.4E-04	0.011	2.7E-03
Dimethyl formamide	68-12-2	6.3E-06	1.6E-06	6.3E-06	1.6E-06	6.3E-06	1.6E-06	6.3E-06	1.6E-06	6.3E-06	1.6E-06	6.3E-06	1.6E-06	6.3E-06	1.6E-06	6.3E-06	1.6E-06	5.1E-05	1.3E-05
Ethylene glycol	107-21-1	1.2E-06	2.9E-07	1.2E-06	2.9E-07	1.1E-05	2.6E-06	1.2E-06	2.9E-07	1.2E-06	2.9E-07	1.2E-06	2.9E-07	1.2E-06	2.9E-07	3.5E-06	8.9E-07	2.1E-05	5.3E-06
Formaldehyde	50-00-0	1.4E-04	3.6E-05	1.4E-04	3.6E-05	1.4E-04	3.6E-05	1.4E-04	3.6E-05	1.4E-04	3.6E-05	1.4E-04	3.6E-05	1.4E-04	3.6E-05	1.4E-04	3.6E-05	1.1E-03	2.9E-04
n-Hexane	110-54-3	3.6E-03	9.1E-04	3.6E-03	9.1E-04	3.6E-03	9.1E-04	3.6E-03	9.1E-04	3.6E-03	9.1E-04	3.6E-03	9.1E-04	3.6E-03	9.1E-04	3.6E-03	9.1E-04	0.029	7.3E-03
Hydrogen Chloride	7647-01-0	1.0E-03	2.5E-04	1.0E-03	2.5E-04	1.0E-03	2.5E-04	1.0E-03	2.5E-04	1.0E-03	2.5E-04	1.0E-03	2.5E-04	1.0E-03	2.5E-04	1.0E-03	2.5E-04	8.0E-03	2.0E-03
Isopropyl alcohol	67-63-0	2.4E-03	6.0E-04	2.4E-03	6.0E-04	1.1E-03	2.7E-04	1.6E-03	4.0E-04	6.2E-03	1.6E-03	1.1E-03	2.7E-04	2.4E-03	6.0E-04	1.1E-03	2.7E-04	0.018	4.6E-03
Methanol	67-56-1	2.1E-03	5.2E-04	2.1E-03	5.2E-04	2.1E-03	5.2E-04	2.1E-03	5.2E-04	2.1E-03	5.2E-04	3.2E-03	8.2E-04	2.1E-03	5.2E-04	2.1E-03	5.2E-04	0.018	4.4E-03
Methylene chloride [Dichloromethane]	75-09-2	8.3E-03	2.1E-03	8.3E-03	2.1E-03	8.3E-03	2.1E-03	8.3E-03	2.1E-03	8.3E-03	2.1E-03	8.3E-03	2.1E-03	8.3E-03	2.1E-03	8.3E-03	2.1E-03	0.067	0.017
Nitric acid	7697-37-2	2.1E-04	5.4E-05	2.1E-04	5.4E-05	2.1E-04	5.4E-05	2.1E-04	5.4E-05	2.1E-04	5.4E-05	2.1E-04	5.4E-05	2.1E-04	5.4E-05	2.1E-04	5.4E-05	1.7E-03	4.3E-04
Phenol	108-95-2	1.1E-05	2.7E-06	1.1E-05	2.7E-06	1.1E-05	2.7E-06	1.1E-05	2.7E-06	1.1E-05	2.7E-06	1.1E-05	2.7E-06	1.1E-05	2.7E-06	1.1E-05	2.7E-06	8.6E-05	2.2E-05
Sulfuric acid	7664-93-9	8.4E-06	2.1E-06	8.4E-06	2.1E-06	8.4E-06	2.1E-06	8.4E-06	2.1E-06	8.4E-06	2.1E-06	8.4E-06	2.1E-06	8.4E-06	2.1E-06	8.4E-06	2.1E-06	6.7E-05	1.7E-05
Toluene	108-88-3	8.3E-04	2.1E-04	8.3E-04	2.1E-04	8.3E-04	2.1E-04	8.3E-04	2.1E-04	8.3E-04	2.1E-04	8.3E-04	2.1E-04	1.9E-03	4.9E-04	8.3E-04	2.1E-04	7.8E-03	1.9E-03
Triethylamine	121-44-8	3.8E-05	9.6E-06	3.8E-05	9.6E-06	3.8E-05	9.6E-06	3.8E-05	9.6E-06	3.8E-05	9.6E-06	3.8E-05	9.6E-06	3.8E-05	9.6E-06	3.8E-05	9.6E-06	3.1E-04	7.7E-05
Carbon Monoxide	630-08-0	1.1E-04	2.8E-05	1.1E-04	2.8E-05	1.1E-04	2.8E-05	1.1E-04	2.8E-05	1.1E-04	2.8E-05	1.1E-04	2.8E-05	1.1E-04	2.8E-05	1.1E-04	2.8E-05	8.8E-04	2.2E-04
Total - All Chemicals Listed		**0.020**	**5.0E-03**	**0.020**	**5.0E-03**	**0.021**	**5.2E-03**	**0.019**	**4.8E-03**	**0.024**	**6.0E-03**	**0.023**	**5.8E-03**	**0.021**	**5.3E-03**	**0.019**	**4.7E-03**	**0.17**	**0.042**

Notes:

(b) Maximum hourly emissions estimate (lbs/hr) = (Annual average emissions [tons/year]) / (annual operation [days/year]) / (daily operation [hrs/day]) x (2,000 lbs/ton) x (conversion factor)

Annual operation for all buildings (days/year) =	260	(1)
Daily operation for all buildings (hrs/day) =	10	(1)
Conversion factor =	5.18	(3)

(c) Annual average emissions estimate (tons/yr) = (Phase I emissions fraction [tons/gsf/yr]) x (building size [gsf])

References:

(1) See Table K-1, Existing Richmond Field Station Phase 1 Source Operation Input Assumptions for Emission Rate Calculations.
(2) RFS Laboratory emissions calculated as part of the cumulative assessment using a method similar to that used for the Phase 1 assessment. See Appendix M.
(3) Based in studies comparing maximum to average emission rates for laboratories. See text for further information.

Table K-11
Existing Richmond Field Station Phase 1 Source Operations TAC Emissions Summary

TAC	CAS	Natural Gas Boilers		Diesel Generators		Laboratory Buildings		Vehicle Refueling Station		Offroad Vehicle Exhaust		Total	
		(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)
DPM (1)	9901	--	--	6.4E-03	8.1E-05	--	--	--	--	0.12	0.012	0.13	0.012
1,3-Butadiene	106-99-0	--	--	2.1E-03	2.7E-05	--	--	--	--	--	--	2.1E-03	2.7E-05
1,2-Epoxybutane	106-88-7	--	--	--	--	1.9E-07	4.8E-08	--	--	--	--	1.9E-07	4.8E-08
7,12-Dimethylbenz(a)anthracene	57-97-6	2.0E-07	5.0E-08	--	--	--	--	--	--	--	--	2.0E-07	5.0E-08
Acetaldehyde	75-07-0	1.1E-04	2.8E-05	3.4E-05	4.3E-07	--	--	--	--	--	--	1.4E-04	2.8E-05
Acrylic acid	79-10-7	--	--	--	--	2.0E-03	4.9E-04	--	--	--	--	2.0E-03	4.9E-04
Arsenic	7440-38-2	2.5E-06	6.2E-07	1.6E-05	2.0E-07	--	--	--	--	--	--	1.8E-05	8.2E-07
Benzene	71-43-2	5.4E-05	1.3E-05	1.9E-03	2.4E-05	2.1E-03	5.2E-04	7.7E-04	1.4E-03	--	--	4.8E-03	2.0E-03
Beryllium	7440-41-7	1.5E-07	3.7E-08	--	--	--	--	--	--	--	--	1.5E-07	3.7E-08
Cadmium	7440-43-9	1.4E-05	3.4E-06	1.5E-05	1.9E-07	--	--	--	--	--	--	2.8E-05	3.6E-06
Chlorobenzene	108-90-7	--	--	2.0E-06	2.5E-08	--	--	--	--	--	--	2.0E-06	2.5E-08
Chloroform	67-66-3	--	--	--	--	0.011	2.7E-03	--	--	--	--	0.011	2.7E-03
Chromium VI	18540-29-9	3.0E-06	7.4E-07	9.9E-07	1.2E-08	--	--	--	--	--	--	3.9E-06	7.5E-07
Cobalt	7440-48-4	1.0E-06	2.6E-07	--	--	--	--	--	--	--	--	1.0E-06	2.6E-07
Copper	7440-50-8	1.1E-05	2.6E-06	4.0E-05	5.1E-07	--	--	--	--	--	--	5.1E-05	3.1E-06
Dichlorobenzene	25321-22-6	1.5E-05	3.7E-06	--	--	--	--	--	--	--	--	1.5E-05	3.7E-06
Dimethyl formamide	68-12-2	--	--	--	--	5.1E-05	1.3E-05	--	--	--	--	5.1E-05	1.3E-05
Ethylbenzene	100-41-4	8.6E-05	2.1E-05	6.7E-05	8.4E-07	--	--	6.0E-04	1.1E-03	--	--	7.5E-04	1.1E-03
Ethylene glycol	107-21-1	--	--	--	--	2.1E-05	5.3E-06	--	--	--	--	2.1E-05	5.3E-06
Fluoranthene	206-44-0	3.7E-08	9.3E-09	--	--	--	--	--	--	--	--	3.7E-08	9.3E-09
Formaldehyde	50-00-0	2.7E-03	6.9E-04	5.0E-04	6.3E-06	1.1E-03	2.9E-04	--	--	--	--	4.4E-03	9.8E-04
Hydrogen Chloride	7647-01-0	--	--	1.8E-03	2.3E-05	8.0E-03	2.0E-03	--	--	--	--	9.8E-03	2.0E-03
Isopropyl alcohol	67-63-0	--	--	--	--	0.018	4.6E-03	--	--	--	--	0.018	4.6E-03
Lead	7439-92-1	6.2E-06	1.6E-06	8.2E-05	1.0E-06	--	--	--	--	--	--	8.8E-05	2.6E-06
Manganese	7439-96-5	4.7E-06	1.2E-06	3.1E-05	3.8E-07	--	--	--	--	--	--	3.5E-05	1.6E-06
Mercury	7439-97-6	3.2E-06	8.1E-07	2.0E-05	2.5E-07	--	--	--	--	--	--	2.3E-05	1.1E-06
Methanol	67-56-1	--	--	--	--	0.018	4.4E-03	--	--	--	--	0.018	4.4E-03
Methylene chloride [Dichloromethane]	75-09-2	--	--	--	--	0.067	0.017	--	--	--	--	0.067	0.017
Naphthalene	91-20-3	3.7E-06	9.3E-07	1.6E-04	2.0E-06	--	--	--	--	--	--	1.6E-04	2.9E-06
n-Hexane	110-54-3	5.7E-05	1.4E-05	1.4E-05	1.7E-07	0.029	7.3E-03	4.3E-04	7.8E-04	--	--	0.030	8.1E-03
Nickel	7440-02-0	2.6E-05	6.5E-06	3.8E-05	4.8E-07	--	--	--	--	--	--	6.5E-05	7.0E-06
Nitric acid	7697-37-2	--	--	--	--	1.7E-03	4.3E-04	--	--	--	--	1.7E-03	4.3E-04
Phenol	108-95-2	--	--	--	--	8.6E-05	2.2E-05	--	--	--	--	8.6E-05	2.2E-05
Propylene	115-07-1	6.6E-03	1.6E-03	3.4E-03	4.2E-05	--	--	--	--	--	--	9.9E-03	1.7E-03
Selenium	7782-49-2	3.0E-07	7.5E-08	2.2E-05	2.7E-07	--	--	--	--	--	--	2.2E-05	3.5E-07
Sulfuric acid	7664-93-9	--	--	--	--	6.7E-05	1.7E-05	--	--	--	--	6.7E-05	1.7E-05
Toluene	108-88-3	3.3E-04	8.2E-05	6.0E-04	7.6E-06	7.8E-03	1.9E-03	3.0E-03	5.4E-03	--	--	0.012	7.5E-03
Triethylamine	121-44-8	--	--	--	--	3.1E-04	7.7E-05	--	--	--	--	3.1E-04	7.7E-05
m-Xylene	108-38-3	--	--	--	--	--	--	3.0E-03	5.4E-03	--	--	3.0E-03	5.4E-03
Xylenes	1330-20-7	2.4E-04	6.1E-05	4.2E-04	5.3E-06	--	--	--	--	--	--	6.6E-04	6.6E-05
NO_2	10102-44-0	0.025	6.2E-03	1.07	0.013	--	--	--	--	1.72	0.17	2.82	0.19
SO_2	7446-09-5	7.9E-04	2.0E-04	2.8E-03	3.5E-05	--	--	--	--	4.8E-03	4.8E-04	8.3E-03	7.1E-04
CO	630-08-0	0.11	0.028	1.58	0.020	8.8E-04	2.2E-04	--	--	100.0	10.00	102	10.0

References:

(1) Assumes all PM_{10} emissions from diesel combustion equals diesel particulate matter (DPM).

(2) NO_2 emissions are shown as NO_X emissions.

Appendix L

Emissions Estimates – Existing Richmond Field Station Sources – LRDP

Table L-1
Existing Richmond Field Station LRDP Source Operation Input Assumptions for Emission Rate Calculations

Source	*Diesel Emergency Engines*		*Natural Gas Boilers*		
	Engine Size [1] (BHP)	**Fuel Usage (gal/hr)**	**Maximum Heat Input [1] (MMBtu/hr)**	**Daily Operation (hrs/day)**	**Annual Fuel Usage [2] (MMBtu/yr)**
Building 112 [3]	87.5	4.4 [a]	1.75	24	875
Building 194 [3]	87.5	4.4 [a]	--	--	--
Building 275 [3]	--	--	0.3	24	150
Building 400a (PH1 - BR1)	--	--	1.35	24	675
Building 400b (PH2 - BR17)	--	--	1.46	24	730
Building 400c (PH2 - BR18)	--	--	1.46	24	730
Building 400d (PH2 - B/3-3)	--	--	1.5	24	750
Building 451 [3]	--	--	0.65	24	325
Building 452 [3]	--	--	0.399	24	199
Building 454 [3]	--	--	0.45	24	225
Building 472 [3]	--	--	0.375	24	187
Building 477 [3]	--	--	0.6	24	300
Building 478a [3]	--	--	0.502	24	251
Building 478b [3]	--	--	0.502	24	251
Building 478c [3]	--	--	1.966	24	983
Building 480 [3]	--	--	0.45	24	225
Building 484 [3]	--	--	1.008	24	504
Building 400 (emergency engine)	87.5	4.4 [a]	--	--	--
Building 400f (fire pump engine)	87.5	4.4 [a]	--	--	--
Total	350	17.8	14.722	--	7,360 [1]

Facility Data			
Source	**Source Parameter**	**Short Term Input (units)**	**Annual Input (units)**
	Facility Operation (Laboratory)	10 (hrs/day) [5]	260 (days/yr) [6]
	Emergency Engine Usage	2 (hrs/day) [7]	25.15 (hrs/yr) [7]
	Gasoline Tank Throughput	0.022 (Mgal/day)	8 (Mgal/yr)
	Diesel Tank Throughput	0.007 (Mgal/day)	2.4 (Mgal/yr)
	Offroad Vehicle Usage	10 (hrs/day)	400 (hrs/yr)

Notes:

(a) Engine fuel consumption (gal/hr) = (Engine size [hp]) x (average brake-specific fuel consumption [Btu/hp-hr]) / (liquid fuel higher heating value [Btu/gal])

Average brake-specific fuel consumption (Btu/hp-hr) = 7,000 (1)

Liquid fuel higher heating value (Btu/gal) = 138,000 (4)

References:

(1) Provided by the University.
(2) Total annual RFS natural gas usage apportioned to individual buildings based on the maximum hourly heat input.
(3) Buildings only included to properly apportion annual natural gas usage to individual buildings. Buildings assumed to be removed during Phase 1.
(4) ULSD higher heating value.
(5) Conservatively assumes laboratory work and offroad equipment usage is conducted over 10 hours per day.
(6) Assumes employee-based operations will generally be active 5 days per week, 52 weeks per year.
(7) Hourly value conservatively assumes a maximum of 2 hours per day of operation for maintenance and testing. Annual value is based on the average historical emergency engine usage from the LBNL LRDP.

Table L-2
Summary of Existing Onsite Off-Road Exhaust Criteria Pollutant Emission Estimates

Pollutant	Vehicle Type	Quantity	Horsepower [1]	Load Factor [2]	Daily hours of operation [3]	Annual hours of operation [3]	Emission Factor [4] (g/hp-hr)	Maximum Daily Emissions Estimate [a] (lbs/day)	Annual Average Emissions Estimate [b] (tons/yr)
ROG	Aerial Lifts	1.0	48	0.31	10	400	1.5	0.50	9.9E-03
	Tractors/Loaders/Backhoes	2.0	39	0.37	10	400	1.5	0.94	1.9E-02
	Sweepers/Scrubbers	1.0	37	0.46	10	400	1.6	0.61	1.2E-02
	Lawnmowers	3.0	28	1.0	10	400	8.4	15	0.30
	Total ROG Emissions							**17**	**0.34**
NO_X	Aerial Lifts	1.0	48	0.31	10	400	5.1	1.7	3.3E-02
	Tractors/Loaders/Backhoes	2.0	39	0.37	10	400	5.2	3.3	6.6E-02
	Sweepers/Scrubbers	1.0	37	0.46	10	400	5.3	2.0	4.0E-02
	Lawnmowers	3.0	28	1.0	10	400	5.7	10	0.21
	Total NO_X Emissions							**17**	**0.34**
CO	Aerial Lifts	1.0	48	0.31	10	400	4.9	1.6	3.2E-02
	Tractors/Loaders/Backhoes	2.0	39	0.37	10	400	5.8	3.7	7.4E-02
	Sweepers/Scrubbers	1.0	37	0.46	10	400	5.9	2.2	4.4E-02
	Lawnmowers	3.0	28	1.0	10	400	545	992	20
	Total CO Emissions							**1,000**	**20**
SO_2	Aerial Lifts	1.0	48	0.31	10	400	7.0E-03	2.3E-03	4.6E-05
	Tractors/Loaders/Backhoes	2.0	39	0.37	10	400	7.0E-03	4.5E-03	8.9E-05
	Sweepers/Scrubbers	1.0	37	0.46	10	400	7.0E-03	2.6E-03	5.3E-05
	Lawnmowers	3.0	28	1.0	10	400	2.1E-02	3.8E-02	7.6E-04
	Total SO_2 Emissions							**4.8E-02**	**9.5E-04**
PM_{10}	Aerial Lifts	1.0	48	0.31	10	400	0.40	0.13	2.7E-03
	Tractors/Loaders/Backhoes	2.0	39	0.37	10	400	0.40	0.25	5.0E-03
	Sweepers/Scrubbers	1.0	37	0.46	10	400	0.43	0.16	3.2E-03
	Lawnmowers	3.0	28	1.0	10	400	0.37	0.67	1.3E-02
	Total PM_{10} Emissions							**1.2**	**2.4E-02**
$PM_{2.5}$	Aerial Lifts	1.0	48	0.31	10	400	0.40	0.13	2.7E-03
	Tractors/Loaders/Backhoes	2.0	39	0.37	10	400	0.40	0.25	5.0E-03
	Sweepers/Scrubbers	1.0	37	0.46	10	400	0.43	0.16	3.2E-03
	Lawnmowers	3.0	28	1.0	10	400	0.37	0.67	1.3E-02
	Total $PM_{2.5}$ Emissions							**1.2**	**2.4E-02**
CO_2	Aerial Lifts	1.0	48	0.31	10	400	568	186	3.7
	Tractors/Loaders/Backhoes	2.0	39	0.37	10	400	568	362	7.2
	Sweepers/Scrubbers	1.0	37	0.46	10	400	568	213	4.3
	Lawnmowers	3.0	28	1.0	10	400	859	1,562	31
	Total CO_2 Emissions							**2,323**	**46**
CH_4	Aerial Lifts	1.0	48	0.31	10	400	0.14	4.5E-02	8.9E-04
	Tractors/Loaders/Backhoes	2.0	39	0.37	10	400	0.13	8.5E-02	1.7E-03
	Sweepers/Scrubbers	1.0	37	0.46	10	400	0.15	5.4E-02	1.1E-03
	Lawnmowers	3.0	28	1.0	10	400	0.47	0.85	1.7E-02
	Total CH_4 Emissions							**1.0**	**2.1E-02**

Notes:
(a) Maximum daily emissions estimate (lbs/day) = (Equipment horsepower [hp]) x (load factor) x (daily hours of operation [hrs/day]) x (emission factor [g/hp-hr]) x (lb/453.59 g)
(b) Annual average emissions estimate (tons/yr) = (Equipment horsepower [hp]) x (load factor) x (annual hours of operation [hrs/yr]) x (emission factor [g/hp-hr]) x (lb/453.59 g) x (ton/2,000 lbs)

References:
(1) Provided by LBNL. Assumes 2 tractor/loader/backhoes at 28 hp and 50 hp (average 39 hp), 1 aerial lift, 1 sweeper/scrubber, and 3 lawnmowers between 26 hp and 29 hp (average 27.5 hp).
(2) Load factors taken from Table D-7: Original OFFROAD and New Load Factors (LF) by Equipment Type.
(3) See Table L-1, Existing Richmond Field Station LRDP Source Operation Input Assumptions for Emission Rate Calculations.
(4) Emission factors from CalEEMod Appendix D tables for the year 2014.

Table L-3
Natural Gas Boiler Criteria Emission Estimates

Pollutant					PM		PM_{10}		$PM_{2.5}$		NO_X		CO		SO_2		VOC		CO_2		CH_4		N_2O		CO_2e	
Emission Factor (lbs/MMscf)					7.60 (1)		7.60 (2)		7.60 (2)		18.72 (a)		84 (4)		0.6 (1)		5.5 (1)		120,162 (b)		2.27 (c)		0.23 (c)		120,280 (d)	
Source	Modeling ID	Maximum Hourly Fuel Usage (8) (MMBtu/hr)	Daily Operation (8) (hrs/day)	Annual Fuel Usage (8) (MMBtu/yr)	Emission Estimates																					
					Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)
Natural Gas Boiler - Building 400a	NGB_400a	1.35	24	675	0.24	2.5E-03	0.24	2.5E-03	0.24	2.5E-03	0.59	6.2E-03	2.67	0.028	0.019	2.0E-04	0.17	1.8E-03	3,817	39.8	0.072	7.5E-04	7.2E-03	7.5E-05	3,821	39.8
Natural Gas Boiler - Building 400b	NGB_400b	1.46	24	730	0.26	2.7E-03	0.26	2.7E-03	0.26	2.7E-03	0.64	6.7E-03	2.89	0.030	0.021	2.1E-04	0.19	2.0E-03	4,128	43.0	0.078	8.1E-04	7.8E-03	8.1E-05	4,132	43.0
Natural Gas Boiler - Building 400c	NGB_400c	1.46	24	730	0.26	2.7E-03	0.26	2.7E-03	0.26	2.7E-03	0.64	6.7E-03	2.89	0.030	0.021	2.1E-04	0.19	2.0E-03	4,128	43.0	0.078	8.1E-04	7.8E-03	8.1E-05	4,132	43.0
Natural Gas Boiler - Building 400d	NGB_400d	1.5	24	750	0.27	2.8E-03	0.27	2.8E-03	0.27	2.8E-03	0.66	6.9E-03	2.96	0.031	0.021	2.2E-04	0.19	2.0E-03	4,241	44.2	0.080	8.3E-04	8.0E-03	8.3E-05	4,245	44.2
Total					**1.03**	**0.011**	**1.03**	**0.011**	**1.03**	**0.011**	**2.54**	**0.026**	**11.4**	**0.12**	**0.081**	**8.5E-04**	**0.75**	**7.8E-03**	**16,314**	**170**	**0.31**	**3.2E-03**	**0.031**	**3.2E-04**	**16,330**	**170**

Notes:

(a) Emission factor (lbs/MMscf) = (NO_2 or CO emission limit [ppmv @ 3% O_2]) x (10^{-6}) x (NO_2 or CO molecular weight [lbs/lb-mol]) x (lb-mol/385.44 ft^3) x (natural gas f-factor [8,710 dscf/MMBtu]) x (20.9% O_2/[20.9% O_2 - 3% O_2]) x (heat content [Btu/scf])

BAAQMD NO_X emission limit (ppmv @ 3% O_2) =	15	(3)
BAAQMD CO emission limit (ppmv @ 3% O_2) =	400	(3)
NO_2 molecular weight (lbs/lb-mol) =	46	
CO molecular weight (lbs/lb-mol) =	28.01	
Natural gas heat content (Btu/scf) =	1,028	(5)

(b) CO_2 emission factor (lbs/MMscf) = (CO_2 emission factor [kg CO_2/MMBtu]) x (default high heat value (MMBtu/scf)) x (10^6 scf/MMscf) x (lb/0.453592 kg)

CO_2 emission factor (kg/MMBtu) =	53.02	(5)
Default high heat value (MMBtu/scf) =	1.028E-03	(5)

(c) CH_4 or N_2O emission factor (lbs/MMscf) = (CH_4 or N_2O emission factor [kg/MMBtu]) x (lb/0.453592 kg) x (natural gas heat content [Btu/scf])

CH_4 emission factor (kg/MMBtu) =	1.0E-03	(6)
N_2O emission factor (kg/MMBtu) =	1.0E-04	(6)
Natural gas heat content (Btu/scf) =	1,028	(5)

(d) CO_2e emission factor (lbs/MMscf) = (CO_2 emission factor [lbs/MMscf]) + (CH_4 emission factor [lbs/MMscf] x CH_4 global warming potential)
+ (N_2O emission factor [lbs/MMscf] x N_2O global warming potential)

Global warming potential of CH_4 =	21	(7)
Global warming potential of N_2O =	310	(7)

(e) Daily emissions estimate (lbs/day) = (Emission factor [lbs/MMscf]) x (maximum hourly heat input [MMBtu/hr]) x (daily hours of operation [hrs/day]) / (natural gas heat content [Btu/scf])

Natural gas heat content (Btu/scf) =	1,020	(5)

(f) Annual emissions estimate (tons/yr) = (emission factor [lbs/MMscf]) x (annual heat input [MMBtu/yr]) / (natural gas heat content [Btu/scf]) x (tons/2,000 lbs)

Natural gas heat content (Btu/scf) =	1,020	(5)

References:

(1) AP-42 Chapter 1.4 (July 1998), Table 1.4-2 "Emission Factors for Criteria Pollutants and Greenhouse Gases from Natural Gas Combustion".
(2) Assumes that 100% of PM is $PM_{2.5}$. Therefore, 100% of PM_{10} is $PM_{2.5}$.
(3) BAAQMD Emission Limits 307.2, 307.3, and 307.4 from Section 9-7-307..
(4) AP-42 Chapter 1.4 (July 1998), Table 1.4-1 "Emission Factors for NO_X and CO from Natural Gas Combustion".
(5) 40 CFR Part 98 Subpart C, Table C-1, Default CO_2 Emission Factors and High Heat Values for Various Types of Fuel.
(6) 40 CFR Part 98 Subpart C, Table C-2, Default CH_4 and N_2O Emission Factors for Various Types of Fuel.
(7) 40 CFR Part 98 Subpart A, Table A-1, Global Warming Potentials.
(8) See Table L-1, Existing Richmond Field Station LRDP Source Operation Input Assumptions for Emission Rate Calculations.

Table L-4
Emergency Diesel Generator Criteria Emission Estimates

Pollutant				Min HP	Max HP	PM		PM_{10}		$PM_{2.5}$		NO_X		CO		SO_2		VOC		CO_2		CH_4		CO_2e	
Emission Factor - Tier 4 Interim (g/hp-hr) (1)				75	99	0.015 (1)		0.015 (1)		0.015 (1)		2.5 (2)		3.7 (2)		-- (3)		0.14 (2)		-- (4)		--		--	
Source	Modeling ID	Generator Power Rating (5) (BHP)	Diesel Fuel Usage (5) (gal/hr)	Load Factor (6)	Annual Operation (5) (hrs/yr)	Emission Estimates																			
						Maximum Daily (a) (lbs/day)	Annual Average (b) (tons/yr)	Maximum Daily (a) (lbs/day)	Annual Average (b) (tons/yr)	Maximum Daily (a) (lbs/day)	Annual Average (b) (tons/yr)	Maximum Daily (a) (lbs/day)	Annual Average (b) (tons/yr)	Maximum Daily (a) (lbs/day)	Annual Average (b) (tons/yr)	Maximum Daily (c) (lbs/day)	Annual Average (b) (tons/yr)	Maximum Daily (a) (lbs/day)	Annual Average (b) (tons/yr)	Maximum Daily (d) (lbs/day)	Annual Average (b) (tons/yr)	Maximum Daily (9) (lbs/day)	Annual Average (b) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (b) (tons/yr)
Existing standby generator - NRLF	DG_NRLF2	88	4.4	0.74	25.15	4.3E-03	2.7E-05	4.3E-03	2.7E-05	4.3E-03	2.7E-05	0.71	4.5E-03	1.06	6.6E-03	1.9E-03	1.2E-05	0.040	2.5E-04	198	1.25	3.6E-03	2.3E-05	198	1.25
Existing Fire Pump NRLF	FP_NRLF2	88	4.4	0.74	25.15	4.3E-03	2.7E-05	4.3E-03	2.7E-05	4.3E-03	2.7E-05	0.71	4.5E-03	1.06	6.6E-03	1.9E-03	1.2E-05	0.040	2.5E-04	198	1.25	3.6E-03	2.3E-05	198	1.25
Total						**8.6E-03**	**5.4E-05**	**8.6E-03**	**5.4E-05**	**8.6E-03**	**5.4E-05**	**1.43**	**9.0E-03**	**2.11**	**0.013**	**3.7E-03**	**2.3E-05**	**0.080**	**5.0E-04**	**396**	**2.49**	**7.2E-03**	**4.5E-05**	**396**	**2.49**

Notes:

(a) Maximum daily emission estimate (lbs/day) = (Emission factor [g/hp-hr]) x (generator power [hp]) x (load factor) x (maximum hours per day [hrs/day]) x (lb/453.59g)
Daily hours of operation (hrs/day) = 2 (5)

(b) Annual average emission estimate (tons/yr) = (Daily emissions [lbs/day]) / (daily hours of operation [hrs/day]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)
Daily hours of operation (hrs/day) = 2 (5)

(c) Maximum daily emissions estimate (lbs/day) = (Fuel sulfur content [ppmw] / 1,000,000) x (generator fuel consumption [gal/hr]) x (daily hours of operation [hrs/day]) x (diesel density [lbs/gal]) x ([SO_2 molecular weight {lbs/lb-mol}] / [sulfur molecular weight {lbs/lb-mol}])
Fuel sulfur content (ppmw) = 15 (7)
Daily hours of operation (hrs/day) = 2 (5)
Diesel density (lbs/gal) = 7
SO_2 molecular weight (lbs/lb-mol) = 64
Sulfur molecular weight (lbs/lb-mol) = 32

(d) Maximum daily emissions estimate (lbs/day) = (Fuel carbon content [%] / 100) x (generator fuel consumption [gal/hr]) x (daily hours of operation [hrs/day]) x (diesel density [lbs/gal]) x ([CO_2 molecular weight {lbs/lb-mol}] / [carbon molecular weight {lbs/lb-mol}])
Fuel carbon content (%) = 87 (8)
Daily hours of operation (hrs/day) = 2 (5)
Diesel density (lbs/gal) = 7
CO_2 molecular weight (lbs/lb-mol) = 44.0
Carbon molecular weight (lbs/lb-mol) = 12.0

(e) CO_2e emissions (lbs/day) = (CO_2 emissions [lbs/day]) + (CH_4 emissions [lbs/day] x CH_4 global warming potential) + (N_2O emissions [lbs/day] x N_2O global warming potential)
CH_4 Global Warming Potential (GWP) = 21 (10)
N_2O Global Warming Potential (GWP) = 310 (10)

References:

(1) Interim Tier IV emission factors are assumed.
(2) CalEEMod Appendix D, Default Data Tables. Table 3.5, OFFROAD Emission Factor Based on Engine Tier. Assumes Tier 4 Final for LBNL-owned small engines (Buildings 9 and 8), and Tier 4 Interim for the Building 6&7 engine.
(3) Sulfur dioxide emissions calculated on a sulfur mass balance basis, assuming 100% of the fuel sulfur content is emitted as SO_2.
(4) Carbon dioxide emissions calculated on a carbon mass balance basis, conservatively assuming 100% of the fuel carbon content is emitted as CO_2.
(5) See Table L-1, Existing Richmond Field Station LRDP Source Operation Input Assumptions for Emission Rate Calculations.
(6) Default load factor for generators in URBEMIS emissions model.
(7) California Code of Regulations Title 13, Division 3, Chapter 5, Article 2, Standards for Diesel Fuel.
(8) AP-42 Chapter 3.3 (October 1996) and 3.4 (October 1996), Footnote to criteria emission factor table.
(9) Assumes methane is 9% of VOC, based on footnote f of Table 3.4-1 in AP-42, Chapter 3.4. VOC emission factor is shown as ROG/TOG in CalEEMod Appendix D ,Table 3.5.
(10) 40 CFR Part 98 Subpart A, Table A-1, Global Warming Potentials.

Table L-5

Gasoline Fueling Emission Estimates

Source		Gasoline Fueling	Diesel Fueling
Annual Gasoline Throughput (Mgal/yr)	(1)	8.0	2.4
Daily Gasoline Throughput (Mgal/day)	(1)	0.022	0.007
Tank height (ft)	(2)	4.0	20.0
Tank equivalent diameter (ft)	(a)	5.7	10.0
Small tank standing loss factor a	(4)	1.379	1.379
Small tank standing loss factor b	(4)	0.152	0.152
Small tank working loss factor f	(4)	9.099	9.099

VOC Source		Emission Factor (lbs/Mgal)	Maximum Daily Emissions Estimate [(b)] (lbs/day)	Annual Average Emissions Estimate [(c)] (tons/yr)	Emission Factor (lbs/Mgal)	Maximum Daily Emissions Estimate [(a)] (lbs/day)	Annual Average Emissions Estimate [(b)] (tons/yr)
Storage Tank Loss VOC [(a)]	(b)	23.10	0.51	0.092	293.55	2.0E-03	3.7E-04
Vehicle Refueling Displacement	(4)	1.1	0.024	4.4E-03	1.1	9.6E-05	1.8E-05
Vehicle Refueling Spillage	(4)	0.7	0.015	2.8E-03	0.7	6.1E-05	1.1E-05
Total VOC		24.9	0.55	0.100	295.3	2.2E-03	4.0E-04

Notes:

(a) Equivalent diameter = 2 x Side 1 of rectangular tank (L_1, ft) x Side 2 of rectangular tank (L_2, ft) / (Side 1 of rectangular tank [L_1, ft]+ Side 2 of rectangular tank [L_2, ft]) (3)

Side 1 of rectangular tank L_1 (ft) = 4 (2)

Side 2 of rectangular tank L_2 (ft) = 10 (2)

(b) VOC Emission Factor (lbs/Mgal) =(a x [tank height {ft} x tank diameter {ft}^{2} / annual gasoline throughput {Mgal/yr}] / [1 + {b x tank height {ft}]) + f (4)

(c) Daily emissions estimate (lbs/day) =(Emission factor [lbs/trip]) x (number of vehicle trips per day)

(d) Annual emissions estimate (lbs/day) =(Emission factor [lbs/trip]) x (number of vehicle trips per year) x (ton/2,000 lbs)

References:

(1) See Table L-1, Existing Richmond Field Station LRDP Source Operation Input Assumptions for Emission Rate Calculations.

(2) Provided by the University.

(3) Taken from http://www.aqmd.gov/aer/Updates/SuppInstruforLiqdOrgStgeTanks.pdf. Loss factors are for Gasoline RVP 10.

(4) Taken from http://www.aqmd.gov/aer/Updates/GuideExManuallyRptTankEmis.pdf.

Table L-6
Existing Richmond Field Station LRDP Source Operations Criteria Pollutant Emissions Summary - Annual Average Daily Emission Rates (1)

Source	Annual Operation (days/yr)	TAC		Criteria												Greenhouse Gases							
		DPM		PM_{10}		$PM_{2.5}$		NO_X		CO		SO_2		VOC		CO_2		CH_4		N_2O		CO_2e	
		(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)
Stationary Sources																							
Diesel generators	260	4.1E-04	5.4E-05	4.1E-04	5.4E-05	4.1E-04	5.4E-05	6.9E-02	9.0E-03	0.10	1.3E-02	1.8E-04	2.3E-05	3.9E-03	5.0E-04	19.2	2.49	3.5E-04	4.5E-05	0	0	19.2	2.49
Natural Gas Boilers	260	--	--	8.3E-02	1.1E-02	8.3E-02	1.1E-02	0.20	2.6E-02	0.91	0.12	6.5E-03	8.5E-04	6.0E-02	7.8E-03	1,307	170	2.5E-02	3.2E-03	2.5E-03	3.2E-04	1,308	170
Gasoline filling	260	--	--	--	--	--	--	--	--	--	--	--	--	0.77	0.10	--	--	--	--	--	--	--	--
Total Onsite Stationary Source Emissions	**--**	**4.1E-04**	**5.4E-05**	**8.3E-02**	**1.1E-02**	**8.3E-02**	**1.1E-02**	**0.27**	**3.5E-02**	**1.02**	**0.13**	**6.7E-03**	**8.7E-04**	**0.83**	**0.11**	**1,326**	**172**	**2.5E-02**	**3.2E-03**	**2.5E-03**	**3.2E-04**	**1,327**	**173**
Onsite Offroad Vehicle Emission Sources																							
Aerial Lifts	260	2.0E-02	2.7E-03	2.0E-02	2.7E-03	2.0E-02	2.7E-03	0.26	3.3E-02	0.25	3.2E-02	3.5E-04	4.6E-05	7.6E-02	9.9E-03	28.7	3.73	--	--	--	--	28.7	3.73
Tractors/Loaders/Backhoes	260	3.9E-02	5.0E-03	3.9E-02	5.0E-03	3.9E-02	5.0E-03	0.51	6.6E-02	0.57	7.4E-02	6.9E-04	8.9E-05	0.15	1.9E-02	55.6	7.23	--	--	--	--	55.6	7.23
Sweepers/Scrubbers	260	2.5E-02	3.2E-03	2.5E-02	3.2E-03	2.5E-02	3.2E-03	0.30	4.0E-02	0.34	4.4E-02	4.0E-04	5.3E-05	9.3E-02	1.2E-02	32.8	4.26	--	--	--	--	32.8	4.26
Lawnmowers	260	0.10	1.3E-02	0.10	1.3E-02	0.10	1.3E-02	1.58	0.21	153	19.8	5.9E-03	7.6E-04	2.34	0.30	240	31.2	--	--	--	--	240	31.2
Onsite Offroad Equipment	**--**	**0.19**	**2.4E-02**	**0.19**	**2.4E-02**	**0.19**	**2.4E-02**	**2.65**	**0.34**	**154**	**20.0**	**7.3E-03**	**9.5E-04**	**2.65**	**0.34**	**357**	**46.5**	**0**	**0**	**0**	**0**	**357**	**46.5**
Total Phase 1 Project Summary	**--**	**0.19**	**2.4E-02**	**0.27**	**3.5E-02**	**0.27**	**3.5E-02**	**2.92**	**0.38**	**155**	**20.1**	**1.4E-02**	**1.8E-03**	**3.49**	**0.45**	**1,684**	**219**	**2.5E-02**	**3.2E-03**	**2.5E-03**	**3.2E-04**	**1,685**	**219**
Onsite Stationary Exhaust	**--**	**4.1E-04**	**5.4E-05**	**8.3E-02**	**1.1E-02**	**8.3E-02**	**1.1E-02**	**0.27**	**3.5E-02**	**1.02**	**0.13**	**6.7E-03**	**8.7E-04**	**0.83**	**0.11**	**1,326**	**172**	**2.5E-02**	**3.2E-03**	**2.5E-03**	**3.2E-04**	**1,327**	**173**
Onsite Offroad Exhaust	**--**	**0.19**	**2.4E-02**	**0.19**	**2.4E-02**	**0.19**	**2.4E-02**	**2.65**	**0.34**	**154**	**20.0**	**7.3E-03**	**9.5E-04**	**2.65**	**0.34**	**357**	**46.5**	**0**	**0**	**0**	**0**	**357**	**46.5**

References:

(1) Daily emission rates are annual average daily emission rates, which are calculated by dividing the annual emission rate by the annual days of operation, and converting form tons to pounds. Annual days of operation is set to 5 days per week, 52 weeks per year.

Table L-7
Onsite Employee Vehicle TAC Emission Estimates

Parameter		Value	Total
Gasoline Refueling VOC Emission Factor (lbs/Mgal)	(2)	24.9	
Annual Gasoline Throughput (Mgal/yr)	(3)	8.0	
Daily Gasoline Throughput (Mgal/day)	(3)	0.022	

TAC	CAS	TAC Percent of Gasoline VOC (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	Maximum Daily Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)
Benzene	71-43-2	1.80	9.8E-04	1.8E-03	9.8E-04	1.8E-03
Ethylbenzene	100-41-4	1.40	7.6E-04	1.4E-03	7.6E-04	1.4E-03
n-Hexane	110-54-3	1.00	5.5E-04	1.0E-03	5.5E-04	1.0E-03
Toluene	108-88-3	7.00	3.8E-03	7.0E-03	3.8E-03	7.0E-03
m-Xylene	108-38-3	7.00	3.8E-03	7.0E-03	3.8E-03	7.0E-03

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (TAC percent of gasoline VOC [%] / 100) x (gasoline refueling VOC emission factor [lbs/Mgal]) x (daily gasoline throughput [Mgal/day]) / (daily hours of operation [hrs/day])

Daily hours of operation (hrs/day) = 10 (3)

(b) Annual emissions estimate (tons/yr) = (TAC percent of gasoline VOC [%] / 100) x (gasoline refueling VOC emission factor [lbs/Mgal]) x (annual gasoline throughput [Mgal/day])

References:

(1) California Air Resources Board Speciation Database. TAC emission fractions are derived from the individual speciation profiles listed. Profiles chosen to best represent the project vehicle fleet and existing gasoline formulation.

(2) Emission Factors source: EMFAC 2011 (Model Years to 2034). Onsite speed set to 15 mile per hour to conservatively estimate onsite emissions. No tire and brake wear emission factors are provided at 15 miles per hour.

(3) See Table L-1, Existing Richmond Field Station LRDP Source Operation Input Assumptions for Emission Rate Calculations.

Table L-8
Natural Gas Boiler TAC Emission Estimates

Source	Natural Gas Boiler - Building 400a	Natural Gas Boiler - Building 400b	Natural Gas Boiler - Building 400c	Natural Gas Boiler - Building 400d	Total
Maximum Hourly Fuel Usage (MMBtu/hr) (1)	1.35	1.46	1.46	1.5	
Daily Hours of Operation (hrs/day) (1)	24	24	24	24	
Annual Fuel Usage (MMBtu/yr) (1)	675	730	730	750	
Modeling ID	NGB_400a	NGB_400b	NGB_400c	NGB_400d	

TAC	CAS	Emission Factor (lbs/MMscf)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)
7,12-Dimethylbenz(a)anthracene	57-97-6	1.6E-05 (2)	2.1E-08	5.3E-09	2.3E-08	5.7E-09	2.3E-08	5.7E-09	2.4E-08	5.9E-09	9.1E-08	2.3E-08
Acetaldehyde	75-07-0	8.9E-03 (3)	1.2E-05	2.9E-06	1.3E-05	3.2E-06	1.3E-05	3.2E-06	1.3E-05	3.3E-06	5.0E-05	1.3E-05
Benzene	71-43-2	4.3E-03 (3)	5.7E-06	1.4E-06	6.2E-06	1.5E-06	6.2E-06	1.5E-06	6.3E-06	1.6E-06	2.4E-05	6.1E-06
Dichlorobenzene	25321-22-6	1.2E-03 (4)	1.6E-06	4.0E-07	1.7E-06	4.3E-07	1.7E-06	4.3E-07	1.8E-06	4.4E-07	6.8E-06	1.7E-06
Ethylbenzene	100-41-4	6.9E-03 (5)	9.1E-06	2.3E-06	9.9E-06	2.5E-06	9.9E-06	2.5E-06	1.0E-05	2.5E-06	3.9E-05	9.8E-06
Fluoranthene	206-44-0	3.0E-06 (2)	4.0E-09	9.9E-10	4.3E-09	1.1E-09	4.3E-09	1.1E-09	4.4E-09	1.1E-09	1.7E-08	4.2E-09
Formaldehyde	50-00-0	2.2E-01 (3)	2.9E-04	7.3E-05	3.2E-04	7.9E-05	3.2E-04	7.9E-05	3.3E-04	8.1E-05	1.3E-03	3.1E-04
n-Hexane	110-54-3	4.6E-03 (5)	6.1E-06	1.5E-06	6.6E-06	1.6E-06	6.6E-06	1.6E-06	6.8E-06	1.7E-06	2.6E-05	6.5E-06
Naphthalene	91-20-3	3.0E-04 (5)	4.0E-07	9.9E-08	4.3E-07	1.1E-07	4.3E-07	1.1E-07	4.4E-07	1.1E-07	1.7E-06	4.2E-07
Propylene	115-07-1	5.3E-01 (5)	7.0E-04	1.8E-04	7.6E-04	1.9E-04	7.6E-04	1.9E-04	7.8E-04	1.9E-04	3.0E-03	7.5E-04
Toluene	108-88-3	2.7E-02 (5)	3.5E-05	8.8E-06	3.8E-05	9.5E-06	3.8E-05	9.5E-06	3.9E-05	9.7E-06	1.5E-04	3.7E-05
Xylenes	1330-20-7	2.0E-02 (5)	2.6E-05	6.5E-06	2.8E-05	7.0E-06	2.8E-05	7.0E-06	2.9E-05	7.2E-06	1.1E-04	2.8E-05
Arsenic	7440-38-2	2.0E-04 (4)	2.6E-07	6.6E-08	2.9E-07	7.2E-08	2.9E-07	7.2E-08	2.9E-07	7.4E-08	1.1E-06	2.8E-07
Beryllium	7440-41-7	1.2E-05 (4)	1.6E-08	4.0E-09	1.7E-08	4.3E-09	1.7E-08	4.3E-09	1.8E-08	4.4E-09	6.8E-08	1.7E-08
Cadmium	7440-43-9	1.1E-03 (4)	1.5E-06	3.6E-07	1.6E-06	3.9E-07	1.6E-06	3.9E-07	1.6E-06	4.0E-07	6.2E-06	1.6E-06
Chromium VI	18540-29-9	2.4E-04 (6)	3.2E-07	7.9E-08	3.4E-07	8.5E-08	3.4E-07	8.5E-08	3.5E-07	8.7E-08	1.3E-06	3.4E-07
Cobalt	7440-48-4	8.4E-05 (4)	1.1E-07	2.8E-08	1.2E-07	3.0E-08	1.2E-07	3.0E-08	1.2E-07	3.1E-08	4.8E-07	1.2E-07
Copper	7440-50-8	8.5E-04 (4)	1.1E-06	2.8E-07	1.2E-06	3.0E-07	1.2E-06	3.0E-07	1.3E-06	3.1E-07	4.8E-06	1.2E-06
Lead	7439-92-1	5.0E-04 (4)	6.6E-07	1.7E-07	7.2E-07	1.8E-07	7.2E-07	1.8E-07	7.4E-07	1.8E-07	2.8E-06	7.1E-07
Manganese	7439-96-5	3.8E-04 (4)	5.0E-07	1.3E-07	5.4E-07	1.4E-07	5.4E-07	1.4E-07	5.6E-07	1.4E-07	2.1E-06	5.4E-07
Mercury	7439-97-6	2.6E-04 (4)	3.4E-07	8.6E-08	3.7E-07	9.3E-08	3.7E-07	9.3E-08	3.8E-07	9.6E-08	1.5E-06	3.7E-07
Nickel	7440-02-0	2.1E-03 (4)	2.8E-06	6.9E-07	3.0E-06	7.5E-07	3.0E-06	7.5E-07	3.1E-06	7.7E-07	1.2E-05	3.0E-06
Selenium	7782-49-2	2.4E-05 (4)	3.2E-08	7.9E-09	3.4E-08	8.6E-09	3.4E-08	8.6E-09	3.5E-08	8.8E-09	1.4E-07	3.4E-08

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/MMscf]) x (maximum hourly heat input [MMBtu/hr])/ (natural gas heat content [Btu/scf])
Natural gas heat content (Btu/scf) = 1,020 (2)

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/MMscf]) x (annual heat input [MMBtu/yr]) / (natural gas heat content [Btu/scf]) x (tons/2,000 lbs)
Natural gas heat content (Btu/scf) = 1,020 (2)

References:

(1) See Table L-1, Existing Richmond Field Station LRDP Source Operation Input Assumptions for Emission Rate Calculations.
(2) AP-42 Chapter 1.4 (July 1998), Table 1.4-3 "Emission Factors For Speciated Organic Compounds from Natural Gas Combustion".
(3) California Air Toxics Emission Factor (CATEF) Database under Natural Gas Boilers.
(4) AP-42 Chapter 1.4 (July 1998), Table 1.4-4 "Emission Factors For Metals from Natural Gas Combustion".
(5) Ventura Air Quality Management District emission factor database.
(6) The AP-42 total chromium emission factor was multiplied by 17% to correct for emissions of hexavalent chromium per EPA assumptions when regulating combustion sources under 40 CFR Part 63 Subpart DDDD.

Table L-9
Emergency Diesel Generator TAC Emission Estimates

Source		Existing standby generator - NRLF	Existing Fire Pump - NRLF	Total
BHP	(1)	88	88	
Diesel Fuel Combustion (gal/hr)	(1)	4.4	4.4	
Load Factor	(2)	0.74	0.74	
Annual Operation (hrs/yr)	(1)	25.15	25.15	
Modeling ID		DG_NRLF2	FP_NRLF2	

TAC	CAS	Emission Factor (lbs/10^3 gal)	Maximum Hourly (lbs/hr)	Annual Average [(a)] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [(a)] (tons/yr)	Maximum Daily Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)
DPM	9901	-- (3)	2.1E-03 (b)	2.7E-05	2.1E-03 (b)	2.7E-05	4.3E-03	5.4E-05
1,3-Butadiene	106-99-0	2.17E-01 (4)	7.1E-04 (c)	9.0E-06	7.1E-04 (c)	9.0E-06	1.4E-03	1.8E-05
Acetaldehyde	75-07-0	3.47E-03 (5)	1.1E-05 (c)	1.4E-07	1.1E-05 (c)	1.4E-07	2.3E-05	2.9E-07
Benzene	71-43-2	1.93E-01 (5)	6.3E-04 (c)	8.0E-06	6.3E-04 (c)	8.0E-06	1.3E-03	1.6E-05
Benzo(a)anthracene	56-55-3	-- (6)	--	--	--	--	0	0
Benzo(b)fluoranthene	205-99-2	-- (6)	--	--	--	--	0	0
Benzo(k)fluoranthene	207-08-9	-- (6)	--	--	--	--	0	0
Chlorobenzene	108-90-7	2.00E-04 (4)	6.6E-07 (c)	8.3E-09	6.6E-07 (c)	8.3E-09	1.3E-06	1.7E-08
Chrysene	218-01-9	-- (6)	--	--	--	--	0	0
Dibenz(a,h)anthracene	53-70-3	-- (6)	--	--	--	--	0	0
Ethylbenzene	100-41-4	6.76E-03 (5)	2.2E-05 (c)	2.8E-07	2.2E-05 (c)	2.8E-07	4.4E-05	5.6E-07
Formaldehyde	50-00-0	5.06E-02 (5)	1.7E-04 (c)	2.1E-06	1.7E-04 (c)	2.1E-06	3.3E-04	4.2E-06
n-Hexane	110-54-3	1.39E-03 (5)	4.6E-06 (c)	5.7E-08	4.6E-06 (c)	5.7E-08	9.1E-06	1.1E-07
Hydrogen Chloride	7647-01-0	1.86E-01 (4)	6.1E-04 (c)	7.7E-06	6.1E-04 (c)	7.7E-06	1.2E-03	1.5E-05
Indeno(1,2,3-cd)pyrene	193-39-5	-- (6)	--	--	--	--	0	0
Naphthalene	91-20-3	1.60E-02 (5)	5.2E-05 (c)	6.6E-07	5.2E-05 (c)	6.6E-07	1.0E-04	1.3E-06
Propylene	115-07-1	3.41E-01 (5)	1.1E-03 (c)	1.4E-05	1.1E-03 (c)	1.4E-05	2.2E-03	2.8E-05
Toluene	108-88-3	6.12E-02 (5)	2.0E-04 (c)	2.5E-06	2.0E-04 (c)	2.5E-06	4.0E-04	5.1E-06
Xylenes	1330-20-7	4.24E-02 (4)	1.4E-04 (c)	1.8E-06	1.4E-04 (c)	1.8E-06	2.8E-04	3.5E-06
Arsenic	7440-38-2	1.60E-03 (4)	5.3E-06 (c)	6.6E-08	5.3E-06 (c)	6.6E-08	1.1E-05	1.3E-07
Cadmium	7440-43-9	1.50E-03 (4)	4.9E-06 (c)	6.2E-08	4.9E-06 (c)	6.2E-08	9.9E-06	1.2E-07
Chromium VI	18540-29-9	1.00E-04 (7)	3.3E-07 (c)	4.1E-09	3.3E-07 (c)	4.1E-09	6.6E-07	8.3E-09
Copper	7440-50-8	4.10E-03 (4)	1.3E-05 (c)	1.7E-07	1.3E-05 (c)	1.7E-07	2.7E-05	3.4E-07
Lead	7439-92-1	8.30E-03 (4)	2.7E-05 (c)	3.4E-07	2.7E-05 (c)	3.4E-07	5.5E-05	6.9E-07
Manganese	7439-96-5	3.10E-03 (4)	1.0E-05 (c)	1.3E-07	1.0E-05 (c)	1.3E-07	2.0E-05	2.6E-07
Mercury	7439-97-6	2.00E-03 (4)	6.6E-06 (c)	8.3E-08	6.6E-06 (c)	8.3E-08	1.3E-05	1.7E-07
Nickel	7440-02-0	3.90E-03 (4)	1.3E-05 (c)	1.6E-07	1.3E-05 (c)	1.6E-07	2.6E-05	3.2E-07
Selenium	7782-49-2	2.20E-03 (4)	7.2E-06 (c)	9.1E-08	7.2E-06 (c)	9.1E-08	1.4E-05	1.8E-07

Modeling ID		DG_NRLF2	FP_NRLF2
Diesel Particulate Emission factor (g/hp-hr)	(6)	0.015	0.015

Notes:

(a) Annual average emission estimate (tons/yr) = (Maximum hourly emissions estimate [lbs/hr]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)

(b) Maximum hourly diesel particulate emissions estimate (lbs/hr) = (Emission factor [g/hp-hr]) x (engine horsepower [hp]) x (load factor) / (453.59 [g/lb])

(c) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/10^3 gal]) x (load factor) x (fuel usage [gal/hr]) x (0.001 gal/10^3 gal)

References:

(1) See Table L-1, Existing Richmond Field Station LRDP Source Operation Input Assumptions for Emission Rate Calculations.

(2) Default load factor for generators in URBEMIS emission model.

(3) See diesel particulate matter emission factors at the bottom of the table.

(4) Ventura County Air Pollution Control District AB 2588 Combustion Emission Factors Database, May 2001.

(5) California Toxic Emission Factor (CATEF) Database, except for Diesel PM. The emission factors for each TAC are averaged for diesel internal combustion engines operating at less than 13% oxygen in the exhaust. Per vendor information, the percent oxygen in the exhaust is less than 13% at loads greater than 50%. It is assumed that the generator would be run at 50% load or greater.

(6) Polycyclic Aromatic Hydrocarbons (PAHs) are assumed to be included in the particulate matter emission factor. PAHs that are not specifically listed in this table, but may be included in the particulate matter emission factor, include Acenaphthylene, Anthracene, Acenaphthene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(g,h,i)perylene, Chrysene, Dibenz(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene. For purposes of this inventory, it is assumed that all particulate is represented as Diesel Particulate Matter (DPM).

(7) The AP-42 total chromium emission factor was multiplied by 17% to correct for emissions of hexavalent chromium per EPA assumptions when regulating combustion sources under 40 CFR Part 63 Subpart DDDD.

Table L-10
Existing Richmond Field Station LRDP Source Operations TAC Emissions Summary

TAC	CAS	Natural Gas Boilers		Diesel Generators		Vehicle Refueling Station		Offroad Vehicle Exhaust		Total	
		(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)
DPM (1)	9901	--	--	4.3E-03	5.4E-05	--	--	0.12	0.024	0.13	0.024
1,3-Butadiene	106-99-0	--	--	1.4E-03	1.8E-05	--	--	--	--	1.4E-03	1.8E-05
7,12-Dimethylbenz(a)anthracene	57-97-6	9.1E-08	2.3E-08	--	--	--	--	--	--	9.1E-08	2.3E-08
Acetaldehyde	75-07-0	5.0E-05	1.3E-05	2.3E-05	2.9E-07	--	--	--	--	7.3E-05	1.3E-05
Arsenic	7440-38-2	1.1E-06	2.8E-07	1.1E-05	1.3E-07	--	--	--	--	1.2E-05	4.1E-07
Benzene	71-43-2	2.4E-05	6.1E-06	1.3E-03	1.6E-05	9.8E-04	1.8E-03	--	--	2.3E-03	1.8E-03
Beryllium	7440-41-7	6.8E-08	1.7E-08	--	--	--	--	--	--	6.8E-08	1.7E-08
Cadmium	7440-43-9	6.2E-06	1.6E-06	9.9E-06	1.2E-07	--	--	--	--	1.6E-05	1.7E-06
Chlorobenzene	108-90-7	--	--	1.3E-06	1.7E-08	--	--	--	--	1.3E-06	1.7E-08
Chromium VI	18540-29-9	1.3E-06	3.4E-07	6.6E-07	8.3E-09	--	--	--	--	2.0E-06	3.4E-07
Cobalt	7440-48-4	4.8E-07	1.2E-07	--	--	--	--	--	--	4.8E-07	1.2E-07
Copper	7440-50-8	4.8E-06	1.2E-06	2.7E-05	3.4E-07	--	--	--	--	3.2E-05	1.5E-06
Dichlorobenzene	25321-22-6	6.8E-06	1.7E-06	--	--	--	--	--	--	6.8E-06	1.7E-06
Ethylbenzene	100-41-4	3.9E-05	9.8E-06	4.4E-05	5.6E-07	7.6E-04	1.4E-03	--	--	8.5E-04	1.4E-03
Fluoranthene	206-44-0	1.7E-08	4.2E-09	--	--	--	--	--	--	1.7E-08	4.2E-09
Formaldehyde	50-00-0	1.3E-03	3.1E-04	3.3E-04	4.2E-06	--	--	--	--	1.6E-03	3.2E-04
Hydrogen Chloride	7647-01-0	--	--	1.2E-03	1.5E-05	--	--	--	--	1.2E-03	1.5E-05
Lead	7439-92-1	2.8E-06	7.1E-07	5.5E-05	6.9E-07	--	--	--	--	5.7E-05	1.4E-06
Manganese	7439-96-5	2.1E-06	5.4E-07	2.0E-05	2.6E-07	--	--	--	--	2.3E-05	7.9E-07
Mercury	7439-97-6	1.5E-06	3.7E-07	1.3E-05	1.7E-07	--	--	--	--	1.5E-05	5.3E-07
Naphthalene	91-20-3	1.7E-06	4.2E-07	1.0E-04	1.3E-06	--	--	--	--	1.1E-04	1.7E-06
n-Hexane	110-54-3	2.6E-05	6.5E-06	9.1E-06	1.1E-07	5.5E-04	1.0E-03	--	--	5.8E-04	1.0E-03
Nickel	7440-02-0	1.2E-05	3.0E-06	2.6E-05	3.2E-07	--	--	--	--	3.7E-05	3.3E-06
Propylene	115-07-1	3.0E-03	7.5E-04	2.2E-03	2.8E-05	--	--	--	--	5.2E-03	7.8E-04
Selenium	7782-49-2	1.4E-07	3.4E-08	1.4E-05	1.8E-07	--	--	--	--	1.5E-05	2.2E-07
Toluene	108-88-3	1.5E-04	3.7E-05	4.0E-04	5.1E-06	3.8E-03	7.0E-03	--	--	4.4E-03	7.0E-03
m-Xylene	108-38-3	--	--	--	--	3.8E-03	7.0E-03	--	--	3.8E-03	7.0E-03
Xylenes	1330-20-7	1.1E-04	2.8E-05	2.8E-04	3.5E-06	--	--	--	--	3.9E-04	3.1E-05
NO_2	10102-44-0	0.11	0.026	0.71	9.0E-03	--	--	1.72	0.34	2.54	0.38
SO_2	7446-09-5	3.4E-03	8.5E-04	1.9E-03	2.3E-05	--	--	4.8E-03	9.5E-04	0.010	1.8E-03
CO	630-08-0	0.48	0.12	1.06	0.013	--	--	100.0	20.0	101	20.1

References:

(1) Assumes all PM_{10} emissions from diesel combustion equals diesel particulate matter (DPM).

(2) NO_2 emissions are shown as NO_X emissions.

Appendix M

Emissions Estimates – Existing Richmond Field Station Laboratories

Table M-1

Total Estimated Air Emissions of Laboratory Non-Radionuclide Liquid Chemicals[(1)]

Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California

CAS Number	Chemical Name	Estimated Emissions (grams/year)	Estimated Emissions (lbs/year)
106-88-7	1,2-Epoxybutane	0.04	0.00
79-10-7	Acrylic acid	446.86	0.99
71-43-2	Benzene	468.94	1.03
630-08-0	Carbon Monoxide	199.63	0.44
67-66-3	Chloroform	2,457.38	5.42
107-21-1	Ethylene glycol	4.79	0.01
50-00-0	Formaldehyde	260.90	0.58
110-54-3	Hexane	6,608.96	14.57
7647-01-0	Hydrochloric acid	1,817.09	4.01
67-63-0	Isopropyl alcohol	4,144.21	9.14
67-56-1	Methanol	4,010.89	8.84
75-09-2	Methylene chloride [Dichloromethane]	15,154.78	33.42
68-12-2	N,N-Dimethyl Formamide	11.56	0.03
7697-37-2	Nitric acid	388.64	0.86
108-95-2	Phenol	19.69	0.04
7664-93-9	Sulfuric acid	15.25	0.03
108-88-3	Toluene	1,765.64	3.89
121-44-8	Triethylamine	70.00	0.15
	Total - All Chemicals Listed	**37,845.26**	**83.45**

Notes:

(1) Estimation methods continued in Appendix M.

Calculation of Liquid Chemical Emissions
Richmond Field Station Existing Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Emission Estimation Approach for Liquids

Step 1: Pour Liquid Into Receiving Container (i.e. Beaker)

Emissions based on quantity poured.

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T From U.S. EPA AP-42 Section 5.2, converted from lbs/10^3 gal to gram/liter and VP in mmHg instead of psia.

where:
S = Saturation Factor (1.45 [unitless]) - From U.S. EPA AP-42 Table 5.2-1
VP = Vapor Pressure at room temperature (mmHg; assume 532 degrees Rankin)
MW = Molecular Weight (grams/mole)
T = Room Temperature (assume 532 degrees Rankin)

Assumptions: Liquid is poured when at room temperature.
Receiving vessel is an open beaker.

Step 2: Stir Liquid in Receiving Container (i.e. Beaker)

Emissions based on number of batches..

Loss (grams/30 min. batch) = $(0.002289*t*A*U^{0.78}*MW^{0.67}*VP)/(R*T)$ From: *Risk Management Program Guidance for Offsite Consequence Analysis*
United States Environmental Protection Agency
Emergency Response (Document 550-B-99-009)
April 1999

where:
t = Batch time in seconds (=1,800)
A = Surface Area (100 cm^2)
U = Surface Wind Speed (0.51 meters/second)
MW = Molecular Weight (grams/mole)
VP = Vapor Pressure at elevated temperature (mmHg)
R = Gas Constant (82.05 atm-cm^3/mole-deg K)
T = Temperature During Use (degrees Kelvin)

Assumptions: If VP(295 K) is > 100 mmHg, no heating is assumed.
*If VP(295 K) is < 100 mmHg, VP(as used) = 2 * VP(298 K), up to 100 mmHg maximum.*
Vessel used is an open beaker.
Diameter of beaker is such that A = 100 cm^2.
Assume that beaker contains pure chemical.
Assume that use occurs within a laboratory fume hood.
Assume fume hood face velocity of 100 ft/min (OSHA recommendation).
Assume batch (use) time of 30 minutes.
For calculation purposes, assume T = 295 deg K. Conservative because temperatures above room temperature would only decrease predicted emission rate.

Calculation of Liquid Chemical Emissions
Richmond Field Station Existing Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California

Calculation Constants

Name	Value	Comment
TempAmbC	21.85	Assumed room temperature in degrees C
TempAmbK	295	Assumed room temperature in degrees K
TempAmbR	532	Assumed room temperature in degrees R
MaxPressBar	0.133	Maximum adjusted vapor pressure in Bars
MaxPressHg	100	Maximum adjusted vapor pressure in mmHg
SatFactor	1.45	Saturation factor for pouring emissions
SurfaceArea	100	Vessel surface area in cm^2
WindSpeed	0.51	Surface Wind Speed (meters/second)
GasConstant	82.05	Gas constant R ($atm\text{-}cm^3$/mole-deg K)

Calculation of Liquid Chemical Emissions
Richmond Field Station Existing Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Chemical Inventory Data (Table M-2)

Conservatively assume specific gravity of 0.7 for laboratory liquids (0.649 liter/lb) when units are in pounds

Batch Assumptions:	Annual Usage	Assumed Annual Batches
	< 0.01 liter	1
	0.01-0.1 liter	5
	0.1-1.0 liter	10
	1.0-10 liter	25
	>10 liter	100

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Data*		*Calculated*	*Recalculated*	*Calculated*	*Entered Data*		*Calculated*
		Inventory Amount		Inventory Amount (liters)	Inventory Amount (liters)	Annual Usage * (liters/yr)	Building	Room	Estimated No. of Batches (per year)
CAS No.	Compound Name	Quantity	Units						
106-88-7	1,2-EPOXYBUTANE	0.1	G	**Units**	0.00006	0.00007	112	r	1
79-10-7	ACRYLIC ACID	2	GAL	7.57000	--	8.88441	167	c	25
71-43-2	BENZENE	4	L	4.00000	--	4.69453	112	fc	25
67-66-3	CHLOROFORM	4	L	4.00000	--	4.69453	112	fc	25
67-66-3	CHLOROFORM	1	L	1.00000	--	1.17363	112	fc	25
67-66-3	CHLOROFORM	1	L	1.00000	--	1.17363	474	fc	25
107-21-1	ETHYLENE GLYCOL	8	GAL	30.28000	--	35.53762	167	c	100
107-21-1	ETHYLENE GLYCOL	4	GAL	15.14000	--	17.76881	197	c	100
107-21-1	ETHYLENE GLYCOL	1	GAL	3.78500	--	4.44220	480	fc	25
50-00-0	FORMALDEHYDE	4	L	4.00000	--	4.69453	112	s	25
50-00-0	FORMALDEHYDE	20	ML	0.02000	--	0.02347	112		5
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)	5	L	5.00000	--	5.86817	112	s	25
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)	500	ML	0.50000	--	0.58682	112	fc	10
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)	2.5	L	2.50000	--	2.93408	112	c	25
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)	1	GAL	3.78500	--	4.44220	276	fc	25
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	16	OZ	0.47318	--	0.55534	450	b	10
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	2	GAL	7.57000	--	8.88441	112	fc	25
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	1	GAL	3.78500	--	4.44220	158	c	25
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	12	L	12.00000	--	14.08360	112	fc	100
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	16	OZ	0.47318	--	0.55534	116	s	10
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	128	OZ	3.78541	--	4.44268	154	b	25
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	1	GAL	3.78500	--	4.44220	275	c	25
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	16	OZ	0.47318	--	0.55534	276	fc	10
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	10	L	10.00000	--	11.73633	473	fh	100
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	3.5	L	3.50000	--	4.10772	478	c	25
67-56-1	METHANOL	5	L	5.00000	--	5.86817	112	fc	25
67-56-1	METHANOL	200	ML	0.20000	--	0.23473	112	fc	10
67-56-1	METHANOL	20	L	20.00000	--	23.47267	112	fc	100
67-56-1	METHANOL	12	L	12.00000	--	14.08360	112	fc	100
67-56-1	METHANOL	1	L	1.00000	--	1.17363	474	fc	25
67-56-1	METHANOL	15	ML	0.01500	--	0.01760	112	r	5
67-56-1	METHANOL	100	ML	0.10000	--	0.11736	112	c	10
67-56-1	METHANOL	10	L	10.00000	--	11.73633	152		100
75-09-2	METHYLENE CHLORIDE (Dichloromethane)	32	L	32.00000	--	37.55627	112	fc	100
75-09-2	METHYLENE CHLORIDE (Dichloromethane)	40	L	40.00000	--	46.94534	112	fc	100
68-12-2	N,N-DIMETHYL FORMAMIDE	100	ML	0.10000	--	0.11736	112	fc	10
110-54-3	n-HEXANE	10	L	10.00000	--	11.73633	112	fc	100
110-54-3	n-HEXANE	1	L	1.00000	--	1.17363	112		25
110-54-3	n-HEXANE	4	L	4.00000	--	4.69453	112	fh	25
110-54-3	n-HEXANE	20	L	20.00000	--	23.47267	112	fc	100
7697-37-2	NITRIC ACID	2500	ML	2.50000	--	2.93408	112	s	25
108-95-2	PHENOL	100	ML	0.10000	--	0.11736	112		10
7664-93-9	SULFURIC ACID AND OLEUM	500	ML	0.50000	--	0.58682	112	s	10
7664-93-9	SULFURIC ACID AND OLEUM	2.5	L	2.50000	--	2.93408	112	fc	25
108-88-3	TOLUENE	12	PT	5.67811	--	6.66402	112	fc	25
108-88-3	TOLUENE	20	L	20.00000	--	23.47267	112	fc	100
108-88-3	TOLUENE	4	L	4.00000	--	4.69453	478	c	25
108-88-3	TOLUENE	1	GAL	3.78500	--	4.44220	275	b	25
121-44-8	TRIETHYLAMINE	100	ML	0.10000	--	0.11736	112	c	10

* Equals inventory x (365 days per yr/311 days)
[311 days = 95th percentile lowest turnover rate for historic use]

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Calculation of Liquid Chemical Emissions
Richmond Field Station Existing Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Vapor Pressure Data (Table M-3)

Antoine Equation: $VP = 10^{[A - (B/(T+C))]}$

where: VP = Vapor Pressure (mmHg or bar, depending on source of A, B, C)
T = Temperature (K or C depending on source of A, B, C)
A, B, C = Antoine coefficients (Reference Temperature should be near 295 deg K)

This list of chemicals comes from LBNL inventory data with solids & gases removed. Must be identical to Chemical Inventory worksheet		*Must be entered manually* For Antoine Eq. @ 295 K				or	*Entered manually* Literature		*Entered manually*	*Calculated values*		*Calculated*
		Antoine Coefficients										
CAS No.	Compound Name	A	B	C	VP Units		VP @ Ref Temp (mmHg)	Ref Temp (K)	Vapor Pressure Reference	Vapor Pressure at Ref	Vapor Pressure at Ref (VP Units)	Adjusted Vapor Pressure [a] (mmHg)
106-88-7	1,2-EPOXYBUTANE						140	294	MSDS	140.000	mmHg	140.00
79-10-7	ACRYLIC ACID	5.65204	648.629	154.683	mmHg				LBNL Data File	95.011	mmHg	100.00
71-43-2	BENZENE	6.90565	1211.033	220.79	mmHg				LBNL Data File	82.145	mmHg	100.00
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
67-66-3	CHLOROFORM	6.4934	929.44	196.03	mmHg				LBNL Data File	168.875	mmHg	168.88
107-21-1	ETHYLENE GLYCOL	8.0908	2088.9	203.5	mmHg				LBNL Data File	0.066	mmHg	0.13
107-21-1	ETHYLENE GLYCOL	8.0908	2088.9	203.5	mmHg				LBNL Data File	0.066	mmHg	0.13
107-21-1	ETHYLENE GLYCOL	8.0908	2088.9	203.5	mmHg				LBNL Data File	0.066	mmHg	0.13
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
50-00-0	FORMALDEHYDE						87.9	294	MSDS, 37% soln.	87.900	mmHg	100.00
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)						190	298	MSDS	190.000	mmHg	190.00
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)						190	298	MSDS	190.000	mmHg	190.00
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	8.11778	1580.92	219.61	mmHg				LBNL Data File	37.191	mmHg	74.38
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
67-56-1	METHANOL	7.8975	1474.08	229.13	mmHg				LBNL Data File	105.731	mmHg	105.73
75-09-2	METHYLENE CHLORIDE (Dichloromethane)	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
75-09-2	METHYLENE CHLORIDE (Dichloromethane)	7.4092	1325.9	252.6	mmHg				LBNL Data File	378.515	mmHg	378.52
68-12-2	N,N-DIMETHYL FORMAMIDE	6.928	1400.87	196.43	mmHg				LBNL Data File	3.238	mmHg	6.48
110-54-3	n-HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	n-HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	n-HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
110-54-3	n-HEXANE	6.87601	1171.17	224.41	mmHg				LBNL Data File	131.881	mmHg	131.88
7697-37-2	NITRIC ACID						48	293	MSDS	48.000	mmHg	96.00
108-95-2	PHENOL						4.65	328	MSDS	4.654	mmHg	9.31
7664-93-9	SULFURIC ACID AND OLEUM						1	419	MSDS	1.000	mmHg	2.00
7664-93-9	SULFURIC ACID AND OLEUM						1	419	MSDS	1.000	mmHg	2.00
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
108-88-3	TOLUENE	6.95464	1344.8	219.48	mmHg				LBNL Data File	24.109	mmHg	48.22
121-44-8	TRIETHYLAMINE	5.8588	695.7	144.8	mmHg				LBNL Data File	48.326	mmHg	96.65

a. If VP (@ ref temp) < 100 mmHg, then VP = Lesser of twice the VP (@ ref temp) or 100 mmHg
If VP (@ ref temp) >= 100 mmHg, then not adjusted

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Calculation of Liquid Chemical Emissions
Richmond Field Station Existing Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Pouring Emissions Estimates (Table M-4)

S = Saturation Factor = 1.45
VP = Vapor Pressure = Chemical-specific
MW = Molecular Weight = Chemical-specific
T = Ambient Temperature (R) = 532

Loss (grams/liter) = 0.02887 * (S*VP*MW)/T
(limited to 700 g/liter)

This list of chemicals comes from LBNL inventory data with solids & gases removed Must be identical to Chemical Inventory worksheet		*MW entered manually*		*Calculated value from separate worksheet*	*Calculated*	*From separate worksheet*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**VP (@ Ref Temp) (mmHg)**	**Pouring Loss Emission Factor (grams/liter)**	**Annual Usage (liters/yr)**	**Annual Emissions (grams/yr)**
106-88-7	1,2-EPOXYBUTANE	72.11	MSDS	140.0	0.79438	0.00007	0.00006
79-10-7	ACRYLIC ACID	72.06	LBNL Data File	95.0	0.53873	8.88441	4.78631
71-43-2	BENZENE	78.1	LBNL Data File	82.1	0.50482	4.69453	2.36989
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	4.69453	7.44844
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	1.17363	1.86211
67-66-3	CHLOROFORM	119.4	LBNL Data File	168.9	1.58662	1.17363	1.86211
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0.1	0.00032	35.53762	0.01150
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0.1	0.00032	17.76881	0.00575
107-21-1	ETHYLENE GLYCOL	63.07	LBNL Data File	0.1	0.00033	4.44220	0.00146
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	4.69453	0.97508
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	87.9	0.20771	0.02347	0.00488
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)	36.47	LBNL Data File	190.0	0.54525	5.86817	3.19959
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)	36.47	LBNL Data File	190.0	0.54525	0.58682	0.31996
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)	36.47	LBNL Data File	190.0	0.54525	2.93408	1.59980
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)	36.47	LBNL Data File	190.0	0.54525	4.44220	2.42209
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	37.2	0.17588	0.55534	0.09767
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	37.2	0.17588	8.88441	1.56260
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	37.2	0.17588	4.44220	0.78130
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	37.2	0.17588	14.08360	2.47705
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	37.2	0.17588	0.55534	0.09767
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	37.2	0.17588	4.44268	0.78139
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	37.2	0.17588	4.44220	0.78130
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	37.2	0.17588	0.55534	0.09767
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	37.2	0.17588	11.73633	2.06421
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	37.2	0.17588	4.10772	0.72247
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	5.86817	1.56716
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	0.23473	0.06269
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	23.47267	6.26865
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	14.08360	3.76119
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	1.17363	0.31343
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	0.01760	0.00470
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	0.11736	0.03134
67-56-1	METHANOL	32.1	LBNL Data File	105.7	0.26706	11.73633	3.13432
75-09-2	METHYLENE CHLORIDE (Dichloromethane)	84.9	LBNL Data File	378.5	2.52868	37.55627	94.96783
75-09-2	METHYLENE CHLORIDE (Dichloromethane)	84.9	LBNL Data File	378.5	2.52868	46.94534	118.70979
68-12-2	N,N-DIMETHYL FORMAMIDE	73.1	LBNL Data File	3.2	0.01862	0.11736	0.00219
110-54-3	n-HEXANE	86.17	LBNL Data File	131.9	0.89422	11.73633	10.49481
110-54-3	n-HEXANE	86.17	LBNL Data File	131.9	0.89422	1.17363	1.04948
110-54-3	n-HEXANE	86.17	LBNL Data File	131.9	0.89422	4.69453	4.19792
110-54-3	n-HEXANE	86.17	LBNL Data File	131.9	0.89422	23.47267	20.98962
7697-37-2	NITRIC ACID	63.02	LBNL Data File	48.0	0.23803	2.93408	0.69839
108-95-2	PHENOL	94.11	MSDS	4.7	0.03447	0.11736	0.00405
7664-93-9	SULFURIC ACID AND OLEUM	98.08	NIST	1.0	0.00772	0.58682	0.00453
7664-93-9	SULFURIC ACID AND OLEUM	98.08	NIST	1.0	0.00772	2.93408	0.02264
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	6.66402	1.16436
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	23.47267	4.10122
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	4.69453	0.82024
108-88-3	TOLUENE	92.1	LBNL Data File	24.1	0.17472	4.44220	0.77616
121-44-8	TRIETHYLAMINE	101	LBNL Data File	48.3	0.38407	0.11736	0.04508

Calculation of Liquid Chemical Emissions
Richmond Field Station Existing Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Emissions from Evaporation During Use (Table M-5)

A = Surface Area (cm^2) = 100
U = Wind Speed (m/s) = 0.51
MW = Molecular Weight (g/mole) = Chemical-specific
VP = Vapor Pressure (mmHg) = Chemical-specific
R = Gas Constant ($atm\text{-}cm^3/mole\text{-}deg\ K$) = 82.05
T = Ambient Temperature (K) = 295

Loss (grams/batch) = $(4.120*A*U^{0.78}*MW^{0.67}*VP)/(R*T)$

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet		*MW entered manually*		*From previous worksheet*	*From previous worksheet*	*Calculated*	*Calculated*
CAS No.	**Compound Name**	**MW (g/mole)**	**MW Reference**	**Adjusted Vapor Pressure (mmHg)**	**Assumed No. of Batches (per yr)**	**Estimated Loss Emission Factor (grams/batch)**	**Estimated Emissions (grams/yr)**
106-88-7	1,2-EPOXYBUTANE	72.11	MSDS	140	1	24.768	0.04
79-10-7	ACRYLIC ACID	72.06	LBNL Data File	100	25	17.683	442.08
71-43-2	BENZENE	78.1	LBNL Data File	100	25	18.663	466.57
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	1047.13
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	699.54
67-66-3	CHLOROFORM	119.4	LBNL Data File	169	25	41.885	699.54
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0	100	0.021	2.12
107-21-1	ETHYLENE GLYCOL	62.07	LBNL Data File	0	100	0.021	2.12
107-21-1	ETHYLENE GLYCOL	63.07	LBNL Data File	0	25	0.021	0.54
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	25	9.837	245.93
50-00-0	FORMALDEHYDE	30.03	LBNL Data File	100	5	9.837	13.99
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)	36.47	LBNL Data File	190	10	21.289	212.89
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)	36.47	LBNL Data File	190	25	21.289	532.22
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)	36.47	LBNL Data File	190	25	21.289	532.22
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	74	100	11.647	1164.72
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	74	25	11.647	291.18
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	74	10	11.647	116.47
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	74	100	11.647	1164.72
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	60.1	LBNL Data File	74	25	11.647	291.18
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	10	10.876	108.76
67-56-1	METHANOL	32.1	LBNL Data File	106	100	10.876	1087.58
67-56-1	METHANOL	32.1	LBNL Data File	106	100	10.876	1087.58
67-56-1	METHANOL	32.1	LBNL Data File	106	25	10.876	271.90
67-56-1	METHANOL	32.1	LBNL Data File	106	5	10.876	10.49
67-56-1	METHANOL	32.1	LBNL Data File	106	10	10.876	69.95
67-56-1	METHANOL	32.1	LBNL Data File	106	100	10.876	1087.58
75-09-2	METHYLENE CHLORIDE (Dichloromethane)	84.9	LBNL Data File	379	100	74.706	7470.55
75-09-2	METHYLENE CHLORIDE (Dichloromethane)	84.9	LBNL Data File	379	100	74.706	7470.55
68-12-2	N,N-DIMETHYL FORMAMIDE	73.1	LBNL Data File	6	10	1.156	11.56
110-54-3	n-HEXANE	86.17	LBNL Data File	132	100	26.289	2628.89
110-54-3	n-HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	n-HEXANE	86.17	LBNL Data File	132	25	26.289	657.22
110-54-3	n-HEXANE	86.17	LBNL Data File	132	100	26.289	2628.89
7697-37-2	NITRIC ACID	63.02	LBNL Data File	96	25	15.518	387.94
108-95-2	PHENOL	94.11	MSDS	9	10	1.968	19.68
7664-93-9	SULFURIC ACID AND OLEUM	98.08	NIST	2	10	0.435	4.35
7664-93-9	SULFURIC ACID AND OLEUM	98.08	NIST	2	25	0.435	10.87
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	100	10.050	1005.02
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
108-88-3	TOLUENE	92.1	LBNL Data File	48	25	10.050	251.25
121-44-8	TRIETHYLAMINE	101	LBNL Data File	97	10	21.429	69.95

Calculation of Liquid Chemical Emissions
Richmond Field Station Existing Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Total Estimated Emissions (Table M-6)

Limit total annual emissions to inventory usage quantity. Assume 1,000 grams/liter when converting liters used to grams.

This list of chemicals comes from merging the purchase and inventory lists Must be identical to Total Usage worksheet		*From previous worksheet (A3)*	*From previous worksheet (A4)*	*Chemical Often Used For Cleaning or Drying?*	*Calculated - Sum of Pouring & Stirring Emissions*
CAS No.	**Compound Name**	**Pouring Annual Emissions (grams/yr)**	**Stirring Annual Emissions (grams/yr)**	**(Yes/No) ***	**Total Annual Emissions * (grams/yr)**
106-88-7	1,2-EPOXYBUTANE	0.000	0.04	No	0.04
79-10-7	ACRYLIC ACID	4.786	442.08	No	446.86
71-43-2	BENZENE	2.370	466.57	No	468.94
67-66-3	CHLOROFORM	7.448	1047.13	No	1054.58
67-66-3	CHLOROFORM	1.862	699.54	No	701.40
67-66-3	CHLOROFORM	1.862	699.54	No	701.40
107-21-1	ETHYLENE GLYCOL	0.011	2.12	No	2.13
107-21-1	ETHYLENE GLYCOL	0.006	2.12	No	2.13
107-21-1	ETHYLENE GLYCOL	0.001	0.54	No	0.54
50-00-0	FORMALDEHYDE	0.975	245.93	No	246.90
50-00-0	FORMALDEHYDE	0.005	13.99	No	14.00
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)	3.200	532.22	No	535.42
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)	0.320	212.89	No	213.21
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)	1.600	532.22	No	533.82
7647-01-0	HYDROCHLORIC ACID (Hydrogen chloride)	2.422	532.22	No	534.64
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	0.098	116.47	No	116.57
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	1.563	291.18	No	292.74
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	0.781	291.18	No	291.96
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	2.477	1164.72	No	1167.19
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	0.098	116.47	No	116.57
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	0.781	291.18	No	291.96
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	0.781	291.18	No	291.96
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	0.098	116.47	No	116.57
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	2.064	1164.72	No	1166.78
67-63-0	ISOPROPYL ALCOHOL (Isopropanol)	0.722	291.18	No	291.90
67-56-1	METHANOL	1.567	271.90	No	273.46
67-56-1	METHANOL	0.063	108.76	No	108.82
67-56-1	METHANOL	6.269	1087.58	No	1093.85
67-56-1	METHANOL	3.761	1087.58	No	1091.35
67-56-1	METHANOL	0.313	271.90	No	272.21
67-56-1	METHANOL	0.005	10.49	No	10.50
67-56-1	METHANOL	0.031	69.95	No	69.99
67-56-1	METHANOL	3.134	1087.58	No	1090.72
75-09-2	METHYLENE CHLORIDE (Dichloromethane)	94.968	7470.55	No	7565.52
75-09-2	METHYLENE CHLORIDE (Dichloromethane)	118.710	7470.55	No	7589.26
68-12-2	N,N-DIMETHYL FORMAMIDE	0.002	11.56	No	11.56
110-54-3	n-HEXANE	10.495	2628.89	No	2639.39
110-54-3	n-HEXANE	1.049	657.22	No	658.27
110-54-3	n-HEXANE	4.198	657.22	No	661.42
110-54-3	n-HEXANE	20.990	2628.89	No	2649.88
7697-37-2	NITRIC ACID	0.698	387.94	No	388.64
108-95-2	PHENOL	0.004	19.68	No	19.69
7664-93-9	SULFURIC ACID AND OLEUM	0.005	4.35	No	4.35
7664-93-9	SULFURIC ACID AND OLEUM	0.023	10.87	No	10.89
108-88-3	TOLUENE	1.164	251.25	No	252.42
108-88-3	TOLUENE	4.101	1005.02	No	1009.12
108-88-3	TOLUENE	0.820	251.25	No	252.07
108-88-3	TOLUENE	0.776	251.25	No	252.03
121-44-8	TRIETHYLAMINE	0.045	69.95	No	70.00

* Chemicals identified as being frequently used to clean, dry, or sterilize glassware and surfaces assigned emissions of at least 50% of usage.

Golder Associates

Calculation of Gas Chemical Emissions
Richmond Field Station Existing Laboratory Usage Scenario
Proposed Richmond Bay Campus Long Range Development Plan, Richmond, California
Total Estimated Gas Emissions (Table M-7)

G = Gas Constant (L/mol) = 22.4

This list of chemicals comes from LBNL inventory data with solids & gases removed		*Entered Manually*	*Entered Manually*	*Entered Manually*	*Entered Manually*	*Entered Data*	*Calculated*
				From LBNL provided data	*From LBNL provided data*		
CAS No.	**Compound Name**	**MW (grams/mol)**	**MW Reference**	**Concentration (%)**	**Max Amount (liters/yr)**	**Building**	**Total Annual Emissions (grams/yr)**
630-08-0	CARBON MONOXIDE	28.01	MSDS	0.400	103.00	112	0.52
630-08-0	CARBON MONOXIDE	28.01	MSDS	100.00	103.00	112	128.80
630-08-0	CARBON MONOXIDE	28.01	MSDS	99.30	56.6337	112	70.32

* Chemicals identified as being frequently used to clean, dry, or sterilize glassware and surfaces assigned emissions of at least 50% of usage.

Appendix N

Emissions Estimates – Hypothetical Phase 2 Operations (includes Phase 1 Sources)

Table N-1
Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources

Source	*Building Size (gsf)*	*Diesel Emergency Generators*		*Natural Gas Boilers*			*Cooling Towers*		
		Engine Size (BHP)	Fuel Usage (gal/hr)	Maximum Heat Input (MMBtu/hr)	Daily Operation (hrs/day)	Annual Fuel Usage (MMBtu/yr)	Number of Cells	Cell Size (tons/cell)	Total Recirc. Rate (gpm)
Buildings 6 and 7	253,954	--	--	24 (4)	24	42,000 (4)	6 (4)	500 (4)	9,000 (b)
Building 6	--	440 (3)	22.3 (a)	--	--	--	--	--	--
Building 7	--	440 (3)	22.3 (a)	--	--	--	--	--	--
Building 8	110,510	440 (4)	22.3 (a)	12 (4)	24	21,000 (4)	3 (4)	500 (4)	4,500 (b)
Building 9	137,451	440 (4)	22.3 (a)	12 (4)	24	21,000 (4)	3 (4)	500 (4)	4,500 (b)
Building 10	117,700	410 (4)	20.8 (a)	11 (4)	24	15,267	3	500 (4)	4,500 (b)
Building 11	67,280	240 (4)	12.2 (a)	6 (4)	24	8,328	2	400 (4)	2,400 (b)
Total	686,895	2410	122.2	65	--	660,000 (5)	--	--	24,900

Source	Source Parameter		Short Term Input (units)	Annual Input (units)
Employee and Facility Data				
	Number of Employees		10,000 (4)	--
	Average Building Occupancy		10 (hrs/day) (6)	260 (days/yr) (7)
	Emergency Generator Usage		2 (hrs/day) (8)	25.15 (hrs/yr) (8)
	Cooling Tower Usage		24 (hrs/day)	6,360 (hrs/yr) (9)
Vehicle Data				
	Vehicle Trips	**Daily Operation (hrs/day)**	**Maximum Daily (trips/day)**	**Average Annual (trips/yr)**
	Employee Trips	16	3,453 (10)	897,702 (11)
	Delivery Truck Trips	16	14 (12)	3,558 (13)
	LBNL - RBC Shuttle Trips	13 (14)	13 (14)	3,380 (14)
	BART - RBC Shuttle Trips	13 (14)	25 (14)	6,500 (14)
	Total trips		3,504	911,140
	Vehicle Idling Times and Round Trip Distances	**Onsite Idling Time (min/trip)**	**Onsite Round Trip Distance (mi/trip)**	**Offsite Round Trip Distance (mi/trip)**
	Employee Vehicles	0 (15)	0.858 (16)	20.4 (c)
	Delivery Trucks	0.08 (20)	0.559 (16)	14.0 (21)
	LBNL - RBC Shuttle	0.08 (22)	0.698 (16)	15.5 (23)
	BART - RBC Shuttle	0.08 (22)	0.698 (16)	8 (23)
	Employee Offsite Round Trip Distance - Modeling (mi/trip)			0.858 (16)
	Delivery Truck Offsite Round Trip Distance - Modeling (mi/trip)			0.705 (16)
	LBNL - RBC Shuttle Round Trip Distance - Modeling (mi/trip)			0.967 (16)
	BART - RBC Shuttle Round Trip Distance (mi/trip)			0.967 (16)
	Average Vehicle Weights			**Average Weight (tons)**
	Employee Vehicles			2.4 (24)
	Delivery Trucks			13 (25)
	LBNL - RBC Shuttle			4.2 (26)
	BART - RBC Shuttle			4.2 (26)
	Mean Vehicle Weight Calculation		**Daily Basis (tons)**	**Annual Basis (tons)**
	Employee Mean Vehicle Weight portion (ton)		2.36 (d)	2.36 (d)
	Delivery Truck Mean Vehicle Weight Portion (ton)		0.051 (d)	0.051 (d)
	LBNL - RBC Shuttle Mean Vehicle Weight Portion (ton)		0.016 (d)	0.016 (d)
	BART - RBC Shuttle Mean Vehicle Weight Portion (ton)		0.030 (d)	0.030 (d)
	Mean Vehicle Weight - sum of weight portions (ton)		2.46	2.46
Additional Site-Specific Data and Constants Used for Emission Calculations				
	Cooling Towers - Equivalent Ton Water Usage (gpm/ton)		3	(e)
	Cooling Towers - Total Dissolved Solids Concentration (ppm)		536	(27)
	Roads - P = No. of Days with Precip. > 0.01 in. (days/yr)		62	(28)

Table N-1 (continued)
Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources

Notes:

(a) Engine fuel consumption (gal/hr) = (Engine size [hp]) x (average brake-specific fuel consumption [Btu/hp-hr]) / (liquid fuel higher heating value [Btu/gal])

Average brake-specific fuel consumption (Btu/hp-hr) =	7,000	(1)
Liquid fuel higher heating value (Btu/gal) =	138,000	(2)

(b) Recirculation rate (gpm) = (Number of cooling tower cells) x (heat removal equivalent tons per cell [tons/cell]) x (equivalent ton water usage [gpm/ton])

(c) Offsite round trip distance (mi/trip) = {(Primary trip length [mi]) x (primary trip percentage [%]) + (primary trip length [mi]) x (diverted trip percentage [%]) x (diverted trip percentage of primary trip length [%]) + (pass-by trip percentage [%]) x (pass-by trip length [mi])} x 2 - (onsite round trip distance [mi/trip])

Primary trip length (mi) =	12.4	(17)
Primary trip percentage (%) =	82	(18)
Diverted trip percentage of primary trip length (%) =	25	(19)
Diverted trip percentage (%) =	15	(18)
Pass-by trip length (mi) =	0.1	(19)
Pass-by trip percentage (%) =	3	(18)

(d) Mean vehicle weight portions (tons) = (Individual vehicle trips [trips/day or trips/yr]) / (total vehicle trips [trips/day or trips/yr]) x (individual vehicle average weight [tons])

(e) Equivalent ton water usage (gpm/ton) = (15,000 Btu/hr/ton) x (hr/60 min) x (gal/8.337 lbs) / (1 Btu/lb-°F) / (10 °F temperature differential)

References:

(1) AP-42 Chapter 3.3 (October 1996), Footnote to Table 3.3-1, "Emission Factors for Uncontrolled Gasoline and Diesel Industrial Engines".
(2) ULSD higher heating value.
(3) Buildings 6 & 7 will have two separate generators, totaling 880 hp.
(4) January 17, 2013 responses from the University.
(5) The annual fuel usage is described in the project description.
(6) Assumes laboratory work is conducted over 10 hours per day. This conservatively estimates hourly emissions .
(7) Assumes employees will generally be visiting the site 5 days per week, 52 weeks per year. This provides a conservative value to calculation the annual employee vehicle trips.
(8) Hourly value conservatively assumes a maximum of 2 hours per day of operation for maintenance and testing. Annual value is based on the average historical emergency engine usage from the previous LBNL LRDP.
(9) January 31, 2013 I.R. responses. Assumes cooling tower fans are off 2,400 hours per year, and only operate at full speed 260 hours per year.
(10) January 17, 2013 response from the University - population increase by approx. 1,000 over the current 300. Assume 1,300 trips per day for Phase 1, scaled up to account for Phase 2 buildings.
(11) Assumes daily worker trips will occur 5 days per week, 52 weeks per year.
(12) Assumption based on Phase 1 analysis.
(13) January 31, 2013 I.R. responses. Assumes that the 10 weekly trips will occur over 5 days per week, 52 weeks per year for Phase 1, scaled up to account for Phase 2 buildings.
(14) Shuttle schedule provided by the University. Assumes shuttle trips occur 5 days per week, 52 weeks per year.
(15) It is assumed that employee vehicles will have negligible idling time.
(16) Onsite and offsite modeling trip distances approximated using the AERMOD modeling software.
(17) CalEEMod Appendix D Table 4.2 "Mobile Trip Characteristics Dependent on Location", Bay Area AQMD. Light duty employee vehicle route is based on the urban home to work (H-W) trip length. Trip lengths in CalEEMod are one way.
(18) CalEEMod Appendix D Table 4.3 "Mobile Trip Rates, Trip Purpose, Trip Type by Land Use", Commercial Land Use Type, Research and Development Land Use Sub Type.
(19) CalEEMod Appendix A Section 5.1, Vehicle Trips. "For pass-by trip links the trip length will be 0.1 miles and diverted trip links the trip length will be 25% of the primary trip length".
(20) Assumes 5 minutes at idle time consistent with California Code of Regulations Section 2485, Airborne Toxic Control Measure to Limit Diesel-Fueled Commercial Motor Vehicle Idling.
(21) CalEEMod Appendix D Table 4.2 "Mobile Trip Characteristics Dependent on Location", Bay Area AQMD. Delivery truck route is based on the urban commercial-NW route. Trip lengths in CalEEMod are one way.
(22) Conservative estimate of idling time for each shuttle drop-off event.
(23) Shuttle bus routes and schedules provided by the University.
(24) CalEEMod Appendix D Table 4.1 "Road Characteristics". Average vehicle weight for Bay Area AQMD.
(25) Based on the EMFAC vehicle class used for estimating emissions: T6 instate small, which has the higher VMT of all comparable categories, and is representative of delivery trucks. Max GVWR = 26,000 lbs. Also assumes that RBC would not be the final destination for deliveries, so only a nominal difference between loaded and unloaded weights is used.
(26) Ford E150 XLT - 5,700 lb curb weight, plus 15 passengers at ~180 lbs/person.
(27) From CRT project emissions calculations, provided by Impact Sciences.
(28) Comparative Climatic Data, National Climatic Data Center, NOAA, 2011. 84 year average for San Francisco AP, CA.

Table N-2
Summary of Offsite On-Road Exhaust Criteria Pollutant Emission Estimates

Pollutant	Vehicle Type	EMFAC Vehicle Class	Maximum Daily Round-Trips [1] (trips/day)	Total Annual Round-Trips [1] (trips/yr)	Round-Trip Distance [1] (miles)	Emission Factors [2] (lbs/VMT)	Maximum Daily Emissions Estimate [a] (lbs/day)	Annual Average Emissions Estimate [b] (tons/yr)
ROG	Delivery Trucks	T6 Instate Small	14	3,558	14	3.9E-04	7.5E-02	9.8E-03
	LBNL - RBC Shuttle	MDV	13	3,380	16	3.7E-04	7.5E-02	9.8E-03
	BART - RBC Shuttle	MDV	25	6,500	8.0	3.7E-04	7.5E-02	9.7E-03
	Employees	LDA	3,453	897,702	20	1.5E-04	10	1.3
	Total ROG Emissions						**10**	**1.4**
NO_X	Delivery Trucks	T6 Instate Small	14	3,558	14	5.1E-03	0.98	0.13
	LBNL - RBC Shuttle	MDV	13	3,380	16	6.6E-04	0.13	1.7E-02
	BART - RBC Shuttle	MDV	25	6,500	8.0	6.6E-04	0.13	1.7E-02
	Employees	LDA	3,453	897,702	20	1.9E-04	14	1.8
	Total NO_X Emissions						**15**	**1.9**
CO	Delivery Trucks	T6 Instate Small	14	3,558	14	1.3E-03	0.26	3.3E-02
	LBNL - RBC Shuttle	MDV	13	3,380	16	4.6E-03	0.92	0.12
	BART - RBC Shuttle	MDV	25	6,500	8.0	4.6E-03	0.92	0.12
	Employees	LDA	3,453	897,702	20	1.9E-03	135	18
	Total CO Emissions						**137**	**18**
SO_2	Delivery Trucks	T6 Instate Small	14	3,558	14	2.5E-05	4.8E-03	6.2E-04
	LBNL - RBC Shuttle	MDV	13	3,380	16	1.3E-05	2.6E-03	3.4E-04
	BART - RBC Shuttle	MDV	25	6,500	8.0	1.3E-05	2.6E-03	3.4E-04
	Employees	LDA	3,453	897,702	20	7.5E-06	0.53	6.9E-02
	Total SO_2 Emissions						**0.54**	**7.0E-02**
PM_{10} Exhaust	Delivery Trucks	T6 Instate Small	14	3,558	14	1.9E-04	3.7E-02	4.8E-03
	LBNL - RBC Shuttle	MDV	13	3,380	16	4.7E-06	9.4E-04	1.2E-04
	BART - RBC Shuttle	MDV	25	6,500	8.0	4.7E-06	9.3E-04	1.2E-04
	Employees	LDA	3,453	897,702	20	3.8E-06	0.27	3.5E-02
	Total PM_{10} Emissions						**0.31**	**4.0E-02**
PM_{10} Tire/Brake	Delivery Trucks	T6 Instate Small	14	3,558	14	3.1E-04	6.0E-02	7.8E-03
	LBNL - RBC Shuttle	MDV	13	3,380	16	9.9E-05	2.0E-02	2.6E-03
	BART - RBC Shuttle	MDV	25	6,500	8.0	9.9E-05	2.0E-02	2.6E-03
	Employees	LDA	3,453	897,702	20	9.9E-05	7.0	0.90
	Total PM_{10} Emissions						**7.1**	**0.92**
$PM_{2.5}$ Exhaust	Delivery Trucks	T6 Instate Small	14	3,558	14	1.8E-04	3.4E-02	4.4E-03
	LBNL - RBC Shuttle	MDV	13	3,380	16	4.3E-06	8.7E-04	1.1E-04
	BART - RBC Shuttle	MDV	25	6,500	8.0	4.3E-06	8.6E-04	1.1E-04
	Employees	LDA	3,453	897,702	20	3.5E-06	0.25	3.2E-02
	Total $PM_{2.5}$ Emissions						**0.28**	**3.7E-02**
$PM_{2.5}$ Tire/Brake	Delivery Trucks	T6 Instate Small	14	3,558	14	1.3E-04	2.5E-02	3.2E-03
	LBNL - RBC Shuttle	MDV	13	3,380	16	3.9E-05	7.9E-03	1.0E-03
	BART - RBC Shuttle	MDV	25	6,500	8.0	3.9E-05	7.8E-03	1.0E-03
	Employees	LDA	3,453	897,702	20	3.9E-05	2.8	0.36
	Total $PM_{2.5}$ Emissions						**2.8**	**0.36**
CO_2	Delivery Trucks	T6 Instate Small	14	3,558	14	2.4	466	61
	LBNL - RBC Shuttle	MDV	13	3,380	16	1.1	221	29
	BART - RBC Shuttle	MDV	25	6,500	8.0	1.1	219	28
	Employees	LDA	3,453	897,702	20	0.56	39,754	5,168
	Total CO_2 Emissions						**40,659**	**5,286**

Notes:
(a) Maximum daily emissions estimate (lbs/day) = (Maximum daily round-trips [trips/day]) x (round-trip distance [miles]) x (emission factor [lbs/VMT])
(b) Annual average emissions estimate (tons/yr) = (Annual round-trips [trips/yr]) x (round-trip distance [miles]) x (emission factor [lbs/VMT]) x (ton/2,000 lbs)

References:
(1) See Table N-1, Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources.
(2) Emission Factors source: Emfac 2011 (Model Years to 2034), typical speed distribution. Carbon dioxide emission factors are representative of post-Low Carbon Fuel Standard implementation.

Table N-3
Summary of Onsite On-Road Exhaust Criteria Pollutant Emission Estimates

Pollutant	Vehicle Type	EMFAC Vehicle Class	Maximum Daily Round-Trips [1] (trips/day)	Total Annual Round-Trips [1] (trips/yr)	Round-Trip Distance [1] (miles)	Emission Factor [2] (lbs/VMT)	Maximum Daily Emissions Estimate [a] (lbs/day)	Annual Average Emissions Estimate [b] (tons/yr)
ROG	Delivery Trucks	T6 Instate Small	14	3,558	0.56	2.1E-03	1.6E-02	2.1E-03
	LBNL - RBC Shuttle	MDV	13	3,380	0.70	4.7E-04	4.2E-03	5.5E-04
	BART - RBC Shuttle	MDV	25	6,500	0.70	4.7E-04	8.1E-03	1.1E-03
	Employees	LDA	3,453	897,702	0.86	1.6E-04	0.47	6.2E-02
	Total ROG Emissions						**0.50**	**6.5E-02**
NO_X	Delivery Trucks	T6 Instate Small	14	3,558	0.56	1.1E-02	8.6E-02	1.1E-02
	LBNL - RBC Shuttle	MDV	13	3,380	0.70	1.0E-03	9.4E-03	1.2E-03
	BART - RBC Shuttle	MDV	25	6,500	0.70	1.0E-03	1.8E-02	2.3E-03
	Employees	LDA	3,453	897,702	0.86	2.9E-04	0.87	0.11
	Total NO_X Emissions						**0.98**	**0.13**
CO	Delivery Trucks	T6 Instate Small	14	3,558	0.56	3.9E-03	3.0E-02	3.9E-03
	LBNL - RBC Shuttle	MDV	13	3,380	0.70	8.0E-03	7.3E-02	9.5E-03
	BART - RBC Shuttle	MDV	25	6,500	0.70	8.0E-03	0.14	1.8E-02
	Employees	LDA	3,453	897,702	0.86	3.3E-03	9.8	1.3
	Total CO Emissions						**10**	**1.3**
SO_2	Delivery Trucks	T6 Instate Small	14	3,558	0.56	0	0	0
	LBNL - RBC Shuttle	MDV	13	3,380	0.70	0	0	0
	BART - RBC Shuttle	MDV	25	6,500	0.70	0	0	0
	Employees	LDA	3,453	897,702	0.86	0	0	0
	Total SO_2 Emissions						**0**	**0**
PM_{10} Exhaust	Delivery Trucks	T6 Instate Small	14	3,558	0.56	2.8E-04	2.2E-03	2.8E-04
	LBNL - RBC Shuttle	MDV	13	3,380	0.70	1.9E-05	1.7E-04	2.2E-05
	BART - RBC Shuttle	MDV	25	6,500	0.70	1.9E-05	3.3E-04	4.3E-05
	Employees	LDA	3,453	897,702	0.86	1.6E-05	4.6E-02	6.0E-03
	Total PM_{10} Emissions						**4.9E-02**	**6.3E-03**
PM_{10} Tire/Brake	Delivery Trucks	T6 Instate Small	14	3,558	0.56	0	0	0
	LBNL - RBC Shuttle	MDV	13	3,380	0.70	0	0	0
	BART - RBC Shuttle	MDV	25	6,500	0.70	0	0	0
	Employees	LDA	3,453	897,702	0.86	0	0	0
	Total PM_{10} Emissions						**0**	**0**
$PM_{2.5}$ Exhaust	Delivery Trucks	T6 Instate Small	14	3,558	0.56	2.6E-04	2.0E-03	2.6E-04
	LBNL - RBC Shuttle	MDV	13	3,380	0.70	1.7E-05	1.6E-04	2.0E-05
	BART - RBC Shuttle	MDV	25	6,500	0.70	1.7E-05	3.0E-04	3.9E-05
	Employees	LDA	3,453	897,702	0.86	1.4E-05	4.3E-02	5.6E-03
	Total $PM_{2.5}$ Emissions						**4.5E-02**	**5.9E-03**
$PM_{2.5}$ Tire/Brake	Delivery Trucks	T6 Instate Small	14	3,558	0.56	0	0	0
	LBNL - RBC Shuttle	MDV	13	3,380	0.70	0	0	0
	BART - RBC Shuttle	MDV	25	6,500	0.70	0	0	0
	Employees	LDA	3,453	897,702	0.86	0	0	0
	Total $PM_{2.5}$ Emissions						**0**	**0**
CO_2	Delivery Trucks	T6 Instate Small	14	3,558	0.56	4.4	34	4.4
	LBNL - RBC Shuttle	MDV	13	3,380	0.70	2.6	24	3.1
	BART - RBC Shuttle	MDV	25	6,500	0.70	2.6	46	5.9
	Employees	LDA	3,453	897,702	0.86	1.3	3,949	513
	Total CO_2 Emissions						**4,052**	**527**

Notes:
(a) Maximum daily emissions estimate (lbs/day) = (Maximum daily round-trips [trips/day]) x (round-trip distance [miles]) x (emission factor [lbs/VMT])
(b) Annual average emissions estimate (tons/yr) = (Annual round-trips [trips/yr]) x (round-trip distance [miles]) x (emission factor [lbs/VMT]) x (ton/2,000 lbs)

References:
(1) See Table N-1, Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources.
(2) Emission Factors source: EMFAC 2011 (Model Years to 2034), 10 mph speed to represent average onsite speeds. Carbon dioxide emission factors are representative of post-Low Carbon Fuel Standard implementation.

Table N-4
Summary of Onsite Idling Exhaust Criteria Pollutant Emission Estimates

Pollutant	Vehicle Type	EMFAC Vehicle Class	Maximum Daily Round-Trips [1] (trips/day)	Total Annual Round-Trips [1] (trips/yr)	Idle Time per Trip [1] (hrs/trip)	Idle Emission Factor [2] (lbs/idle-hour)	Maximum Daily Emissions Estimate [a] (lbs/day)	Annual Average Emissions Estimate [b] (tons/yr)
ROG	Delivery Trucks	T6 Instate Small	14	3,558	8.3E-02	4.3E-03	4.9E-03	6.4E-04
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	3.6E-03	3.9E-03	5.1E-04
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	3.6E-03	7.5E-03	9.7E-04
	Employees	LDA	3,453	897,702	0	1.2E-03	0	0
	Total ROG Emissions						**1.6E-02**	**2.1E-03**
NO_X	Delivery Trucks	T6 Instate Small	14	3,558	8.3E-02	0.15	0.17	2.2E-02
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	6.0E-03	6.5E-03	8.4E-04
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	6.0E-03	1.2E-02	1.6E-03
	Employees	LDA	3,453	897,702	0	1.7E-03	0	0
	Total NO_X Emissions						**0.19**	**2.4E-02**
CO	Delivery Trucks	T6 Instate Small	14	3,558	8.3E-02	4.9E-02	5.6E-02	7.3E-03
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	4.7E-02	5.1E-02	6.6E-03
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	4.7E-02	9.8E-02	1.3E-02
	Employees	LDA	3,453	897,702	0	1.9E-02	0	0
	Total CO Emissions						**0.21**	**2.7E-02**
SO_2	Delivery Trucks	T6 Instate Small	14	3,558	8.3E-02	1.6E-04	1.8E-04	2.4E-05
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	0	0	0
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	0	0	0
	Employees	LDA	3,453	897,702	0	0	0	0
	Total SO_2 Emissions						**1.8E-04**	**2.4E-05**
PM_{10} Exhaust	Delivery Trucks	T6 Instate Small	14	3,558	8.3E-02	4.8E-04	5.4E-04	7.0E-05
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	1.5E-04	1.6E-04	2.1E-05
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	1.5E-04	3.1E-04	4.1E-05
	Employees	LDA	3,453	897,702	0	1.2E-04	0	0
	Total PM_{10} Emissions						**1.0E-03**	**1.3E-04**
$PM_{2.5}$ Exhaust	Delivery Trucks	T6 Instate Small	14	3,558	8.3E-02	4.4E-04	5.0E-04	6.5E-05
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	1.4E-04	1.5E-04	2.0E-05
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	1.4E-04	2.9E-04	3.8E-05
	Employees	LDA	3,453	897,702	0	1.1E-04	0	0
	Total $PM_{2.5}$ Emissions						**9.4E-04**	**1.2E-04**
CO_2	Delivery Trucks	T6 Instate Small	14	3,558	8.3E-02	16	18	2.3
	LBNL - RBC Shuttle	MDV	13	3,380	8.3E-02	18	19	2.5
	BART - RBC Shuttle	MDV	25	6,500	8.3E-02	18	37	4.8
	Employees	LDA	3,453	897,702	0	9.1	0	0
	Total CO_2 Emissions						**74**	**9.6**

Notes:
(a) Maximum daily emissions estimate (lbs/day) = (Maximum daily round-trips [trips/day]) x (idle time per trip [hrs/trip]) x (emission factor [lbs/idle-hr])
(b) Annual average emissions estimate (tons/yr) = (Annual round-trips [trips/yr]) x (idle time per trip [hrs/trip]) x (emission factor [lbs/idle-hr]) x (ton/2,000 lbs)

References:
(1) See Table N-1, Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources.
(2) Emission Factors source: EMFAC 2011 (Model Years to 2034). Emissions for Light Duty Vehicle Idling assumed to be negligible, and thus not quantified. Carbon dioxide emission factors are representative of post-Low Carbon Fuel Standard implementation.

Table N-5

Onsite Parking Lot Emission Estimates

Source		Parking Lot (total)
EMFAC Vehicle Class	(1)	LDA
Number of Vehicle Trips per Day	(2)	3,453
Number of Vehicle Trips per Year	(2)	897,702
Modeling ID		LOT_EX

Pollutant	Emission Factor (3) (lbs/trip)	Maximum Daily Emissions Estimate (a) (lbs/day)	Annual Average Emissions Estimate (b) (tons/yr)
PM_{10}	6.97E-06	0.024	3.1E-03
$PM_{2.5}$	6.45E-06	0.022	2.9E-03
NO_X	2.62E-04	0.91	0.12
CO	4.37E-03	15.1	1.96
SO_2	1.70E-06	5.9E-03	7.6E-04
ROG	7.14E-04	2.47	0.32
CO_2	0.16	562	73.0

Notes:

(a) Daily emissions estimate (lbs/day) =(Emission factor [lbs/trip]) x (number of vehicle trips per day)

(b) Annual emissions estimate (lbs/day) =(Emission factor [lbs/trip]) x (number of vehicle trips per year) x (ton/2,000 lbs)

References:

(1) LDA represents light-duty employee vehicles.

(2) See Table N-1, Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources.

(3) EMFAC 2011. Emission factors are based on the stationary starting exhaust, diurnal, hot soak, and resting loss vehicle portions of the LDA class emissions, on a per trip basis.

Table N-6
Onsite Paved Road Dust Emission Estimates

Parameter		Employee Vehicles	Delivery Trucks	LBNL - RBC Shuttle	BART - RBC Shuttle	Total
Onsite Roundtrip Distance (mi/trip)	(1)	0.9	0.6	0.7	0.7	
Maximum Daily Trips (trips/day)	(1)	3,453	14	13	25	
Annual Trips (trips/yr)	(1)	897,702	3,558	3,380	6,500	

Pollutant	Daily Emission Factor [a] (lbs/VMT)	Annual Emission Factor [b] (lbs/VMT)	Maximum Daily Emissions Estimate [c] (lbs/day)	Annual Average Emissions Estimate [d] (tons/yr)	Maximum Daily Emissions Estimate [c] (lbs/day)	Annual Average Emissions Estimate [d] (tons/yr)	Maximum Daily Emissions Estimate [c] (lbs/day)	Annual Average Emissions Estimate [d] (tons/yr)	Maximum Daily Emissions Estimate [c] (lbs/day)	Annual Average Emissions Estimate [d] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate (tons/yr)
PM	9.8E-03	9.4E-03	28.9	3.60	0.075	9.3E-03	0.089	0.011	0.17	0.021	29.3	3.64
PM_{10}	2.0E-03	1.9E-03	5.79	0.72	0.015	1.9E-03	0.018	2.2E-03	0.034	4.2E-03	5.86	0.73
$PM_{2.5}$	4.8E-04	4.6E-04	1.42	0.18	3.7E-03	4.6E-04	4.4E-03	5.4E-04	8.4E-03	1.0E-03	1.44	0.18

Notes:

(a) Maximum daily emission factor (lbs/VMT) = $(k \times (sL)^{0.91} \times (W)^{1.02})$

k = aerodynamic particle size multiplier (PM) =	0.011	(2)
k = aerodynamic particle size multiplier (PM_{10}) =	0.0022	(2)
k = aerodynamic particle size multiplier ($PM_{2.5}$) =	0.00054	(2)
sL = surface material silt content (g/m^2) =	0.32	(3)
W = mean vehicle weight (tons) =	2.5	(4)

(b) Annual emission factor (lbs/VMT) = $(k \times (sL)^{0.91} \times (W)^{1.02}) \times ((1-P)/4N)$

k = aerodynamic particle size multiplier (PM) =	0.011	(2)
k = aerodynamic particle size multiplier (PM_{10}) =	0.0022	(2)
k = aerodynamic particle size multiplier ($PM_{2.5}$) =	0.00054	(2)
sL = surface material silt content (g/m^2) =	0.32	(3)
W = mean vehicle weight (tons) =	2.5	(4)
P = number of wet days (0.01 inches of precip.) =	62	(1)
N = number of days in averaging period =	365	

(c) Maximum daily emissions estimate (lbs/day) = (Emission factor [lbs/VMT]) x (maximum daily vehicle trips [trips/day]) x (onsite roundtrip distance [mi/trip]) x (1 - [control efficiency {%}] / 100)

Control efficiency (%) =	0%	(5)

(d) Annual emissions estimate (tons/yr) = (Emission factor [lbs/VMT]) x (annual vehicle trips [trips/yr]) x (onsite roundtrip distance [mi/trip]) x (ton/2,000 lbs) x (1 - [control efficiency {%}] / 100)

Control efficiency (%) =	0%	(5)

References:

(1) See Table N-1, Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources.
(2) AP-42 Chapter 13.2.1 (January, 2011), Table 13.2.1-1 "Particle Size Multipliers for Paved Road Equation".
(3) Section 7.9 of the CARB Emission Inventory Methodology. Assumes offsite roads are equivalent to local roads as shown in Table 3 (silt loading of 0.32 g/m^2).
(4) Mean vehicle weight is calculated as the weighted average of the individual vehicle weights (average of unloaded and loaded weight), weighted based on the individual annual truck trips divided by total annual truck trips.
(5) Engineering estimate.

Table N-7
Offsite Paved Road Dust Emission Estimates

Parameter		Employee Vehicles	Delivery Trucks	LBNL - RBC Shuttle	BART - RBC Shuttle	Total
Offsite Roundtrip Distance (mi/trip)	(1)	20	14	16	8	
Maximum Daily Trips (trips/day)	(1)	3,453	14	13	25	
Annual Trips (trips/yr)	(1)	897,702	3,558	3,380	6,500	

Pollutant	Daily Emission Factor [(a)] (lbs/VMT)	Annual Emission Factor [(b)] (lbs/VMT)	Maximum Daily Emissions Estimate [(c)] (lbs/day)	Annual Average Emissions Estimate [(d)] (tons/yr)	Maximum Daily Emissions Estimate [(c)] (lbs/day)	Annual Average Emissions Estimate [(d)] (tons/yr)	Maximum Daily Emissions Estimate [(c)] (lbs/day)	Annual Average Emissions Estimate [(d)] (tons/yr)	Maximum Daily Emissions Estimate [(c)] (lbs/day)	Annual Average Emissions Estimate [(d)] (tons/yr)	Maximum Daily Emissions Estimate (lbs/day)	Annual Average Emissions Estimate (tons/yr)
PM	1.3E-03	1.2E-03	89.6	11.2	0.24	0.030	0.26	0.032	0.25	0.032	90.4	11.2
PM_{10}	2.5E-04	2.4E-04	17.9	2.23	0.049	6.1E-03	0.051	6.4E-03	0.051	6.3E-03	18.1	2.25
$PM_{2.5}$	6.2E-05	6.0E-05	4.40	0.55	0.012	1.5E-03	0.013	1.6E-03	0.012	1.6E-03	4.44	0.55

Notes:

(a) Maximum daily emission factor (lbs/VMT) = $(k \times (sL)^{0.91} \times (W)^{1.02})$

k = aerodynamic particle size multiplier (PM) =	0.011	(2)
k = aerodynamic particle size multiplier (PM_{10}) =	0.0022	(2)
k = aerodynamic particle size multiplier ($PM_{2.5}$) =	0.00054	(2)
sL = surface material silt content (g/m^2) =	0.035	(3)
W = mean vehicle weight (tons) =	2.4	(3)

(b) Annual emission factor (lbs/VMT) = $(k \times (sL)^{0.91} \times (W)^{1.02}) \times ((1-P)/4N)$

k = aerodynamic particle size multiplier (PM) =	0.011	(2)
k = aerodynamic particle size multiplier (PM_{10}) =	0.0022	(2)
k = aerodynamic particle size multiplier ($PM_{2.5}$) =	0.00054	(2)
sL = surface material silt content (g/m^2) =	0.035	(3)
W = mean vehicle weight (tons) =	2.4	(3)
P = number of wet days (0.01 inches of precip.) =	62	(1)
N = number of days in averaging period =	365	

(c) Maximum daily emissions estimate (lbs/day) = (Emission factor [lbs/VMT]) x (maximum daily vehicle trips [trips/day]) x (offsite roundtrip distance [mi/trip]) x (1 - [control efficiency {%}] / 100)

Control efficiency (%) =	0%	(4)

(d) Annual emissions estimate (tons/yr) = (Emission factor [lbs/VMT]) x (annual vehicle trips [trips/yr]) x (offsite roundtrip distance [mi/trip]) x (ton/2,000 lbs) x (1 - [control efficiency {%}] / 100)

Control efficiency (%) =	0%	(4)

References:

(1) See Table N-1, Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources.
(2) AP-42 Chapter 13.2.1 (January, 2011), Table 13.2.1-1 "Particle Size Multipliers for Paved Road Equation".
(3) Section 7.9 of the CARB Emission Inventory Methodology. Assumes offsite roads are equivalent to major/collector roads as shown in Table 3 (silt loading of 0.035 g/m^2).
(4) Engineering estimate.

Table N-8
Natural Gas Boiler Criteria Emission Estimates

Pollutant					PM		PM_{10}		$PM_{2.5}$		NO_X		CO		SO_2		VOC		CO_2		CH_4		N_2O		CO_2e	
Emission Factor (lbs/MMscf)					7.60 (1)		7.60 (2)		7.60 (2)		18.72 (a)		84 (4)		0.6 (1)		5.5 (1)		120,162 (b)		2.27 (c)		0.23 (c)		120,280 (d)	
Source	Modeling ID	Maximum Hourly Fuel Usage (8) (MMBtu/hr)	Daily Operation (8) (hrs/day)	Annual Fuel Usage (8) (MMBtu/yr)	Emission Estimates																					
					Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (f) (tons/yr)
Natural Gas Boiler - Buildings 6 and 7	NGB_B6_7	24	24	42,000	4.26	0.16	4.26	0.16	4.26	0.16	10.5	0.39	47.1	1.73	0.34	0.012	3.08	0.11	67,328	2,474	1.27	0.047	0.13	4.7E-03	67,394	2,476
Natural Gas Boiler - Building 8	NGB_B8	12	24	21,000	2.13	0.078	2.13	0.078	2.13	0.078	5.24	0.19	23.5	0.86	0.17	6.2E-03	1.54	0.057	33,664	1,237	0.63	0.023	0.063	2.3E-03	33,697	1,238
Natural Gas Boiler - Building 9	NGB_B9	12	24	21,000	2.13	0.078	2.13	0.078	2.13	0.078	5.24	0.19	23.5	0.86	0.17	6.2E-03	1.54	0.057	33,664	1,237	0.63	0.023	0.063	2.3E-03	33,697	1,238
Natural Gas Boiler - Building 10	NGB_B10	11	24	15,267	1.95	0.057	1.95	0.057	1.95	0.057	4.81	0.14	21.6	0.63	0.15	4.5E-03	1.41	0.041	30,859	899	0.58	0.017	0.058	1.7E-03	30,889	900
Natural Gas Boiler - Building 11	NGB_B11	6	24	8,328	1.06	0.031	1.06	0.031	1.06	0.031	2.62	0.076	11.8	0.34	0.084	2.4E-03	0.77	0.022	16,832	491	0.32	9.3E-03	0.032	9.3E-04	16,849	491
Total					**11.5**	**0.40**	**11.5**	**0.40**	**11.5**	**0.40**	**28.4**	**0.99**	**127**	**4.43**	**0.91**	**0.032**	**8.35**	**0.29**	**182,347**	**6,338**	**3.44**	**0.12**	**0.34**	**0.012**	**182,526**	**6,344**

Notes:

(a) Emission factor (lbs/MMscf) = (NO_2 or CO emission limit [ppmv @ 3% O_2]) x (10^{-6}) x (NO_2 or CO molecular weight [lbs/lb-mol]) x (lb-mol/385.44 ft^3) x (natural gas f-factor [8,710 dscf/MMBtu]) x (20.9% O_2/[20.9% O_2 - 3% O_2]) x (heat content [Btu/scf])

BAAQMD NO_X emission limit (ppmv @ 3% O_2) =	15	(3)
BAAQMD CO emission limit (ppmv @ 3% O_2) =	400	(3)
NO_2 molecular weight (lbs/lb-mol) =	46	
CO molecular weight (lbs/lb-mol) =	28.01	
Natural gas heat content (Btu/scf) =	1,028	(5)

(b) CO_2 emission factor (lbs/MMscf) = (CO_2 emission factor [kg CO_2/MMBtu]) x (default high heat value (MMBtu/scf)) x (10^6 scf/MMscf) x (lb/0.453592 kg)

CO_2 emission factor (kg/MMBtu) =	53.02	(5)
Default high heat value (MMBtu/scf) =	1.028E-03	(5)

(c) CH_4 or N_2O emission factor (lbs/MMscf) = (CH_4 or N_2O emission factor [kg/MMBtu]) x (lb/0.453592 kg) x (natural gas heat content [Btu/scf])

CH_4 emission factor (kg/MMBtu) =	1.0E-03	(6)
N_2O emission factor (kg/MMBtu) =	1.0E-04	(6)
Natural gas heat content (Btu/scf) =	1,028	(5)

(d) CO_2e emission factor (lbs/MMscf) = (CO_2 emission factor [lbs/MMscf]) + (CH_4 emission factor [lbs/MMscf] x CH_4 global warming potential) + (N_2O emission factor [lbs/MMscf] x N_2O global warming potential)

Global warming potential of CH_4 =	21	(7)
Global warming potential of N_2O =	310	(7)

(e) Daily emissions estimate (lbs/day) = (Emission factor [lbs/MMscf]) x (maximum hourly heat input [MMBtu/hr]) x (daily hours of operation [hrs/day]) / (natural gas heat content [Btu/scf])

Natural gas heat content (Btu/scf) =	1,028	(5)

(f) Annual emissions estimate (tons/yr) = (emission factor [lbs/MMscf]) x (annual heat input [MMBtu/yr]) / (natural gas heat content [Btu/scf]) x (tons/2,000 lbs)

Natural gas heat content (Btu/scf) =	1,020	(5)

References:

(1) AP-42 Chapter 1.4 (July 1998), Table 1.4-2 "Emission Factors for Criteria Pollutants and Greenhouse Gases from Natural Gas Combustion".
(2) Assumes that 100% of PM is $PM_{2.5}$. Therefore, 100% of PM_{10} is $PM_{2.5}$.
(3) BAAQMD Emission Limits 307.2, 307.3, and 307.4 from Section 9-7-307..
(4) AP-42 Chapter 1.4 (July 1998), Table 1.4-1 "Emission Factors for NO_X and CO from Natural Gas Combustion".
(5) 40 CFR Part 98 Subpart C, Table C-1, Default CO_2 Emission Factors and High Heat Values for Various Types of Fuel.
(6) 40 CFR Part 98 Subpart C, Table C-2, Default CH_4 and N_2O Emission Factors for Various Types of Fuel.
(7) 40 CFR Part 98 Subpart A, Table A-1, Global Warming Potentials.
(8) See Table N-1, Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources.

Table N-9
Emergency Diesel Generator Criteria Emission Estimates

Pollutant				Min HP	Max HP	PM	PM_{10}	$PM_{2.5}$	NO_X	CO	SO_2	VOC	CO_2	CH_4	CO_2e
Emission Factor - Phase 1 Tier 4 Final (g/hp-hr)				440		0.01 (1)	0.01 (1)	0.01 (1)	0.3 (2)	2.2 (2)	-- (3)	0.14 (2)	-- (4)	--	--
Emission Factor - Tier 4 Final (g/hp-hr)				100	174	0.015 (1)	0.015 (1)	0.015 (1)	0.3 (2)	3.7 (2)	-- (3)	0.14 (2)	-- (4)	--	--
Emission Factor - Tier 4 Final (g/hp-hr)				175	749	0.015 (1)	0.015 (1)	0.015 (1)	0.3 (2)	2.2 (2)	-- (3)	0.14 (2)	-- (4)	--	--
Emission Factor - Tier 4 Final (g/hp-hr)				750	2,000	0.03 (1)	0.03 (1)	0.03 (1)	2.6 (2)	2.2 (2)	-- (3)	0.14 (2)	-- (4)	--	--
Emission Factor - Phase 1 Tier 4 Interim (g/hp-hr)				440		0.015 (2)	0.015 (2)	0.015 (2)	1.5 (2)	2.6 (2)	-- (3)	0.14 (2)	-- (4)	--	--
Source	Modeling ID	Generator Power Rating (5) (BHP)	Diesel Fuel Usage (5) (gal/hr)	Load Factor (6)	Annual Operation (5) (hrs/yr)	Tier 4 Final - Emission Estimates									
						Maximum Daily (a) (lbs/day)	Annual Average (b) (tons/yr)	Maximum Daily (a) (lbs/day)	Annual Average (b) (tons/yr)	Maximum Daily (a) (lbs/day)	Annual Average (b) (tons/yr)	Maximum Daily (a) (lbs/day)	Annual Average (b) (tons/yr)	Maximum Daily (a) (lbs/day)	Annual Average (b) (tons/yr)
Diesel Generator - Building 8	DG_B8	440	22.3	0.74	25.15	0.014	9.0E-05	0.014	9.0E-05	0.014	9.0E-05	0.43	2.7E-03	3.16	0.020
Diesel Generator - Building 9	DG_B9	440	22.3	0.74	25.15	0.014	9.0E-05	0.014	9.0E-05	0.014	9.0E-05	0.43	2.7E-03	3.16	0.020
Diesel Generator - Building 10	DG_B10	410	20.8	0.74	25.15	0.020	1.3E-04	0.020	1.3E-04	0.020	1.3E-04	0.40	2.5E-03	2.94	0.019
Diesel Generator - Building 11	DG_B11	240	12.2	0.74	25.15	0.012	7.4E-05	0.012	7.4E-05	0.012	7.4E-05	0.23	1.5E-03	1.72	0.011
						Tier 4 Interim - Emission Estimates									
Diesel Generator - Building 6	DG_B6	440	22.3	0.74	25.15	0.022	1.4E-04	0.022	1.4E-04	0.022	1.4E-04	2.15	0.014	3.73	0.023
Diesel Generator - Building 7	DG_B7	440	22.3	0.74	25.15	0.022	1.4E-04	0.022	1.4E-04	0.022	1.4E-04	2.15	0.014	3.73	0.023
Total						0.10	6.5E-04	0.10	6.5E-04	0.10	6.5E-04	5.80	0.036	18.4	0.12

Source	Modeling ID	Maximum Daily (c) (lbs/day)	Annual Average (b) (tons/yr)	Maximum Daily (d) (lbs/day)	Annual Average (b) (tons/yr)	Maximum Daily (9) (lbs/day)	Annual Average (b) (tons/yr)	Maximum Daily (e) (lbs/day)	Annual Average (b) (tons/yr)
Diesel Generator - Building 8	DG_B8	9.4E-03	5.9E-05	0.20	1.3E-03	996	6.26	0.018	1.1E-04	996	6.27
Diesel Generator - Building 9	DG_B9	9.4E-03	5.9E-05	0.20	1.3E-03	996	6.26	0.018	1.1E-04	996	6.27
Diesel Generator - Building 10	DG_B10	8.7E-03	5.5E-05	0.19	1.2E-03	928	5.84	0.017	1.1E-04	929	5.84
Diesel Generator - Building 11	DG_B11	5.1E-03	3.2E-05	0.11	6.9E-04	543	3.42	9.9E-03	6.2E-05	544	3.42
Diesel Generator - Building 6	DG_B6	9.4E-03	5.9E-05	0.20	1.3E-03	996	6.26	0.018	1.1E-04	996	6.27
Diesel Generator - Building 7	DG_B7	9.4E-03	5.9E-05	0.20	1.3E-03	996	6.26	0.018	1.1E-04	996	6.27
Total		0.051	3.2E-04	1.10	6.9E-03	5,456	34.3	0.099	6.2E-04	5,458	34.3

Notes:

(a) Maximum daily emission estimate (lbs/day) = (Emission factor [g/hp-hr]) x (generator power [hp]) x (load factor) x (maximum hours per day [hrs/day]) x (lb/453.59g)

Daily hours of operation (hrs/day) = 2 (5)

(b) Annual average emission estimate (tons/yr) = (Daily emissions [lbs/day]) / (daily hours of operation [hrs/day]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)

Daily hours of operation (hrs/day) = 2 (5)

(c) Maximum daily emissions estimate (lbs/day) = (Fuel sulfur content [ppmw] / 1,000,000) x (generator fuel consumption [gal/hr]) x (daily hours of operation [hrs/day]) x (diesel density [lbs/gal]) x ([SO_2 molecular weight {lbs/lb-mol}] / [sulfur molecular weight {lbs/lb-mol}])

Fuel sulfur content (ppmw) = 15 (7)
Daily hours of operation (hrs/day) = 2 (5)
Diesel density (lbs/gal) = 7
SO_2 molecular weight (lbs/lb-mol) = 64
Sulfur molecular weight (lbs/lb-mol) = 32

(d) Maximum daily emissions estimate (lbs/day) = (Fuel carbon content [%] / 100) x (generator fuel consumption [gal/hr]) x (daily hours of operation [hrs/day]) x (diesel density [lbs/gal]) x ([CO_2 molecular weight {lbs/lb-mol}] / [carbon molecular weight {lbs/lb-mol}])

Fuel carbon content (%) = 87 (8)
Daily hours of operation (hrs/day) = 2 (5)
Diesel density (lbs/gal) = 7
CO_2 molecular weight (lbs/lb-mol) = 44.0
Carbon molecular weight (lbs/lb-mol) = 12.0

(e) CO_2e emissions (lbs/day) = (CO_2 emissions [lbs/day]) + (CH_4 emissions [lbs/day] x CH_4 global warming potential) + (N_2O emissions [lbs/day] x N_2O global warming potential)

CH_4 Global Warming Potential (GWP) = 21 (10)
N_2O Global Warming Potential (GWP) = 310 (10)

References:

(1) The University has committed to purchasing engines for buildings 7 and 8 that achieve 0.01 g/hp-hr particulate matter emissions. Buildings 6 and 7 will not be under the control of LBNL, so interim Tier IV emission factors are assumed. All other engines will be based on Tier IV emission factors. Assumes all PM is PM2.5.
(2) CalEEMod Appendix D, Default Data Tables. Table 3.5, OFFROAD Emission Factor Based on Engine Tier. Assumes Tier 4 Final for LBNL-owned small engines (Buildings 9 and 8), and Tier 4 Interim for the Building 6&7 engine.
(3) Sulfur dioxide emissions calculated on a sulfur mass balance basis, assuming 100% of the fuel sulfur content is emitted as SO_2.
(4) Carbon dioxide emissions calculated on a carbon mass balance basis, conservatively assuming 100% of the fuel carbon content is emitted as CO_2.
(5) See Table N-1, Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources.
(6) Default load factor for generators in URBEMIS emissions model.
(7) California Code of Regulations Title 13, Division 3, Chapter 5, Article 2, Standards for Diesel Fuel.
(8) AP-42 Chapter 3.3 (October 1996) and 3.4 (October 1996), Footnote to criteria emission factor table.
(9) Assumes methane is 9% of VOC, based on footnote f of Table 3.4-1 in AP-42, Chapter 3.4. VOC emission factor is shown as ROG/TOG in CalEEMod Appendix D ,Table 3.5.
(10) 40 CFR Part 98 Subpart A, Table A-1, Global Warming Potentials.

Table N-10
Cooling Tower Particulate Emission Estimates

Pollutant					PM		PM_{10}		$PM_{2.5}$	
					Emission Estimates					
Source	Modeling ID	Total Circulation Water Rate [1] (gpm)	Drift Loss of Circulating Water [2] (%)	Annual Operation [1] (hrs/yr)	Maximum Daily [a] (lbs/day)	Annual Average [b] (tons/yr)	Maximum Daily [c] (lbs/day)	Annual Average [b] (tons/yr)	Maximum Daily [d] (lbs/day)	Annual Average [b] (tons/yr)
Cooling Tower - Building 8	CTB8C#	4,500	0.005	6,360	1.45	0.19	1.29	0.17	0.77	0.10
Cooling Tower - Building 9	CTB9C#	4,500	0.005	6,360	1.45	0.19	1.29	0.17	0.77	0.10
Cooling Tower - Building 10	CTB10C#	4,500	0.005	6,360	1.45	0.19	1.29	0.17	0.77	0.10
Cooling Tower - Building 11	CTB11C#	2,400	0.005	6,360	0.77	0.10	0.69	0.091	0.41	0.055
Cooling Tower - Buildings 6 and 7	CTB6_7C#	9000	0.005	6,360	2.90	0.38	2.58	0.34	1.55	0.21
Total					**8.01**	**1.06**	**7.14**	**0.95**	**4.28**	**0.57**

Notes:

(a) Maximum daily emissions estimate (lbs/day) = (Circulation water rate [gpm]) x (density of water [lbs/gal]) x (total dissolved solids concentration [ppmw]) x (10^{-6}) x (drift loss of circulating water [%] / 100) x (60 min/hr) x (daily hours of operation [hrs/day])

Total dissolved solids concentration (ppmw) = 536 (1)
Density of water (lbs/gal) = 8.34
Daily hours of operation (hrs/day) = 24 (1)

(b) Annual emissions estimate (tons/yr) = (Daily emissions [lbs/day]) / (daily hours of operation [hrs/day]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)

Daily hours of operation (hrs/day) = 24 (1)

(c) Maximum daily emissions estimate (lbs/day) = (PM emissions estimate [lbs/day]) x (percent of PM_{10} emissions [%] / 100)

Percent of PM_{10} emissions (%) = 89.0 (3)

(d) Maximum daily emissions estimate (lbs/day) = (PM_{10} emissions estimate [lbs/day]) x ($PM_{2.5}$ fraction of PM_{10})

$PM_{2.5}$ fraction of PM_{10} = 0.6 (4)

References:

(1) See Table N-1, Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources.
(2) Engineering judgment based on past work with industrial cooling towers.
(3) From the technical paper "Calculating Realistic PM10 Emissions from Cooling Towers", by Joel Reisman and Gordon Frisbie. The percent PM_{10} is based on total dissolved content.
(4) From Appendix A - Updated CEIDARS Table with PM2.5 Fractions to the CEQA handbook, supplemental information.

Table N-11
Hypothetical Phase 2 Operations Criteria Pollutant Emissions Summary - Annual Average Daily Emission Rates (1)

Source	Annual Operation (days/yr)	TAC		Criteria												Greenhouse Gases							
		DPM		PM_{10}		$PM_{2.5}$		NO_X		CO		SO_2		VOC		CO_2		CH_4		N_2O		CO_2e	
		(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)	(lbs/day)	(tons/yr)
Stationary Sources																							
Diesel generators	260	5.0E-03	6.5E-04	5.0E-03	6.5E-04	5.0E-03	6.5E-04	0.28	3.6E-02	0.89	0.12	2.5E-03	3.2E-04	5.3E-02	6.9E-03	264	34.3	4.8E-03	6.2E-04	0	0	264	34.3
Natural Gas Boilers	260	--	--	3.08	0.40	3.08	0.40	7.59	0.99	34.1	4.43	0.24	3.2E-02	2.23	0.29	48,751	6,338	0.92	0.12	9.2E-02	1.2E-02	48,799	6,344
Cooling Towers	260	--	--	7.27	0.95	4.36	0.57	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Onsite Stationary Source Emissions	**--**	**5.0E-03**	**6.5E-04**	**10.4**	**1.35**	**7.45**	**0.97**	**7.87**	**1.02**	**35.0**	**4.55**	**0.25**	**3.2E-02**	**2.28**	**0.30**	**49,015**	**6,372**	**0.92**	**0.12**	**9.2E-02**	**1.2E-02**	**49,063**	**6,378**
Onsite On-Road Vehicle Emission Sources																							
Onsite On-Road Exhaust - Delivery Trucks	260	2.2E-03	2.8E-04	2.2E-03	2.8E-04	2.0E-03	2.6E-04	8.6E-02	1.1E-02	3.0E-02	3.9E-03	0	0	1.6E-02	2.1E-03	33.5	4.36	--	--	--	--	33.5	4.36
Onsite On-Road Exhaust - LBNL-RBC Shuttle	260	--	--	1.7E-04	2.2E-05	1.6E-04	2.0E-05	9.4E-03	1.2E-03	7.3E-02	9.5E-03	0	0	4.2E-03	5.5E-04	23.7	3.08	--	--	--	--	23.7	3.08
Onsite On-Road Exhaust - BART-RBC Shuttle	260	--	--	3.3E-04	4.3E-05	3.0E-04	3.9E-05	1.8E-02	2.3E-03	0.14	1.8E-02	0	0	8.1E-03	1.1E-03	45.6	5.93	--	--	--	--	45.6	5.93
Onsite On-Road Exhaust - Employee Vehicles	260	--	--	4.6E-02	6.0E-03	4.3E-02	5.6E-03	0.87	0.11	9.76	1.27	0	0	0.47	6.2E-02	3,949	513	--	--	--	--	3,949	513
Onsite On-Road Dust - Delivery Trucks	260	--	--	1.4E-02	1.9E-03	3.5E-03	4.6E-04	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Onsite On-Road Dust - LBNL-RBC Shuttle	260	--	--	1.7E-02	2.2E-03	4.2E-03	5.4E-04	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Onsite On-Road Dust - BART-RBC Shuttle	260	--	--	3.3E-02	4.2E-03	8.0E-03	1.0E-03	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Onsite On-Road Dust - Employee Vehicles	260	--	--	5.54	0.72	1.36	0.18	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Onsite Idling Exhaust - Delivery Trucks	260	5.4E-04	7.0E-05	5.4E-04	7.0E-05	5.0E-04	6.5E-05	0.17	2.2E-02	5.6E-02	7.3E-03	1.8E-04	2.4E-05	4.9E-03	6.4E-04	17.8	2.32	--	--	--	--	17.8	2.32
Onsite Idling Exhaust - LBNL-RBC Shuttle	260	--	--	1.6E-04	2.1E-05	1.5E-04	2.0E-05	6.5E-03	8.4E-04	5.1E-02	6.6E-03	0	0	3.9E-03	5.1E-04	19.1	2.49	--	--	--	--	19.1	2.49
Onsite Idling Exhaust - BART-RBC Shuttle	260	--	--	3.1E-04	4.1E-05	2.9E-04	3.8E-05	1.2E-02	1.6E-03	9.8E-02	1.3E-02	0	0	7.5E-03	9.7E-04	36.8	4.79	--	--	--	--	36.8	4.79
Total Onsite Vehicle Parking Lot Emissions	**260**	**--**	**--**	**2.4E-02**	**3.1E-03**	**2.2E-02**	**2.9E-03**	**0.91**	**0.12**	**15.1**	**1.96**	**5.9E-03**	**7.6E-04**	**2.47**	**0.32**	**562**	**73.0**	**--**	**--**	**--**	**--**	**562**	**73.0**
Total Onsite On-Road Vehicle Emissions	**--**	**2.7E-03**	**3.5E-04**	**5.68**	**0.74**	**1.44**	**0.19**	**2.07**	**0.27**	**25.3**	**3.29**	**6.1E-03**	**7.9E-04**	**2.99**	**0.39**	**4,687**	**609**	**--**	**--**	**--**	**--**	**4,687**	**609**
Offsite On-Road Emissions																							
Offsite On-Road Exhaust - Delivery Trucks	260	3.7E-02	4.8E-03	9.7E-02	1.3E-02	5.9E-02	7.6E-03	0.98	0.13	0.26	3.3E-02	4.8E-03	6.2E-04	7.5E-02	9.8E-03	466	60.5	--	--	--	--	466	60.5
Offsite On-Road Exhaust - LBNL-RBC Shuttle	260	--	--	2.1E-02	2.7E-03	8.8E-03	1.1E-03	0.13	1.7E-02	0.92	0.12	2.6E-03	3.4E-04	7.5E-02	9.8E-03	221	28.7	--	--	--	--	221	28.7
Offsite On-Road Exhaust - BART-RBC Shuttle	260	--	--	2.1E-02	2.7E-03	8.7E-03	1.1E-03	0.13	1.7E-02	0.92	0.12	2.6E-03	3.4E-04	7.5E-02	9.7E-03	219	28.5	--	--	--	--	219	28.5
Offsite On-Road Exhaust - Employee Vehicles	260	--	--	7.22	0.94	3.01	0.39	13.7	1.77	135	17.5	0.53	6.9E-02	10.2	1.33	39,754	5,168	--	--	--	--	39,754	5,168
Offsite On-Road Dust - Delivery Trucks	260	--	--	4.7E-02	6.1E-03	1.1E-02	1.5E-03	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Offsite On-Road Dust - LBNL-RBC Shuttle	260	--	--	4.9E-02	6.4E-03	1.2E-02	1.6E-03	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Offsite On-Road Dust - BART-RBC Shuttle	260	--	--	4.9E-02	6.3E-03	1.2E-02	1.6E-03	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Offsite On-Road Dust - Employee Vehicles	260	--	--	17.2	2.23	4.21	0.55	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Offsite On-Road Vehicle Emissions	**--**	**3.7E-02**	**4.8E-03**	**24.7**	**3.21**	**7.33**	**0.95**	**14.9**	**1.94**	**137**	**17.8**	**0.54**	**7.0E-02**	**10.5**	**1.36**	**40,659**	**5,286**	**--**	**--**	**--**	**--**	**40,659**	**5,286**
Total Phase 1 Project Summary	**--**	**4.5E-02**	**5.8E-03**	**40.7**	**5.29**	**16.2**	**2.11**	**24.8**	**3.23**	**197**	**25.6**	**0.79**	**0.10**	**15.7**	**2.05**	**94,362**	**12,267**	**0.92**	**0.12**	**9.2E-02**	**1.2E-02**	**94,409**	**12,273**
Onsite Stationary Exhaust	**--**	**5.0E-03**	**6.5E-04**	**10.4**	**1.35**	**7.45**	**0.97**	**7.87**	**1.02**	**35.0**	**4.55**	**0.25**	**3.2E-02**	**2.28**	**0.30**	**49,015**	**6,372**	**0.92**	**0.12**	**9.2E-02**	**1.2E-02**	**49,063**	**6,378**
Onsite Mobile Exhaust	**--**	**2.7E-03**	**3.5E-04**	**7.4E-02**	**9.6E-03**	**6.8E-02**	**8.9E-03**	**2.07**	**0.27**	**25.3**	**3.29**	**6.1E-03**	**7.9E-04**	**2.99**	**0.39**	**4,687**	**609**	**0**	**0**	**0**	**0**	**4,687**	**609**
Onsite Fugitive Dust	**--**	**0**	**0**	**5.61**	**0.73**	**1.38**	**0.18**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**
Offsite Mobile Exhaust	**--**	**3.7E-02**	**4.8E-03**	**7.36**	**0.96**	**3.08**	**0.40**	**14.9**	**1.94**	**137**	**17.8**	**0.54**	**7.0E-02**	**10.5**	**1.36**	**40,659**	**5,286**	**0**	**0**	**0**	**0**	**40,659**	**5,286**
Offsite Fugitive Dust	**--**	**0**	**0**	**17.3**	**2.25**	**4.25**	**0.55**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**

References:

(1) Daily emission rates are annual average daily emission rates, which are calculated by dividing the annual emission rate by the annual days of operation, and converting form tons to pounds. Annual days of operation is set to 5 days per week, 52 weeks per year.

Table N-12
Onsite Employee Vehicle TAC Emission Estimates

Parameter		Parking Lot Emissions					Onroad Emissions
		Hot Soak / Running Evaporative	Resting Evaporative / Diurnal	Starting	Idling	Total	Running
Organic Speciation Profile	(1)	660	661	664	2105		2105
LDA TOG Emission Factor	(2)	8.19E-04 (lbs/vehicle)	1.52E-04 (lbs/vehicle)	3.33E-04 (lbs/vehicle)	1.99E-03 (lbs/hr)		1.74E-04 (lbs/VMT)
Maximum Daily Vehicle Trips (trips/day)	(3)	3,453	3,453	3,453	3,453		3,453
Annual Vehicle Trips (trips/yr)	(3)	897,702	897,702	897,702	897,702		897,702

TAC	CAS	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (c) (lbs/hr)	Annual Average Emissions Estimate (d) (tons/yr)	Maximum Hourly Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (e) (lbs/hr)	Annual Average Emissions Estimate (f) (tons/yr)
1,3-Butadiene	106-99-0	No Data	--	--	No Data	--	--	7.0E-03	5.0E-04	1.0E-03	5.5E-03	0	0	5.0E-04	1.0E-03	5.5E-03	1.8E-04	3.7E-04
2-Butanone	78-93-3	No Data	--	--	No Data	--	--	6.0E-04	4.3E-05	9.0E-05	2.0E-04	0	0	4.3E-05	9.0E-05	2.0E-04	6.4E-06	1.3E-05
Acetaldehyde	75-07-0	No Data	--	--	No Data	--	--	5.2E-03	3.7E-04	7.8E-04	2.8E-03	0	0	3.7E-04	7.8E-04	2.8E-03	9.0E-05	1.9E-04
Acrolein	107-02-8	No Data	--	--	No Data	--	--	1.1E-03	7.9E-05	1.6E-04	1.3E-03	0	0	7.9E-05	1.6E-04	1.3E-03	4.2E-05	8.7E-05
Benzene	71-43-2	0.010	1.8E-03	3.7E-03	3.6E-03	1.2E-04	2.5E-04	0.024	1.7E-03	3.6E-03	0.025	0	0	3.6E-03	7.6E-03	0.025	7.9E-04	1.7E-03
Ethylbenzene	100-41-4	0.016	2.9E-03	6.0E-03	1.2E-03	3.9E-05	8.2E-05	0.016	1.1E-03	2.4E-03	0.011	0	0	4.1E-03	8.5E-03	0.011	3.4E-04	7.0E-04
Formaldehyde	50-00-0	No Data	--	--	No Data	--	--	0.013	9.0E-04	1.9E-03	0.016	0	0	9.0E-04	1.9E-03	0.016	5.1E-04	1.1E-03
Methanol	67-56-1	1.0E-04	1.8E-05	3.7E-05	No Data	--	--	2.9E-03	2.1E-04	4.3E-04	1.2E-03	0	0	2.3E-04	4.7E-04	1.2E-03	3.9E-05	8.0E-05
Naphthalene	91-20-3	1.4E-03	2.5E-04	5.1E-04	No Data	--	--	7.0E-04	5.0E-05	1.0E-04	5.0E-04	0	0	3.0E-04	6.2E-04	5.0E-04	1.6E-05	3.3E-05
n-Hexane	110-54-3	7.6E-03	1.3E-03	2.8E-03	0.015	5.1E-04	1.1E-03	0.018	1.3E-03	2.7E-03	0.016	0	0	3.1E-03	6.5E-03	0.016	5.1E-04	1.1E-03
Propylene	115-07-1	No Data	--	--	No Data	--	--	0.033	2.4E-03	5.0E-03	0.031	0	0	2.4E-03	5.0E-03	0.031	9.8E-04	2.0E-03
Styrene	100-42-5	No Data	--	--	No Data	--	--	2.6E-03	1.9E-04	3.9E-04	1.2E-03	0	0	1.9E-04	3.9E-04	1.2E-03	3.9E-05	8.0E-05
Toluene	108-88-3	0.051	9.0E-03	0.019	0.017	5.6E-04	1.2E-03	0.074	5.3E-03	0.011	0.058	0	0	0.015	0.031	0.058	1.9E-03	3.9E-03
m-Xylene	108-38-3	0.027	4.8E-03	9.9E-03	3.4E-03	1.1E-04	2.3E-04	0.053	3.8E-03	7.9E-03	0.036	0	0	8.7E-03	0.018	0.036	1.1E-03	2.4E-03
o-Xylene	95-47-6	0.016	2.8E-03	5.9E-03	1.3E-03	4.3E-05	8.9E-05	0.018	1.3E-03	2.7E-03	0.012	0	0	4.2E-03	8.7E-03	0.012	4.0E-04	8.3E-04
p-Xylene	106-42-3	0.014	2.5E-03	5.1E-03	1.1E-03	3.6E-05	7.5E-05	No Data	--	--	No Data	--	--	2.5E-03	5.2E-03	No Data	--	--

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/vehicle]) x (maximum daily vehicle trips [trips/day]) x (TAC emission fraction) / (daily hours of operation [hrs/day])
Daily hours of operation (hrs/day) = 16 (3)

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/vehicle]) x (annual vehicle trips [trips/yr]) x (ton/2,000 lbs) x (TAC emission fraction)

(c) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/hr]) x (maximum daily vehicle trips [trips/day]) x (idling time per trip [hrs/trip]) x (TAC emission fraction) / (daily hours of operation [hrs/day])
Idling time per trip (hrs/trip) = 0 (3)
Daily hours of operation (hrs/day) = 16 (3)

(d) Annual emissions estimate (tons/yr) = (Emission factor [lbs/hr]) x (annual vehicle trips [trips/yr]) x (idling time per trip [hrs/trip]) x (ton/2,000 lbs) x (TAC emission fraction)
Idling time per trip (hrs/trip) = 0 (3)

(e) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/VMT]) x (maximum daily vehicle trips [trips/day]) x (onsite roundtrip distance [mi/trip]) x (TAC emission fraction) / (daily hours of operation [hrs/day])
Onsite roundtrip distance (mi/trip) = 0.86 (3)
Daily hours of operation (hrs/day) = 16 (3)

(f) Annual emissions estimate (tons/yr) = (Emission factor [lbs/VMT]) x (annual vehicle trips [trips/yr]) x (onsite roundtrip distance [mi/trip]) x (ton/2,000 lbs) x (TAC emission fraction)
Onsite roundtrip distance (mi/trip) = 0.86 (3)

References:

(1) California Air Resources Board Speciation Database. TAC emission fractions are derived from the individual speciation profiles listed. Profiles chosen to best represent the project vehicle fleet and existing gasoline formulation.
(2) Emission Factors source: EMFAC 2011 (Model Years to 2034). Onsite speed set to 15 mile per hour to conservatively estimate onsite emissions. No tire and brake wear emission factors are provided at 15 miles per hour.
(3) See Table N-1, Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources.

Table N-13
Offsite Employee Vehicle TAC Emission Estimates

Parameter		Onroad Emissions						Total
		Running		Tire Wear		Brake Wear		
Speciation Profile	(1)	2105	(organic)	472	(particulate)	473	(particulate)	
LDA Emission Factor (lbs/VMT)	(2)	6.64E-05	(TOG)	1.8E-05	(PM_{10})	8.1E-05	(PM_{10})	
Maximum Daily Vehicle Trips (trips/day)	(3)	3,453		3,453		3,453		
Annual Vehicle Trips (trips/yr)	(3)	897,702		897,702		897,702		

TAC	CAS	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of PM_{10} (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of PM_{10} (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	Maximum Hourly Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)
1,3-Butadiene	106-99-0	5.5E-03	1.6E-03	3.3E-03	--	--	--	--	--	--	1.6E-03	3.3E-03
2-Butanone	78-93-3	2.0E-04	5.8E-05	1.2E-04	--	--	--	--	--	--	5.8E-05	1.2E-04
Acetaldehyde	75-07-0	2.8E-03	8.2E-04	1.7E-03	--	--	--	--	--	--	8.2E-04	1.7E-03
Acrolein	107-02-8	1.3E-03	3.8E-04	7.9E-04	--	--	--	--	--	--	3.8E-04	7.9E-04
Benzene	71-43-2	0.025	7.2E-03	0.015	--	--	--	--	--	--	7.2E-03	0.015
Ethylbenzene	100-41-4	0.011	3.1E-03	6.4E-03	--	--	--	--	--	--	3.1E-03	6.4E-03
Formaldehyde	50-00-0	0.016	4.6E-03	9.6E-03	--	--	--	--	--	--	4.6E-03	9.6E-03
Methanol	67-56-1	1.2E-03	3.5E-04	7.3E-04	--	--	--	--	--	--	3.5E-04	7.3E-04
Naphthalene	91-20-3	5.0E-04	1.5E-04	3.0E-04	--	--	--	--	--	--	1.5E-04	3.0E-04
n-Hexane	110-54-3	0.016	4.7E-03	9.7E-03	--	--	--	--	--	--	4.7E-03	9.7E-03
Propylene	115-07-1	0.031	8.9E-03	0.019	--	--	--	--	--	--	8.9E-03	0.019
Styrene	100-42-5	1.2E-03	3.5E-04	7.3E-04	--	--	--	--	--	--	3.5E-04	7.3E-04
Toluene	108-88-3	0.058	0.017	0.035	--	--	--	--	--	--	0.017	0.035
m-Xylene	108-38-3	0.036	0.010	0.022	--	--	--	--	--	--	0.010	0.022
o-Xylene	95-47-6	0.012	3.6E-03	7.5E-03	--	--	--	--	--	--	3.6E-03	7.5E-03
Lead	7439-92-1	--	--	--	1.6E-04	1.2E-05	2.6E-05	5.0E-05	1.8E-05	3.7E-05	3.0E-05	6.3E-05
Manganese	7439-96-5	--	--	--	1.0E-04	7.8E-06	1.6E-05	1.7E-03	6.1E-04	1.3E-03	6.1E-04	1.3E-03
Nickel	7440-02-0	--	--	--	5.0E-05	3.9E-06	8.1E-06	6.6E-04	2.4E-04	4.9E-04	2.4E-04	5.0E-04
Arsenic	7440-38-2	--	--	--	No Data	--	--	1.0E-05	3.6E-06	7.4E-06	3.6E-06	7.4E-06
Copper	7440-50-8	--	--	--	4.9E-04	3.8E-05	7.9E-05	0.011	4.1E-03	8.5E-03	4.1E-03	8.6E-03
Vanadium	7440-62-2	--	--	--	No Data	--	--	6.6E-04	2.4E-04	4.9E-04	2.4E-04	4.9E-04
Bromine	7726-95-6	--	--	--	1.5E-05	1.2E-06	2.4E-06	4.0E-05	1.4E-05	3.0E-05	1.5E-05	3.2E-05
Selenium	7782-49-2	--	--	--	2.0E-05	1.6E-06	3.2E-06	2.0E-05	7.1E-06	1.5E-05	8.7E-06	1.8E-05
Chlorine	7782-50-5	--	--	--	7.8E-03	6.1E-04	1.3E-03	1.5E-03	5.4E-04	1.1E-03	1.1E-03	2.4E-03

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/VMT]) x (maximum daily vehicle trips [trips/day]) x (offsite roundtrip distance [mi/trip]) x (TAC emission fraction) / (daily hours of operation [hrs/day])

Offsite roundtrip distance (mi/trip) = 20.4 (3)

Daily hours of operation (hrs/day) = 16 (3)

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/VMT]) x (annual vehicle trips [trips/yr]) x (offsite roundtrip distance [mi/trip]) x (ton/2,000 lbs) x (TAC emission fraction)

Offsite roundtrip distance (mi/trip) = 20.4 (3)

References:

(1) California Air Resources Board Speciation Database. TAC emission fractions are derived from the individual speciation profiles listed. Profiles chosen to best represent the project vehicle fleet and existing gasoline formulation.

(2) Emission Factors source: EMFAC 2011 (Model Years to 2034).

(3) See Table N-1, Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources.

Table N-14
Onsite Shuttle TAC Emission Estimates

Parameter		LBNL - RBC Shuttle		BART - RBC Shuttle		Total
		Idling	Running	Idling	Running	
Organic Speciation Profile	(1)	2105	2105	2105	2105	
MDV TOG Emission Factor	(2)	5.47E-03 (lbs/hr)	4.75E-04 (lbs/VMT)	5.47E-03 (lbs/hr)	4.75E-04 (lbs/VMT)	
Maximum Daily Vehicle Trips (trips/day)	(3)	13	13	25	25	
Annual Vehicle Trips (trips/yr)	(3)	3,380	3,380	6,500	6,500	
Idling Time per Trip (hrs/trip)	(3)	0.083	--	0.083	--	
Daily Hours of Operation (hrs/day)	(3)	13	13	13	13	
Onsite Roundtrip[Distance (mi/trip)	(3)	--	0.698	--	0.698	

TAC	CAS	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (c) (lbs/hr)	Annual Average Emissions Estimate (d) (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (c) (lbs/hr)	Annual Average Emissions Estimate (d) (tons/yr)	Maximum Hourly Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)
1,3-Butadiene	106-99-0	5.5E-03	2.5E-06	4.2E-06	5.5E-03	1.8E-06	3.1E-06	5.5E-03	4.8E-06	8.2E-06	5.5E-03	3.5E-06	5.9E-06	1.3E-05	2.1E-05
2-Butanone	78-93-3	2.0E-04	9.1E-08	1.5E-07	2.0E-04	6.6E-08	1.1E-07	2.0E-04	1.8E-07	3.0E-07	2.0E-04	1.3E-07	2.2E-07	4.6E-07	7.8E-07
Acetaldehyde	75-07-0	2.8E-03	1.3E-06	2.2E-06	2.8E-03	9.3E-07	1.6E-06	2.8E-03	2.5E-06	4.1E-06	2.8E-03	1.8E-06	3.0E-06	6.4E-06	1.1E-05
Acrolein	107-02-8	1.3E-03	5.9E-07	1.0E-06	1.3E-03	4.3E-07	7.3E-07	1.3E-03	1.1E-06	1.9E-06	1.3E-03	8.3E-07	1.4E-06	3.0E-06	5.1E-06
Benzene	71-43-2	0.025	1.1E-05	1.9E-05	0.025	8.2E-06	1.4E-05	0.025	2.2E-05	3.7E-05	0.025	1.6E-05	2.7E-05	5.7E-05	9.6E-05
Ethylbenzene	100-41-4	0.011	4.8E-06	8.1E-06	0.011	3.5E-06	5.9E-06	0.011	9.2E-06	1.6E-05	0.011	6.7E-06	1.1E-05	2.4E-05	4.1E-05
Formaldehyde	50-00-0	0.016	7.2E-06	1.2E-05	0.016	5.2E-06	8.9E-06	0.016	1.4E-05	2.3E-05	0.016	1.0E-05	1.7E-05	3.6E-05	6.2E-05
Methanol	67-56-1	1.2E-03	5.5E-07	9.2E-07	1.2E-03	4.0E-07	6.7E-07	1.2E-03	1.1E-06	1.8E-06	1.2E-03	7.7E-07	1.3E-06	2.8E-06	4.7E-06
Naphthalene	91-20-3	5.0E-04	2.3E-07	3.9E-07	5.0E-04	1.7E-07	2.8E-07	5.0E-04	4.4E-07	7.4E-07	5.0E-04	3.2E-07	5.4E-07	1.2E-06	1.9E-06
n-Hexane	110-54-3	0.016	7.3E-06	1.2E-05	0.016	5.3E-06	9.0E-06	0.016	1.4E-05	2.4E-05	0.016	1.0E-05	1.7E-05	3.7E-05	6.2E-05
Propylene	115-07-1	0.031	1.4E-05	2.4E-05	0.031	1.0E-05	1.7E-05	0.031	2.7E-05	4.5E-05	0.031	2.0E-05	3.3E-05	7.0E-05	1.2E-04
Styrene	100-42-5	1.2E-03	5.5E-07	9.2E-07	1.2E-03	4.0E-07	6.7E-07	1.2E-03	1.1E-06	1.8E-06	1.2E-03	7.7E-07	1.3E-06	2.8E-06	4.7E-06
Toluene	108-88-3	0.058	2.6E-05	4.4E-05	0.058	1.9E-05	3.2E-05	0.058	5.1E-05	8.5E-05	0.058	3.7E-05	6.2E-05	1.3E-04	2.2E-04
m-Xylene	108-38-3	0.036	1.6E-05	2.7E-05	0.036	1.2E-05	2.0E-05	0.036	3.1E-05	5.3E-05	0.036	2.3E-05	3.8E-05	8.2E-05	1.4E-04
o-Xylene	95-47-6	0.012	5.7E-06	9.6E-06	0.012	4.1E-06	7.0E-06	0.012	1.1E-05	1.8E-05	0.012	7.9E-06	1.3E-05	2.9E-05	4.8E-05

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/hr]) x (maximum daily vehicle trips [trips/day]) x (idling time per trip [hrs/trip]) x (TAC emission fraction) / (daily hours of operation [hrs/day])

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/hr]) x (annual vehicle trips [trips/yr]) x (idling time per trip [hrs/trip]) x (ton/2,000 lbs) x (TAC emission fraction)

(c) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/VMT]) x (maximum daily vehicle trips [trips/day]) x (onsite roundtrip distance [mi/trip]) x (TAC emission fraction) / (daily hours of operation [hrs/day])
Offsite roundtrip distance (mi/trip) = 0.86 (3)

(d) Annual emissions estimate (tons/yr) = (Emission factor [lbs/VMT]) x (annual vehicle trips [trips/yr]) x (onsite roundtrip distance [mi/trip]) x (ton/2,000 lbs) x (TAC emission fraction)
Offsite roundtrip distance (mi/trip) = 0.86 (3)

References:

(1) California Air Resources Board Speciation Database. TAC emission fractions are derived from the individual speciation profiles listed. Profiles chosen to best represent the project vehicle fleet and existing gasoline formulation.

(2) Emission Factors source: EMFAC 2011 (Model Years to 2034). Onsite speed set to 15 mile per hour to conservatively estimate onsite emissions. No tire and brake wear emission factors are provided at 15 miles per hour.

(3) See Table N-1, Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources.

Table N-15
Offsite Shuttle TAC Emission Estimates

Parameter		LBNL - RBC Shuttle							BART - RBC Shuttle						
		Running		Tire Wear		Brake Wear		Total	Running		Tire Wear		Brake Wear		Total
Speciation Profile	(1)	2105	(organic)	472	(particulate)	473	(particulate)		2105	(organic)	472	(particulate)	473	(particulate)	
MDV Emission Factor (lbs/VMT)	(2)	1.79E-04	(TOG)	1.8E-05	(PM_{10})	8.1E-05	(PM_{10})		1.79E-04	(TOG)	1.8E-05	(PM_{10})	8.1E-05	(PM_{10})	
Maximum Daily Vehicle Trips (trips/day)	(3)	13		13		13			25		25		25		
Annual Vehicle Trips (trips/yr)	(3)	3,380		3,380		3,380			6,500		6,500		6,500		
Daily Hours of Operation (hrs/day)	(3)	13		13		13			13		13		13		
Offsite Roundtrip[Distance (mi/trip)	(3)	15.5		15.5		15.5			8.0		8.0		8.0		

TAC	CAS	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of PM_{10} (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of PM_{10} (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	Maximum Hourly Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)	TAC Emission Fraction of TOG (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of PM_{10} (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	TAC Emission Fraction of PM_{10} (1)	Maximum Hourly Emissions Estimate (a) (lbs/hr)	Annual Average Emissions Estimate (b) (tons/yr)	Maximum Hourly Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)
1,3-Butadiene	106-99-0	5.5E-03	1.5E-05	2.6E-05	--	--	--	--	--	--	1.5E-05	2.6E-05	5.5E-03	1.5E-05	2.6E-05	--	--	--	--	--	--	1.5E-05	2.6E-05
2-Butanone	78-93-3	2.0E-04	5.6E-07	9.4E-07	--	--	--	--	--	--	5.6E-07	9.4E-07	2.0E-04	5.5E-07	9.3E-07	--	--	--	--	--	--	5.5E-07	9.3E-07
Acetaldehyde	75-07-0	2.8E-03	7.8E-06	1.3E-05	--	--	--	--	--	--	7.8E-06	1.3E-05	2.8E-03	7.7E-06	1.3E-05	--	--	--	--	--	--	7.7E-06	1.3E-05
Acrolein	107-02-8	1.3E-03	3.6E-06	6.1E-06	--	--	--	--	--	--	3.6E-06	6.1E-06	1.3E-03	3.6E-06	6.1E-06	--	--	--	--	--	--	3.6E-06	6.1E-06
Benzene	71-43-2	0.025	6.9E-05	1.2E-04	--	--	--	--	--	--	6.9E-05	1.2E-04	0.025	6.8E-05	1.2E-04	--	--	--	--	--	--	6.8E-05	1.2E-04
Ethylbenzene	100-41-4	0.011	2.9E-05	4.9E-05	--	--	--	--	--	--	2.9E-05	4.9E-05	0.011	2.9E-05	4.9E-05	--	--	--	--	--	--	2.9E-05	4.9E-05
Formaldehyde	50-00-0	0.016	4.4E-05	7.4E-05	--	--	--	--	--	--	4.4E-05	7.4E-05	0.016	4.4E-05	7.4E-05	--	--	--	--	--	--	4.4E-05	7.4E-05
Methanol	67-56-1	1.2E-03	3.3E-06	5.6E-06	--	--	--	--	--	--	3.3E-06	5.6E-06	1.2E-03	3.3E-06	5.6E-06	--	--	--	--	--	--	3.3E-06	5.6E-06
Naphthalene	91-20-3	5.0E-04	1.4E-06	2.3E-06	--	--	--	--	--	--	1.4E-06	2.3E-06	5.0E-04	1.4E-06	2.3E-06	--	--	--	--	--	--	1.4E-06	2.3E-06
n-Hexane	110-54-3	0.016	4.4E-05	7.5E-05	--	--	--	--	--	--	4.4E-05	7.5E-05	0.016	4.4E-05	7.5E-05	--	--	--	--	--	--	4.4E-05	7.5E-05
Propylene	115-07-1	0.031	8.5E-05	1.4E-04	--	--	--	--	--	--	8.5E-05	1.4E-04	0.031	8.4E-05	1.4E-04	--	--	--	--	--	--	8.4E-05	1.4E-04
Styrene	100-42-5	1.2E-03	3.3E-06	5.6E-06	--	--	--	--	--	--	3.3E-06	5.6E-06	1.2E-03	3.3E-06	5.6E-06	--	--	--	--	--	--	3.3E-06	5.6E-06
Toluene	108-88-3	0.058	1.6E-04	2.7E-04	--	--	--	--	--	--	1.6E-04	2.7E-04	0.058	1.6E-04	2.7E-04	--	--	--	--	--	--	1.6E-04	2.7E-04
m-Xylene	108-38-3	0.036	9.9E-05	1.7E-04	--	--	--	--	--	--	9.9E-05	1.7E-04	0.036	9.8E-05	1.7E-04	--	--	--	--	--	--	9.8E-05	1.7E-04
o-Xylene	95-47-6	0.012	3.4E-05	5.8E-05	--	--	--	--	--	--	3.4E-05	5.8E-05	0.012	3.4E-05	5.8E-05	--	--	--	--	--	--	3.4E-05	5.8E-05
Lead	7439-92-1	--	--	--	1.6E-04	4.4E-08	7.4E-08	5.0E-05	6.3E-08	1.1E-07	1.1E-07	1.8E-07	--	--	--	1.6E-04	4.3E-08	7.3E-08	5.0E-05	6.2E-08	1.1E-07	1.1E-07	1.8E-07
Manganese	7439-96-5	--	--	--	1.0E-04	2.7E-08	4.6E-08	1.7E-03	2.1E-06	3.6E-06	2.2E-06	3.7E-06	--	--	--	1.0E-04	2.7E-08	4.6E-08	1.7E-03	2.1E-06	3.6E-06	2.1E-06	3.6E-06
Nickel	7440-02-0	--	--	--	5.0E-05	1.4E-08	2.3E-08	6.6E-04	8.3E-07	1.4E-06	8.4E-07	1.4E-06	--	--	--	5.0E-05	1.4E-08	2.3E-08	6.6E-04	8.2E-07	1.4E-06	8.4E-07	1.4E-06
Arsenic	7440-38-2	--	--	--	No Data	--	--	1.0E-05	1.3E-08	2.1E-08	1.3E-08	2.1E-08	--	--	--	No Data	--	--	1.0E-05	1.2E-08	2.1E-08	1.2E-08	2.1E-08
Copper	7440-50-8	--	--	--	4.9E-04	1.3E-07	2.3E-07	0.011	1.4E-05	2.4E-05	1.5E-05	2.5E-05	--	--	--	4.9E-04	1.3E-07	2.2E-07	0.011	1.4E-05	2.4E-05	1.4E-05	2.4E-05
Vanadium	7440-62-2	--	--	--	No Data	--	--	6.6E-04	8.3E-07	1.4E-06	8.3E-07	1.4E-06	--	--	--	No Data	--	--	6.6E-04	8.2E-07	1.4E-06	8.2E-07	1.4E-06
Bromine	7726-95-6	--	--	--	1.5E-05	4.1E-09	6.9E-09	4.0E-05	5.0E-08	8.5E-08	5.4E-08	9.2E-08	--	--	--	1.5E-05	4.1E-09	6.9E-09	4.0E-05	5.0E-08	8.4E-08	5.4E-08	9.1E-08
Selenium	7782-49-2	--	--	--	2.0E-05	5.5E-09	9.2E-09	2.0E-05	2.5E-08	4.2E-08	3.1E-08	5.2E-08	--	--	--	2.0E-05	5.4E-09	9.2E-09	2.0E-05	2.5E-08	4.2E-08	3.0E-08	5.1E-08
Chlorine	7782-50-5	--	--	--	7.8E-03	2.1E-06	3.6E-06	1.5E-03	1.9E-06	3.2E-06	4.0E-06	6.8E-06	--	--	--	7.8E-03	2.1E-06	3.6E-06	1.5E-03	1.9E-06	3.2E-06	4.0E-06	6.7E-06

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/VMT]) x (maximum daily vehicle trips [trips/day]) x (offsite roundtrip distance [mi/trip]) x (TAC emission fraction) / (daily hours of operation [hrs/day])

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/VMT]) x (annual vehicle trips [trips/yr]) x (offsite roundtrip distance [mi/trip]) x (ton/2,000 lbs) x (TAC emission fraction)

References:

(1) California Air Resources Board Speciation Database. TAC emission fractions are derived from the individual speciation profiles listed. Profiles chosen to best represent the project vehicle fleet and existing gasoline formulation.

(2) Emission Factors source: EMFAC 2011 (Model Years to 2034).

(3) See Table N-1, Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources.

Table N-16
Natural Gas Boiler TAC Emission Estimates

Source	Natural Gas Boiler - Buildings 6 and 7	Natural Gas Boiler - Building 8	Natural Gas Boiler - Building 9	Natural Gas Boiler - Building 10	Natural Gas Boiler - Building 11	Total
Maximum Hourly Fuel Usage (MMBtu/hr) (1)	24	12	12	11	6	
Daily Hours of Operation (hrs/day) (1)	24	24	24	24	24	
Annual Fuel Usage (MMBtu/yr) (1)	42,000	21,000	21,000	15,267	8,328	
Modeling ID	NGB_B6_7	NGB_B8	NGB_B9	NGB_B10	NGB_B11	

TAC	CAS	Emission Factor (lbs/MMscf)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly (a) (lbs/hr)	Annual Average (b) (tons/yr)	Maximum Hourly Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)
7,12-Dimethylbenz(a)anthracene	57-97-6	1.6E-05 (2)	3.8E-07	3.3E-07	1.9E-07	1.6E-07	1.9E-07	1.6E-07	1.7E-07	1.2E-07	9.4E-08	6.5E-08	1.0E-06	8.4E-07
Acetaldehyde	75-07-0	8.9E-03 (3)	2.1E-04	1.8E-04	1.0E-04	9.1E-05	1.0E-04	9.1E-05	9.6E-05	6.6E-05	5.2E-05	3.6E-05	5.7E-04	4.7E-04
Benzene	71-43-2	4.3E-03 (3)	1.0E-04	8.9E-05	5.1E-05	4.4E-05	5.1E-05	4.4E-05	4.6E-05	3.2E-05	2.5E-05	1.8E-05	2.7E-04	2.3E-04
Dichlorobenzene	25321-22-6	1.2E-03 (4)	2.8E-05	2.5E-05	1.4E-05	1.2E-05	1.4E-05	1.2E-05	1.3E-05	9.0E-06	7.1E-06	4.9E-06	7.6E-05	6.3E-05
Ethylbenzene	100-41-4	6.9E-03 (5)	1.6E-04	1.4E-04	8.1E-05	7.1E-05	8.1E-05	7.1E-05	7.4E-05	5.2E-05	4.1E-05	2.8E-05	4.4E-04	3.6E-04
Fluoranthene	206-44-0	3.0E-06 (2)	7.1E-08	6.2E-08	3.5E-08	3.1E-08	3.5E-08	3.1E-08	3.2E-08	2.2E-08	1.8E-08	1.2E-08	1.9E-07	1.6E-07
Formaldehyde	50-00-0	2.2E-01 (3)	5.2E-03	4.6E-03	2.6E-03	2.3E-03	2.6E-03	2.3E-03	2.4E-03	1.7E-03	1.3E-03	9.0E-04	0.014	0.012
n-Hexane	110-54-3	4.6E-03 (5)	1.1E-04	9.5E-05	5.4E-05	4.7E-05	5.4E-05	4.7E-05	5.0E-05	3.4E-05	2.7E-05	1.9E-05	2.9E-04	2.4E-04
Naphthalene	91-20-3	3.0E-04 (5)	7.1E-06	6.2E-06	3.5E-06	3.1E-06	3.5E-06	3.1E-06	3.2E-06	2.2E-06	1.8E-06	1.2E-06	1.9E-05	1.6E-05
Propylene	115-07-1	5.3E-01 (5)	0.012	0.011	6.2E-03	5.5E-03	6.2E-03	5.5E-03	5.7E-03	4.0E-03	3.1E-03	2.2E-03	0.034	0.028
Toluene	108-88-3	2.7E-02 (5)	6.2E-04	5.5E-04	3.1E-04	2.7E-04	3.1E-04	2.7E-04	2.9E-04	2.0E-04	1.6E-04	1.1E-04	1.7E-03	1.4E-03
Xylenes	1330-20-7	2.0E-02 (5)	4.6E-04	4.1E-04	2.3E-04	2.0E-04	2.3E-04	2.0E-04	2.1E-04	1.5E-04	1.2E-04	8.0E-05	1.3E-03	1.0E-03
Arsenic	7440-38-2	2.0E-04 (4)	4.7E-06	4.1E-06	2.4E-06	2.1E-06	2.4E-06	2.1E-06	2.2E-06	1.5E-06	1.2E-06	8.2E-07	1.3E-05	1.1E-05
Beryllium	7440-41-7	1.2E-05 (4)	2.8E-07	2.5E-07	1.4E-07	1.2E-07	1.4E-07	1.2E-07	1.3E-07	9.0E-08	7.1E-08	4.9E-08	7.6E-07	6.3E-07
Cadmium	7440-43-9	1.1E-03 (4)	2.6E-05	2.3E-05	1.3E-05	1.1E-05	1.3E-05	1.1E-05	1.2E-05	8.2E-06	6.5E-06	4.5E-06	7.0E-05	5.8E-05
Chromium VI	18540-29-9	2.4E-04 (6)	5.6E-06	4.9E-06	2.8E-06	2.5E-06	2.8E-06	2.5E-06	2.6E-06	1.8E-06	1.4E-06	9.7E-07	1.5E-05	1.3E-05
Cobalt	7440-48-4	8.4E-05 (4)	2.0E-06	1.7E-06	9.9E-07	8.6E-07	9.9E-07	8.6E-07	9.1E-07	6.3E-07	4.9E-07	3.4E-07	5.4E-06	4.4E-06
Copper	7440-50-8	8.5E-04 (4)	2.0E-05	1.8E-05	1.0E-05	8.8E-06	1.0E-05	8.8E-06	9.2E-06	6.4E-06	5.0E-06	3.5E-06	5.4E-05	4.5E-05
Lead	7439-92-1	5.0E-04 (4)	1.2E-05	1.0E-05	5.9E-06	5.1E-06	5.9E-06	5.1E-06	5.4E-06	3.7E-06	2.9E-06	2.0E-06	3.2E-05	2.6E-05
Manganese	7439-96-5	3.8E-04 (4)	8.9E-06	7.8E-06	4.5E-06	3.9E-06	4.5E-06	3.9E-06	4.1E-06	2.8E-06	2.2E-06	1.6E-06	2.4E-05	2.0E-05
Mercury	7439-97-6	2.6E-04 (4)	6.1E-06	5.4E-06	3.1E-06	2.7E-06	3.1E-06	2.7E-06	2.8E-06	1.9E-06	1.5E-06	1.1E-06	1.7E-05	1.4E-05
Nickel	7440-02-0	2.1E-03 (4)	4.9E-05	4.3E-05	2.5E-05	2.2E-05	2.5E-05	2.2E-05	2.3E-05	1.6E-05	1.2E-05	8.6E-06	1.3E-04	1.1E-04
Selenium	7782-49-2	2.4E-05 (4)	5.6E-07	4.9E-07	2.8E-07	2.5E-07	2.8E-07	2.5E-07	2.6E-07	1.8E-07	1.4E-07	9.8E-08	1.5E-06	1.3E-06

Notes:

(a) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/MMscf]) x (maximum hourly heat input [MMBtu/hr])/ (natural gas heat content [Btu/scf])
Natural gas heat content (Btu/scf) = 1,020 (2)

(b) Annual emissions estimate (tons/yr) = (Emission factor [lbs/MMscf]) x (annual heat input [MMBtu/yr]) / (natural gas heat content [Btu/scf]) x (tons/2,000 lbs)
Natural gas heat content (Btu/scf) = 1,020 (2)

References:

(1) See Table N-1, Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources.
(2) AP-42 Chapter 1.4 (July 1998), Table 1.4-3 "Emission Factors For Speciated Organic Compounds from Natural Gas Combustion".
(3) California Air Toxics Emission Factor (CATEF) Database under Natural Gas Boilers.
(4) AP-42 Chapter 1.4 (July 1998), Table 1.4-4 "Emission Factors For Metals from Natural Gas Combustion".
(5) Ventura Air Quality Management District emission factor database.
(6) The AP-42 total chromium emission factor was multiplied by 17% to correct for emissions of hexavalent chromium per EPA assumptions when regulating combustion sources under 40 CFR Part 63 Subpart DDDD.

Golder Associates

Table N-17
Emergency Diesel Generator TAC Emission Estimates

Source	Diesel Generator - Building 6	Diesel Generator - Building 7	Diesel Generator - Building 8	Diesel Generator - Building 9	Diesel Generator - Building 10	Diesel Generator - Building 11	Total
BHP [1]	440	440	440	440	410	240	
Diesel Fuel Combustion (gal/hr) [1]	22.3	22.3	22.3	22.3	20.8	12.2	
Load Factor [2]	0.74	0.74	0.74	0.74	0.74	0.74	
Annual Operation (hrs/yr) [1]	25.15	25.15	25.15	25.15	25.15	25.15	
Modeling ID	DG_B6	DG_B7	DG_B8	DG_B9	DG_B10	DG_B11	

TAC	CAS	Emission Factor (lbs/10^3 gal)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average [a] (tons/yr)	Maximum Hourly Emissions Estimate (lbs/hr)	Annual Average Emissions Estimate (tons/yr)
DPM	9901	-- [3]	0.011 [b]	1.4E-04	0.011 [b]	1.4E-04	7.2E-03 [b]	9.0E-05	7.2E-03 [b]	9.0E-05	0.010 [b]	1.3E-04	5.9E-03 [b]	7.4E-05	0.052	6.5E-04
1,3-Butadiene	106-99-0	2.17E-01 [4]	3.6E-03 [c]	4.5E-05	3.6E-03 [c]	4.5E-05	3.6E-03 [c]	4.5E-05	3.6E-03 [c]	4.5E-05	3.3E-03 [c]	4.2E-05	2.0E-03 [c]	2.5E-05	0.020	2.5E-04
Acetaldehyde	75-07-0	3.47E-03 [5]	5.7E-05 [c]	7.2E-07	5.7E-05 [c]	7.2E-07	5.7E-05 [c]	7.2E-07	5.7E-05 [c]	7.2E-07	5.3E-05 [c]	6.7E-07	3.1E-05 [c]	3.9E-07	3.1E-04	3.9E-06
Benzene	71-43-2	1.93E-01 [5]	3.2E-03 [c]	4.0E-05	3.2E-03 [c]	4.0E-05	3.2E-03 [c]	4.0E-05	3.2E-03 [c]	4.0E-05	3.0E-03 [c]	3.7E-05	1.7E-03 [c]	2.2E-05	0.017	2.2E-04
Benzo(a)anthracene	56-55-3	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	0	0
Benzo(b)fluoranthene	205-99-2	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	0	0
Benzo(k)fluoranthene	207-08-9	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	0	0
Chlorobenzene	108-90-7	2.00E-04 [4]	3.3E-06 [c]	4.2E-08	3.3E-06 [c]	4.2E-08	3.3E-06 [c]	4.2E-08	3.3E-06 [c]	4.2E-08	3.1E-06 [c]	3.9E-08	1.8E-06 [c]	2.3E-08	1.8E-05	2.3E-07
Chrysene	218-01-9	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	0	0
Dibenz(a,h)anthracene	53-70-3	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	0	0
Ethylbenzene	100-41-4	6.76E-03 [5]	1.1E-04 [c]	1.4E-06	1.1E-04 [c]	1.4E-06	1.1E-04 [c]	1.4E-06	1.1E-04 [c]	1.4E-06	1.0E-04 [c]	1.3E-06	6.1E-05 [c]	7.7E-07	6.1E-04	7.7E-06
Formaldehyde	50-00-0	5.06E-02 [5]	8.3E-04 [c]	1.0E-05	8.3E-04 [c]	1.0E-05	8.3E-04 [c]	1.0E-05	8.3E-04 [c]	1.0E-05	7.8E-04 [c]	9.8E-06	4.6E-04 [c]	5.7E-06	4.6E-03	5.8E-05
n-Hexane	110-54-3	1.39E-03 [5]	2.3E-05 [c]	2.9E-07	2.3E-05 [c]	2.9E-07	2.3E-05 [c]	2.9E-07	2.3E-05 [c]	2.9E-07	2.1E-05 [c]	2.7E-07	1.3E-05 [c]	1.6E-07	1.3E-04	1.6E-06
Hydrogen Chloride	7647-01-0	1.86E-01 [4]	3.1E-03 [c]	3.9E-05	3.1E-03 [c]	3.9E-05	3.1E-03 [c]	3.9E-05	3.1E-03 [c]	3.9E-05	2.9E-03 [c]	3.6E-05	1.7E-03 [c]	2.1E-05	0.017	2.1E-04
Indeno(1,2,3-cd)pyrene	193-39-5	-- [6]	--	--	--	--	--	--	--	--	--	--	--	--	0	0
Naphthalene	91-20-3	1.60E-02 [5]	2.6E-04 [c]	3.3E-06	2.6E-04 [c]	3.3E-06	2.6E-04 [c]	3.3E-06	2.6E-04 [c]	3.3E-06	2.5E-04 [c]	3.1E-06	1.4E-04 [c]	1.8E-06	1.4E-03	1.8E-05
Propylene	115-07-1	3.41E-01 [5]	5.6E-03 [c]	7.1E-05	5.6E-03 [c]	7.1E-05	5.6E-03 [c]	7.1E-05	5.6E-03 [c]	7.1E-05	5.2E-03 [c]	6.6E-05	3.1E-03 [c]	3.9E-05	0.031	3.9E-04
Toluene	108-88-3	6.12E-02 [5]	1.0E-03 [c]	1.3E-05	1.0E-03 [c]	1.3E-05	1.0E-03 [c]	1.3E-05	1.0E-03 [c]	1.3E-05	9.4E-04 [c]	1.2E-05	5.5E-04 [c]	6.9E-06	5.5E-03	7.0E-05
Xylenes	1330-20-7	4.24E-02 [4]	7.0E-04 [c]	8.8E-06	7.0E-04 [c]	8.8E-06	7.0E-04 [c]	8.8E-06	7.0E-04 [c]	8.8E-06	6.5E-04 [c]	8.2E-06	3.8E-04 [c]	4.8E-06	3.8E-03	4.8E-05
Arsenic	7440-38-2	1.60E-03 [4]	2.6E-05 [c]	3.3E-07	2.6E-05 [c]	3.3E-07	2.6E-05 [c]	3.3E-07	2.6E-05 [c]	3.3E-07	2.5E-05 [c]	3.1E-07	1.4E-05 [c]	1.8E-07	1.4E-04	1.8E-06
Cadmium	7440-43-9	1.50E-03 [4]	2.5E-05 [c]	3.1E-07	2.5E-05 [c]	3.1E-07	2.5E-05 [c]	3.1E-07	2.5E-05 [c]	3.1E-07	2.3E-05 [c]	2.9E-07	1.4E-05 [c]	1.7E-07	1.4E-04	1.7E-06
Chromium VI	18540-29-9	1.00E-04 [7]	1.7E-06 [c]	2.1E-08	1.7E-06 [c]	2.1E-08	1.7E-06 [c]	2.1E-08	1.7E-06 [c]	2.1E-08	1.5E-06 [c]	1.9E-08	9.0E-07 [c]	1.1E-08	9.0E-06	1.1E-07
Copper	7440-50-8	4.10E-03 [4]	6.8E-05 [c]	8.5E-07	6.8E-05 [c]	8.5E-07	6.8E-05 [c]	8.5E-07	6.8E-05 [c]	8.5E-07	6.3E-05 [c]	7.9E-07	3.7E-05 [c]	4.6E-07	3.7E-04	4.7E-06
Lead	7439-92-1	8.30E-03 [4]	1.4E-04 [c]	1.7E-06	1.4E-04 [c]	1.7E-06	1.4E-04 [c]	1.7E-06	1.4E-04 [c]	1.7E-06	1.3E-04 [c]	1.6E-06	7.5E-05 [c]	9.4E-07	7.5E-04	9.4E-06
Manganese	7439-96-5	3.10E-03 [4]	5.1E-05 [c]	6.4E-07	5.1E-05 [c]	6.4E-07	5.1E-05 [c]	6.4E-07	5.1E-05 [c]	6.4E-07	4.8E-05 [c]	6.0E-07	2.8E-05 [c]	3.5E-07	2.8E-04	3.5E-06
Mercury	7439-97-6	2.00E-03 [4]	3.3E-05 [c]	4.2E-07	3.3E-05 [c]	4.2E-07	3.3E-05 [c]	4.2E-07	3.3E-05 [c]	4.2E-07	3.1E-05 [c]	3.9E-07	1.8E-05 [c]	2.3E-07	1.8E-04	2.3E-06
Nickel	7440-02-0	3.90E-03 [4]	6.4E-05 [c]	8.1E-07	6.4E-05 [c]	8.1E-07	6.4E-05 [c]	8.1E-07	6.4E-05 [c]	8.1E-07	6.0E-05 [c]	7.5E-07	3.5E-05 [c]	4.4E-07	3.5E-04	4.4E-06
Selenium	7782-49-2	2.20E-03 [4]	3.6E-05 [c]	4.6E-07	3.6E-05 [c]	4.6E-07	3.6E-05 [c]	4.6E-07	3.6E-05 [c]	4.6E-07	3.4E-05 [c]	4.3E-07	2.0E-05 [c]	2.5E-07	2.0E-04	2.5E-06

Modeling ID	DG_B6	DG_B7	DG_B8	DG_B9	DG_B10	DG_B11
Diesel Particulate Emission factor (g/hp-hr) [6]	0.015	0.015	0.01	0.01	0.015	0.015

Notes:
(a) Annual average emission estimate (tons/yr) = (Maximum hourly emissions estimate [lbs/hr]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)
(b) Maximum hourly diesel particulate emissions estimate (lbs/hr) = (Emission factor [g/hp-hr]) x (engine horsepower [hp]) x (load factor) / (453.59 [g/lb])
(c) Maximum hourly emissions estimate (lbs/hr) = (Emission factor [lbs/10^3 gal]) x (load factor) x (fuel usage [gal/hr]) x (0.001 gal/10^3 gal)

References:
(1) See Table N-1, Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources.
(2) Default load factor for generators in URBEMIS emission model.
(3) See diesel particulate matter emission factors at the bottom of the table.
(4) Ventura County Air Pollution Control District AB 2588 Combustion Emission Factors Database, May 2001.
(5) California Toxic Emission Factor (CATEF) Database, except for Diesel PM. The emission factors for each TAC are averaged for diesel internal combustion engines operating at less than 13% oxygen in the exhaust. Per vendor information, the percent oxygen in the exhaust is less than 13% at loads greater than 50%. It is assumed that the generator would be run at 50% load or greater.
(6) Polycyclic Aromatic Hydrocarbons (PAHs) are assumed to be included in the particulate matter emission factor. PAHs that are not specifically listed in this table, but may be included in the particulate matter emission factor, include Acenaphthylene, Anthracene, Acenaphthene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(g,h,i)perylene, Chrysene, Dibenz(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene. For purposes of this inventory, it is assumed that all particulate is represented as Diesel Particulate Matter (DPM).
(7) The AP-42 total chromium emission factor was multiplied by 17% to correct for emissions of hexavalent chromium per EPA assumptions when regulating combustion sources under 40 CFR Part 63 Subpart DDDD.

Table N-18
Cooling Tower Particulate Emission Estimates

Pollutant				Bromine	
				Emissions Estimates	
Source	Modeling ID	PM_{10} Emission Rate [1] (lbs/day)	Annual Operation [1] (hrs/yr)	Maximum Daily [a] (lbs/hr)	Annual Average [b] (tons/yr)
Cooling Tower - Building 8	CTB8C#	1.29	6,360	1.0E-04	3.2E-04
Cooling Tower - Building 9	CTB9C#	1.29	6,360	1.0E-04	3.2E-04
Cooling Tower - Building 10	CTB10C#	1.29	6,360	1.0E-04	3.2E-04
Cooling Tower - Building 11	CTB11C#	0.69	6,360	5.3E-05	1.7E-04
Cooling Tower - Buildings 6 and 7	CTB6_7C#	2.58	6,360	2.0E-04	6.4E-04
Total				**5.5E-04**	**1.8E-03**

Notes:
(a) Maximum daily emissions estimate (lbs/day) = (PM_{10} emission rate [lbs/day]) x (ChemTreat CL-4910 bromine concentration [ppm]) / (total dissolved solids concentration [ppm]) / (daily hours of operation [hrs/day])

ChemTreat CL-4910 bromine concentration (ppm) =	1	(2)
Total dissolved solids concentration (ppmw) =	536	(3)
Daily hours of operation (hrs/day) =	24	(3)

(b) Annual emissions estimate (tons/yr) = (Hourly emissions [lbs/hr]) x (annual hours of operation [hrs/yr]) x (ton/2,000 lbs)

References:
(1) See Table N-10, Cooling Tower Particulate Emission Estimates.
(2) Provided by ChemTreat.
(3) See Table N-1, Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources.

Table N-19
Total Estimated Air Emissions of Laboratory Non-Radionuclide Liquid Chemicals

Source				Lab Hood Exhaust Stack - Buildings 6 and 7		Lab Hood Exhaust Stack - Building 8		Lab Hood Exhaust Stack - Building 9		Lab Hood Exhaust Stack - Building 10		Lab Hood Exhaust Stack - Building 11		Total	
Building size (gsf)			[1]	253,954		110,510		137,451		117,700		67,280			
Modeling ID				LAB_B6_7		LAB_B8		LAB_B9		LAB_B10		LAB_B11			
TAC	CAS	Total Phase I Emissions [2] (tons/yr)	Phase I Emissions Fraction [a] (tons/gsf/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [2] (tons/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [2] (tons/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [2] (tons/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [c] (tons/yr)	Maximum Hourly [b] (lbs/hr)	Annual Average [c] (tons/yr)	Maximum Hourly (lbs/hr)	Annual Average (tons/yr)
1,3-Butadiene	106-99-0	3.2E-04	6.3E-10	--	--	1.3E-03	3.2E-04	--	--	2.9E-04	7.4E-05	1.7E-04	4.2E-05	1.7E-03	4.3E-04
1,4-Dioxane	123-91-1	3.4E-03	6.8E-09	--	--	0.012	3.1E-03	1.4E-03	3.5E-04	3.2E-03	8.0E-04	1.8E-03	4.6E-04	0.019	4.7E-03
Acetaldehyde	75-07-0	1.6E-04	3.2E-10	--	--	6.3E-04	1.6E-04	--	--	1.5E-04	3.7E-05	8.5E-05	2.1E-05	8.7E-04	2.2E-04
Acrolein	107-02-8	7.7E-05	1.5E-10	3.1E-04	7.7E-05	--	--	--	--	7.2E-05	1.8E-05	4.1E-05	1.0E-05	4.2E-04	1.1E-04
Acrylic acid	79-10-7	1.1E-05	2.2E-11	--	--	4.4E-05	1.1E-05	--	--	1.0E-05	2.6E-06	5.9E-06	1.5E-06	6.0E-05	1.5E-05
Aniline	62-53-3	2.7E-06	5.4E-12	9.7E-07	2.4E-07	9.7E-06	2.4E-06	--	--	2.5E-06	6.3E-07	1.4E-06	3.6E-07	1.5E-05	3.7E-06
Benzene	71-43-2	2.1E-03	4.3E-09	2.1E-03	5.1E-04	4.4E-03	1.1E-03	2.1E-03	5.1E-04	2.0E-03	5.0E-04	1.1E-03	2.9E-04	0.012	2.9E-03
Benzyl chloride	100-44-7	5.7E-06	1.1E-11	--	--	2.3E-05	5.7E-06	--	--	5.3E-06	1.3E-06	3.0E-06	7.6E-07	3.1E-05	7.8E-06
Bromine	7726-95-6	1.2E-06	2.5E-12	--	--	4.9E-06	1.2E-06	--	--	1.2E-06	2.9E-07	6.6E-07	1.7E-07	6.8E-06	1.7E-06
Carbon tetrachloride	56-23-5	3.2E-04	6.5E-10	1.3E-03	3.2E-04	--	--	--	--	3.0E-04	7.6E-05	1.7E-04	4.4E-05	1.8E-03	4.4E-04
Chloroform	67-66-3	0.051	1.0E-07	0.082	0.020	0.074	0.018	0.049	0.012	0.048	0.012	0.027	6.9E-03	0.28	0.070
Diethanolamine	111-42-2	3.3E-09	6.6E-15	7.6E-09	1.9E-09	1.9E-09	4.7E-10	3.8E-09	9.5E-10	3.1E-09	7.8E-10	1.8E-09	4.5E-10	1.8E-08	4.6E-09
Dimethyl formamide	68-12-2	5.7E-04	1.1E-09	1.4E-03	3.6E-04	7.9E-04	2.0E-04	5.1E-05	1.3E-05	5.3E-04	1.3E-04	3.0E-04	7.6E-05	3.1E-03	7.8E-04
Epichlorohydrin	106-89-8	1.6E-05	3.2E-11	--	--	6.5E-05	1.6E-05	--	--	1.5E-05	3.8E-06	8.7E-06	2.2E-06	8.9E-05	2.2E-05
Ethylbenzene	100-41-4	1.0E-04	2.0E-10	--	--	4.0E-04	1.0E-04	--	--	9.3E-05	2.3E-05	5.3E-05	1.3E-05	5.5E-04	1.4E-04
Ethylene dichloride [EDC]	107-06-2	2.3E-03	4.6E-09	--	--	9.2E-03	2.3E-03	--	--	2.1E-03	5.4E-04	1.2E-03	3.1E-04	0.013	3.1E-03
Ethylene glycol	107-21-1	6.0E-06	1.2E-11	1.2E-05	3.0E-06	4.7E-06	1.2E-06	7.0E-06	1.8E-06	5.6E-06	1.4E-06	3.2E-06	8.0E-07	3.3E-05	8.2E-06
Ethylene glycol monomethyl ether	109-86-4	8.5E-05	1.7E-10	--	--	3.4E-04	8.5E-05	--	--	7.9E-05	2.0E-05	4.5E-05	1.1E-05	4.6E-04	1.2E-04
Formaldehyde	50-00-0	0.014	2.7E-08	0.043	0.011	3.5E-03	8.7E-04	7.5E-03	1.9E-03	0.013	3.2E-03	7.3E-03	1.8E-03	0.074	0.019
Glutaraldehyde	111-30-8	4.9E-05	9.8E-11	1.4E-04	3.6E-05	1.3E-05	3.3E-06	3.9E-05	9.8E-06	4.6E-05	1.1E-05	2.6E-05	6.6E-06	2.7E-04	6.7E-05
n-Hexane	110-54-3	0.044	8.8E-08	0.027	6.9E-03	0.14	0.035	8.7E-03	2.2E-03	0.041	0.010	0.024	5.9E-03	0.24	0.060
Hydrogen Chloride	7647-01-0	0.042	8.3E-08	0.090	0.023	0.049	0.012	0.028	7.0E-03	0.039	9.8E-03	0.022	5.6E-03	0.23	0.057
Hydrogen fluoride	7664-39-3	4.1E-05	8.2E-11	1.6E-04	4.1E-05	--	--	--	--	3.9E-05	9.7E-06	2.2E-05	5.5E-06	2.3E-04	5.7E-05
Isopropyl alcohol	67-63-0	0.039	7.8E-08	0.063	0.016	0.047	0.012	0.046	0.012	0.036	9.1E-03	0.021	5.2E-03	0.21	0.053
Lindane [gamma-Hexachlorocyclohexane]	58-89-9	1.3E-10	2.6E-16	5.2E-10	1.3E-10	--	--	--	--	1.2E-10	3.1E-11	7.0E-11	1.8E-11	7.2E-10	1.8E-10
m-Cresol	108-39-4	1.3E-06	2.6E-12	2.6E-06	6.5E-07	2.6E-06	6.5E-07	--	--	1.2E-06	3.1E-07	7.0E-07	1.7E-07	7.1E-06	1.8E-06
Methanol	67-56-1	0.050	1.0E-07	0.061	0.015	0.13	0.033	8.4E-03	2.1E-03	0.047	0.012	0.027	6.7E-03	0.27	0.068
2-Butanone	78-93-3	1.1E-03	2.1E-09	--	--	4.3E-03	1.1E-03	--	--	1.0E-03	2.5E-04	5.7E-04	1.4E-04	5.9E-03	1.5E-03
Methyl tert-butyl ether	1634-04-4	7.5E-04	1.5E-09	3.1E-04	7.7E-05	2.7E-03	6.7E-04	--	--	7.0E-04	1.8E-04	4.0E-04	1.0E-04	4.1E-03	1.0E-03
Methylene chloride [Dichloromethane]	75-09-2	0.056	1.1E-07	4.6E-03	1.2E-03	0.22	0.055	3.1E-04	7.7E-05	0.052	0.013	0.030	7.5E-03	0.30	0.076
Nitric acid	7697-37-2	2.1E-03	4.1E-09	--	--	6.5E-03	1.6E-03	1.7E-03	4.3E-04	1.9E-03	4.8E-04	1.1E-03	2.8E-04	0.011	2.8E-03
Tetrachloroehtene	127-18-4	2.6E-04	5.2E-10	--	--	1.0E-03	2.6E-04	--	--	2.4E-04	6.1E-05	1.4E-04	3.5E-05	1.4E-03	3.6E-04
Phosphoric acid	7664-38-2	5.9E-06	1.2E-11	7.5E-06	1.9E-06	1.0E-05	2.5E-06	6.0E-06	1.5E-06	5.5E-06	1.4E-06	3.2E-06	7.9E-07	3.2E-05	8.1E-06
Propylene glycol monomethyl ether	107-98-2	1.1E-05	2.1E-11	--	--	2.1E-05	5.3E-06	2.1E-05	5.3E-06	1.0E-05	2.5E-06	5.7E-06	1.4E-06	5.8E-05	1.5E-05
Propylene oxide	75-56-9	4.7E-07	9.3E-13	1.9E-06	4.7E-07	--	--	--	--	4.4E-07	1.1E-07	2.5E-07	6.2E-08	2.5E-06	6.4E-07
Styrene	100-42-5	3.0E-05	6.0E-11	--	--	1.2E-04	3.0E-05	--	--	2.8E-05	7.0E-06	1.6E-05	4.0E-06	1.6E-04	4.1E-05
Sulfuric acid	7664-93-9	2.1E-04	4.1E-10	3.4E-04	8.6E-05	4.1E-04	1.0E-04	6.7E-05	1.7E-05	1.9E-04	4.8E-05	1.1E-04	2.8E-05	1.1E-03	2.8E-04
Toluene	108-88-3	5.1E-03	1.0E-08	8.3E-03	2.1E-03	0.012	3.0E-03	3.1E-04	7.7E-05	4.8E-03	1.2E-03	2.7E-03	6.9E-04	0.028	7.0E-03
Trichloroethylene	79-01-6	1.2E-03	2.3E-09	1.2E-03	2.9E-04	3.5E-03	8.8E-04	--	--	1.1E-03	2.7E-04	6.2E-04	1.6E-04	6.4E-03	1.6E-03
Triethylamine	121-44-8	1.4E-03	2.8E-09	1.2E-03	3.1E-04	4.4E-03	1.1E-03	--	--	1.3E-03	3.3E-04	7.5E-04	1.9E-04	7.7E-03	1.9E-03
Xylenes	1330-20-7	9.6E-04	1.9E-09	3.8E-03	9.6E-04	--	--	--	--	8.9E-04	2.2E-04	5.1E-04	1.3E-04	5.2E-03	1.3E-03
Total - All Chemicals Listed		**0.32**	**6.3E-07**	**0.39**	**0.098**	**0.72**	**0.18**	**0.15**	**0.039**	**0.30**	**0.075**	**0.17**	**0.043**	**1.74**	**0.44**

Notes:

(a) Phase I emissions fraction (tons/gsf/yr) = (Phase I emissions [tons/yr]) / (total Phase I building gsf)

Total Phase I building gsf = 501,915 (1)

(b) Maximum hourly emissions estimate (lbs/hr) = (Annual average emissions [tons/year]) / (annual operation [days/year]) / (daily operation [hrs/day]) x (2,000 lbs/ton) x (conversion factor)

Annual operation for all buildings (days/year) = 260 (1)

Daily operation for all buildings (hrs/day) = 10 (1)

Conversion factor = 5.18 (3)

(c) Annual average emissions estimate (tons/yr) = (Phase I emissions fraction [tons/gsf/yr]) x (building size [gsf])

References:

(1) See Table N-1, Hypothetical Phase 2 Operations Input Assumptions for Emission Rate Calculations - Including Phase 1 Sources.

(2) Phase 1 Laboratory emissions calculated as part of the Phase 1 assessment. See Appendix G.

(3) Based in studies comparing maximum to average emission rates for laboratories. See text for further information.

Table N-20
Hypothetical Phase 2 Operations TAC Emissions Summary

TAC	CAS	Natural Gas Boilers		Diesel Generators		Cooling Towers		Laboratory Buildings		Onsite Onroad Exhaust		Offsite Onroad Exhaust		Total	
		(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)	(lbs/hr)	(tons/yr)
DPM [1]	9901	--	--	0.052	6.5E-04	--	--	--	--	1.7E-04	3.5E-04	2.3E-03	4.8E-03	0.054	5.8E-03
1,3-Butadiene	106-99-0	--	--	0.020	2.5E-04	--	--	1.7E-03	4.3E-04	6.9E-04	1.4E-03	1.6E-03	3.4E-03	0.024	5.5E-03
1,4-Dioxane	123-91-1	--	--	--	--	--	--	0.019	4.7E-03	--	--	--	--	0.019	4.7E-03
2-Butanone	78-93-3	--	--	--	--	--	--	5.9E-03	1.5E-03	5.0E-05	1.0E-04	5.9E-05	1.2E-04	6.0E-03	1.7E-03
7,12-Dimethylbenz(a)anthracene	57-97-6	1.0E-06	8.4E-07	--	--	--	--	--	--	--	--	--	--	1.0E-06	8.4E-07
Acetaldehyde	75-07-0	5.7E-04	4.7E-04	3.1E-04	3.9E-06	--	--	8.7E-04	2.2E-04	4.7E-04	9.7E-04	8.3E-04	1.7E-03	3.0E-03	3.4E-03
Acrolein	107-02-8	--	--	--	--	--	--	4.2E-04	1.1E-04	1.2E-04	2.6E-04	3.8E-04	8.0E-04	9.3E-04	1.2E-03
Acrylic acid	79-10-7	--	--	--	--	--	--	6.0E-05	1.5E-05	--	--	--	--	6.0E-05	1.5E-05
Aniline	62-53-3	--	--	--	--	--	--	1.5E-05	3.7E-06	--	--	--	--	1.5E-05	3.7E-06
Arsenic	7440-38-2	1.3E-05	1.1E-05	1.4E-04	1.8E-06	--	--	--	--	--	--	3.6E-06	7.4E-06	1.6E-04	2.0E-05
Benzene	71-43-2	2.7E-04	2.3E-04	0.017	2.2E-04	--	--	0.012	2.9E-03	4.5E-03	9.3E-03	7.3E-03	0.015	0.041	0.028
Benzyl chloride	100-44-7	--	--	--	--	--	--	3.1E-05	7.8E-06	--	--	--	--	3.1E-05	7.8E-06
Beryllium	7440-41-7	7.6E-07	6.3E-07	--	--	--	--	--	--	--	--	--	--	7.6E-07	6.3E-07
Bromine	7726-95-6	--	--	--	--	5.5E-04	1.8E-03	6.8E-06	1.7E-06	--	--	1.5E-05	3.2E-05	5.8E-04	1.8E-03
Cadmium	7440-43-9	7.0E-05	5.8E-05	1.4E-04	1.7E-06	--	--	--	--	--	--	--	--	2.1E-04	6.0E-05
Carbon tetrachloride	56-23-5	--	--	--	--	--	--	1.8E-03	4.4E-04	--	--	--	--	1.8E-03	4.4E-04
Chlorine	7782-50-5	--	--	--	--	--	--	--	--	--	--	1.1E-03	2.4E-03	1.1E-03	2.4E-03
Chlorobenzene	108-90-7	--	--	1.8E-05	2.3E-07	--	--	--	--	--	--	--	--	1.8E-05	2.3E-07
Chloroform	67-66-3	--	--	--	--	--	--	0.28	0.070	--	--	--	--	0.28	0.070
Chromium VI	18540-29-9	1.5E-05	1.3E-05	9.0E-06	1.1E-07	--	--	--	--	--	--	--	--	2.4E-05	1.3E-05
Cobalt	7440-48-4	5.4E-06	4.4E-06	--	--	--	--	--	--	--	--	--	--	5.4E-06	4.4E-06
Copper	7440-50-8	5.4E-05	4.5E-05	3.7E-04	4.7E-06	--	--	--	--	--	--	4.2E-03	8.6E-03	4.6E-03	8.7E-03
Dichlorobenzene	25321-22-6	7.6E-05	6.3E-05	--	--	--	--	--	--	--	--	--	--	7.6E-05	6.3E-05
Diethanolamine	111-42-2	--	--	--	--	--	--	1.8E-08	4.6E-09	--	--	--	--	1.8E-08	4.6E-09
Dimethyl formamide	68-12-2	--	--	--	--	--	--	3.1E-03	7.8E-04	--	--	--	--	3.1E-03	7.8E-04
Epichlorohydrin	106-89-8	--	--	--	--	--	--	8.9E-05	2.2E-05	--	--	--	--	8.9E-05	2.2E-05
Ethylbenzene	100-41-4	4.4E-04	3.6E-04	6.1E-04	7.7E-06	--	--	5.5E-04	1.4E-04	4.4E-03	9.2E-03	3.1E-03	6.4E-03	9.1E-03	0.016
Ethylene dichloride [EDC]	107-06-2	--	--	--	--	--	--	0.013	3.1E-03	--	--	--	--	0.013	3.1E-03
Ethylene glycol	107-21-1	--	--	--	--	--	--	3.3E-05	8.2E-06	--	--	--	--	3.3E-05	8.2E-06
Ethylene glycol monomethyl ether	109-86-4	--	--	--	--	--	--	4.6E-04	1.2E-04	--	--	--	--	4.6E-04	1.2E-04
Fluoranthene	206-44-0	1.9E-07	1.6E-07	--	--	--	--	--	--	--	--	--	--	1.9E-07	1.6E-07
Formaldehyde	50-00-0	0.014	0.012	4.6E-03	5.8E-05	--	--	0.074	0.019	1.4E-03	3.0E-03	4.7E-03	9.7E-03	0.099	0.043
Glutaraldehyde	111-30-8	--	--	--	--	--	--	2.7E-04	6.7E-05	--	--	--	--	2.7E-04	6.7E-05
Hydrogen Chloride	7647-01-0	--	--	0.017	2.1E-04	--	--	0.23	0.057	--	--	--	--	0.25	0.058
Hydrogen fluoride	7664-39-3	--	--	--	--	--	--	2.3E-04	5.7E-05	--	--	--	--	2.3E-04	5.7E-05
Isopropyl alcohol	67-63-0	--	--	--	--	--	--	0.21	0.053	--	--	--	--	0.21	0.053
Lead	7439-92-1	3.2E-05	2.6E-05	7.5E-04	9.4E-06	--	--	--	--	--	--	3.0E-05	6.3E-05	8.1E-04	9.9E-05
Lindane [gamma-Hexachlorocyclohexane]	58-89-9	--	--	--	--	--	--	7.2E-10	1.8E-10	--	--	--	--	7.2E-10	1.8E-10
Manganese	7439-96-5	2.4E-05	2.0E-05	2.8E-04	3.5E-06	--	--	--	--	--	--	6.2E-04	1.3E-03	9.2E-04	1.3E-03
m-Cresol	108-39-4	--	--	--	--	--	--	7.1E-06	1.8E-06	--	--	--	--	7.1E-06	1.8E-06
Mercury	7439-97-6	1.7E-05	1.4E-05	1.8E-04	2.3E-06	--	--	--	--	--	--	--	--	2.0E-04	1.6E-05
Methanol	67-56-1	--	--	--	--	--	--	0.27	0.068	2.7E-04	5.5E-04	3.5E-04	7.4E-04	0.27	0.070
Methyl tert-butyl ether	1634-04-4	--	--	--	--	--	--	4.1E-03	1.0E-03	--	--	--	--	4.1E-03	1.0E-03
Methylene chloride [Dichloromethane]	75-09-2	--	--	--	--	--	--	0.30	0.076	--	--	--	--	0.30	0.076
Naphthalene	91-20-3	1.9E-05	1.6E-05	1.4E-03	1.8E-05	--	--	--	--	3.1E-04	6.5E-04	1.5E-04	3.1E-04	1.9E-03	9.9E-04
n-Hexane	110-54-3	2.9E-04	2.4E-04	1.3E-04	1.6E-06	--	--	0.24	0.060	3.7E-03	7.7E-03	4.7E-03	9.8E-03	0.25	0.078
Nickel	7440-02-0	1.3E-04	1.1E-04	3.5E-04	4.4E-06	--	--	--	--	--	--	2.4E-04	5.0E-04	7.3E-04	6.1E-04
Nitric acid	7697-37-2	--	--	--	--	--	--	0.011	2.8E-03	--	--	--	--	0.011	2.8E-03
Phosphoric acid	7664-38-2	--	--	--	--	--	--	3.2E-05	8.1E-06	--	--	--	--	3.2E-05	8.1E-06
Propylene	115-07-1	0.034	0.028	0.031	3.9E-04	--	--	--	--	3.4E-03	7.1E-03	9.0E-03	0.019	0.077	0.054
Propylene glycol monomethyl ether	107-98-2	--	--	--	--	--	--	5.8E-05	1.5E-05	--	--	--	--	5.8E-05	1.5E-05
Propylene oxide	75-56-9	--	--	--	--	--	--	2.5E-06	6.4E-07	--	--	--	--	2.5E-06	6.4E-07
Selenium	7782-49-2	1.5E-06	1.3E-06	2.0E-04	2.5E-06	--	--	--	--	--	--	8.7E-06	1.8E-05	2.1E-04	2.2E-05
Styrene	100-42-5	--	--	--	--	--	--	1.6E-04	4.1E-05	2.3E-04	4.7E-04	3.5E-04	7.4E-04	7.5E-04	1.2E-03
Sulfuric acid	7664-93-9	--	--	--	--	--	--	1.1E-03	2.8E-04	--	--	--	--	1.1E-03	2.8E-04
Tetrachloroehtene	127-18-4	--	--	--	--	--	--	1.4E-03	3.6E-04	--	--	--	--	1.4E-03	3.6E-04
Toluene	108-88-3	1.7E-03	1.4E-03	5.5E-03	7.0E-05	--	--	0.028	7.0E-03	0.017	0.035	0.017	0.035	0.069	0.079
Trichloroethylene	79-01-6	--	--	--	--	--	--	6.4E-03	1.6E-03	--	--	--	--	6.4E-03	1.6E-03
Triethylamine	121-44-8	--	--	--	--	--	--	7.7E-03	1.9E-03	--	--	--	--	7.7E-03	1.9E-03
Vanadium	7440-62-2	--	--	--	--	--	--	--	--	--	--	2.4E-04	4.9E-04	2.4E-04	4.9E-04
m-Xylene	108-38-3	--	--	--	--	--	--	--	--	9.9E-03	0.021	0.011	0.022	0.020	0.042
o-Xylene	95-47-6	--	--	--	--	--	--	--	--	4.6E-03	9.6E-03	3.7E-03	7.6E-03	8.3E-03	0.017
p-Xylene	106-42-3	--	--	--	--	--	--	--	--	2.5E-03	5.2E-03	--	--	2.5E-03	5.2E-03
Xylenes	1330-20-7	1.3E-03	1.0E-03	3.8E-03	4.8E-05	--	--	5.2E-03	1.3E-03	--	--	--	--	0.010	2.4E-03
NO_2	10102-44-0	1.18	0.99	2.90	0.036	--	--	--	--	0.13	0.27	0.040	0.084	4.26	1.38
SO_2	7446-09-5	0.038	0.032	0.026	3.2E-04	--	--	--	--	3.8E-04	7.9E-04	1.4E-03	3.0E-03	0.065	0.036
CO	630-08-0	5.31	4.43	9.22	0.12	--	--	--	--	1.58	3.29	0.36	0.76	16.5	8.60

References:

(1) Assumes all PM_{10} emissions from mobile source combustion equals diesel particulate matter (DPM).

(2) NO_2 emissions are shown as NO_X emissions.

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Appendix C

Biological Resources

Richmond Field Station
Grassland Constraints Analysis

FINAL

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University of California, Berkeley

April 17, 2013

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Richmond Field Station
Grassland Constraints Analysis

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SUMMARY

The University of California proposes to establish a new major research campus at properties it owns in Richmond, California, including the Richmond Field Station (RFS), for consolidation of biosciences programs of the Lawrence Berkeley National Laboratory (LBNL) and for development of additional research-related facilities for both LBNL and UC Berkeley (UCB). The University proposes to rename a subset of the properties as the "Richmond Bay Campus" ("RBC").

The RFS, a satellite property for UCB which is located in the City of Richmond in the western portion of Contra Costa County, supports a coastal terrace prairie grassland vegetation community, which is a unique natural vegetation community in the region. Since 1993, numerous vegetation community studies have been conducted and restoration and management activities have taken place within the RFS site.

Wildlife Research Associates and Jane Valerius Environmental Consulting were commissioned by the University to conduct a constraints analysis of the coastal terrace prairie grassland. The intent of this analysis is to compile available information, consider these resources present on-site and provide some insight into environmental issues that should be addressed during environmental review processes under the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA). As part of the analysis of the current condition of the coastal terrace prairie grassland on the RFS site, we evaluated these meadow areas based on a variety of Special Status vegetation criteria established by the California Department of Fish and Wildlife (CDFW), as well as on other parameters that are unique to the site. The habitat value affecting qualifiers (e.g., size of the meadow, whether it is spatially isolated, hydrologically changed, etc.) are evaluated per meadow, which provides a more precise description of the existing grasslands values. Based on this review, potential impacts from the proposed development can be better addressed during the NEPA and CEQA process.

Located on the eastern edge of the San Francisco Bay, in the City of Richmond, the RFS is bounded by Meade Street, which runs parallel to Interstate 580 to the north, by Meeker Slough/Regatta Boulevard to the west and by South 46th Street to the east. The East Bay Regional Park District Bay Trail traverses the western portion of the property along the West Stege saltmarsh. The entire RFS campus encompasses 162 acres, of which 42 acres are undeveloped meadows that support grasslands. The site topography consists of gently south-facing, sloping lands with poorly drained clay soils.

The coastal terrace prairie grassland has undergone on-site restoration as part of the mitigation required for impacts of on-going remediation of historic contamination at the site. A collaborative effort between Jepson Herbarium and other UCB staff and faculty, the Watershed Project Staff, and local restoration experts, resulted in creation of grassland goals and objectives for the area identified for mitigation restoration. In 2003, the restoration was begun and monitoring occurred for four years. In 2007 a grassland maintenance regime that included mowing schedules per season, with appropriate heights to ensure survivorship of perennial grasses was instigated.

This analysis is an update describing existing conditions on the site and new vegetation classifications. We ranked the quality of coastal terrace prairie grassland habitat based on presence of absolute cover of California oatgrass (>25%) and/or purple needlegrass (5%) as described by the membership rule of the series in the Manual of California Vegetation (Sawyer, et al. 2009).

Coastal Terrace Prairie Grasslands Constraints
In general, lands used for mitigation cannot be impacted with future projects. Therefore, the southern portion of the Big Meadow and central portion of the West Meadow cannot be impacted due to their designation as mitigation lands, because remediation of the Western Stege Marsh in 2003 required unavoidable paving of a portion of historic grassland to create asphalt mixing pads for sediments removed from the marsh (The Watershed Project 2007, p. 4 of 77). On-site restoration of an ecosystem that has been degraded, damaged, or destroyed is often used as in-kind mitigation for impacts to sensitive communities and mitigation ratios have been developed for similar vegetation communities.

According to David Amme (2005), there are no other sites that match the soils and hydrology that occur at the RFS. If insufficient acreage occurs on the RFS site to mitigate for impacts to the coastal terrace prairie, then off-site creation mitigation may potentially be required, which would also require consultation with the agencies during the CEQA review. Such opportunities would have to be further investigated.

A buffer or set back should be developed between any buildings and the coastal terrace prairie grassland so that factors associated with construction and structures (i.e., soil compaction, high flow runoff from the roofs, etc.) do not impact the edges of the prairie grasslands. These factors potentially impacting the grasslands would have to be investigated and addressed during the CEQA review.

A geotechnical study would be required to determine adverse effect to the soils and hydrology in the Big Meadow if trenching, excavation or underground tunneling is proposed that will disrupt the soil profile. The grasses can reach 3 to 4 feet in rooting depth and California oatgrass is associated with mesic sites so any alteration of the hydrology, whether surface or groundwater, could have an adverse impact.

Although green roofs, similar in concept to the replanting of a concrete berm, often use native plant species, they are typically species that are adapted to shallow soils, usually less than 12 inches in depth, and are fragile in windy areas. In addition, the slopes of berms would require complex drainage and watering systems to prevent water from taking the path of least resistance and to remain on the berm long enough for adequate moisture.

Wildlife Constraints
Removal of the Eucalyptus grove may result in impacts to the monarch butterfly habitat, which is limited in the San Francisco Bay Area. Further analysis would be required to consider possible alternative species plantings that may also provide monarch habitat.

Removal of the Eucalyptus grove and existing shrubs may result in impacts to nesting birds if conducted during the nesting season (March through August). It is recommended that removal occur outside the nesting season.

Removal of existing buildings may impact roosting bats. A bat habitat assessment evaluating the potential for roosting is required prior to any removal and can be conducted at any time of the year. If suitable roosting habitat is determined to be present, it is recommended that removal of such habitat occur outside the hibernation season (October through February) and the maternity season (April through August).

1.0 INTRODUCTION

Wildlife Research Associates and Jane Valerius Environmental Consulting were commissioned to conduct a constraints analysis of the coastal terrace prairie grassland. The purpose of this constraints analysis is to assist the University of California, Berkeley (UCB) and Lawrence Berkeley National Laboratory (LBNL) with the identification of key environmental issues that should be analyzed during the planning and preliminary analysis of proposed development at the University of California Richmond Field Station, located in the southern portion of the City of Richmond, Contra Costa County, with regards to biological resources. This constraints analysis primarily focuses on environmental compliance with respect to the coastal terrace prairie grassland, a vegetation community that is unique to this portion of the western Contra Costa County.

Considered one of the largest and best-preserved remaining areas of native coastal grasslands once prevalent throughout the San Francisco Bay Area (Tetra Tech and Sea Engineering 2007), the coastal terrace prairie grassland at RFS, as described by *A Manual of California Vegetation* (Sawyer, et al. 2009), which provides a standardized, systematic classification and description of vegetation in the California, is made up of two vegetation alliances. These alliances are the California oatgrass prairie (*Danthonia californica*) (#41.050.00) and purple needlegrass grassland (*Nassella pulchra*) (#41.150.00) and are identified in the California Natural Diversity Data Base, run by the California Department of Fish and Wildlife (CDFW), as coastal terrace prairie grassland and valley needlegrass grassland, respectively.

The intent of this analysis is to compile available information, consider these resources present on-site and provide some insight into environmental issues that will need to be addressed during the environmental review and permitting process. As part of the analysis of the current condition of the coastal terrace prairie grassland on the RFS site, we evaluated these meadow areas based on a variety of Special Status vegetation criteria established by the CDFW, as well as on other parameters that are unique to the site. The habitat value affecting qualifiers (e.g., size of the meadow, whether it is spatially isolated, hydrologically altered, etc.) are evaluated per meadow, which provides a more precise description of the existing grasslands values. Based on this review, potential impacts from the proposed development can be better addressed and the grassland areas that are identified with higher values than other areas can be better protected. Specifically, the purpose is to (1) determine whether there are potential liabilities or "fatal flaws" that would preclude or prohibit project implementation and (2) assess the project and recommended alternatives from an environmental permitting/compliance perspective including potential permitting and mitigation requirements, timelines and costs.

1.1 Existing Area Description

The Richmond Field Station, located at 1301 South 46th Street in Richmond California, is currently owned by the University of California Regents for use by the UCB campus. Once part of the larger Rancho San Pablo, the RFS is located on the eastern edge of the San Francisco Bay, in the south central portion of the City of Richmond (Figure 1). The RFS is bounded by Meade Street, which runs parallel to Interstate 580 to the north, by Meeker Slough/Regatta Boulevard to the west and by South 46th Street to the east. The East Bay Regional Park District Bay Trail traverses the southern portion of the property along the Western Stege saltmarsh. Totaling 162 acres, the upland habitat encompasses 96 acres, which is comprised of industrial-zoned land used primarily for research and education (Tetra Tech and Sea Engineering 2007). Of these 96 acres, approximately 42 acres are undeveloped meadows that support grasslands.

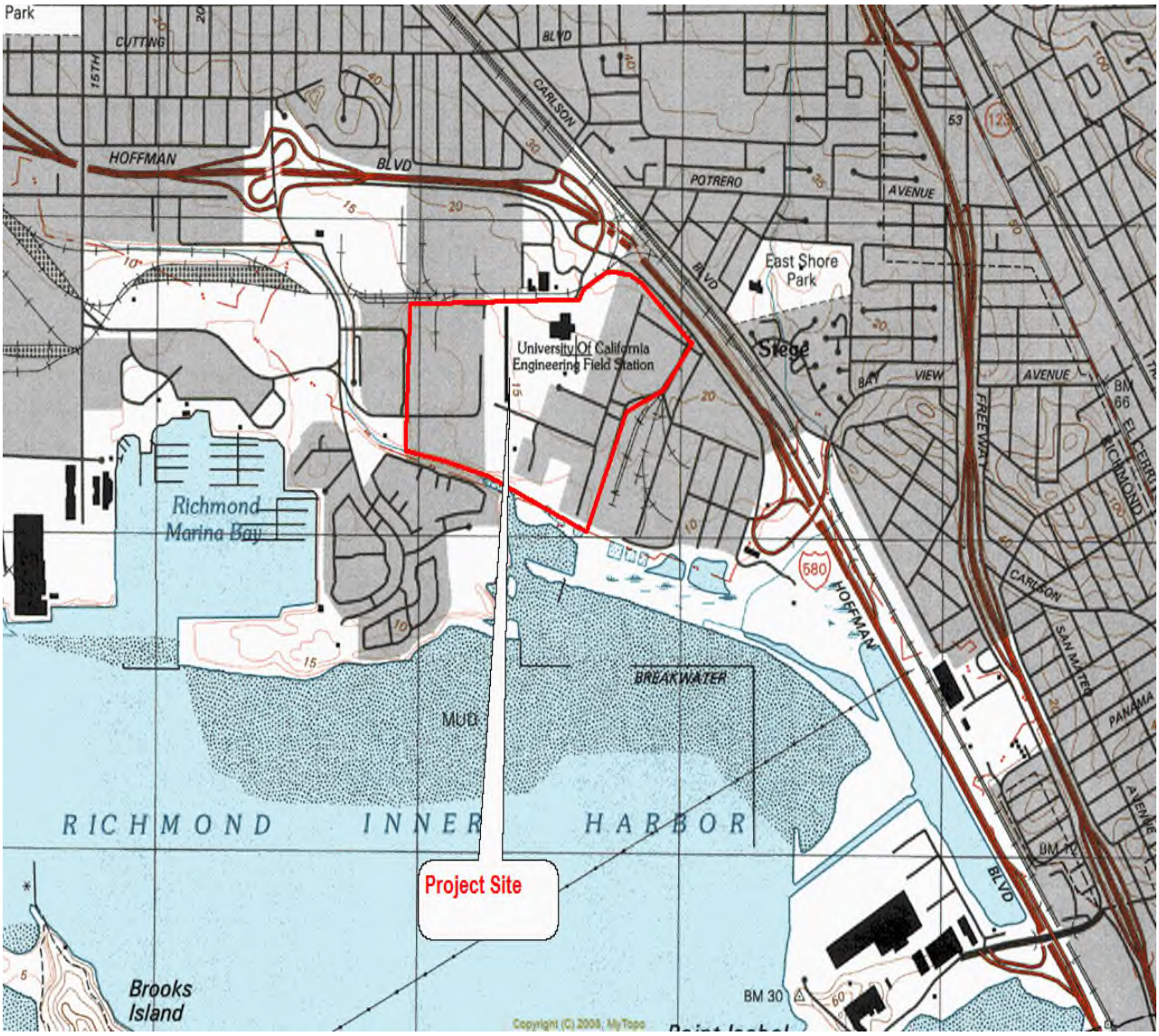

Figure 1 – Richmond Field Station Project Site

The undeveloped meadows, comprised of 13 discrete areas, are located primarily along the western portion of the RFS with the largest (Big Meadow) being 13 acres, as shown Figure 2 of the *Richmond Field Station Final Botanical Survey Report* (URS 2007) (Figure 2). All other meadows range in size between 1-5 acres. For purposes of this report, the property consists of those lands within the 96 acre property boundaries which comprise grasslands and seasonal wetlands.

The soil is a mixture of poorly drained clay of the Clear Lake –Cropley Association, that often forms a perched water table in the winter rainy season and has a high shrink-swell potential, and the Joice-Reyes association, that is very poorly drained saline mucks and silty clays on saltwater marshes and tidal flats (USDA 1977).

1.2 Background Studies

As described in the *Richmond Research Center Master Plan Environmental Impact Report: Existing Conditions of Grassland Resources* (David Amme Associates 1993), biological studies have been conducted at the RFS since 1963. Among the research completed are small mammal enclosure experiments, and inventories of flowering plants, reptiles, amphibians, mammals and birds. In the report, the study area was divided into three discrete areas, 1) the area east of the eucalyptus grove, 2) the area west of the eucalyptus grove, and 3) the created land south of the chain-link fence (now located south of the existing EPA building) (David Amme Associates 1993).

After conducting field surveys in October and November 1993, Amme further refined these three areas into grasslands that were classified into four categories and are described as follows (David Amme Associates 1993):

- Disturbed/closely mowed grassland – this vegetation type is directly related to mowing regime and is dominated by California oatgrass with purple needlegrass in fewer numbers.
- Disturbed/exotic grassland – this vegetation type is dominated by exotic grasses and weeds and existed where recent soil disturbance and compaction occurred.
- Disturbed coastal prairie – this vegetation type contains between 10 to 50% cover of native prairie plant species mixed with exotic weeds and grasses depending on the site, moisture regime or mowing frequency. In areas of irregular topography vernal standing water was evident. Small mounds of soil deposition allow for native perennial grasses and forbs
- Least disturbed coastal prairie – this vegetation type contains 50% cover of native prairie species. In some areas native vegetation constitutes up to 100% of vegetative cover.

Although coastal terrace prairie has been reported in other localities in Contra Costa County, the RFS site was identified as unique in that it represented the only coastal prairie grassland on lowland clay soils (David Amme Associates 1993). As a result, this original study concluded that the remnant coastal prairie grassland was scientifically and ecologically invaluable and virtually impossible to recreate (David Amme Associates 1993).

Since 1993, the science of restoration has progressed and evidence of restoration can be seen at the RFS. As mitigation for loss of an historic grassland area that was used for staging facilities as part of the marsh soil remediation for the Stege Marsh in 2003, as described in the *Berkeley*

URS	Richmond Field Station - UC Berkeley Project - 17325753.00	Study Area	Figure 2

Richmond Field Station Remediation and Restoration Project Habitat Restoration Progress Report 2003 – 2007 (The Watershed Project 2007), portions of the coastal terrace prairie on the RFS were restored. A collaborative effort between Jepson Herbarium and other UCB staff and faculty, the Watershed Project Staff and local restoration experts resulted in creation of grassland goals and objectives for the area identified for mitigation restoration.

The area chosen for restoration was within the 19-acres located in the western portion of the RFS, as depicted in Figure 10 of the *Richmond Field Station Working Paper* (UC Berkeley 2002). Within these 19 acres, UC Berkeley Chancellor Chang-Lin Tien (Tien 1996), describing a master plan for the Field Station that was never completed, identified 8.7-acres of coastal terrace prairie grassland "situated in the center of one of the largest contiguous open areas on the property" that would be set aside as a "valuable reserve." Chancellor Tien further stated that the Master Plan incorporated measures for protection of the habitat, such as no development of the coastal prairie grassland area and establishment of the area as a valuable reserve. The letter further identifies preservation measures, such as guidelines to protect the grassland, fencing to discourage human intrusion, preservation of a grassland corridor along the western boundary of the Richmond Field Station property between the prime grassland and the marsh and shoreline open space (Tien 1996).

Although the Richmond Field Station master plan was never completed, the preservation principle was carried forward. The *Richmond Field Station Working Paper* (UC Berkeley 2002), created to establish a land use framework for RFS that reflects "an optimal balance of program needs and environmental stewardship," further expands on Chancellor Tien's letter and proposes to preserve 19 acres of grassland and seasonal wetlands that occur in the western portion of the RFS (Figure 10, UC Berkeley 2002). Under the Recommended Development Principles in this paper is, "*Principle 1. Preserve the most valuable native grassland and wetland habitat areas on the site and link these to the salt marsh via a grassland corridor."*

Specific details on the mitigation requirements, goals, objectives and methods are described in the *Habitat Restoration Progress Report 2003 – 2007* (The Watershed Project 2007). The grassland resources at the RFS have been identified as areas of Unique Restoration Opportunities in the Baylands Ecosystem Habitat Goals Report (http://www.sfei.org/sfbaygoals/docs/goals1999/outline.html) completed through the Wetlands Ecosystems Goals Project (Tetra Tech and Sea Engineering 2007).

In 2004, to ensure control of non-native and invasive species in the mitigation restoration area, a pilot program of hand removal was instigated in the upland grassland plots identified for mitigation (The Watershed Project 2007). Various control methods were analyzed and included hand removal and mulching (with 3-6 inches of sterile rice straw), herbicide treatment (1.5 % glyphosate), herbicide treatment (1.5% glyphosate) and mulch (with 3-6 inches of sterile rice straw) and hand removal (Blasland, Bouck & Lee, Inc. 2004). Control efforts were further refined and presented in the *Richmond Field Station Remediation and Restoration Project Habitat Restoration Progress Report 2003 – 2007* (The Watershed Project 2007), with specific techniques identified per invasive species.

The results of the four years of monitoring of the coastal terrace prairie grassland, which was conducted prior to controlling invasive species, provided ocular estimates of invasive non-native species ranging between 60-70% of absolute cover for Harding grass, with an additional 15% of other invasive plant species (The Watershed Project 2007). Following treatments and 2 years of revegetation in the Big Meadow, non-native cover dropped to 25% with an average of 48% cover of natives, with the remainder being covered by mulch or bare soil, with high survivorship

(>60%) being reported (The Watershed Project 2007). The overall survivorship of planting the West Meadow was less (<30%), due to compacted substrate and fragments of cement and other debris (The Watershed Project 2007).

In 2007, URS recommended a native grassland maintenance and exotic plant control mowing regime that included mowing in the spring and summer, at an appropriate height of 6 to 8 inches to ensure survivorship of perennial grasses (URS 2007).

1.3 Regulatory Considerations

This vegetation community and individual plants are not protected under the Federal Endangered Species Act. At the State level, the CDFW has designated some plant communities as "sensitive natural communities" (CDFG 2013). The primary purpose of the classification is to assist in the location and determination of significance and rarity of various vegetation types. Thus, ranking of natural communities by their rarity and threat is an important facet of the classification. In the List of California Terrestrial Natural Communities Recognized by The California Natural Diversity Database (CNDDB) April 2013 Edition document, as in previous CNDDB community lists, asterisks (*) denote special communities that are either known or believed to be of high priority for inventory in CNDDB. Lead and trustee agencies may request that impacts to these communities be addressed in environmental documents. Local agencies may also have policies requiring avoidance of rare community types. Our professional experience and industry standards have shown that mitigation is typically required (LSA Associates 2006; WRA 2008), and varies between restoration of degraded habitats on-site to creation of new habitats located off-site.

Although no specific mitigation requirements are established for impacting coastal terrace prairie grassland under CEQA, industry standards have shown that mitigation ratios of 1:1 for on-site restoration are typical (LSA Associates 2006; WRA 2008). Restoration, as defined by The Society for Ecological Restoration (www.ser.org) and quoted by Stromberg, et.al. (2007), is, "…the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed." An ecosystem has recovered and is considered restored through a variety of parameters, such as, a) it contains a characteristic assemblage of the species that occur in the reference ecosystem and that provide appropriate community structure, b) the physical environment of the restored ecosystem is capable of sustaining reproducing populations of the species necessary for its continued stability, c) it apparently functions normally for its ecological stage of development, and signs of dysfunction are absent, d) it is suitably integrated into a larger ecological matrix or landscape, with which it interacts through abiotic and biotic flows and exchanges, and e) it is sufficiently resilient to endure the normal periodic stress events in the local environment that serve to maintain the integrity of the ecosystem, among others.

If insufficient acreage occurs on the RFS site to mitigate for impacts to the coastal terrace prairie, then off-site creation mitigation may potentially be required, which would also require consultation with the agencies during the CEQA review. Therefore, the requirements for off-site creation are unknown at this time.

2.0 METHODS AND LIMITATIONS

For this constraints analysis, we reviewed the following reports (chronological order) and articles prepared for the RFS:

- Richmond Field Station Final Botanical Survey Report - URS 2007
- Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California - Tetra Tech EM Inc and Sea Engineering Inc. 2007
- Final Report for the University of California, Berkeley Richmond Field Station Remediation and Restoration Project Habitat Restoration Progress Report (2003 – 2007), and Appendices – The Watershed Project 2007.
- UC Richmond Field Station's Remnant Coastal Terrace Grassland – Amme 2005
- Invasive/Exotic Vegetation Management Program – Blasland, Bouck and Lee, 2004
- West Stege Marsh Upland Revegetation Plan (2003-5) U.C. Berkeley Field Station Aquatic Outreach Institute 2004
- Invasive/Exotic Vegetation Management Program. University of California, Berkeley, Richmond Field Station - BBL, Inc. January 2004.
- Richmond Field Station Remediation Project: Initial Study California Environmental Quality Act – URS 2003
- Richmond Field Station Working Paper - U.C. Berkeley 2002
- Baylands Ecosystem Habitat Goals: A report of the habitat recommendations - San Francisco Bay Area Wetlands Ecosystem Goals Project 1999.
- Letter to Honorable Tom Bates, Member of the Assembly - Chancellor Tien, C. 1996.
- Richmond Research Center Master Plan. Environmental Impact Report. Existing Opportunities and Constraints Report - Brady & Associates Planners and Landscape Architects 1994.
- Richmond Research Center Master Plan, Environmental Impact Report: Existing Conditions of Grassland Resources - Amme 1993
- Native Perennial Grass Establishment and Management – Paul Kephart and David Amme 1992.
- The Natural Areas of the University of California Richmond Field Station - Gutstein 1989.

Two site visits were conducted, on April 19 and May 15, 2012, by Wildlife Research Associates ecologist Trish Tatarian, and Jane Valerius Environmental Consulting botanist and plant ecologist Jane Valerius. The site visits were conducted to ground truth and update the results of the *Richmond Field Station Final Botanical Survey Report* (URS 2007), in which coastal terrace prairie grassland was identified and mapped based on the presence of either California oat grass or purple needle grass, as well as with ≥6 other East Bay California Native Plant Society (EBCNPS) ranked A or B plant species. This update reflects the latest rankings of grassland habitats adopted by the agencies.

2.1 Standardized Grassland Evaluation

To update the results from the URS (2007) report, we ranked the quality of coastal terrace prairie grassland habitat based on presence of absolute cover of purple needlegrass (5%) and/or California oatgrass (>25%), as described by the membership rule of the series in the Manual of California Vegetation (MCV) (Sawyer, et al. 2009) (Appendix A), and was not dependent on the presence of other native plant species. The rankings at the RFS meadows are as follows:

High Quality: California oatgrass (>50%) and/or purple needlegrass (20%)
Medium Quality: California oatgrass (25-50%) and/or purple needlegrass (5-19%)
Low Quality: California oatgrass (0-24%) and/or purple needlegrass (0-4%)

To determine absolute cover, Jane Valerius conducted reléve surveys (Mueller-Dombois, et al. 1974; CNPS 2000), which entailed focused walking transects through the known vegetative community/alliance (i.e., California oatgrass). Relevés can be used in vegetation studies as a practical, relatively fast means of collecting information on vegetation. We assumed, based on the information provided on soils and other site factors presented in the Richmond Field Station Final Botanical Survey Report (URS 2007), that the sampling was homogeneous for coastal terrace prairie grassland and we were able to focus on the percent cover of each species to determine if the plot (i.e., meadow allocation) supported the minimum percentage of individuals to allow it to qualify for either California oatgrass or purple needle grass.

This reléve methodology allowed us the quickest way to analyze and evaluate the areas using the membership rules from MCV (Sawyer et al 2009). This method consisted of subjective sampling, and was qualitative, allowing us to estimate species cover based on basal area rather than measure it, but also allowed for quantitative measurements for the two target species: California oatgrass and purple needlegrass.

2.2 Qualitative Grassland Evaluation Criteria

We further evaluated the quality of the coastal terrace prairie grasslands beyond the membership rule of the series in the MCV (Sawyer, et al. 2009). We used the California Department of Fish and Game (CDFG) method for *Addressing High Priority Vegetation Types* (http://www.dfg.ca.gov/biogeodata/vegcamp/natural_comm_background.asp), which allows for judgment of quality based on a flexible set of criteria such as the range of existing sustainable occurrences of this element or vegetation type based on site quality, defensibility, size, and surrounding landscapes. These criteria vary based on the type of vegetation or natural community and the range of existing occurrences known. For example, high quality natural vegetation will have the following characteristics:

- lack of invasive exotic species,
- no evidence of human-caused disturbance such as roads or excessive livestock grazing, or high-grade logging,
- evidence of reproduction present (sprouts, seedlings, adult individuals of reproductive age), and
- no significant insect or disease damage, etc.

We also used criteria for evaluating impacts to Natural Communities (DFG *Protocols for Surveying and Evaluating Impacts to Special Status Natural Communities* - http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/Protocols_for_Surveying_and_Evaluating_Impacts.pdf), but did not evaluate potential impacts to the community from a specific project. We evaluated the quality of the grassland community based on the following:

- consideration of nearby populations and total species distribution;
- the consideration of nearby occurrences of special status communities and natural community distribution; and
- analysis of potential threats, including those from invasive species, to the plants and natural communities.

Based on the above criteria and evaluations, the following value affecting qualifiers were used for the coastal terrace prairie at the RFS, using the background reports stated above for baseline information. The Big Meadow was used as the control meadow for the following qualifiers:

- Acreage – Larger, contiguous areas have more value than smaller, disconnected areas. We evaluated the meadows from the potential effects from eucalyptus trees, which are non-native, provide a very high canopy cover, and are allelopathic (i.e., chemical leachates from leaves and bark cause understorey suppression) reducing the viability of native herbaceous grasses. As a result, eucalyptus trees were removed from the acreages of meadows available.
- Location to eucalyptus grove – areas located east of the eucalyptus grove are smaller in size, shaded and surrounded by development and receive landscaping/maintenance mowing regime. All of these factors reduce the value and integrity of the grassland areas. Areas to the west of the eucalyptus are larger in acreage, are spatially connected, are not shaded, have less development and invasive plant control mowing regime.
- Management Regime (mowing) - a) *Exotic plant control* -The URS (2007) report recommended that exotic plant species be controlled by mowing, which entailed spring and summer mowing at a height of 6-8 inches.
  b) *Landscaping/maintenance* – landscape mowing which typically occurs once a month, reduces the non-vegetative reproduction (i.e., seed source).
- Previous disturbances (1993-2012) – such as soil deposition, are based on Amme (1993).
- Wetlands present - Wetlands were identified based on Current Conditions Report (Tetra Tech and Sea Engineering 2007).
- Hydrology alteration – coastal terrace prairie grassland requires wetland mesic soil conditions. If the hydrology is altered (i.e., channelized for directing locational flow for purposes of draining a meadow) to reduce the mesic conditions, then the value for the community is reduced.
- Reproduction present/absent – 2012 surveys not conducted during the flowering season.
- Insect/disease -
- Species diversity – Species composition is based on the URS (2007) report.
- Threats – a) *Invasive species* (Shrub/Herbaceous) – invasive control required for coyote bush and Harding grass
  b) *Disconnected spatially* – trees located between meadows that reduce seed dispersal
  c) *Surrounded by development* – buildings reduce seed dispersal, roadways are not considered barriers other than hydrologic alteration from channelization
  d) *Wind isolated* – prevailing wind direction occurs from the south and southeast from Richardson Bay.

In summary, at the landscape level, on the east side of the eucalyptus groves, the barriers between the meadows (i.e., Eucalyptus Meadow, North Meadow Far North Meadow, etc.) include the trees and the buildings. On the west side, at the landscape level, these barriers are not present between the meadows.

To provide further ranking of these criteria per meadow, we assigned the number "1" when it was beneficial for grasslands (i.e., wetlands present) and a "0" when it was not beneficial (e.g., hydrology altered). For the standardized evaluation of vegetative presence, we rate high quality with "3" and low quality with "1". The following are the rankings.

Table 1: Qualitative Criteria Rankings

Standardized evaluation based on % cover	**H=3, M=2, L=1**	
Acreage [a]	**>3 = 1**	**<3 = 0**
Location to eucalyptus grove	**W = 1**	**E = 0**
Management Regime (mowing) [b]		
Exotic plant control	**Y = 1**	**N=0**
Landscaping/ maintenance	Y = 0	N= 1
Previous disturbances (1993-2012) [c]	**Y=0**	**N=1**
Wetlands Present [d]	**Y=1**	**N=0**
Hydrology altered	**N=1**	**Y=0**
Reproduction present	**Y=1**	**N=0**
Insect/disease	**n/a**	**n/a**
Species diversity [e]	**>6 =1**	**<6 = 0**
Threats		
Invasive species (Shrub/Herbaceous)	n/a	n/a
Disconnected spatially	Y=0	N=1
Surrounded by development [f]	Y=0	N=1
Wind isolated	Y=0	N=1

Note: Value 1 = beneficial to grasslands
Value 0 = not beneficial to grasslands

3.0 EXISTING CONDITIONS

3.1 Setting

The 162-acre RFS parcel is located within the San Francisco Bay Coastal Bioregion (Welsh 1994). This bioregion is located within central California and is located on the east side of the San Francisco Bay. Habitats within this bioregion include both mesic (moist) habitats, such as saltwater and freshwater marsh along the bay, and xeric (dry) habitats, such as chaparral and coastal sage scrub in the hills, and are typical of a Mediterranean type climate. Annual winter precipitation has averaged 25.4 inches over the past 200 years (Welsh 1994). The dominant prevailing wind directions in this portion of the San Francisco Bay are from the south southeast, as measured at the Richmond Pier (http://www.windfinder.com/windstats/windstatistic_richmond_pier.htm).

The Richmond Field Station, located at 1301 South 46th Street in Richmond California, is currently owned by the U.C. Regents for the use by the UCB campus. Once part of the larger Rancho San Pablo, the RFS is located in the eastern edge of the San Francisco Bay, in the City of Richmond (Figure 1). The RFS is bounded by Meade Street off Interstate 580 to the north, by Meeker Lough/Regatta Boulevard to the west and by South 46th Street to the east. The East Bay Regional Park District Bat Trail traverses the western portion of the property. Totaling 162 acres, the upland habitat encompasses 96 acres, which is comprised of industrial-zoned land used primarily for research and education. Of these 96 acres, approximately 42 acres are undeveloped meadows that support native grasslands.

Aerial analysis on Google Earth shows that in 1939 the area was surveyed and sidewalks appear to be installed but no grading had occurred. Structures and eucalyptus trees are present on the main portion of the RFS at this time.

3.2 Vegetation Communities

Several vegetation communities, as described by Holland (1986), occur on the RFS site. This classification of overall community identification will provide an easier understanding for the reader and provides an umbrella that is encompassing the specific alliances, as described in Sawyer, et al. (2009). The communities described below refer to those that are located within the 96-acre portion of the RFS and are based on descriptions from the *Manual of California Vegetation* (Sawyer, et al. 2009).

Coastal terrace prairie is typically found within a belt extending from the coast to a few kilometers and usually contains significant amounts of both native and exotic perennial species. California oatgrass (*Danthonia californica*) is the characteristic species in the northern and more coastal part of coastal prairie grassland with purple needle grass (*Nasella pulchra*) also being abundant in this region (D'Antonio, et al. 2000).

3.2.1 Coastal Terrace Prairie Grassland

Danthonia californica Herbaceous Alliance or California oat grass prairie – California oat grass prairie is defined as being dominant or co-dominant in the herbaceous layer with a variety of other native and non-native species and must comprise greater than 50% relative cover or 25% absolute cover in the herbaceous layer (Sawyer et al. 2009). California oatgrass is a perennial bunchgrass with loosely clustered, coarse stem or culms. This species is supported in a habitat that is seasonally or permanently saturated with a shallow water table. Water chemistry can

include both freshwater and saline water. It can occur in valley bottoms, and the lower portions of alluvial slopes as well as in uplands on coastal bluffs, terraces, slopes and ridges. The national list of wetland plants (NWPL 2012 (http://rsgisias.crrel.usace.army.mil/NWPL/doc/proc_2012/ERDC-CRREL_TR-12-11_NWPL_2012.pdf) lists California oatgrass as a facultative species. Often considered part of coastal prairie, this alliance extends from coastal terraces to inland bald hills. Species dominance varies at a fine scale. It often mixes with tree series at a coarser scale, such as Douglas-fir - tanoak series, Oregon white oak series, Redwood series.

California oatgrass is one of the only perennial bunchgrasses with long-lived seed and a stand can be rapidly revived from a latent seed bank with mowing, weeding and clearing. This species establishes very slowly but is a persistent grower and it roots can eventually reach down to 3 or 4 feet. It thrives in rich, loamy and clay soils (Amme 2003b).

Nasella pulchra Herbaceous Alliance or Purple needle grass grassland – Purple needle grass is dominant or characteristically present in the herbaceous layer and occurs with other perennial grasses and usually has 10% relative cover or 5% absolute cover in the herbaceous layer (Sawyer, et al. 2009). Purple needle grass is a native, cool-season perennial bunch grass that expands when tussocks fragment. The plant produces large quantities of viable seed, but seedling establishment is generally low (Sawyer, et al. 2009). This species occurs in all topographic locations, typically on soils with a high clay content. Vegetative growth of purple needlegrass is greatest from March through late May or early June, depending on onset of drought. Flowers begin to develop in early May, and seed is mature and dispersed by late July. Stands of this once extensive series now typically include non-native annual species mixed with the perennial grasses and herbs. Purple needle grass regenerates primarily by tillering (i.e. root spreading) and, similar to bulbs and rhizomes, fragmentation of bunches. Fragmentation is an important form of regeneration for purple needle grass; it is an adaptation that allows recovery from defoliation by high-intensity, short-duration grazing and/or fire. Ripgut, soft chess, and foxtail chess are common, as are slender oats, wild oats, and Italian ryegrass. Foothill needlegrass, nodding needlegrass, and purple needlegrass occur sympatrically, but do not typically mix. The species tend to segregate based on substrate and slope factors.

Purple needlegrass is a species with wide ecological tolerance and excellent restoration potential (Ludlow, et al. 2007). It is a long-lived bunchgrass and thrives on sunny, south-facing slopes and plain of the foothill grassland. It stays green into the early summer and gradually becomes dormant in mid to late summer. This species also forms a deep root system 3 to 4 feet deep. Purple needle grass has good seedling vigor and can be seeded or planted by plugs (Amme 2003a).

Recruitment of purple needle grass has been shown to be reduced by the adverse environment created by high densities of non-native annual species (Dyer and Rice 1997). Successful attempts to increase populations of purple needle grass must involve management to reduce the negative effects or competition of non-natives through effective management techniques such as weeding and grazing.

3.2.2 Standard Grassland Evaluation

From a botanical analysis, using the MCV (Sawyer, et al. 2009) requirements for % of absolute cover for a vegetation alliance alone, our evaluation resulted in two of the meadows meeting the high quality habitats standard, compared to the URS (2007) evaluation, in which three meadows were evaluated as being high quality habitat. The habitat quality evaluation of on-site meadows, past and present, are presented in Table 2. However, we further identified five meadows as being moderate quality habitat, whereas URS (2007) did not have any; nor did they identify any low quality habitat. Our analysis identified seven meadows with low quality habitat based on a botanical presence of absolute cover of either *Danthonia* or *Nassella*. The differences between the two habitat ratings are discussed in the methods section, and reveal the changes in vegetation classification in the past five years.

Table 2: Comparison of evaluations of the meadows habitat quality – Richmond Field Station, Richmond, CA.

Meadows	Acreage	Quality of Habitat		
		D. Amme Associates (1993)[1]	URS (2007)[2]	Wildlife Research Associates (2012)[3]
Northwest	3	Disturbed/closely mowed	None	Medium
West	4	Disturbed/exotic/disturbed coastal prairie	High	High
EPA South	1	Disturbed/exotic	None	Low
EPA North	2	Disturbed coastal prairie/closely mowed	High	Medium
Big *	13	Disturbed coastal Prairie/Least disturbed coastal prairie	High	High
Central	2.8	Disturbed/closely mowed	None	Medium
Gull	1	Disturbed/closely mowed	None	Low
North	5	Disturbed/closely mowed	None	Low
Eucalyptus	5	Disturbed/closely mowed	None	Medium
Far North	1	Disturbed/closely mowed	None	Low
East	1	Disturbed/closely mowed	none	Low
Northeast	1	Disturbed/closely mowed	none	Low
580	2	Disturbed/closely mowed	none	Low

Note – Quality of Habitat Evaluated Based on:

1 = vegetation surveys conducted outside flowering season.

2 = grassland and presence of > 6 native plant species.

3 = % of species absolute cover, with *High Quality*: California oatgrass (>50%) and/or purple needlegrass (20%); *Medium Quality*: California oatgrass (25-50%) and/or purple needlegrass (5-19%), and *Low Quality*: California oatgrass (0-24%) and/or purple needlegrass (0-4%)

*= the Northern portion of the Big Meadow, which is disturbed, is not included in the 13 acres.

In 1993, several areas were identified as disturbed coastal prairie, specifically a portion in the west central area of the Big Meadow, the central portion of the West Meadow and a strip of disturbed/closely mowed grassland surrounding the disturbed coastal prairie and a block that is shown as recent disturbance of the EPA Meadow N (David Amme Associates 1993).

In our analysis we also identified the northern portion of the Big Meadow, which is not part of the 13 acres identified above (URS 2007), as being disturbed grassland, lacking any native species. Please refer to the *Richmond Field Station Habitat Enhancement and Mitigation Analysis* (Wildlife Research Associates 2013) for further analysis.

The EPA Meadow S area is also identified as an area that has been disturbed, has uneven or higher elevations, and where native grasses and plants are lacking and would be a good candidate for coastal prairie grassland creation. The URS (2007) maps also show that this area lacks native grasses and sensitive plants, although California oatgrass and sun cups (*Camissonia ovata*) are mapped in this area (URS 2007).

3.2.3 Qualitative Grassland Evaluation

After evaluating the meadows based on the standardized criteria of percent cover, as explained in Chapter 2, Table 3 provides a synopsis of the refinement of the habitat qualities of the meadows.

Table 3: Meadow Qualitative Evaluations - Richmond Field Station, Richmond, CA

Meadow characteristics	Big Meadow	Northwest	West	EPA north	EPA south	North	580	Central	Eucalyptus	Gull	East	Northeast	Far North
Acreage [a]	13	3	4	2	1	3.9	1	2.5	1.8	1	1	1	1
Location to eucalyptus grove	W	W	SW	SW	SW	E	NE	S	E	E	E	E	N
Management Regime (mowing) [b]													
Exotic plant control	Y	N	Y	Y	N	N	N	N	N	N	N	N	N
Landscaping/ maintenance	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y
Previous disturbances (1993-2012) [c]	Y	Y	N	Y	Y	N	N	N	N	N	N	N	N
Potential* Wetlands Present** [d] ***(visual obs.)	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N
Hydrology altered	N	N	N	N	N	Y	Y	N	Y	Y	Y	Y	na
Reproduction present/absent	P	P	P	P	P	A	A	A	A	na	na	na	na
Insect/disease	na	na	na	na	na	na	na	na	na	na	na	na	na
Species diversity [e]	6+	4	6+	6+	1	3	1	1	2	1	2	2	0
Threats													
Invasive species (Shrub/Herbaceous)	S	S	S	H	S	H	H	H	H	H	H	H	H
Disconnected spatially	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y
Surrounded by development [f]	N	N	N	N	N	N	Y	Y	N	Y	Y	Y	N
Wind isolated	N	N	N	N	N	Y	Y	N	Y	Y	Y	Y	Y

Notes:
a = URS (2007) acreages and modified for removal of eucalyptus trees in Eucalyptus Meadow, North Meadow and Central Meadow.
b = URS (2007) recommended mowing regimes.
c = Previous disturbances, such as recent soil deposition from ~1993, are based on Amme (1993).
d = Wetlands were identified based on Current Conditions Report (Tetra Tech and Sea Engineers 2007) and visual observations in the field in 2012.
e = Species diversity was based on the URS (2007) report and includes those native species that were identified by the EBCNPS for Ranks A and B, excluding the two grass species, *Nassella* sp. and *Danthonia* sp.
f = Development is classified for this report as buildings and does not include roadways.

The following is a description per meadow identifying the criteria and qualities present in each meadow. These evaluations are then applied in the *Richmond Field Station Habitat Enhancement and Mitigation Analysis* (Wildlife Research Associates 2013). A synopsis of these attributes is presented in Table 4 (page 22).

Big Meadow: Big Meadow, approximately 13.3 acres in size (URS 2007), is the largest of the grassland areas on the RFS site. It has the highest plant species diversity and is being managed via a mowing regime to maintain and increase the native grasses and forbs. This area has benefited from exotic species control and is rated as a high quality grassland area for the site based on the percent cover of plants. It is composed primarily of coastal terrace prairie grassland; however, the northern portion, located outside the URS (2007) designated 13 acre, is comprised of low quality habitat. It has been moderately disturbed due to subdivision work conducted in the early 1900s (Amme 1993). Despite this historical disturbance, the coastal terrace prairie is more or less intact. The Big Meadow has high presence of California oatgrass and purple needlegrass in addition to seventeen (17) species of listed sensitive plants, 10 of which are EBCNPS Rank A or B (URS 2007), along with many common native species. The remnant coastal terrace prairie grassland in Big Meadow is largely undisturbed, is scientifically and ecologically invaluable, and is virtually impossible to recreate from a non-coastal terrace prairie habitat (Amme 1993). In summary, the qualitative evaluations presented in Table 3 are as follows:

- Large area (relative to other areas on site)
- West of the Eucalyptus grove - is an open area with no shade from trees.
- Highest species diversity of all the other areas on site.
- Invasive exotics are controlled via mowing program
- Not channelized
- Good reproduction of natives.
- Not disconnect spatially
- Not surrounded by development
- Not wind isolated.
- Wetlands present.

Due to these factors, Big Meadow is designated as high quality grassland habitat (Table 4)

Northwest Meadow: Northwest Meadow, approximately three acres in size, is located west of the Eucalyptus grove and west of the Big Meadow. Although it is separated from the Big Meadow by the Fog Buildings is it spatially connected and contiguous to the Big Meadow and West Meadow. According to the URS (2007) report, adjacent roadwork and building construction has somewhat disturbed this site. Seven listed plant species (EBCNPS Rank A, B or C) were mapped for this area in addition to California oatgrass and purple Needlegrass and other, common native plants. Only 4 of the 7 listed plant species were Rank A or B so this area did not meet the URS criteria for defining high quality grassland habitat. However, since 2007 the presence of California oatgrass and purple Needlegrass has increased in this area making it a high quality grassland habitat based on the membership rules as defined by the Manual of California Vegetation (Sawyer, et al. 2009). In summary, the qualitative evaluations presented in Table 3 are as follows:

- Located west of the Eucalyptus grove in the relatively undeveloped portion of the campus and in an open area with not shade from trees
- High species diversity.
- Not channelized

- Good reproduction of natives.
- Not disconnect spatially
- Not surrounded by development
- Not wind isolated.
- Wetlands present.

Due to these factors, Northwest Meadow is designated as high quality grassland habitat (Table 4)

West Meadow: West Meadow, approximately four acres in size, is located west of the Eucalyptus grove and is connected spatially to the Big Meadow, Northwest Meadow and EPA Meadows North and South. This grassland is composed of both disturbed/exotic grassland and disturbed coastal prairie, with an isolated patch of minimally disturbed coastal prairie (URS 2007). A small concrete foundation is present in the middle of the site along with coyote bush which is invading into the grassland area. Eleven species of EBCNPS listed sensitive plants and 6 EBCNPS Rank A or B plant species were mapped for this area in addition to California oatgrass and purple Needlegrass. Based on the URS (2007) the West Meadow has received some disturbance but because there are 6 EBCNPS Rank A or B plants present, the site met the URS (2007) definition of high quality grassland habitat. In summary, the qualitative evaluations presented in Table 3 are as follows:

- Located west of the Eucalyptus grove in the relatively undeveloped portion of the campus and in an open area with not shade from trees
- High species diversity.
- Invasive exotics are controlled via mowing program
- Not channelized
- Good reproduction of natives.
- Not disconnect spatially
- Not surrounded by development
- Not wind isolated.
- Wetlands present.

Due to these factors, West Meadow is designated as high quality grassland habitat (Table 4)

EPA Meadow North: EPA Meadow North, approximately two acres in size, is located in the western portion of the campus southwest of the Eucalyptus grove. EPA Meadow N is a regularly mowed grassland with one small structure present on the site. The grassland in EPA Meadow N is somewhat disturbed and 12 sensitive plant species occur at this location in addition to California oatgrass and purple Needlegrass. The site also supports 6 other EBCNPS Rank A or B plant species sot that this area meets the URS operational definition of high quality grassland habitat. In summary, the qualitative evaluations presented in Table 3 are as follows:

- Located west of the Eucalyptus grove in the relatively undeveloped portion of the campus and in an open area with no shade from trees
- High species diversity.
- Invasive exotics are controlled via mowing program
- Not channelized
- Good reproduction of natives.
- Not disconnect spatially
- Not surrounded by development

- Not wind isolated.
- Wetlands present.

Due to these factors, EPA Meadow North is designated as high quality grassland habitat (Table 4)

EPA Meadow South: EPA Meadow S, approximately one acre in size, is located south of the EPA Laboratory. This area is regularly mowed (URS 2007) and the soils in this area have been partially disturbed in the past as evidenced by mounding and uneven grades in this area. California oatgrass and purple needlegrass occur on the site but in low cover. Brown-headed rush (*Juncus phaeocephalus*), an EBCNPS Rank B species also occurs in proximity to the site along with 3 species of sensitive plants. The site does not meet the URS (2007) operational definition of high quality grassland habitat. This site is dominated primarily by non-native species along with coyote bush which is invading into the grassland area along with non-native blackberry. In summary, the qualitative evaluations presented in Table 3 are as follows:

- The grassland area is small and highly disturbed with uneven grades and areas where soil material has been dumped.
- Presence of invasive herbaceous and shrub species.
- Low species diversity.

Due to these factors, EPA Meadow South is designated as medium quality grassland habitat (Table 4).

North Meadow: North Meadow, approximately five acres in size, is the second largest grassland on the RFS site. This area is located east of the Eucalyptus grove and east of the Big Meadow. According to the URS (2007) report this area is regularly mowed and while the site has experienced disturbance, one EBCNPS Rank B and 6 EBCNPS listed sensitive plants occur on the site in addition to California oatgrass and purple needlegrass. This site did not meet the URS criteria of a high quality grassland habitat because it lacked the 6 or greater EBCNPS ranked A or B plant species. In summary, the qualitative evaluations presented in Table 3 are as follows:

- Located east of the Eucalyptus grove in the more developed portion of the campus.
- Receives higher maintenance (mowing regime) for landscaping purposes and not specifically for exotic control.
- Hydrology channelized
- Presence of invasive, herbaceous species;
- Disconnect spatially
- Wind isolated.

Due to these factors, North Meadow is designated as low quality grassland habitat (Table 4).

580 Meadow: 580 Meadow, approximately two acres in size, is located in the far northeastern corner of the campus, east of the Eucalyptus grove. A complex of buildings occurs along its west boundary with Interstate 580 and a rail line along the northeast boundary and Robin Drive on its south boundary. It is located in an area with a long history of industrial use and has been disturbed since the turn of the twentieth century (URS, 2003 & 2007). This meadow is composed of regularly mown grassland and non-native plants with a few stands of coyote bush. This site has experienced disturbance and four listed sensitive plants occur on the site. The site did not meet the URS operational definition of high quality grassland habitat, since only one EBCNPS

Rank B plant species occurs in this area in addition to California oatgrass and purple needlegrass. In summary, the qualitative evaluations presented in Table 3 are as follows:

- Small size.
- Located east of the Eucalyptus grove in the more developed portion of the campus.
- Receives higher maintenance (mowing regime) for landscaping purposes and not specifically for exotic control.
- Hydrology channelized
- Presence of invasive, herbaceous species;
- Disconnect spatially.
- Surrounded by development.
- Wind isolated.

Due to these factors, 580 Meadow is designated as low quality grassland habitat (Table 4).

Central Meadow: Central Meadow is composed of a 2.5-acre open area and is located south of the Eucalyptus grove and in the developed eastern campus area. The 0.3-acre area included in the URS (2007) report was dropped from this analysis due to the eucalyptus cover. This site is regularly mowed and has experienced disturbance because part of it was used as a staging area during the remediation project (URS 2007). Six EBCNPS listed sensitive plants were mapped in this area in addition to California oatgrass and purples needled grass. However, only 3 EBCNPS Rank B plant species were mapped so that this area does not meet the URS operational definition of high quality grassland habitat. In summary, the qualitative evaluations presented in Table 3 are as follows:

- Located in the eastern, more developed portion of the campus.
- Receives higher maintenance (mowing regime) for landscaping purposes and not specifically for exotic control.
- Presence of invasive, herbaceous species;
- Disconnect spatially.
- Surrounded by development.

Due to these factors, Central Meadow is designated as low quality grassland habitat (Table 4).

Eucalyptus Meadow: Eucalyptus Meadow was identified as a five acres site in the URS 2007 report but this includes 3.24 acres of Eucalyptus trees leaving only 1.76 acres of open grassland. This area is regularly mowed and has several structures, an access road bisecting the meadow and several small parking lots. This site has experienced disturbance in the past (URS 2007). Six listed sensitive plants were mapped for the site, however the site does not meet the URS operational definition of high quality grassland habitat, since only three EBCNPS Rank A or B plant species occur in addition to California oatgrass and purple needlegrass. In summary, the qualitative evaluations presented in Table 3 are as follows:

- Located in the eastern, more developed portion of the campus.
- The grassland area is small, isolated and surrounded by Eucalyptus trees.
- Receives higher maintenance (mowing regime) for landscaping purposes and not specifically for exotic control.
- Presence of invasive, herbaceous species;
- Hydrology channelized.
- Disconnect spatially.

- Surrounded by development.

Due to these factors, Eucalyptus Meadow is designated as low quality grassland habitat (Table 4).

Gull Meadow: Gull Meadow, approximately one acre in size, is located east of the Eucalyptus grove in the more developed portion of the campus. Its few open areas are regularly mowed and the meadow has been disturbed by the construction of a small complex of structures and a parking lot. California oatgrass and an isolated patch of small-bract sedge (*Carex subbracteata*) occur on the site. Two listed sensitive plants occur on the site in limited numbers. This site has experienced extensive disturbance and site does not meet the URS operational definition of high quality grassland habitat. In summary, the qualitative evaluations presented in Table 3 are as follows:

- Located in the eastern, more developed portion of the campus.
- The grassland area is small, isolated, and altered by past disturbance.
- Receives higher maintenance (mowing regime) for landscaping purposes and not specifically for exotic control.
- Presence of invasive, herbaceous species;
- Hydrology channelized.
- Disconnect spatially.
- Surrounded by development.
- Wind isolated.

Due to these factors, Gull Meadow is designated as low quality grassland habitat (Table 4)

East Meadow: East Meadow, approximately one acre in size, is located in the more developed eastern portion of the campus east of the Eucalyptus grove. This site is regularly mowed and has been previously disturbed with the construction of a parking lot, and two structures. Four EBCNPS listed sensitive plants and 3 EBCNPS Rank B plant species occur on the site in addition to California oatgrass and purple needlegrass. The site does not meet the URS operational definition of high quality grassland habitat. In summary, the qualitative evaluations presented in Table 3 are as follows:

- Located in the eastern, more developed portion of the campus.
- The grassland area is small, isolated, and altered by past disturbance.
- Receives higher maintenance (mowing regime) for landscaping purposes and not specifically for exotic control.
- Presence of invasive, herbaceous species;
- Hydrology channelized.
- Disconnect spatially.
- Surrounded by development.
- Wind isolated.

Due to these factors, East Meadow is designated as low quality grassland habitat (Table 4).

Northeast Meadow: Northeast Meadow, approximately one acre in size, is located in the more developed eastern portion of the campus east of the Eucalyptus grove. It is regularly mowed and has been disturbed in the past. A parking lot, a several small structures and a large paved area are present on the site and topsoil in a portion of the site appears to have been removed (URS 2007). Four EBCNPS listed sensitive plants and one EBCNPS Rank B plant species occur here in

addition to California oatgrass and purple needlegrass. The site does not meet the URS operational definition of high quality grassland habitat. In summary, the qualitative evaluations presented in Table 3 are as follows:

- Located in the eastern, more developed portion of the campus.
- The grassland area is small, isolated, and altered by past disturbance.
- Receives higher maintenance (mowing regime) for landscaping purposes and not specifically for exotic control.
- Presence of invasive, herbaceous species;
- Hydrology channelized.
- Disconnect spatially.
- Surrounded by development.
- Wind isolated.

Due to these factors, Northeast Meadow is designated as low quality grassland habitat (Table 4).

Far North Meadow: Far North Meadow, approximately one acre in size, is located in the northeastern corner of the campus outside of the RFS boundary fence. Interstate 580 and a rail line are the northwest boundary, three RFS buildings are near its east boundary, and Eucalyptus Meadow forms the south boundary. It is located in an area with a long history of industrial use and has been thoroughly disturbed since the turn of the twentieth century (URS 2003). This meadow is overgrown with non-native herbaceous species and no listed plants were observed in this area. In summary, the qualitative evaluations presented in Table 3 are as follows:

- The grassland area is small, isolated, and altered by past disturbance.
- Receives higher maintenance (mowing regime) for landscaping purposes and not specifically for exotic control.
- Presence of invasive, herbaceous species.
- No coastal grass species present.
- Dominance by non-native plants.
- Disconnect spatially.
- Wind isolated.

Due to these factors, Far North Meadow is designated as low quality grassland habitat (Table 4).

Based on the above criteria and evaluations, the meadows are ranked as to their quality of habitats, whether certain attributes are beneficial to the grassland meadow or not beneficial, and are presented in Table 4 Quality of Meadow Habitat.

Table 4: Quality of Meadow Habitat - Richmond Field Station, Richmond, CA

Quality of Meadow	Big Meadow	Northwest	West	EPA north	EPA south	North	580	Central	Eucalyptus	Gull	East	Northeast	Far North
Standardized evaluation	3	2	3	2	1	1	1	2	2	1	1	1	1
Acreage	1	1	1	0	0	1	0	0	0	0	0	0	0
Location to eucalyptus grove	1	1	1	1	1	0	0	0	0	0	0	0	0
Management Regime (mowing)													
Exotic plant control	1	0	1	1	0	0	0	0	0	0	0	0	0
Landscaping/ maintenance	1	1	1	1	1	0	0	0	0	0	0	0	0
Previous disturbances (1993-2012)	0	0	1	0	0	1	1	1	1	1	1	1	1
Wetlands Present	1	1	1	1	0	0	0	0	0	0	0	0	0
Hydrology altered	1	1	1	1	1	0	0	1	0	0	0	0	0
Reproduction present	1	1	1	1	1	0	0	0	0	0	0	0	0
Insect/disease	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Species diversity	1	0	1	1	0	0	0	0	0	0	0	0	0
Threats													
Invasive species	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Disconnected spatially	1	1	1	1	1	0	0	0	0	0	0	0	0
Surrounded by development	1	1	1	1	1	1	0	0	1	0	0	0	1
Wind isolated	1	1	1	1	0	0	0	0	0	0	0	0	0
TOTAL	**14**	**11**	**15**	**12**	**7**	**4**	**2**	**4**	**4**	**2**	**2**	**2**	**3**
High	√	√	√	√									
Medium					√								
Low						√	√	√	√	√	√	√	√

Ranking Values (based on a maximum value of 15)
High = 11 or greater
Medium = 6 to 10
Low = 1 to 5

3.3 Wildlife Habitats

Several wildlife habitats, which include vegetation communities and anthropogenic structures, occur within the 96-acre property; however, the descriptions below pertain only to those habitats discussed in this constraints analysis, mainly the grasslands.

The value of a site to wildlife is influenced by a combination of the physical and biological features of the immediate environment. Species diversity is a function of diversity of abiotic and biotic conditions and is greatly affected by human use of the land. The wildlife habitat quality of an area, therefore, is ultimately determined by the type, size, and diversity of vegetation communities present and their degree of disturbance. Wildlife habitats are typically distinguished by vegetation type, with varying combinations of plant species providing different resources for use by wildlife. The following is a discussion of the wildlife species supported by the on-site habitats, as described by *A Guide to Wildlife Habitats of California* (Mayer and Laudenslayer 1989).

3.3.1 Grassland

Grassland habitat, including native and non-native grasslands, attract reptiles and amphibians, such as northern alligator lizard (*Gerrhonotus multicarinatus*), western fence lizard (*Sceloporus occidentalis*), and Pacific slender salamander (*Batrachoseps attenuatus*), which feed on invertebrates found within and beneath fallen logs or other debris within the vegetation community. This habitat also attracts avian seed-eating and insect-eating species of birds and mammals. California quail (*Lophortyx californicus*), mourning dove (*Zenaidura macroura*), and meadowlark (*Sturnella neglecta*) are a few seed-eaters that nest and forage in grasslands. One type of grassland bird guild (those that nest and forage in grasslands) includes California horned lark (*Eremophila alpestris actia*), savannah sparrow (*Passerculus sandwichensis*), and western meadowlark, all species of conservation and management concern, and can be indicators of the health of the habitat. During previous studies, two of the three species, savannah sparrow and western meadowlark, were reported occurring in the grasslands between 1987 and 1989 (Gustein 1989). Insect-eaters such as scrub jays (*Aphelocoma coerulescens*), barn swallows (*Hirundo rustica*), and mockingbirds (*Mimus polyglottus*) use the habitat for foraging only. Grasslands are important foraging grounds for aerial and ground foraging insect-eating bat species such as myotis (*Myotis* spp.) and pallid bat (*Antrozous pallidus*). A large number of other mammal species such as California vole (*Microtus californicus*), Botta's pocket gopher (*Thomomys bottae*), California ground squirrel (*Spermophilus beecheyi*) and black-tailed jackrabbit (*Lepus californicus*) also forage and nest within grasslands and have been reported on the site (Gustein 1989). Small rodents attract raptors (birds of prey) such as owls that hunt at night, as well as day-hunting raptors such as red-tailed hawks (*Buteo jamaicensis*), northern harrier (*Circus cyaneus*) and white-shouldered kite (*Elanus leucurus*), among others, which have been reported on the site (Gustein 1989). Black-tailed deer (*Odoicoileus hemionus californicus*) use grassland for grazing and, if the grass is tall enough, for nesting at night.

One invertebrate species, the Ohlone tiger beetle (*Cincidela ohlone*), is a specialist of the coastal terrace prairie grassland habitat. However, this species occurs in coastal terrace prairie habitats located south of San Francisco Bay and does not occur in the Richmond Area (CNDDB 2012).

3.4 Wildlife Movement Corridors

Wildlife movement includes migration (*i.e*., usually one way per season), inter-population movement (*i.e*., long-term genetic flow) and small travel pathways (*i.e.,* daily movement corridors within an animal's territory). While small travel pathways usually facilitate movement for daily home range activities such as foraging or escape from predators, they also provide connection between outlying populations and the main corridor, permitting an increase in gene flow between populations.

These linkages between habitat types can extend for miles between primary habitat areas and occur on a large scale throughout California. Habitat linkages facilitate movement between populations located in discrete areas and populations located within larger habitat areas. The mosaic of habitats found within a large-scale landscape results in wildlife populations that consist of discrete sub-populations comprising a large single population, often referred to as a meta-population. Even where patches of pristine habitat are fragmented, such as occurs with coastal terrace prairie grassland and other grasslands, the movement between wildlife populations is facilitated through habitat linkages, migration corridors and movement corridors. Depending on the condition of the corridor, genetic flow between populations may be high in frequency, thus allowing high genetic diversity within the population, or may below in frequency. Potentially low frequency genetic flow may lead to complete isolation and, if pressures are strong, potential extinction (McCullough 1996; Whittaker 1998).

As a vegetative community, the coastal terrace prairie grassland is isolated to the RFS; however, other grasslands (both native and non-native) occur in the general area and provide much of the same habitat value for wildlife as the coastal terrace prairies grassland. As a result, the grassland at the RFS provides the western most habitat available along the Inner Richmond Harbor. Movement corridors within the project area include the Stege saltmarsh on the southern border, the slough that runs along the western border, and the meadows located on the western portion of the site. The eucalyptus grove provides a movement corridor for those species that do not like to be exposed, such as California quail and brown towhees. The developed habitat provides an area for movement for raccoons, skunks and opossums.

Impacts and mitigation measures for these grasslands will be evaluated during the NEPA and CEQA process and are not part of this report. All opportunities for potential enhancement, restoration and creation will be also evaluated during that review.

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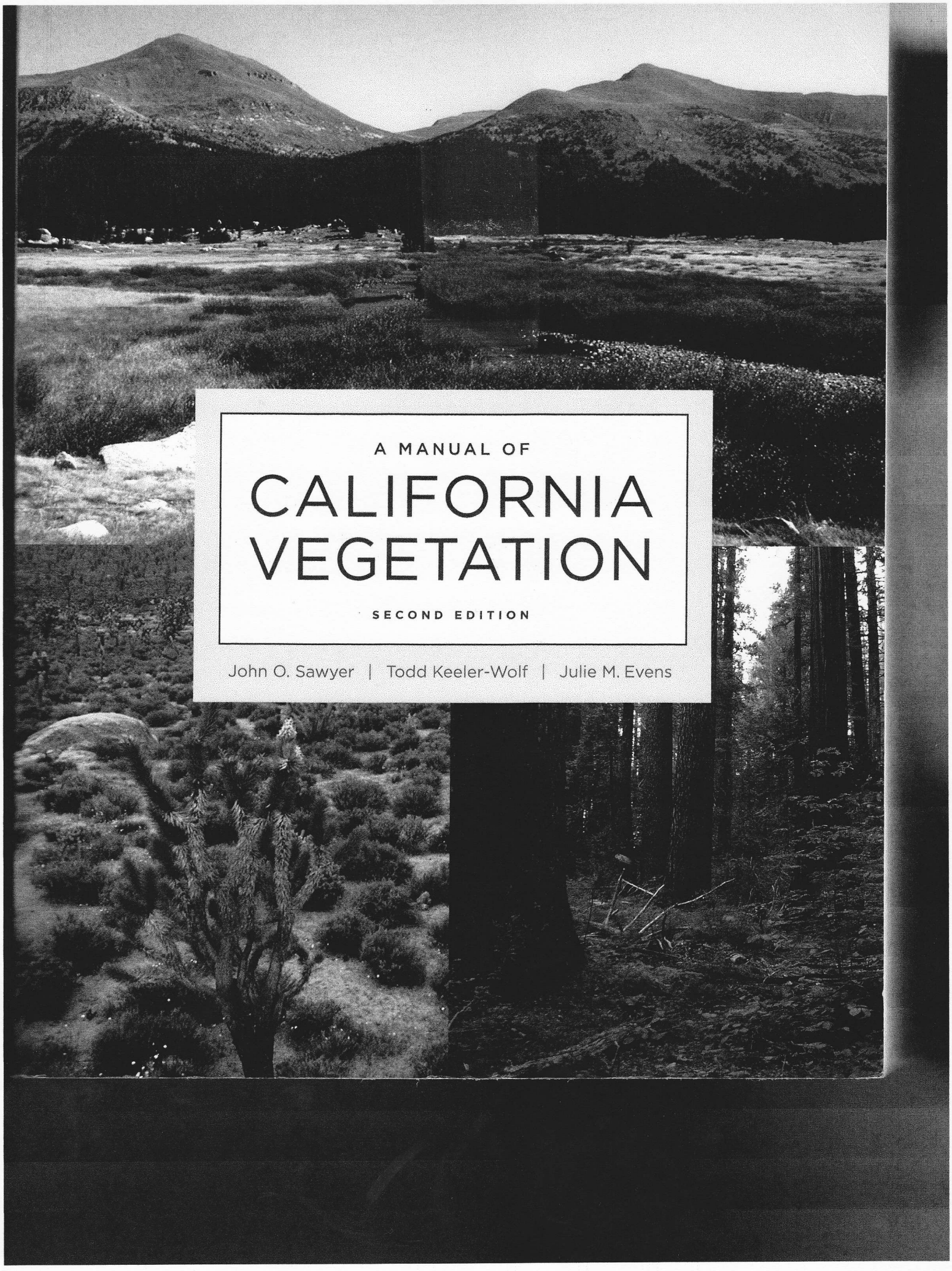
Fig. 3: Northwest Meadow looking north.

Fig. 4: EPA Meadow South looking northeast.

Fig. 5: West Meadow looking south.

APPENDIX A: Manual of California Vegetation Membership Rules



A MANUAL OF CALIFORNIA VEGETATION

SECOND EDITION

John O. Sawyer | Todd Keeler-Wolf | Julie M. Evens

Danthonia californica Herbaceous Alliance

California oat grass prairie

***Danthonia californica* is dominant or co-dominant in the herbaceous layer** with *Aira caryophyllea, Anthoxanthum odoratum, Arrhenatherum elatius, Bromus carinatus, Carex tumulicola, D. pilosa, Epilobium* spp., *Festuca* spp., *Holcus lanatus, Iris douglasiana, Juncus arcticus, Lolium perenne, Muhlenbergia filiformis, Melica californica, Nassella pulchra, Plantago lanceolata, Poa pratensis, P. secunda, Potentilla gracilis, Pteridium aquilinum, Ranunculus californicus, R. occidentalis, Rumex acetosella,* and *Sisyrinchium bellum*. Emergent trees and shrubs such as *Baccharis pilularis* or *Lupinus rivularis* may be present at low cover. Herbs < 1 m; canopy is open to intermittent.

Habitats: Coastal bluffs, valley bottoms, floodplains, terraces, slopes, ridge tops. The USFWS Wetland Inventory (1996 national list) recognizes *Danthonia californica* as a FACW plant. **Elevation:** 0–2200 m.

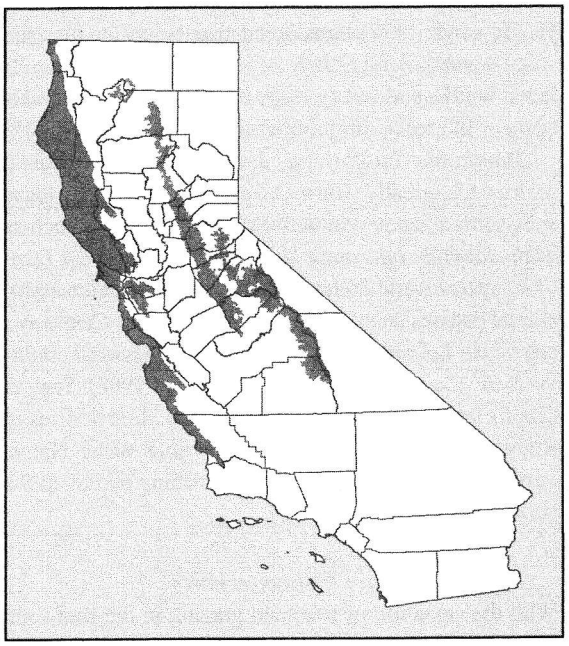
Rarity ranking: G4 S3. **MCV:** California oat grass series. **NVCS:** *Danthonia californica* herbaceous alliance. **Calveg:** Perennial grass/herbs. **Holland:** Bald Hills grassland, Coastal terrace prairies, Great Basin grassland. **Munz:** Coastal prairie. **WHR:** Perennial grassland.

Membership Rules

Danthonia californica > 50% relative cover in the herbaceous canopy (Keeler-Wolf et al. 2003a).

Life History Traits of Principal Species

Life forms	Polycarpic perennial; herb
Seed storage	Transient
Seed longevity	Short
Mode of dispersal	Animal; wind
Germination agents	None
Mode of sprouting	Underground structures (culms)
Survivability after fire/disturbance	Fire-hardy; high sprouter
Disturbance-stimulated flowering	No
Reproductive range	Life of plant
Recruitment	Medium
Regional variation	Low



Danthonia californica generally > 25% absolute cover in the herbaceous layer (S. Smith 1998).

Remarks

Danthonia californica is a perennial bunchgrass with loosely clustered, coarse culms. Seedlings establish on bare soil. Plants are tolerant of moderate grazing (Heady et al. 1963). It occurs in coastal prairies and woodlands. It also can dominate inland meadows at low and montane elevations.

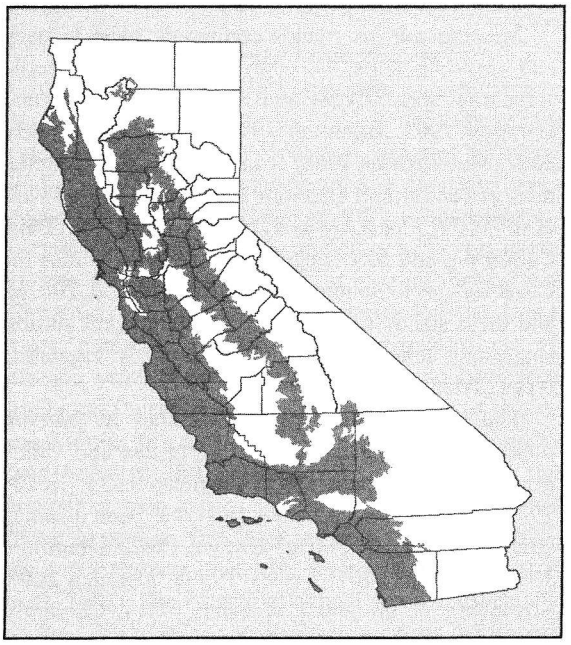
Perennial grasslands with rich, moist soils along the central coast are referred to as coastal prairie (Ford and Hayes 2007). On the north coast north of Marin Co., the coastal prairie occurs in two settings: terrace prairies along the coastline, and the Bald Hills prairies on inland ridges and hilltops. Stands with similar species composition also occur inland in California where annual rainfall is greater than 100 cm. We include grasslands on these two settings in this alliance. The type was also extensive in the Rogue,

Nassella pulchra Herbaceous Alliance
Purple needle grass grassland

***Nassella pulchra* is dominant or characteristically present in the herbaceous layer** with other perennial grasses, including *Elymus glaucus, Festuca californica, Hordeum brachyantherum, Koeleria macrantha, Lolium perenne, Melica californica, M. imperfecta, N. lepida, N. cernua,* and *Poa secunda,* and with perennials, such as *Calochortus* spp., *Calystegia* spp., *Sanicula* spp., and *Sisyrinchium bellum.* Annual herbs, including *Astragalus* spp., *Avena barbata, A. fatua, Bromus hordeaceus, B. rubens, Clarkia* spp., *Cryptantha* spp., *Eremocarpus setigerus, Erodium* spp., *Hirschfeldia incana, Holocarpha virgata, Lasthenia* spp., *Lepidium nitidum, Lupinus* spp., *Plantago* spp., and *Trifolium* spp., are common. Emergent *Artemisia californica, Eriogonum fasciculatum, Hazardia squarrosa,* and other shrubs and trees may be present at low cover. Herbs < 1 m; cover is open to continuous.

Habitats: Valley and foothill areas on all topographic locations. Inland soils are deep with high clay content, or shallow and rocky near the coast. **Elevation:** 0–1300 m.

Rarity ranking: *G4 S3?.* **MCV:** Purple needlegrass series. **NVCS:** *Nassella pulchra* herbaceous alliance. **Calveg:** Perennial grass/herbs. **Holland:** Valley needlegrass grassland. **Munz:** Valley grassland. **WHR:** Perennial grassland.



Membership Rules

Nassella pulchra usually > 10% relative cover of the herbaceous layer (Evens and San 2005, Klein and Evens 2005, Keeler-Wolf and Evens 2006).

Nassella pulchra > 5% absolute cover as a characteristic to dominant species in the herbaceous layer (Klein et al. 2007).

Life History Traits of Principal Species

Life forms	Polycarpic perennial; herb
Seed storage	Transient
Seed longevity	Short
Mode of dispersal	Animals; gravity; wind
Germination agents	None
Mode of sprouting	Buds on large branches or trunks (basal buds, tillers)
Survivability after fire/ disturbance	Fire-hardy; high sprouter
Disturbance-stimulated flowering	No
Reproductive range	Long-lived
Recruitment	High
Regional variation	Medium

Remarks

Nassella pulchra is a native, cool-season perennial bunch grass that expands when tussocks fragment. Plants produce large quantities of viable seed, but seedling establishment is generally low. Seedlings appear to establish more successfully on ground that is bare. *N. pulchra* varies with seasonal weather conditions, and the wet growing season favors plants (Steinberg 2002c, Stromberg et al. 2007). *N. cernua* sometimes occurs in the same area as this species, especially in southern California, but they do not typically mix (Steinberg 2002c). These needle grasses tend to segregate based on substrate and slope factors (Kellogg and

WETLAND DELINEATION REPORT FOR PORTIONS OF THE RICHMOND FIELD STATION RICHMOND, CALIFORNIA

July 2013

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LIST OF ACRONYMS

Acronym or Abbreviation	Full Phrase
asl	above sea level
FAC	facultative
FACU	facultative upland
FACW	facultative wetland
NRCS	US Department of Agriculture, Natural Resources Conservation Service
NWI	National Wetland Inventory
OBL	obligate
RBC	Richmond Bay Campus
RFS	Richmond Field Station
UC	University of California
UPL	upland
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture

SECTION 1
INTRODUCTION

1.1 BACKGROUND

The Richmond Field Station (RFS) is an off-site academic teaching and research facility owned by the University of California (UC) and managed by UC Berkeley since 1950. The RFS was selected as the preferred site for a second campus for consolidation of biosciences projects and activities managed by the Lawrence Berkeley National Laboratory. The proposed name of the new facility is the Richmond Bay Campus (RBC). The subject of the wetland delineation is 16 acres that comprise a subset of the initial development footprint for the RBC.

The purpose of this report is to provide results of wetland delineation activities on a 16-acre portion of the initial development footprint for the RBC. Wetlands are defined as those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (USACE 1987). Explicit in the definition are positive wetland indicators of three environmental parameters: hydrology, soil, and vegetation (USACE 1987). The three criteria are evaluated using US Army Corps of Engineers (USACE) wetland delineation forms completed in the field. Wetlands generally include swamps, marshes, bogs, and similar areas. As a subset of waters of the United States, jurisdictional wetlands are subject to Section 404 of the Clean Water Act and/or or Section 10 of the Rivers and Harbors Act. Jurisdictional wetlands typically include: traditional navigable waters, wetlands adjacent to navigable waters, non-navigable tributaries of traditional navigable waters that are relatively permanent, and wetlands that abut such tributaries (EPA 2007).

As shown in this report, one area within the 16-acre footprint was found to meet the above wetland definition, which is consistent with both the Clean Water Act and the 10 CFR Part 1022 wetland definitions. As presented in Section 3.3, this wetland does not appear to fall under the jurisdiction of the USACE.

1.2 PROJECT LOCATION

The RBC project site is at 1301 South 46th Street in the City of Richmond, Contra Costa County, California (37.919° N, -122.33° W). The 133-acre RBC project site is bounded on the west by a Pacific Gas and Electric (PG&E) service station, the north by Regatta Boulevard, the northeast by Meade Street, the east by the western side of South 46th Street, and the south by the San Francisco Bay. Interstate 580 (I-580) runs parallel to Meade Street along the northeastern boundary of the RBC project site (Figure 1-1).

1.3 PROJECT STUDY AREA

The project study area is a subset of the RBC project site bordered on the east by South 46th Street, the south by the Western Stege Marsh, the west by Avocet Way, and the north by Lark Drive (Figure 1-2). The southern portion of the project study area is approximately 10 feet above sea level (asl). Current redevelopment plans for the project study area include three buildings totaling 600,000 gross square feet, parking areas, and landscaping.

1.4 GENERAL SITE CONDITIONS

1.4.1 Ecological Features

Habitat types observed in the vicinity of the RBC site include native coastal terrace grasslands, coastal scrub, tidal marsh, tidal mudflats, and open slough channels associated with Western Stege Marsh (south of and outside the project study area). The marsh includes native cordgrass (*Spartina foliosa*) and other vegetation that provides habitat for the endangered California clapper rail (*Rallus longirostris obsoletus*).

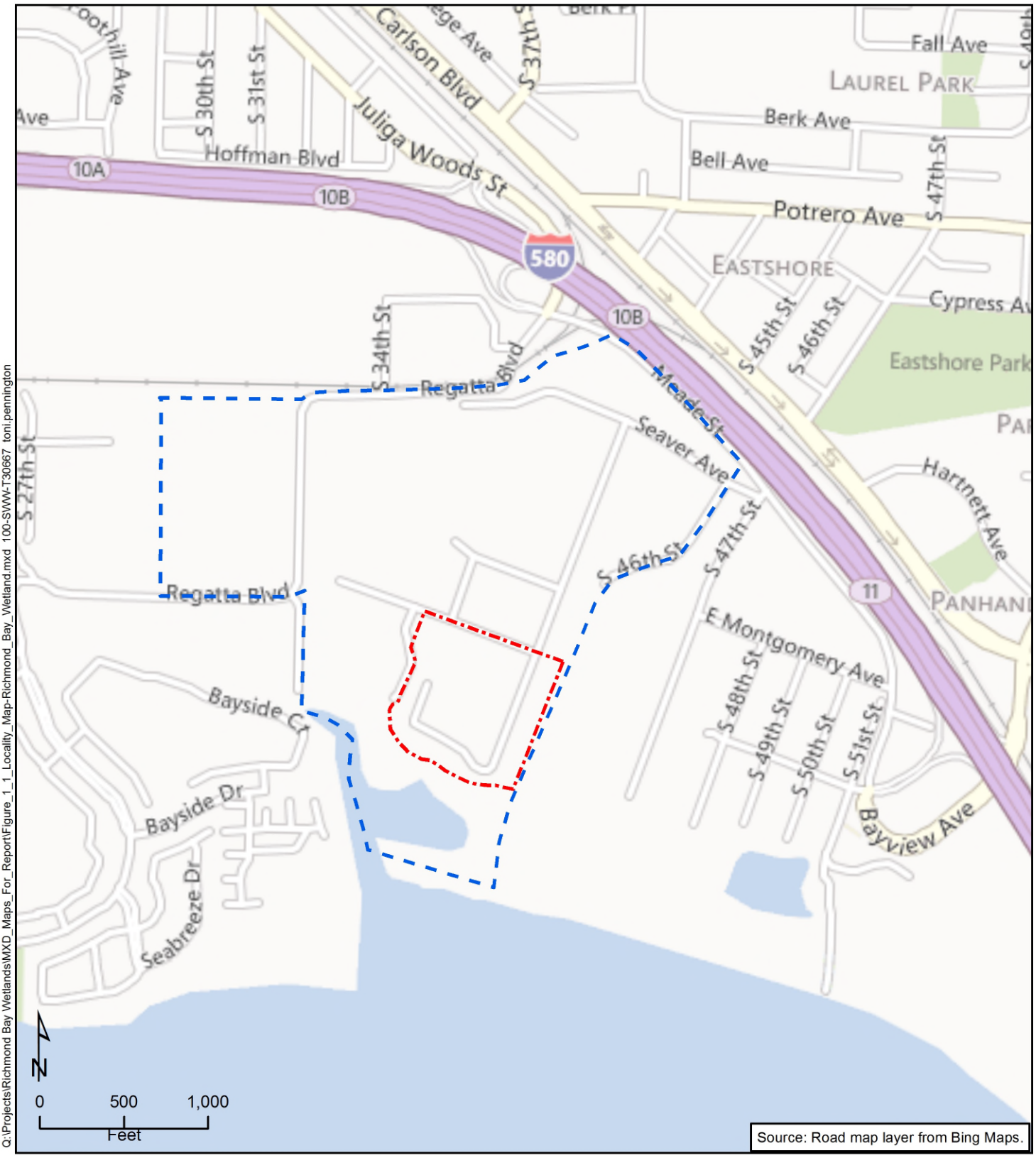
Within the project study area, the grassland habitat area includes both native and nonnative plant species, which provide primary habitat, such as nesting and foraging, and secondary habitat, such as movement corridors. Manmade landscaping and nonnative grasslands are also found. Monarch butterflies (*Danaus plexippus*) a California sensitive species, use eucalyptus trees in the central portion of the site for cover and thermal regulation during the winter months.

1.4.2 Precipitation

Table 1-1 lists the average and measured precipitation data (WETS table) (NRCS 2013a). Precipitation data in the days preceding the site visits was obtained from the California Department of Water Resources Data Exchange Center (Station ID: RHL). An initial investigation of the project study area was done on January 4, 2013, with focused field evaluations on February 13 and 15, 2013. In the week prior to the January 4 site visit, 0.04 inch of precipitation was recorded. In the week prior to the February 13 and 15 site visits, no precipitation was recorded.

1.4.3 Soils

Two soil types were identified from the US Department of Agriculture, Natural Resources Conservation Service (NRCS) Custom Soil Report for Contra Costa County, California: Urban Land and Clear Lake Clay (NRCS 2013b, NRCS 2013c). Clear Lake Clay is considered to have hydric properties, meaning soil map unit components are likely to meet



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Legend

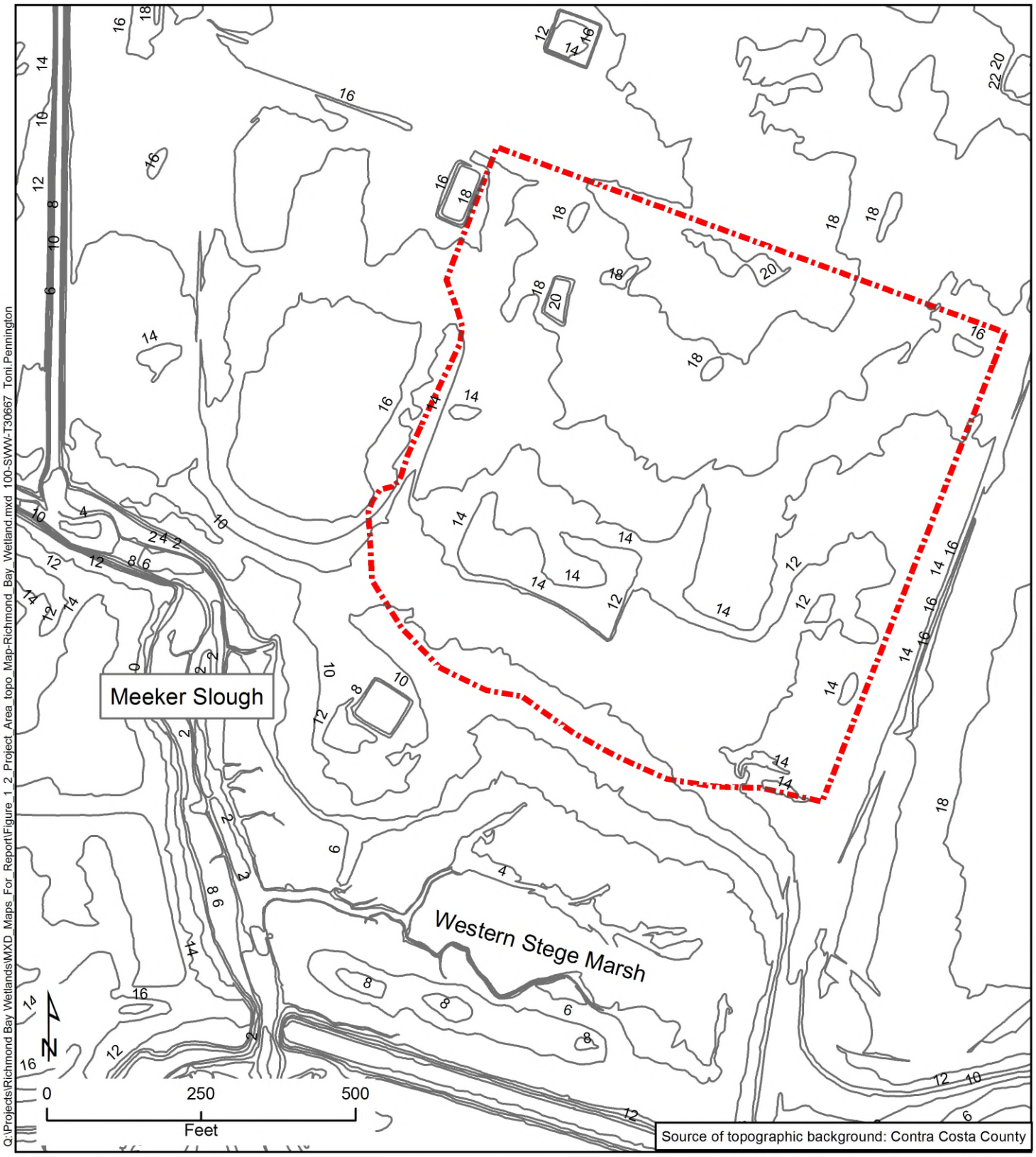
- Richmond Bay Campus Site
- Project Study Area

TETRA TECH

Locality Map

Richmond Field Station
Wetland Delineation
Richmond, California

Figure 1-1



Legend

2 ft. contour intervals

Project Study Area

TETRA TECH

Project Study Area

Richmond Field Station
Wetland Delineation
Richmond, California

Figure 1-2

Table 1-1
Precipitation Data

Month	Temperature (°F)			Precipitation (Inches)				
				Avg	30% Chance Will Have		Avg # of Days w/.1 or More	Avg Total Snowfall
	Avg Daily Max	Avg Daily Min	Avg		Less Than	More Than		
January	57.7	42.7	50.2	4.71	2.09	5.75	7	0.0
February	61.8	45.4	53.6	4.24	1.72	5.15	7	0.0
March	63.9	47.1	55.5	3.55	1.31	4.29	6	0.0
April	67.3	49.0	58.2	1.35	0.57	1.64	3	0.0
May	69.3	51.8	60.6	0.54	0.01	0.52	1	0.0
June	71.7	54.6	63.1	0.17	0.00	0.16	0	0.0
July	71.5	55.8	63.6	0.07	0.00	0.00	0	0.0
August	72.0	56.5	64.3	0.10	0.00	0.00	0	0.0
September	74.1	56.5	65.3	0.27	0.00	0.00	0	0.0
October	72.3	53.3	62.8	1.40	0.45	1.71	2	0.0
November	64.4	47.9	56.2	3.31	1.15	3.98	5	0.0
December	58.1	42.9	50.5	3.35	1.85	4.16	6	0.0

Creation Date: 08/29/2002
Latitude: 3756 Longitude: 12221 Elevation: 00060
State FIPS/County (FIPS): 06013 County Name: Contra Costa
Start yr – 1971 End yr. - 2000
Source: WETS Station, Richmond, CA7114; NRCS 2013a
% – percent # – number
Avg – average w/ – with

the hydric soil definition but field indicators are necessary for verification (NRCS 2013b). Clear Lake Clay is typically found on 0 to 2 percent slopes and is considered poorly drained (NRCS 2013b).

1.4.4 Land Uses

Land uses are primarily dedicated to research buildings, roadways, parking lots, and landscaped and undeveloped open areas. The adjacent lands include industrial/office uses, I-580, and low to medium density residential neighborhoods. The adjacent property to the east is the location of former chemical production operations, currently owned by Cherokee Simeon Venture I, LLC. Western Stege Marsh is immediately to the south of the RBC site and drains into San Francisco Bay. The Western Stege Marsh Project Restoration Area is a 9.40-acre compensatory mitigation wetland characterized by salt grass (*Distichlis spicata*), Pacific cordgrass (*Spartina foliosa*), and pickleweed (*Salicornia virginica*).

1.5 SITE DISTURBANCE

Historic and recent disturbance has resulted in significantly disturbed soils at the RBC site. Historic disturbance includes significant infill of Western Stege Marsh and original site development in the 1950s. Large quantities of pyrite cinders were deposited on the RBC site from prior to 1950 through 2002. Remedial activities have included removal of approximately 28,000 cubic yards of contaminated soil and marsh sediment, excavation of

an area at the outfall of a storm drain in Meeker Slough, and removal of an additional 3,300 cubic yards of contaminated soils from six upland areas.

Recent disturbance at the site includes regular maintenance of drainage swales that drain water from across the property. This has resulted in frequent soil disturbance that likely affects hydric soil indicators. Many of the dominant plant species are weedy invasives such as Harding grass (*Phalaris aquatica*) and sweet fennel (*Foeniculum vulgare*). These opportunistic species are not considered hydrophytic (Lichvar and Kartesz 2012); however, they may be taking advantage of increased soil moisture when native perennials are not yet established.

SECTION 2
METHODS

2.1 SAMPLE SCHEDULE

The project study area was visited by Tetra Tech biologist Shannon Lindquist on January 4, 2013 to assess the condition of the existing habitats. All habitat types were noted with particular consideration given to the presence of potential wetland features (e.g., a seasonal wetland, vegetated channels, and lined swales).

Tetra Tech biologists Toni Pennington and Darlene Siegel did the wetland delineation on February 13 and 15, 2013.

2.2 SAMPLING PROTOCOLS

This wetland delineation followed the 1987 *Corps of Engineers Wetland Delineation Manual* (USACE manual) (USACE 1987) and the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region (Version 2.)*. National Wetland Inventory (NWI) (USFWS 2013) maps and the California Wetlands Portal were reviewed to determine if wetlands had been previously identified in the project study area. According to these sources, no wetlands are known to be in the project study area; however, the Western Stege Marsh, a jurisdictional water body, is immediately south of the project study area.

During the January site visit, the area was qualitatively surveyed to identify potential wetlands and other waters of the US. At that time, standing water was observed in stormwater drainages. During the formal delineation upland and wetland plots were sampled to characterize community distinctions and to facilitate wetland boundary determinations according to USACE (1987). In general, test pits were dug at locations with clear breaks of topography, vegetation, or hydrologic features. Sample points were positioned to be distinctly in wetland and upland communities, and then as necessary to identify where one or more parameters disappeared in the transitional zone between the two habitat types. At each sample plot, indicators of vegetation, hydrology, and soils were documented. Where all three wetland criteria were positive, the area was identified as a wetland (USACE 1987). Wetland determination data forms are in Appendix B.

Vegetation strata were surveyed using circular plots: 30-foot diameter for tree and woody vine stratum, 15-foot-diameter for shrub and sapling, and 5-foot diameter for herbaceous strata. Dominant plants were identified to the species level with total percent cover estimated for each stratum. All plant species were documented and dominants were calculated based on their percent cover in each stratum. Lichvar and Kartesz (2012) was used to determine a plant's indicator status (facultative upland [FACU], facultative [FAC], facultative wetland [FACW], or obligate [OBL]). Plants not listed in Lichvar and Kartesz (2012) were considered upland (UPL) plant species.

Soil test pits were dug to a standard depth of 16 inches for determination of wetland hydrology and hydric soil indicators. No standing water, saturated soils, or high water table was observed. Soil horizons and textures were identified for each sample plot and soil matrix and redoximorphic features, if present, were determined using Munsell® Soil Color Charts (Munsell 2009) and WTI (2010). All potential wetlands were mapped to sub-meter accuracy with a Trimble GeoExplorer 6000 Series Geo XH global positioning (GPS) unit. Data were post-processed and transferred to global information system (GIS) shapefiles using Pathfinder 5.0 and were then overlain onto topographic base maps using ArcMap 10.

2.3 ADDITIONAL DATA SOURCES

Additional resources used included results of a recent botanical survey at the RFS ([URS] 2007), the National Wetlands Plant List (Lichvar and Kartesz 2012), and soil surveys for Contra Costa County (NRCS 2013b).

SECTION 3
DESCRIPTION OF WETLANDS AND OTHER WATERS OF THE UNITED STATES

Based on the site visit in January, two areas were targeted for the formal delineation in February. Specific sample points were targeted for investigation as they had been previously determined as potential wetlands or other waters of the United States. A total of seven sample points were collected within the project study area, and one was collected just outside the project study area (Figure 3-1) to determine whether all wetland indicators were present. We found 1) two vegetated drainage channels with evidence of recent water flow and 2) a small herbaceous wetland swale downstream of the drainage channel (Figure 3-2).

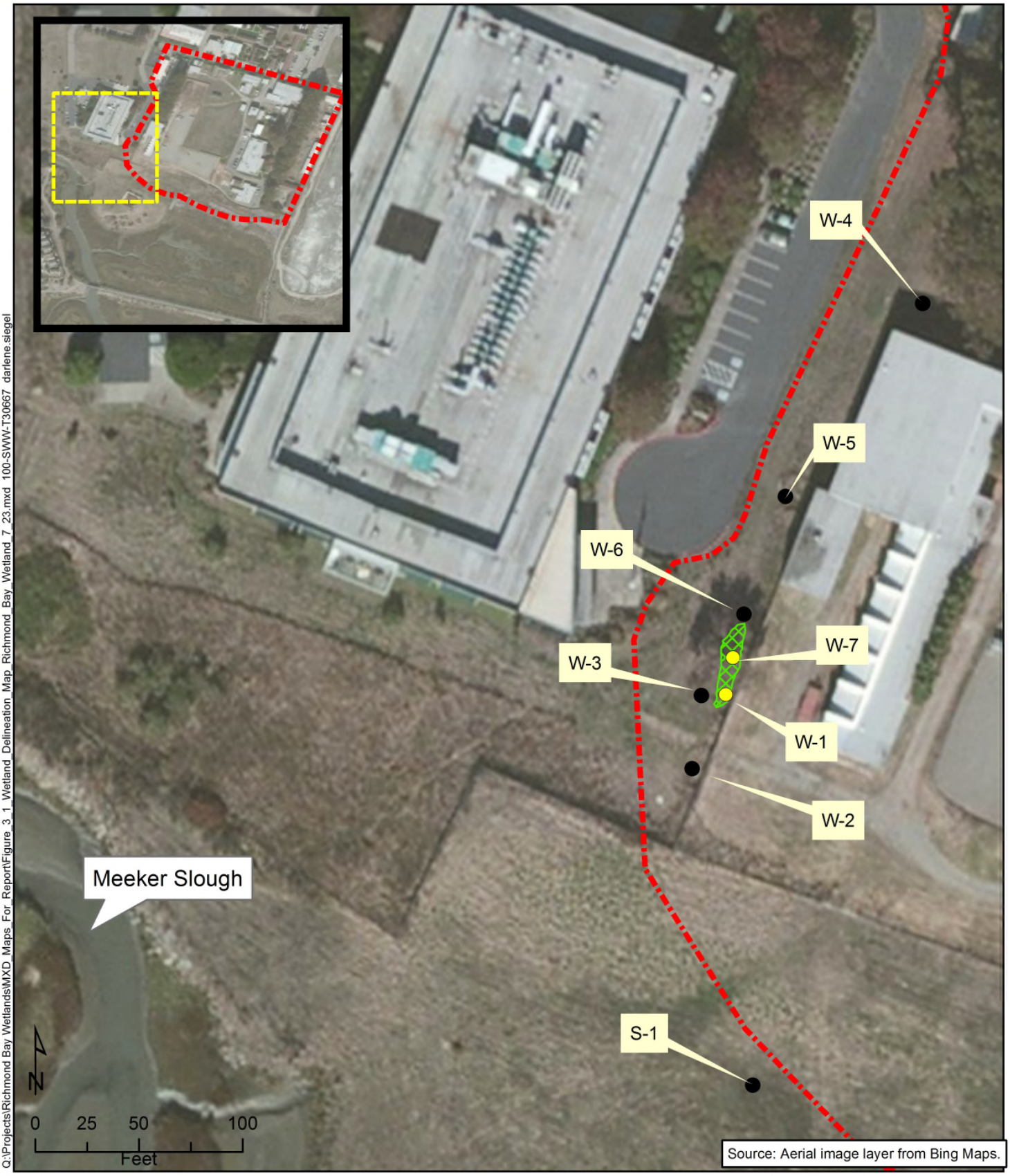
3.1 DRAINAGE CHANNELS

An asphalt-lined channel, located on the east side of the project study area, drains water from adjacent buildings (see inset graphic on Figure 3-2). Water moves south-southwest to a culvert under a driveway after which it daylights once before continuing underground to an outlet located outside the project area.

A vegetated channel is north of Building 128, between Building 275 and a fence line (Figure 3-2 and Photo 1, Appendix A). The channel appears to drain water from around Building 275 and carries water south for approximately 230 feet, turns west and drains to a box culvert at the northwest corner of Building 128 (Photo 2, Appendix A). From there, water flows due south (Photo 3, Appendix A) for approximately 180 feet to a 300-square-foot herbaceous wetland swale. The channel is periodically maintained to convey water. Sample points W-4, W-5, and W-6 were along this channel (Figure 3-1). Again, wetland determination data forms are in Appendix B.

3.1.1 Vegetation

Common plant species observed along this drainage channel included: Harding grass (*Phalaris aquatica*), bur clover (*Medicago polymorpha*), doves foot geranium (*Geranium molle*), narrow leaf plantain (*Plantago lanceolata*), and spring vetch (*Vinca sativa*). The dominant plant species along the channel, Harding grass, is FACU, which is not considered a vegetation indicator for wetlands.



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Legend

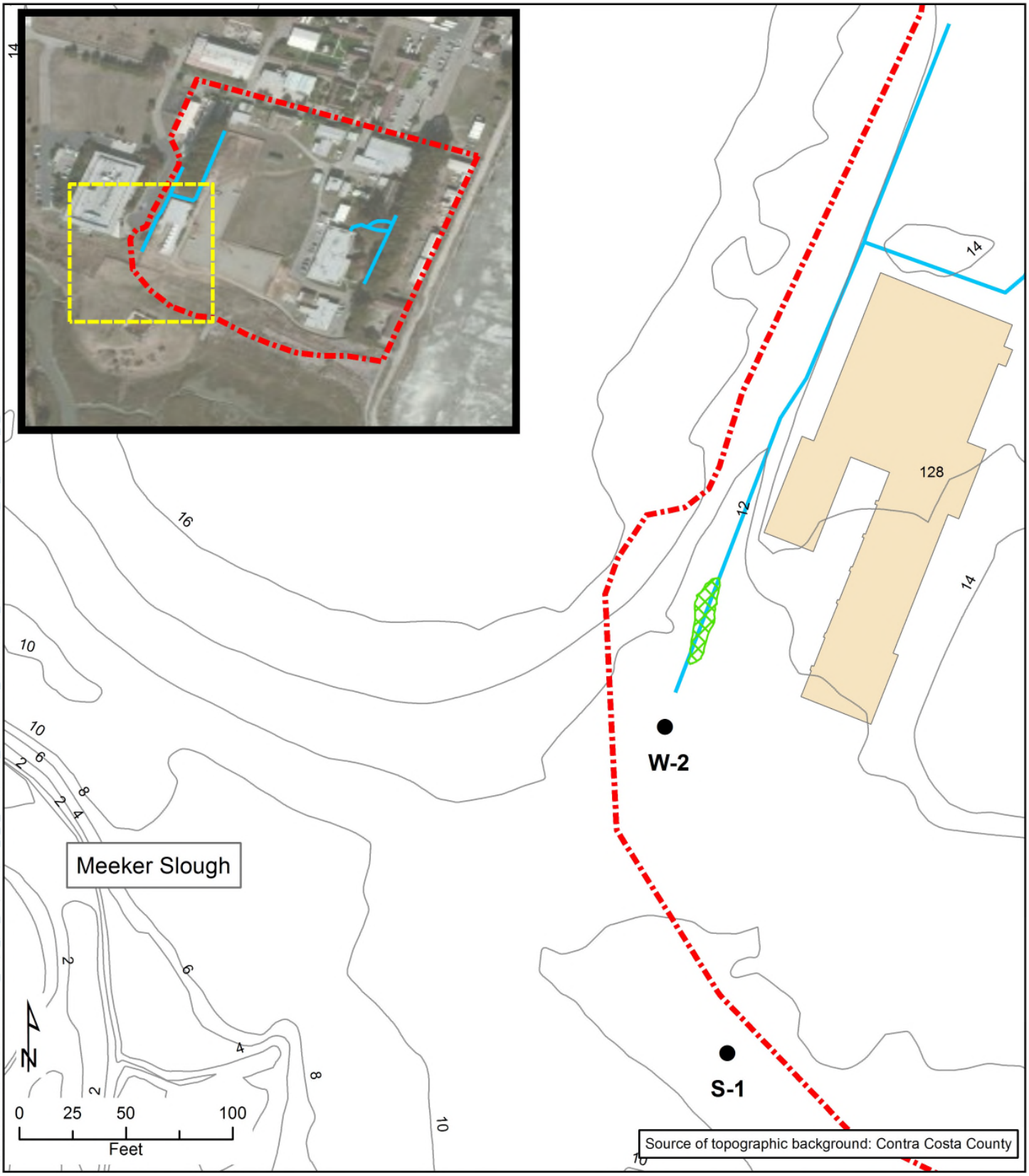
- Project Study Area
- Herbaceous Wetland
- Wetland Sample Point
- Non-wetland Sample Point
- Enlarged Area

TETRA TECH

Wetland Delineation Map

Richmond Field Station
Wetland Delineation
Richmond, California

Figure 3-1



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Legend

- Non-wetland Sample Point
- Drainage Channel
- 2 ft. Contour Intervals
- Building
- Project Study Area
- Enlarged Area
- Herbaceous Wetland (Non-Jurisdictional)

TETRA TECH

Preliminary Jurisdictional Determination Analysis

Richmond Field Station
Wetland Delineation
Richmond, California

Figure 3-2

3.1.2 Soils

Soils in this vicinity are delineated by the NRCS as Clear Lake Clay and Urban Land (NRCS 2013b). The description for Clear Lake Clay in the Custom Soil Resource Report is somewhat incongruent with field observations. We found relatively loamy soils at sample point W-4 with four color layers in the matrix profile, including a redox dark surface (F6) which is a hydric indicator for wetlands. Despite this indicator, all three criteria were not observed.

3.1.3 Hydrology

The channel conveys water that drains from adjacent buildings. Water is conveyed along an open swale (Photo 1, Appendix A), to an underground culvert (Photo 2, Appendix A), then daylights again and joins another underground culvert (Photo 3, Appendix A). Despite this, there were no indicators of wetland hydrology at sample point W-4. Wetland hydrology indicators were observed at sample points W-5 (water marks and sediment deposits) and W-6 (water-stained leaves). Standing water was observed during the January 2013 site visit, but no standing water was observed during the February 2013 wetland delineation.

3.2 HERBACEOUS WETLAND SWALE

A 300-square-foot herbaceous wetland swale was observed in the southwest corner of the project study area (Photos 4 and 5, Appendix A) (Figure 3-1). The area is periodically maintained to convey water. No standing water was observed during the February wetland delineation.

Sample points W-1 and W-7 were collected in this wetland and sample points W-3 and W-6 were collected immediately adjacent to, but outside the wetland. Sample point W-2 was taken below a culvert that drains the wetland; however all three wetland indicators were not met at this sample point. Sample point S-1 was collected to the southeast of the wetland and outside the project study area. During the January preliminary site visit, it appeared water could accumulate in the vicinity of sample point S-1; however no hydric indicators were found during the February wetland delineation (Figure 3-1).

3.2.1 Vegetation

The dominant plant species observed in the wetland swale was brown-headed rush, *Juncus phaeocephalus* (FACW), which is a vegetation indicator for wetlands. The *J. phaeocephalus* was not in flower, so identification was largely based on previous documentation of the species at the RFS (URS 2007). Without flowers, it could be mistaken for *J. effusus*; however, *J. effusus* is also FACW, so the indicator for hydric vegetation would remain the same.

3.2.2 Soils

Soils in the wetland swale are mapped as Urban Land (NRCS 2013b). We found clay loam soils of 7.5 YR 3/1 throughout the matrix in sample points W-1 and W-8 with prominent redoximorphic features (redox dark surface [F6]), a profile indicative of hydric soils and indicator of wetlands.

3.2.3 Hydrology

The source of water to the wetland swale is largely from the drainage channel from the north. The second culvert (Photo 3, Appendix A) appears to also convey water from the east, as indicated by the location of known underground water conveyances (Figure 3-2). Water is conveyed from the wetland swale, to the south, through a third culvert (Photo 5, Appendix A) where it flows to another open swale for approximately 20 feet. Beyond this point, there is very little evidence of an open swale. Another underground culvert carries water off the project study area to Western Stege Marsh (Figure 3-2). There were no indicators of wetland hydrology below the wetland swale.

3.3 PRELIMINARY WETLAND BOUNDARY AND JURISDICTIONAL DETERMINATION

Based on the information in Section 3.1, the drainage channel does not possess the required three wetland indicators and is not a wetland.

The boundary of the wetland swale was based on the dominance of FACW vegetation, hydric soils, and wetland hydrology indicators compared to adjacent upland vegetation, soils, and hydrology. Within the wetland, *J. phaeocephalus* was found growing in a distinct circular area with water-stained leaves around the perimeter. Soils within the wetland swale were somewhat problematic as the area is known to be regularly maintained for water conveyance; however, there was sufficient evidence for redox dark surfaces (hydric soil indicator F6). The paired upland sample points (W-3 and W-6) were dominated by FACU plant species (largely Harding grass) with brownish soils (10YR 3/2) and no hydrology indicators. Due to topographic variation (gradual slope to the southeast) below the third culvert and lack of sufficient moisture, the wetland swale is not directly hydrologically connected to the navigable waters of Meeker Slough. Also, the wetland swale is not adjacent to Meeker Slough or other navigable waters. As a result, the wetland swale does not appear to be jurisdictional.

Sample point W-2 was collected below the wetland swale and the third culvert (Figure 3-2). The site was dominated by Harding grass (FACU) and, despite being located below a culvert, there were no soil or hydrology indicators at the time of survey. Sample point S-1, collected further southeast of the wetland swale, did not provide evidence for hydric vegetation, soils, or hydrology during the February 2013 site visit (Figure 3-2).

In general, it appears that water moves from the drainage channel along the western side of the project area, through two culverts to the wetland swale, and out below the third culvert. Below this, there is a slight topographic slope toward the southeast (away from Meeker Slough) in the vicinity of sample point S-1 (Figure 3-2). The area surrounding S-1 is a slight artificial depression that appears to be an artifact of the construction activities for the remediation and restoration of the site. While this depression appears to trap runoff from above, it does not pond for sufficient duration to form all three hydric indicators, nor does it appear to allow water to drain to navigable waters. As a result, the depression surrounding sample point S-1 does not possess the required three wetland indicators and is not a wetland.

3.4 DISCLAIMER

This report documents the investigation, best professional judgment, and conclusions of the investigators. It should be considered a Preliminary Jurisdictional Determination and used at your own risk until it has been approved in writing by the US Army Corps of Engineers, San Francisco District, Regulatory Program.

SECTION 4
LITERATURE CITED

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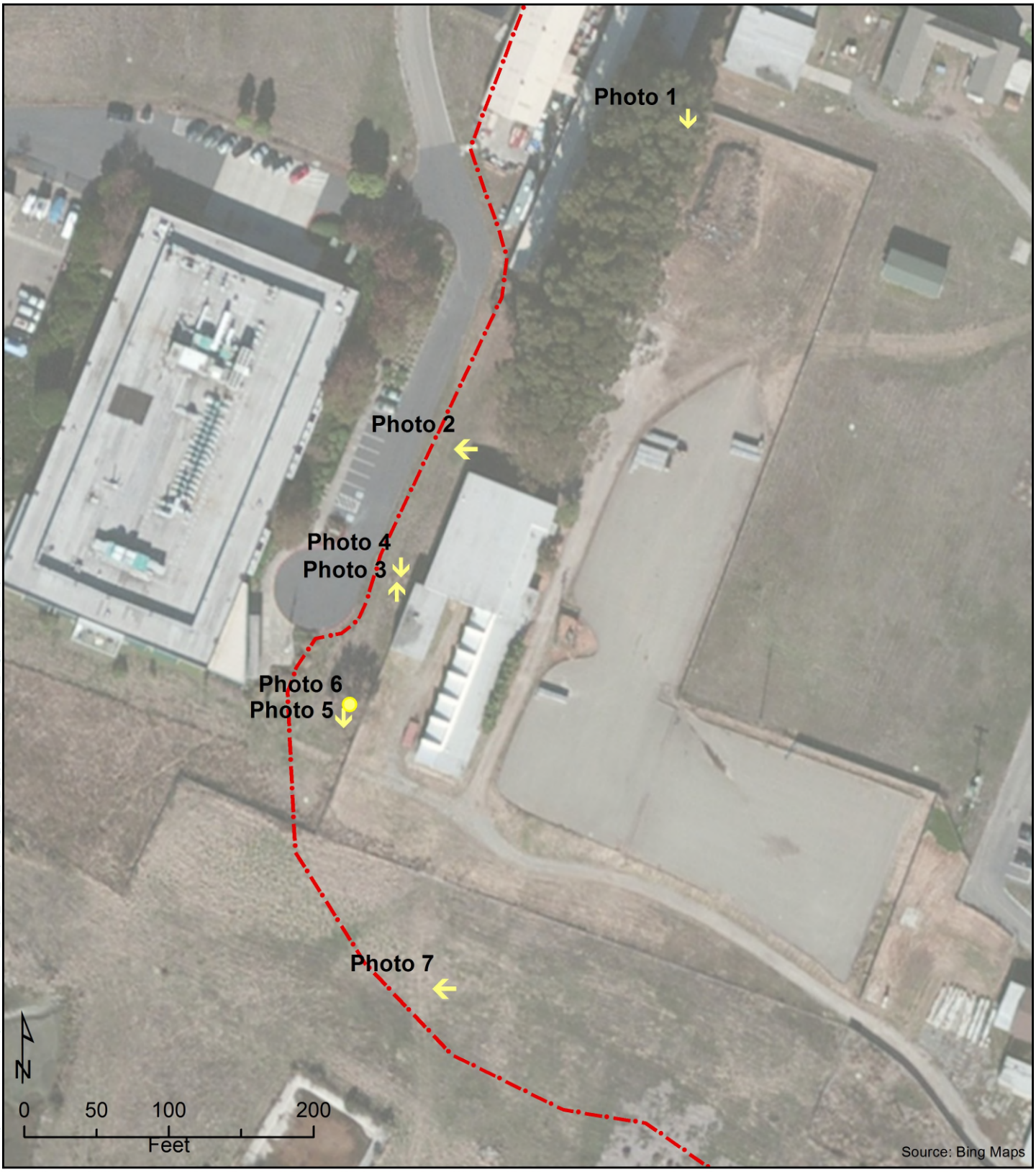
Appendix A

Photo Log



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Location and direction of photo points referenced in the report and Appendix A

Photo Log Location Map

Legend

Project Study Area

TETRA TECH

Richmond Field Station
Wetland Delineation
Richmond, CA

Figure A-1

Photo 1. Drainage channel that flows south parallel to Building 275 (facing south).

Photo 2. Drainage shown in Photo 1, as it turns west at Building 128 and flows into a box culvert (facing west).

Photo 3. Box culvert west of Building 128. Channel flows underground from previous culvert and exits here where it combines with wetland swale (facing north).

Photo 4. Wetland swale from Photo 3 continues to flow as a channel to the fence line (facing south).

Photo 5. Wetland swale from previous photo flows into a culvert to pass under Heron Drive and continues as a narrow channel (facing south).

Photo 6. Wetland swale (300 square feet).

Photo 7. Sample point S-1 located south of Building 128 and Heron Drive, in a nonnative grassland habitat (facing west). During the January 2013 site visit, hydric vegetation in the area suggested a potential depressional wetland; however, no hydric soils or wetland hydrology indicators were recorded during the February 2013 delineation.

Appendix B

Wetland Determination Data Forms

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Phase I RBC City/County: Contra Costa Sampling Date: 2/13/13

Applicant/Owner: UC Berkeley State: CA Sampling Point: S-1

Investigator(s): Pennington, Siegel Section, Township, Range: NW1/4 SW1/4 S20, T1NR4W

Landform (hillslope, terrace, etc.): Flat Local relief (concave, convex, none): None Slope (%): <1

Subregion (LRR): C Lat: 37.9124529741 Long: -122.336346409 Datum: WGS 84

Soil Map Unit Name: Urban Land NWI classification: None

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil X, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** Yes _____ No X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:

Area has been significantly altered within the last nine years.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 30 ft.)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	
Sapling/Shrub Stratum (Plot size: 15 ft.)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	
Herb Stratum (Plot size: 5 ft.)			
1. Lotus corniculatus	25	Y	FAC
2. Plantago lanceolata	10	N	FAC
3. Rumex crispus	15	N	FAC
4. Geranium molle	15	N	UPL
5. Helminthotheca echiodes	5	N	FACU
6. Phalaris aquatica	25	Y	FACU
7. Distichlis spicata	10	N	FAC
8.			
	100	= Total Cover	
Woody Vine Stratum (Plot size: 30 ft.)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0 % Cover of Biotic Crust _____

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	0	x 1 =	0
FACW species	0	x 2 =	0
FAC species	60	x 3 =	180
FACU species	30	x 4 =	120
UPL species	15	x 5 =	75
Column Totals:	105 (A)		375 (B)

Prevalence Index = B/A = 3.57

Hydrophytic Vegetation Indicators:

☐ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes _____ No X

Remarks:

SOIL

Sampling Point: S-1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-16	10YR 3/1	100						

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes _____ **No** X

Remarks:

Filled in 2002 with approximately 4 ft. top soil. Historic aerials indicate inundation by Stege Marsh in 1939, but substantial fill prior to 1960's and further manipulation of the area in 2004.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- ___ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes _____ No X Depth (inches): _____

Water Table Present? Yes _____ No X Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes _____ No X Depth (inches): _____

Wetland Hydrology Present? Yes _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Phase I RBC City/County: Contra Costa Sampling Date: 2/13/13

Applicant/Owner: UC Berkeley State: CA Sampling Point: W-1

Investigator(s): Pennington, Siegel Section, Township, Range: NW1/4 SW1/4 S20, T1NR4W

Landform (hillslope, terrace, etc.): Flat Local relief (concave, convex, none): Concave Slope (%): 0

Subregion (LRR): C Lat: 37.9129699332 Long: -122.336403839 Datum: WGS 84

Soil Map Unit Name: Urban Land NWI classification: None

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil X, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No _____	**Is the Sampled Area within a Wetland?** Yes X No _____
Hydric Soil Present?	Yes X No _____	
Wetland Hydrology Present?	Yes X No _____	

Remarks:

Low area that drains adjacent upland areas and parking lot to the west. Drains through culverts to the south. Receiving area has no significant wetland indicators. Area is periodically maintained for water conveyance.

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: 30 ft.)			
1.			
2.			
3.			
4.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: 15 ft.)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: 5 ft.)			
1. Phalaris aquatica	10	N	FACU
2. Lotus corniculatus	5	N	FAC
3. Medicago polymorpha	5	N	FACU
4. Geranium molle	10	N	UPL
5. Vinca sativa	5	N	UPL
6. Juncus phacocephalus	65	Y	FACW
7.			
8.			
	130 = Total Cover		
Woody Vine Stratum (Plot size: 30 ft.)			
1.			
2.			
	0 = Total Cover		

% Bare Ground in Herb Stratum 0 % Cover of Biotic Crust _____

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species _____	x 1 = _____
FACW species _____	x 2 = _____
FAC species _____	x 3 = _____
FACU species _____	x 4 = _____
UPL species _____	x 5 = _____
Column Totals: _____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

- ☑ Dominance Test is >50%
- ___ Prevalence Index is ≤3.0[1]
- ___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No _____

Remarks:

J. phaeorephalris conspicuous, but isolated. Juncus spp. was not in flower, however, J. phaeoephalus previously reported on site. Eucalyptus polyanthemos growing adjacent to, but not in the wetland.

SOIL

Sampling Point: W-1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-8	7.5 YR 3/1	92	5 YR 3/4	8	C	M	CL	
8-16	7.5 YR 3/1	100					CL	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ✔ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes X No ____

Remarks:

Area commonly maintained for water conveyance; seasonally ponded due to run-off from adjacent roof tops.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- ___ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ✔ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ____ No X Depth (inches): _____

Water Table Present? Yes ____ No X Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes ____ No X Depth (inches): _____

Wetland Hydrology Present? Yes X No ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Standing water observed above this area 1/4/13

Remarks:

Ponded water reported to occur during the rainy season (Oct - March for this area). None observed during this site visit. 0.24 inches recorded within last 7 days (Contra Costa Co. Flood Control and Water Conservation District - Gage 21).

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Phase I RBC City/County: Contra Costa Sampling Date: 2/13/13

Applicant/Owner: UC Berkeley State: CA Sampling Point: W-2

Investigator(s): Pennington, Siegel Section, Township, Range: NW1/4 SW1/4 S20, T1NR4W

Landform (hillslope, terrace, etc.): Flat Local relief (concave, convex, none): None Slope (%): <1

Subregion (LRR): C Lat: 37.9128709279 Long: -122.336458151 Datum: WGS 84

Soil Map Unit Name: Urban Land NWI classification: None

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** Yes _____ No X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: 30 ft.)			
1.			
2.			
3.			
4.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: 15 ft.)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: 5 ft.)			
1. Vinca sativa	10	N	UPL
2. Helminthotheca echiodes	10	N	FACU
3. Medicago polymorpha	5	N	FACU
4. Geranium molle	5	N	UPL
5. Phalaris aquatica	90	Y	FACU
6. Foeniculum vulgare	5	N	UPL
7.			
8.			
	125 = Total Cover		
Woody Vine Stratum (Plot size: 30 ft.)			
1.			
2.			
	0 = Total Cover		

% Bare Ground in Herb Stratum 0 % Cover of Biotic Crust _____

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 0 (A)

Total Number of Dominant Species Across All Strata: 1 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 0 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	0	x 1 =	0
FACW species	0	x 2 =	0
FAC species	0	x 3 =	0
FACU species	105	x 4 =	420
UPL species	20	x 5 =	100
Column Totals:	125 (A)		520 (B)

Prevalence Index = B/A = 4.16

Hydrophytic Vegetation Indicators:

☐ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes _____ No X

Remarks:

SOIL

Sampling Point: W-2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-18	10YR 3/1	100					CL	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes _____ **No** X

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- ___ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes _____ No X Depth (inches): _____

Water Table Present? Yes _____ No X Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes _____ No X Depth (inches): _____

Wetland Hydrology Present? Yes _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Drained area below small culvert; below sample point W-1; however, no hydraulic indicators. Standing water may occur during wet season, but no evidence of long duration ponding.

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Phase I RBC City/County: Contra Costa Sampling Date: 2/13/13

Applicant/Owner: UC Berkeley State: CA Sampling Point: W-3

Investigator(s): Pennington, Siegel Section, Township, Range: NW1/4 SW1/4 S20, T1NR4W

Landform (hillslope, terrace, etc.): Flat Local relief (concave, convex, none): None Slope (%): <1

Subregion (LRR): C Lat: 37.9129680169 Long: -122.336444924 Datum: WGS 84

Soil Map Unit Name: Urban Land NWI classification: None

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** Yes _____ No X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 30 ft.)	Absolute % Cover	Dominant Species?	Indicator Status
1. Eucalyptus polyanthemos	25	Y	UPL
2.			
3.			
4.			
	25	= Total Cover	
Sapling/Shrub Stratum (Plot size: 15 ft.)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	
Herb Stratum (Plot size: 5 ft.)			
1. Phalaris aquatica	80	Y	FACU
2. Lotus cornicalatus	5	N	FAC
3. Helminthotheca echioides	5	N	FACU
4. Vinca sativa	5	N	UPL
5. Geranium molle	8	N	UPL
6. Medicago polymorpha	8	N	FACU
7.			
8.			
	111	= Total Cover	
Woody Vine Stratum (Plot size: 30 ft.)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0 % Cover of Biotic Crust _____

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 0 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 0 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	0	x 1 =	0
FACW species	0	x 2 =	0
FAC species	5	x 3 =	15
FACU species	93	x 4 =	372
UPL species	38	x 5 =	190
Column Totals:	136 (A)		577 (B)

Prevalence Index = B/A = 4.24

Hydrophytic Vegetation Indicators:

☐ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes _____ No X

Remarks:

SOIL

Sampling Point: W-3

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-16	10YR 3/2	100					CL	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes _____ **No** X

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- ___ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes _____ No X Depth (inches): _____

Water Table Present? Yes _____ No X Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes _____ No X Depth (inches): _____

Wetland Hydrology Present? Yes _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Phase I RBC City/County: Contra Costa Sampling Date: 2/13/13

Applicant/Owner: UC Berkeley State: CA Sampling Point: W-4

Investigator(s): Pennington, Siegel Section, Township, Range: NW1/4 SW1/4 S20, T1NR4W

Landform (hillslope, terrace, etc.): Flat Local relief (concave, convex, none): None Slope (%): <1

Subregion (LRR): C Lat: 37.9134929656 Long: -122.336087861 Datum:

Soil Map Unit Name: Clear Lake Clay NWI classification: None

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil X, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** Yes _____ No X
Hydric Soil Present?	Yes X	No _____	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:

Area is periodically maintained for water conveyance. Drains water from adjacent roof tops.

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: 30 ft.)			
1. Eucalyptus polyanthemos	5	Y	UPL
2.			
3.			
4.			
	5	= Total Cover	
Sapling/Shrub Stratum (Plot size: 15 ft.)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	
Herb Stratum (Plot size: 5 ft.)			
1. Medicago polymorpha	5	N	FACU
2. Geranium molle	5	N	UPL
3. Phalaris aquatica	90	Y	FACU
4. Plantago lanceolata	10	N	FAC
5. Helminthotheca echiodes	5	N	FACU
6. Vinca sativa	5	N	UPL
7.			
8.			
	120	= Total Cover	
Woody Vine Stratum (Plot size: 30 ft.)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0 % Cover of Biotic Crust _____

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 0 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 0 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	0	x 1 =	0
FACW species	0	x 2 =	0
FAC species	0	x 3 =	0
FACU species	100	x 4 =	400
UPL species	15	x 5 =	75
Column Totals:	120 (A)		475 (B)

Prevalence Index = B/A = 3.95

Hydrophytic Vegetation Indicators:

☐ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes _____ No X

Remarks:

SOIL

Sampling Point: W-4

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-3	10YR 3/2	100					L	
3-9	10 YR 3/1	65	7.5 YR 5/2	45	LL		LL	
9-10	10 YR 3/1	95	5 YR 4/4	5			SCL	
10-16	10 YR 3/1	90	5 YR 4/4	10			SCL	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ☑ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** X **No** _____

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- ___ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes _____ No X Depth (inches): _____

Water Table Present? Yes _____ No X Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes _____ No X Depth (inches): _____

Wetland Hydrology Present? **Yes** _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

The sample point is in the immediate vicinity of a culvert that drains water from adjacent roof tops; however, no evidence of ponding during the site visit.

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Phase I RBC City/County: Contra Costa Sampling Date: 2/13/13

Applicant/Owner: UC Berkeley State: CA Sampling Point: W-5

Investigator(s): Pennington, Siegel Section, Township, Range: NW1/4 SW1/4 S20, T1NR4W

Landform (hillslope, terrace, etc.): Flat Local relief (concave, convex, none): Concave Slope (%): <1

Subregion (LRR): C Lat: 37.9132336613 Long: -122.336310776 Datum: WGS 84

Soil Map Unit Name: Clear Lake Clay NWI classification: None

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil X, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** Yes _____ No X
Hydric Soil Present?	Yes X	No _____	
Wetland Hydrology Present?	Yes X	No _____	

Remarks:

Areas is periodically maintained for water conveyance. Drains water from adjacent roof tops.

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: 30 ft.)			
1.			
2.			
3.			
4.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: 15 ft.)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: 5 ft.)			
1. Phalaris aquatica	95	Y	FACU
2. Medicago polymorpha	5	N	FACU
3. Geranium molle	5	N	UPL
4. Plantago lanceolata	5	N	FAC
5.			
6.			
7.			
8.			
	110 = Total Cover		
Woody Vine Stratum (Plot size: 30 ft.)			
1.			
2.			
	0 = Total Cover		

% Bare Ground in Herb Stratum 0 % Cover of Biotic Crust _____

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 0 (A)

Total Number of Dominant Species Across All Strata: 1 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	0	x 1 =	
FACW species	0	x 2 =	
FAC species	1	x 3 =	
FACU species	100	x 4 =	400
UPL species	5	x 5 =	25
Column Totals:	105 (A)		425 (B)

Prevalence Index = B/A = 4.04

Hydrophytic Vegetation Indicators:

☐ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes _____ No X

Remarks:

SOIL

Sampling Point: W-5

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-4	10YR 4/1	95	5 YR 4/6	5	C	M	CL	
4-16	10 YR 4/1	98	5 YR 4/6	2	C	M	CL	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ✔ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** X **No** _____

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ✔ Water Marks (B1) (**Nonriverine**)
- ✔ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes _____ No X Depth (inches): _____

Water Table Present? Yes _____ No X Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes _____ No X Depth (inches): _____

Wetland Hydrology Present? **Yes** X **No** _____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Phase I RBC City/County: Contra Costa Sampling Date: 2/15/13

Applicant/Owner: UC Berkeley State: CA Sampling Point: W-6

Investigator(s): Pennington, Siegel Section, Township, Range: NW1/4 SW1/4 S20, T1NR4W

Landform (hillslope, terrace, etc.): Flat Local relief (concave, convex, none): Concave Slope (%): <1

Subregion (LRR): C Lat: 37.9130765936 Long: -122.33637623 Datum: WGS 84

Soil Map Unit Name: Urban Land NWI classification: None

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil X, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** Yes _____ No X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes X	No _____	

Remarks:

Areas is periodically maintained for water conveyance. Drains water from adjacent roof tops.

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: 30 ft.)			
1.			
2.			
3.			
4.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: 15 ft.)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: 5 ft.)			
1. Phalaris aquatica	95	Y	FACU
2. Geranium molle	5	N	UPL
3. Helminthotheca echiodes	5	N	FACU
4. Plantago lanceolata	5	N	FAC
5.			
6.			
7.			
8.			
	110 = Total Cover		
Woody Vine Stratum (Plot size: 30 ft.)			
1.			
2.			
	0 = Total Cover		

% Bare Ground in Herb Stratum 0 % Cover of Biotic Crust _____

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 0 (A)

Total Number of Dominant Species Across All Strata: 1 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species 0	x 1 = 0
FACW species 0	x 2 = 0
FAC species 1	x 3 = 15
FACU species 100	x 4 = 400
UPL species 5	x 5 = 25
Column Totals: 110 (A)	440 (B)

Prevalence Index = B/A = 4.0

Hydrophytic Vegetation Indicators:

☐ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes _____ No X

Remarks:

SOIL

Sampling Point: W-6

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-8	10YR 3/1	100					CL	
8-16	10 YR 4/1	92	7.5 YR 5/1	8	C	M	CL	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ☑ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes _____ No X

Remarks:

Soils are disturbed due to regular maintenance. Otherwise F8 conditions might be expected.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- ___ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ☑ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes _____ No X Depth (inches): _____

Water Table Present? Yes _____ No X Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes _____ No X Depth (inches): _____

Wetland Hydrology Present? Yes X No _____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Phase I RBC City/County: Contra Costa Sampling Date: 2/15/13

Applicant/Owner: UC Berkeley State: CA Sampling Point: W-7

Investigator(s): Pennington, Siegel Section, Township, Range: NW1/4 SW1/4 S20, T1NR4W

Landform (hillslope, terrace, etc.): Flat Local relief (concave, convex, none): Concave Slope (%): <1

Subregion (LRR): C Lat: 37.913018875 Long: -122.336392944 Datum: WGS 84

Soil Map Unit Name: Urban Land NWI classification: None

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No _____	**Is the Sampled Area within a Wetland?** Yes X No _____
Hydric Soil Present?	Yes X No _____	
Wetland Hydrology Present?	Yes X No _____	

Remarks:

Areas is periodically maintained for water conveyance. Drains water from adjacent roof tops.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 30 ft.)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: 15 ft.)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: 5 ft.)			
1. Juncus phaecephalus	90	Y	FACW
2. Vinca sativa	5	N	UPL
3. Helminthotheca echiodes	5	N	FACU
4.			
5.			
6.			
7.			
8.			
	100 = Total Cover		
Woody Vine Stratum (Plot size: 30 ft.)			
1.			
2.			
	0 = Total Cover		

% Bare Ground in Herb Stratum 0 % Cover of Biotic Crust _____

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species _____	x 1 = _____
FACW species _____	x 2 = _____
FAC species _____	x 3 = _____
FACU species _____	x 4 = _____
UPL species _____	x 5 = _____
Column Totals: _____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

- ✔ Dominance Test is >50%
- ___ Prevalence Index is ≤3.0[1]
- ___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No _____

Remarks:

Eucalyptus polyanthemos growing adjacent to, but not inside the wetland.

SOIL

Sampling Point: W-7

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-8	7.5 YR 3/1	95	5 YR 3/4	5	C	M	CL	
8-10	7.5 YR 3/1	65	5 YR 3/4	35	C	M	CL	
10-16	7.5 YR 3/1	90	5 YR 3/4	10	C	M	CL	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ☑ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** X **No** _____

Remarks:

Area commonly maintained for water conveyance; seasonally ponded due to run-off from adjacent roof tops.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- ___ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ☑ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes _____ No X Depth (inches): _____

Water Table Present? Yes _____ No X Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes _____ No X Depth (inches): _____

Wetland Hydrology Present? **Yes** X **No** _____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Appendix D

Cultural Resources

CULTURAL RESOURCES INVENTORY REPORT

FOR

PORTIONS OF THE RICHMOND PROPERTIES

RICHMOND, CONTRA COSTA COUNTY, CALIFORNIA

March 2013

PREPARED FOR:
Tetra Tech, Inc.
1999 Harrison Street, Suite 500
Oakland, CA 94612

PREPARED BY:
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San Anselmo, CA 94960

MANAGEMENT SUMMARY

This report presents the results of the cultural resources investigation, which included the identification of archaeological resources and cultural landscape features, for portions of the University of California's Richmond properties in Richmond, Contra Costa County, California. Within the 133-acre area comprised of these properties, the University of California proposes to consolidate the biosciences programs of the Lawrence Berkeley National Laboratory and to develop additional facilities for use by both the Lawrence Berkeley National Laboratory and University of California, Berkeley, and other institutional or industry counterparts for research and development focused on energy, environment, and health. The Phase 1 development plan would construct the first three buildings within a smaller 16-acre area on these properties.

Due to the involvement of the United States Department of Energy, the proposed Phase 1 development is a federal undertaking as defined by Section 106 of the National Historic Preservation Act and its implementing regulations, 36 Code of Federal Regulations Part 800. Therefore, only the smaller 16-acre area is subject to Section 106 regulations in order to take into account the effect of the undertaking on any historic property (i.e., district, site, building, structure, or object) that is included in or eligible for inclusion in the National Register of Historic Places. This cultural resources investigation was conducted to identify archaeological resources and cultural landscape features that may meet the definition of a historic property under the National Historic Preservation Act, per 36 CFR 800.4. Built environment resources, such as buildings and structures, are addressed in a separate historic properties survey report. The United States Department of Energy is the lead federal agency under Section 106.

This investigation also complies with the California Environmental Quality Act (Title 14 of the California Code of Regulations 15064.5). The 133-acre is subject to programmatic-level analysis under CEQA, while the smaller 16-acre area (where specific project construction will occur) will be subject to project-level analysis under CEQA. The University of California is the lead agency under CEQA.

This investigation included background research for the 133-acre area, which is considered the Study Area. The Area of Potential Effects is the smaller 16-acre area, which is considered the Phase 1 development plan area. Since the Area of Potential Effects is subject to Section 106 regulations, this area required a field survey as well as background research. Pursuant to Section 106 of the National Historic Preservation Act, 36 Code of Federal Regulations Part 800.4, this report documents the methods used to identify all historic properties within the Area of Potential Effects. Findings for this report are based on the following:

- A cultural resources records search and historic map review for the Study Area at the Northwest Information Center of the California Historic Resource Inventory System at California State University, Sonoma;
- the initiation of Section 106 consultation with Native American groups and individuals identified by the Native American Heritage Commission (36 CFR Part 800.2(a));
- an inventory survey of the Area of Potential Effects; and,
- documentation of newly identified cultural resources (i.e., archaeological resources and cultural landscape features) within the Area of Potential Effects on California Department of Parks and Recreation 523 forms.

The results of the records search indicate that there is one previously recorded prehistoric shellmound, CA-CC0-157, within the Study Area. The field survey resulted in the identification of two newly identified historic period cultural resources within the Area of Potential Effects, GANDA-622-01 (Eucalyptus Stands 1 and 2), which consists of historic period landscape features, and GANDA-ISO-622-01, an isolated historic period bottle. These resources were formally recorded on Department of Parks and Recreation 523 forms, but not evaluated for their potential for eligibility for listing in the National Register of Historic Places and California Register of Historical Resources.

This inventory report includes the methods and results of background research consisting of a records search and a literature review; geoarchaeological, prehistoric, ethnographic, and historical background information; a field survey; a geoarchaeological sensitivity analysis; and consultation with the Native American Heritage Commission and potentially interested Native American groups and individuals; as well as recommendations for any subsequent archaeological work to meet the requirements of Section 106 and 36 Code of Federal Regulations 800.4. This investigation addresses only archaeological resources and cultural landscape features within the Area of Potential Effects. The identification and evaluation of the built environment resources have been addressed in a separate report.

While this investigation did not result in the identification of any newly or previously documented prehistoric archaeological resources within the Area of Potential Effects, the geoarchaeological analysis, environmental setting, and close proximity of several prehistoric shellmounds to the Area of Potential Effects and Study Area indicate that the Area of Potential Effects has a high sensitivity for the presence of buried and surface prehistoric resources. In addition, there is evidence of historic use of the site based on results of the background research and field survey; therefore, there is the potential for the presence of historic period archaeological resources as well.

This cultural resources investigation adheres to the California Office of Historic Preservation's *Archaeological Resource Management Reports Recommended Contents and Format* (1990); the *Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation* (48 CFR 44716); and the United States Army Corps of Engineers' *Guidelines for Compliance with Section 106 of the National Historic Preservation Act* (2012).

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1.0 INTRODUCTION

The University of California (UC or the University) proposes to establish a new major research campus at properties it owns in Richmond, California. The new campus would consolidate biosciences programs of the Lawrence Berkeley National Laboratory (LBNL) and develop additional facilities for use by both LBNL and UC Berkeley and other institutional or industry counterparts for energy, environment, and health research. The approximately 133-acre site is located at 1301 South 46th Street in the South Shoreline area of the City of Richmond (Figures 1 and 2), approximately five miles northwest of the UC Berkeley campus and the LBNL site in Berkeley. The University is developing Phase 1 development plans that would result in the demolition of 25 existing structures totaling approximately 107,000 gross square feet (gsf). Phase 1 would then consolidate existing LBNL bioscience programs currently in leased space into three new buildings totaling up to 600,000 gsf with an occupancy of approximately 1,000 average daily population (adp). Phase 1 development work would occur in a smaller 16-acre area within the larger 133-acre project area.

The National Historic Preservation Act (NHPA) of 1966, as amended, requires that every federal agency consider the effect of its undertakings on historic properties. The United States Department of Energy (DOE) is the lead federal agency for the Phase 1 development plan. The Phase 1 development plan is an undertaking as defined in 36 Code of Federal Regulations (CFR) §800.16(y) with the potential to cause effects on historical properties (36 CFR §800.3(a)). As such, DOE will address Section 106 of the NHPA to take into account the effect of the undertaking on any historic property (i.e., district, site, building, structure, or object) that is included in or eligible for inclusion in the National Register of Historic Places (NRHP). This investigation was conducted to identify archaeological resources and cultural landscape features that may meet the definition of a historic property under the NHPA, as per 36 CFR 800.4. This investigation meets the requirements for compliance with the California Environmental Quality Act (CEQA) (Title 14 CCR 15064.5). The 133-acre is subject to programmatic-level analysis under CEQA, while the smaller 16-acre area (where specific project construction would occur) is subject to project-level analysis under CEQA. The University of California is the lead agency under CEQA.

This report includes the methods and results of background research that consists of a records search and a literature review; prehistoric, ethnographic, and historic background information; a field survey; a geoarchaeological sensitivity analysis; and consultation with the Native American Heritage Commission (NAHC) and potentially interested Native American groups and individuals, as well as recommendations for complying with the requirements of Section 106 and 36 CFR 800. This investigation addresses only archaeological resources within the APE. The identification and evaluation of the built environment resources have been addressed in a separate report (Tetra Tech 2013a [Draft] *Historic Properties Survey for Portions of Richmond Field Station*).

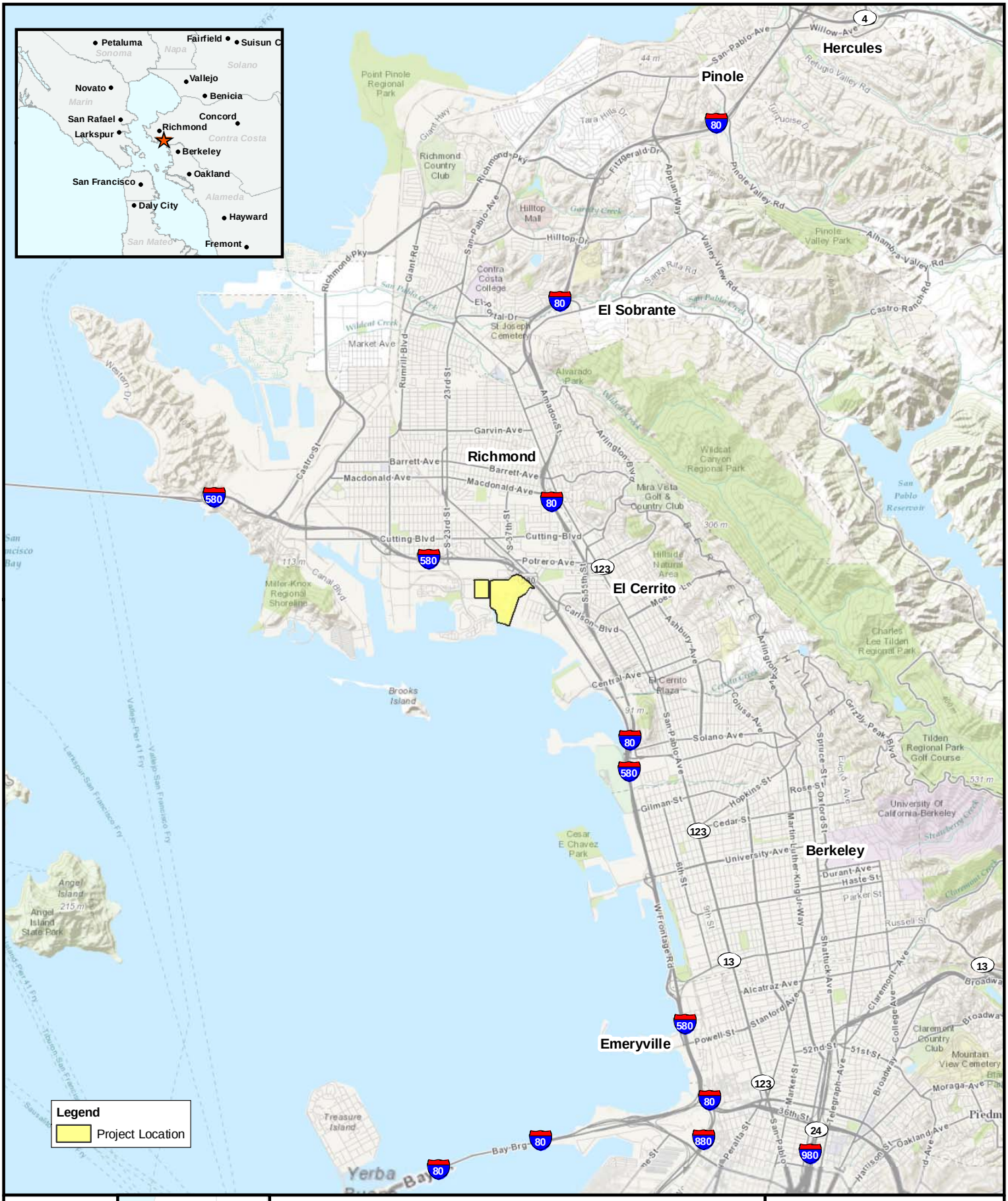
Archaeologists who conducted this investigation meet the Secretary of Interior's Professional Qualification Standards and agree to comply with the Secretary of Interior's Professional Qualification Standards for the Guidelines for Archaeology and Historic Preservation (1983; 48 CFR 44716).

DEFINITION OF THE AREA OF POTENTIAL EFFECTS - PHASE 1 DEVELOPMENT AREA

The Area of Potential Effects (APE) encompasses the Phase 1 development area, which is the 16-acre portion where building demolition and site preparation work would occur (Figures 3 and 4). Because the DOE is implementing the Phase 1 development plan, the APE is subject to Section 106 regulations. It is also subject to project-level CEQA analysis. The redevelopment includes demolishing 25 existing structures and removing approximately 170 immature and mature eucalyptus and pine trees as part of the Phase 1 site preparation work. The remainder of the existing trees would not be disturbed, and approximately 75 immature drought-resistant trees would be planted as a feature of the Phase 1 development. The southern portion of the Phase 1 site is in an area that is potentially subject to water inundation due to sea level rise, a tsunami, or a 100-year flood. In order to protect the Phase 1 facilities from potential inundation, the base elevation of the Phase 1 area would be increased from an average of approximately 10 feet above sea level (asl) to approximately 15 feet asl, and the base elevation of the facilities would be constructed at 15 feet asl. This will require adding approximately 70,000 cubic yards of soil at varying depths over an area of approximately 12 acres. The proposed depth of ground disturbance is not currently defined but is expected to be extensive due to the removal of trees, buildings, and preparations for development.

DEFINITION OF THE STUDY AREA

The Study Area encompasses the larger 133-acre site (Figure 3), which consists of developed upland areas with buildings used for academic teaching and research activities and spaces leased by private entities, a north-south oriented planting of eucalyptus trees in the central portion of the site, areas of coastal grasslands, a tidal salt marsh (known as the Western Stege Marsh), and a transition zone between the upland areas and the marsh. Grasslands occur in a number of meadows and comprise about 14 acres of the site. The Bay Trail is south of the site. The University purchased the original Richmond Field Station landholdings in 1950. From 1870 to 1950, much of the property belonged to the California Cap Company, which manufactured explosives. The southeast portion of the uplands area was used for explosive manufacturing from the 1870s until the University acquired the land (Tetra Tech 2013b). The portion of the Study Area outside of the APE (described above) is not subject to Section 106 regulations. However, Section 106 may be completed on a project-by-project basis if future activities outside the APE but within the Study Area constitute a federal undertaking per Section 106 regulations. This larger area outside the APE but within the Study Area is also subject to programmatic-level analysis under CEQA.



GANDA

Project Location

0 1 2 3 Mi

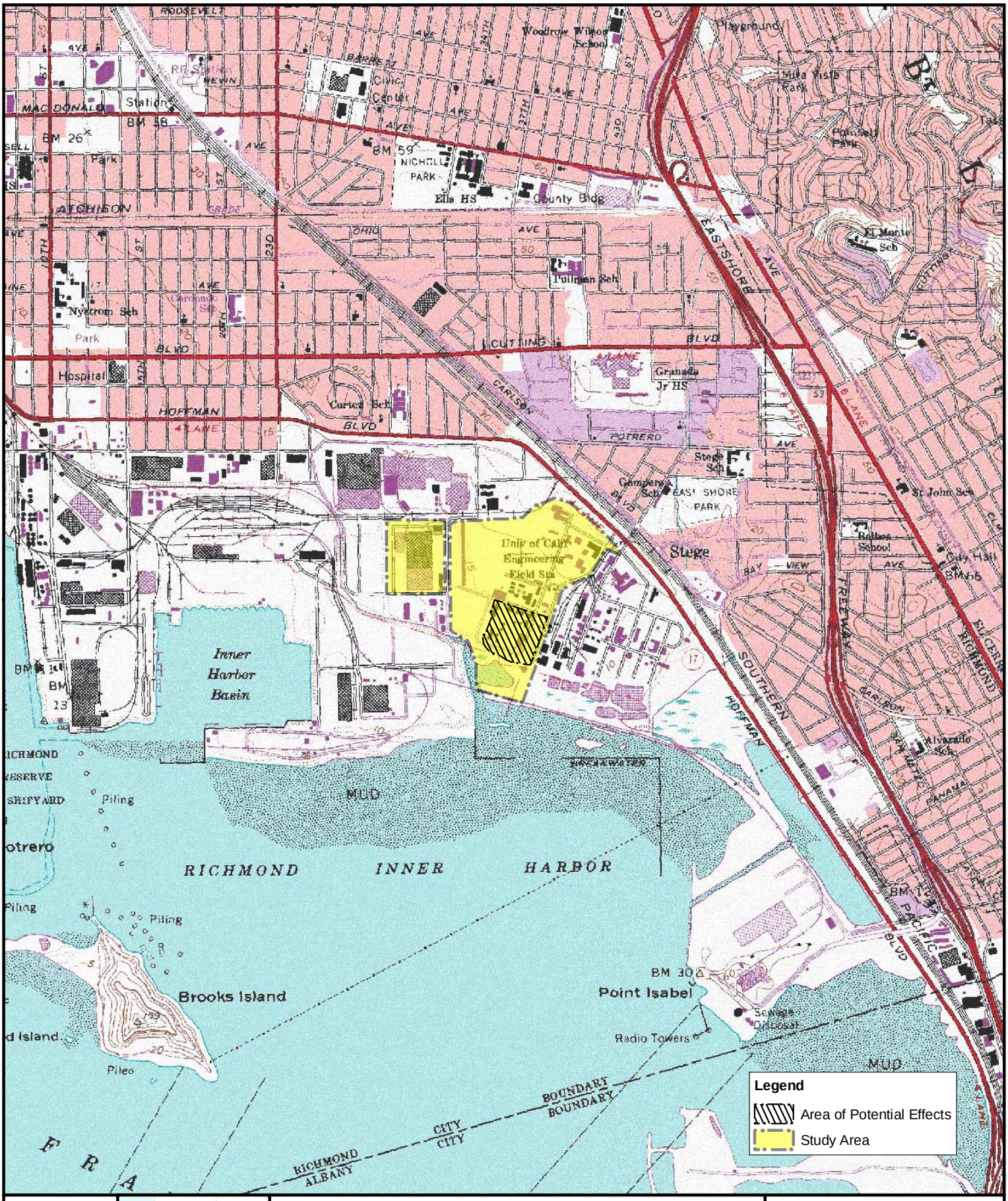
0 1 2 3 4 5 Km

USGS 7.5' Quad: RICHMOND (1993)
Legal Description: T01N R04W Sec 19, 20

1:95,040
One In = 1.5 Mi

Figure 1
Project Vicinity
Portions of the Richmond Properties

Contra Costa County, CA



GANDA

0 1,000 2,000 3,000 4,000 ft

0 300 600 900 1,200 m

USGS 7.5' Quad: RICHMOND (1993)
Legal Description: T01N R04W Sec 19, 20

1:24,000
One In = 2,000 Ft

Figure 2
Project Location Map
Portions of the Richmond Properties

Contra Costa County, CA

GANDA

Project Location

0 250 500 750 1,000 ft

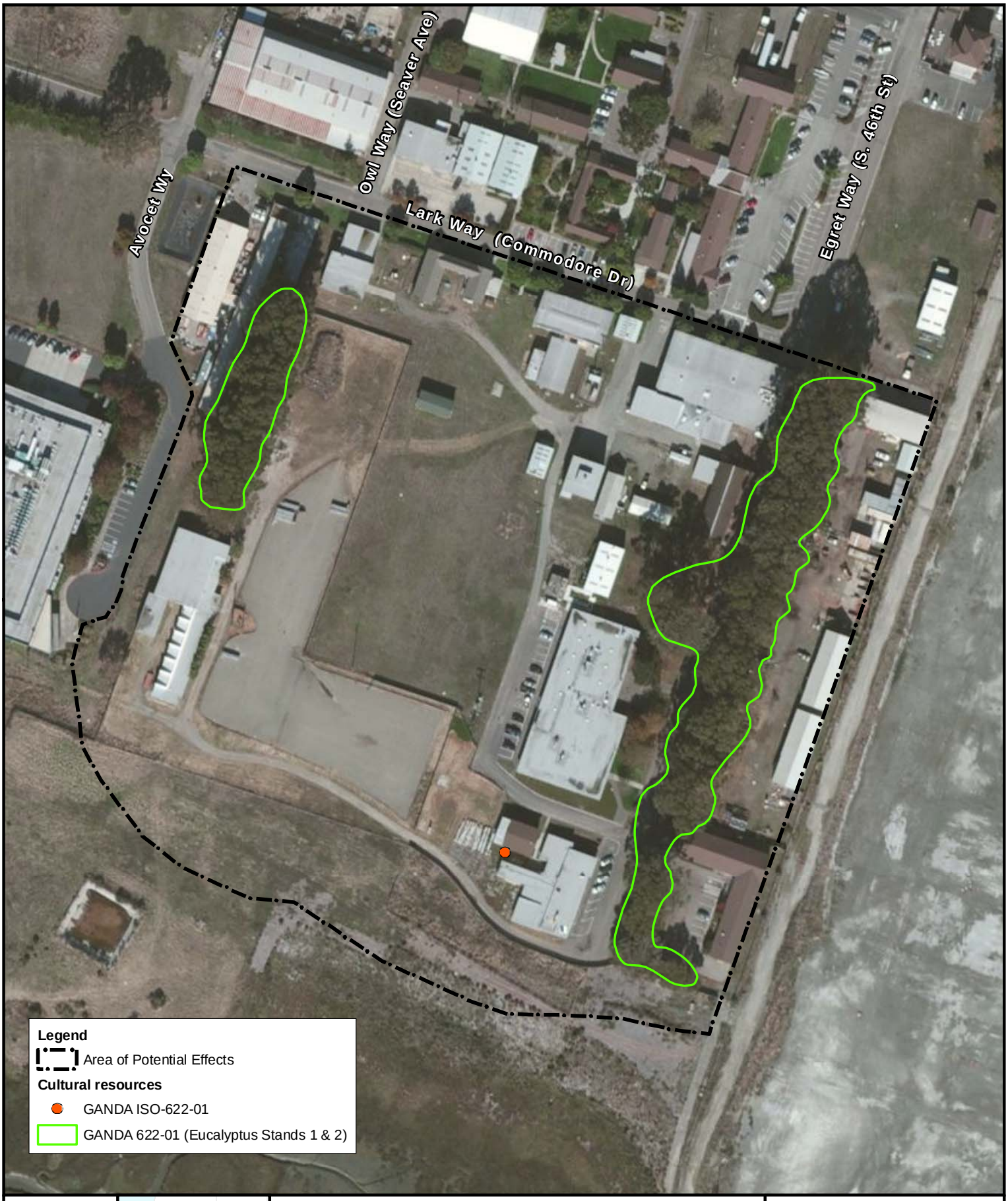
0 75 150 225 300 m

USGS 7.5' Quad: RICHMOND (1993)
Legal Description: T01N R04W Sec 19, 20

1:6,000
One In = 500 Ft

Figure 3
Study Area and
Area of Potential Effects
Portions of the Richmond Properties

Contra Costa County, CA



GANDA

0 75 150 225 300 Ft

0 25 50 75 100 M

USGS 7.5' Quad: RICHMOND (1993)
Legal Description: T01N R04W Sec 19, 20

1:1,800
One In = 150 Ft

Figure 4
Area of Potential Effects
Portions of the Richmond Properties

Contra Costa County, CA

PROJECT LOCATION

The approximately 133-acre site is located at 1301 South 46th Street in the South Shoreline area of the City of Richmond, approximately 5 miles northwest of the UC Berkeley campus and the LBNL site in Berkeley. The site is a portion of the UC-owned properties in Richmond, composed of four parcels: a parcel that contains the currently developed upland portion known as the Richmond Field Station (RFS); a recently acquired developed parcel along Regatta Boulevard immediately west of the upland area; and two parcels that comprise tidal lands and open waters in San Francisco Bay. The site is located within Township 1 North/Range 4 West/Sections 19 and 20, Mount Diablo Base Line and Meridian, as depicted on the Richmond (1993) 7.5' topographical quadrangle maps (Figure 3) (Tetra Tech 2013b).

The 133-acre site is bounded on the west by a PG&E service station, on the north by railroad tracks and Regatta Boulevard, on the east by South 46th Street, and on the south by the San Francisco Bay. Interstate 580 (I-580) runs parallel to Meade Street along the northeastern boundary of the site. Land uses surrounding the site include industrial/office uses and a major interstate freeway, with low-/medium-density residential neighborhoods. Regatta Boulevard, along the northern boundary, is adjacent to a railroad spur and a business complex developed with one- to two-story buildings. Bio-Rad Laboratories, a private research equipment manufacturing company, is located immediately west of the site. The adjacent property to the east is the location of former chemical production operations previously owned by several entities, including Stauffer and Zeneca, and currently owned by Cherokee Simeon Venture I, LLC.

The Marina Bay residential neighborhood, across Meeker Slough, and southwest of the site, consists of a mix of multi- and single-family residences. Low- and medium-density residential uses are also located across I-580, north of the Meade Street boundary of the site.

PROJECT DESCRIPTION

The University proposes to establish a new major research campus for consolidation of biosciences programs of the LBNL and for development of additional facilities for research and development focused on energy, environment, and health by LBNL, UC Berkeley, and synergistic institutional or industry counterparts.

The University is preparing a Long Range Development Plan (LRDP) in support of the research and academic goals for this proposed new research campus. An LRDP is defined by statute (Public Resources Code [PRC] 21080.09) as a "physical development and land use plan to meet the academic and institutional objectives for a particular campus or medical center of public higher education." The proposed 2013 LRDP addresses sustainability, land use, access and circulation, utilities and infrastructure, and open space and landscaping, and provides a policy and design framework to guide the development of up to 5.4 million square feet of new research, development, and support space at the site. Design principles in the proposed LRDP feature preservation of the site's important natural open spaces including the San Francisco Bay, marsh, and coastal grasslands. The proposed 2013 LRDP will guide the growth and development of the campus through the year 2050.

The University is also developing Phase 1 development plans that would construct the first three new buildings within a 16-acre area. Two of these buildings would be approximately 110,000 to 150,000 gsf each, and the third building would be up to 300,000 gsf for a total of up to 600,000 gsf. These new buildings would house the following institutions:

- LBNL's Joint Genome Institute (JGI) which UC LBNL manages for the US Department of Energy (DOE)
- Joint BioEnergy Institute (JBEI), a multi-institutional partnership led by UC LBNL

- Advanced Biofuels Process Demonstration Unit (ABPDU), which UC LBNL manages for DOE
- Knowledge Base (KBase), a multi-institutional collaboration led by UC LBNL

In addition, the facilities would house other LBNL biosciences projects and activities, and a conference facility, a dining facility, and various support facilities. Construction of Phase 1 would commence in 2014, and the buildings would be occupied starting in 2017 or 2018. Development of Phase 1 would add approximately 1,000 to the adp of the site, increasing the adp from 300 to 1,300 (Tetra Tech 2013b).

2.0 REGULATORY CONTEXT

The regulatory framework that mandates consideration of cultural resources in project planning includes federal, state, and local governments. Cultural resources include prehistoric and historic archaeological sites, districts, and objects; and locations of important historic events or sites of traditional and/or cultural importance to various groups. Cultural resources may be determined significant or potentially significant in terms of national, state, or local criteria, either individually or in combination. Resource evaluation criteria are determined by the compliance requirements of each specific project.

FEDERAL REGULATIONS

Section 106 of the National Historic Preservation Act (NHPA)

Section 106 of the NHPA requires federal agencies, and those they fund or have approval authority over, to consider the effects of their actions on properties that may be eligible for listing or are listed in the National Register of Historic Places (NRHP). To determine whether an undertaking could affect NRHP eligible properties, cultural resources (including archaeological, historical, and architectural properties) must be inventoried and evaluated for listing in the NRHP. Although compliance with Section 106 is the responsibility of the lead federal agency, others can undertake the work necessary to comply with Section 106. The Section 106 process entails five primary steps, listed below.

1. Initiate consultation and public involvement.

2. Identify and evaluate historic properties within the APE.

3. Assess effects of the project on historic properties.

4. If there are historic properties that will be affected, consult with the State Historic Preservation Officer (SHPO) regarding adverse effects on historic properties. This consultation will result in a memorandum of agreement (MOA), if determined appropriate.

5. Proceed in accordance with the MOA, if appropriate.

National Register of Historic Places (NRHP) Criteria for Evaluation

An archaeological site's significance is determined in part using the NRHP's Criteria for Evaluation at 36 CFR 60.4, which state that "the quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association" and meet one or more of the following criteria:

a) associated with events that made a significant contribution to the broad patterns of our history (Criterion A);

b) associated with the lives of persons significant to our past (Criterion B);

c) embodies the distinctive characteristics of a type, period, or method of construction; or that represents the work of a master, or that possesses high artistic values; or that represent a

significant and distinguishable entity whose components may lack individual distinction (Criterion C); and/or

d) has yielded, or may be likely to yield, information important in prehistory or history (Criterion D).

Archaeologists generally evaluate archaeological resources using Criterion D in order to determine their potential to yield information. Criterion D emphasizes the importance of the information encompassed in an archaeological site, rather than its inherent value as a surviving example of a particular architectural type, or its historical association with an important person or event. If the SHPO determines that a cultural resource is eligible for inclusion to the NRHP, then it is automatically eligible for the California Register of Historical Resources (CRHR). If a resource does not have the level of integrity necessitated by the NRHP, it may still be eligible for the CRHR, which allows for a lower level of integrity (see below).

National Register of Historic Places (NRHP) Seven Aspects of Integrity

Cultural resources integrity is determined using the NRHP's seven aspects of integrity at 36 CFR 60.4, which state that a historic property must not only be shown to be significant under the NRHP criteria, but it also must retain historic integrity. The seven aspects of integrity include location, design, setting, materials, workmanship, feeling, and association. A property must meet one or more of the Criteria for Evaluation before a determination can be made about its integrity (National Register Bulletin 15).

STATE REGULATIONS

California Environment Quality Act (CEQA)

The CEQA Statute and Guidelines include procedures for identifying, analyzing, and disclosing potential adverse impacts to historical resources, which include all resources listed in or formally determined eligible for the NRHP, the CRHR, or local registers. CEQA further defines a "historical resource" as a resource that meets any of the following criteria:

- A resource listed in, or determined to be eligible for listing in, the National Register of Historic Places or California Register of Historical Resources.

- A resource included in a local register of historical resources, as defined in Section 5020.1(k) of the Public Resources Code, unless the preponderance of evidence demonstrates that it is not historically or culturally significant.

- A resource identified as significant (i.e., rated 1-5) in a historical resource survey meeting the requirements of Public Resource Code Section 5024.1(g) (Department of Parks and Recreation Form 523), unless the preponderance of evidence demonstrates that it is not historically or culturally significant.

- Any object, building, structure, site, area, place, record, or manuscript which a lead agency determines to be historically significant or significant in the architectural, engineering, scientific, economic, agricultural, educational, social, political, military, or cultural annals of California, provided the determination is supported by substantial evidence in light of the whole record. Generally, a resource is considered "historically significant" if it meets the criteria for listing on the CRHR (CEQA Guidelines Section 15064.5).

California Register of Historical Resources (CRHR) Criteria of Evaluation

The CRHR is a listing of State of California resources that are significant within the context of California's history, and includes all resources listed in or formally determined eligible for the NRHP. The CRHR is a state-wide program of similar scope to the NRHP. In addition, properties designated under municipal or county ordinances are also eligible for listing in the CRHR. A historic resource must be significant at the local, state, or national level under one or more of the following criteria defined in the California Code of Regulations Title 14, Chapter 11.5, Section 4850:

1. It is associated with events or patterns of events that have made a significant contribution to the broad patterns of local or regional history, or the cultural heritage of California or the United States; or

2. It is associated with the lives of persons important to local, California, or national history; or

3. It embodies the distinctive characteristics of a type, period, region, or method of construction, or represents the work of a master, or possesses high artistic values; or

4. It has yielded, or has the potential to yield, information important to the prehistory or history of the local area, California, or the nation.

The CRHR criteria are similar to NRHP criteria, and are tied to CEQA.

Regulations Concerning Discovery of Human Remains

California Public Resources Code §5097.98 (Notification of Native American human remains, descendants; disposition of human remains and associated grave goods) mandates that the lead agency adhere to the following regulations when a project results in the identification or disturbance of Native American human remains:

a) Whenever the Native American Heritage Commission receives notification of a discovery of Native American human remains from a county coroner pursuant to subdivision (c) of Section 7050.5 of the Health and Safety Code, it shall immediately notify those persons it believes to be most likely descended from the deceased Native American. The descendants may, with the permission of the owner of the land or his or her authorized representative, inspect the site of the discovery of the Native American remains and may recommend to the owner or the person responsible for the excavation work means for treating or disposing of, with appropriate dignity, the human remains and any associated grave goods. The descendants shall complete their inspection and make their recommendation within 24 hours of their notification by the commission. The recommendation may include the scientific removal and nondestructive analysis of human remains and items associated with Native American burials.

b) Whenever the Native American Heritage Commission is unable to identify a descendent, or the descendent identified fails to make a recommendation, or the landowner or his or her authorized representative rejects the recommendation of the descendent, and the mediation provided for in subdivision (k) of Section 5097.94 fails to provide measures acceptable to the landowner, the landowner or his or her authorized representative shall reinter the human remains and items associated with Native American burials with appropriate dignity on the property, in a location not subject to further subsurface disturbance.

c) Notwithstanding the provisions of Section 5097.9, the provisions of this section, including those actions taken by the landowner or his or her authorized representative to implement this section, and any action taken to implement an agreement developed pursuant to subdivision (l) of Section 5097.94, shall be exempt from the requirements of the California Environmental Quality Act [Division 13 (commencing with Section 21000)].

d) Notwithstanding the provisions of Section 30244, the provisions of this section, including those actions taken by the landowner or his or her authorized representative to implement this section, and any action taken to implement an agreement developed pursuant to subdivision (1) of Section 5097.94, shall be exempt from the requirements of the California Coastal Act of 1976 [Division 20 (commencing with Section 30000)].

3.0 BACKGROUND

The following is a summary of the environmental, prehistoric, ethnographic, and historic background pertaining to Contra Costa County and the project vicinity. This section also presents the existing setting and context used to assess the sensitivity for prehistoric and historic cultural resources within the APE and Study Area.

EXISTING ENVIRONMENT

The project area is located along the San Francisco Bay shoreline in the southeastern portion of the City of Richmond. Land use adjacent to the APE consists of industrial/office and low- to medium-density residential areas, along with a major interstate freeway. The APE is bordered to the south by marshes and tidal flats of the bay. The two upland parcels within the APE are currently developed with approximately 80 one- and two-story buildings, roadways, parking lots, and landscaped areas. The uplands area, which has been the location of a variety of industrial enterprises dating back to the mid-19th century, also contains previously disturbed, currently undeveloped open space.

Climate

The project area is characterized by a Mediterranean climate, with cool moist winters and hot dry summers influenced by the moderating effects of the San Francisco Bay and the Pacific Ocean. The average yearly high temperature is 90 degrees Fahrenheit and the average yearly low is 31 degrees Fahrenheit. The average yearly precipitation is approximately 38 inches, in the form of rain occurring mostly between the months of November and March (US Climate Data 2012).

Geology

The Study Area and APE are located on Holocene age alluvium mapped as (Qha=Quaternary Holocene alluvium) (Figure 5) which consists of clay to sand and gravel sized sediments derived from upland streams, as well as eolian (wind) derived silt and sand deposition. The alluvium is interdigitated with late Holocene estuarine muds (Qhym=Quaternary Holocene young mud). This geological setting suggests a bay shoreline environment during the late Holocene (last 5,000 years), which is consistent with the local and regional archaeological record as being a resource rich environment that was heavily utilized and occupied by prehistoric and contact period Native American populations.

PREHISTORIC CONTEXT

Archaeological investigations in California and elsewhere seek to explain past human culture, continuity, and change. Archaeological interpretation of material remains can address many aspects of past human behavior, including when people occupied an area and at which time of the year; the technological and natural resources available; social organization; settlement patterns; relationships with neighboring groups in terms of trade, competition, and conflict; ceremonial systems; and external environmental issues. Prior to the use of dating techniques such as radiocarbon dating and obsidian hydration, the archaeological record was largely defined by artifact collections and mortuary practices identified during large-scale excavations. Current archaeological research helps to explain a wide array of questions regarding prehistoric human culture and adaptive responses, as well as the ongoing issue of chronology.

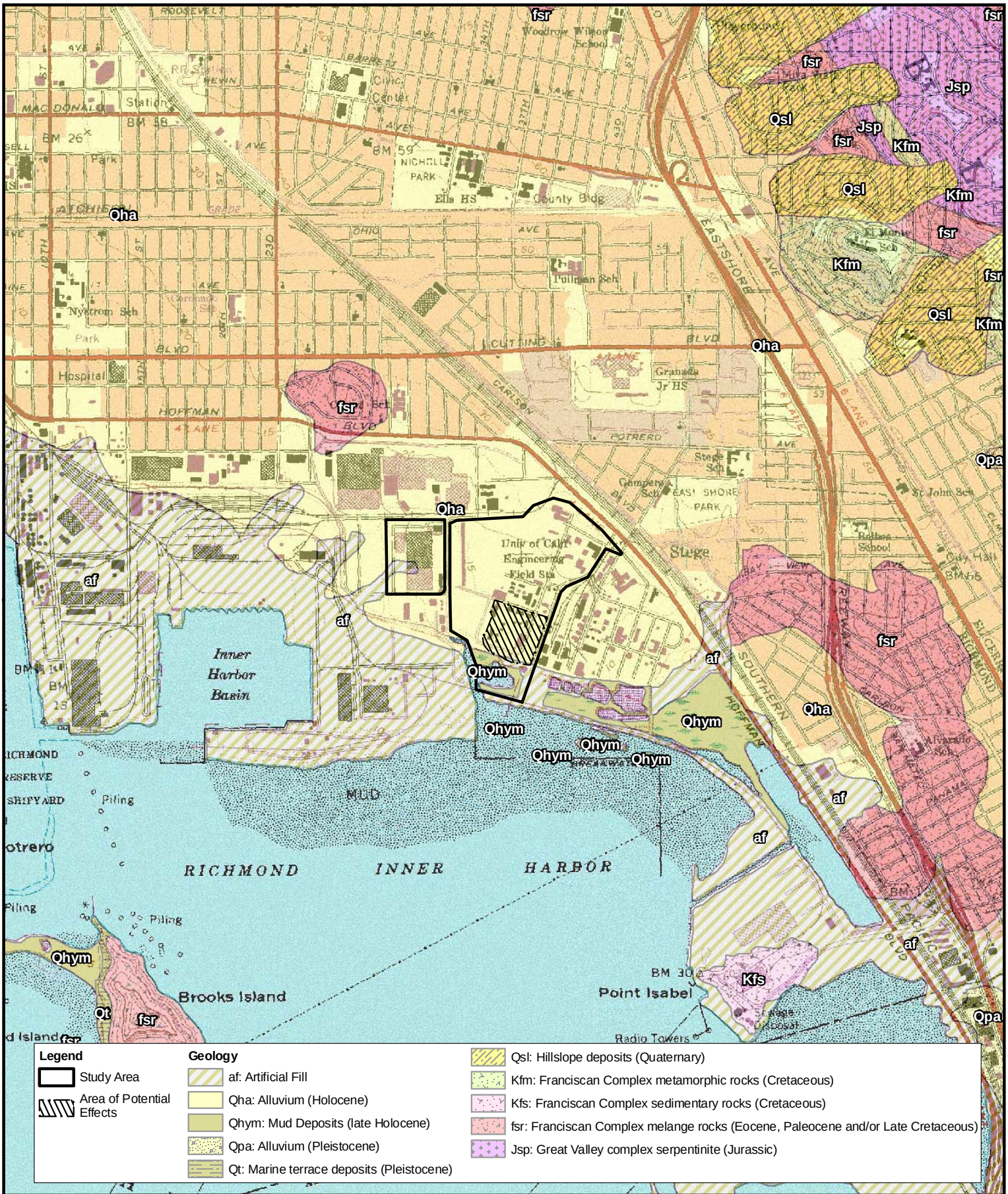


Figure 5
Underlying Geology
Portions of the Richmond Properties

Contra Costa County, CA

Moratto (2004), Fredrickson (1973), and other researchers (Milliken et al. 2007), have divided the prehistory of this region into seven general time periods. These periods represent patterns developed from archaeological data recovered from archaeological investigations of the San Francisco Bay Area counties. The periods include the Paleo-Indian, Lower Archaic, Middle Archaic, Initial Upper Archaic, Late Upper Archaic, Lower Emergent, and Terminal Late periods. These are briefly described below.

Paleo-Indian Period (11550 to 8550 calibrated Before Present [cal BP]) [1]

The oldest site from the Paleo-Indian Period representing the Central Valley and greater San Francisco Bay Area is located in King County, in the southern San Joaquin Valley. This site, CA-KIN-32, also referred to as the Witt site at Tulare Lake, yielded radiocarbon dates from human remains of approximately 9,429 to 13,852 years before present (cal BP). Archaeological investigations at Los Vaqueros Reservoir Watershed in southeast Contra Costa County have produced an artifact assemblage dating to 9,800 years cal BP (Ziesing 1997), which indicates a considerably longer span of prehistoric occupation than what had been previously accepted. These sites are typically situated near shoreline or marshes, or along pluvial lake shores, and are usually buried deep beneath Holocene alluvial deposits. According to Milliken et al. (2007:114), most, if not all of the archaeological material from this time period has either been eroded away or buried by alluvial deposits and therefore, is rarely represented in the archaeological record.

Early Holocene (Lower Archaic Period) (8550 to 5550 cal BP)

Similar to the Paleo-Indian Period, most of the archaeological discoveries for the Lower Archaic Period are represented by isolated finds (Rosenthal et al. 2007:147). Examples from this period include artifacts recovered from CA-CCO-637 and CA-CCO-696 in the Los Vaqueros Reservoir Watershed. Pestles with wooden mortars were encountered at CA-CCO-637 and have been dated to 6570 cal BP (Rosenthal et al. 2007:153; Milliken et al. 2007:115), and a charcoal sample excavated from the deepest component of CA-CCO-696 revealed a date of 9870 cal BP. Associated artifacts at this site also included a wide-stemmed projectile point of Napa Glass Mountain obsidian and plant remains including acorns and wild cucumbers (Rosenthal et al. 2007:152).

In general the Lower Archaic Period is associated with artifacts such as wide-stemmed point types (Borax Lake Wide Stem) and milling implements (i.e., handstones and milling slabs) signifying the increased use of, and reliance on, plant resources. Furthermore, social systems appear to have been developing and becoming more elaborate during this time period.

Early Period (Middle Archaic Period) (5500 to 2500 cal BP)

Distinct cultural adaptations are demonstrated at sites dating to the Middle Archaic Period. Cultural materials from this period are typically described as originating from the foothills or valley traditions. Artifact assemblages for the foothill tradition are composed of flaked stone dart points and cobble tools similar to those of the Lower Archaic. These sites are also characterized by rock-filled hearths and ovens, and "cairn capped" graves (Rosenthal et al. 2007). Middle Archaic sites of the valley tradition are fairly well represented in the archaeological record and are prevalent throughout Contra Costa County. For example, artifact assemblages and paleobotanical studies from sites CA-CCO-18/548 and CA-CCO-637 have produced data regarding extremely diverse technological and dietary remains suggesting the emergence of organized subsistence and increased occupation along river

[1] "cal BP" means calibrated years before present, present starts at 1950.

corridors (Rosenthal et al. 2007). Tabular pendants, incised slate, and perforated stone plummets are rare, but have been identified across a broad geographical area during this time period.

Some of the oldest documented sites in the San Francisco Bay Area are from the Middle Archaic Period and are located in Contra Costa and Alameda counties. These prehistoric sites include, CA-CCO-637 (described above) in the Los Vaqueros Reservoir Watershed, CA-CCO-308 in San Ramon Valley, and CA-ALA-483 in the Livermore Valley, which contained deeply buried deposits of mortar and pestle assemblages (Miliken et al. 2007). Also associated with this time period are three important shellmounds, CA-ALA-307, CA-CCO-295, and CA-MRN-152, located in the central San Francisco Bay Area (Milliken et al. 2007). Twenty-three radiocarbon dates were taken from CA-ALA-307 (West Berkeley site), the earliest yielded a timeframe spanning 4,980 to 4,840 cal BP (Lighfoot and Luby 2002:270). Elliptical house floors with postholes were encountered at the Rossmoor site (CA-CCO-309), in southern Contra Costa County, which may indicate a shift towards sedentism or semisedentism during this period (Miliken et al 2007). It is important to note that both the *Olivella* and *Haliotis* (commonly known as abalone) rectangular beads are represented in the Bay Area during the Early Period from approximately 4,780 years ago and continued in use until 2,800 years ago (Milliken et al 2007). The fishing net sinker is also a typical period marker for the Middle Archaic period.

The Middle Archaic Period is also associated with the Windmiller Pattern or cultural sequence for this period (Rosenthal et al. 2007). However, the advent, spatial distribution, and variation across the regional landscape of the Windmiller Pattern are not clearly defined at this time. Situated in riverine, marshland, or valley floor settings, as well as on small knolls above prehistoric seasonal floodplains, most Windmiller Pattern sites contain ventrally extended burials that are oriented to the west. These sites generally contain large amounts of mortuary artifacts which indicate social hierarchy, and often include large projectile points and a variety of fishing gear such as net weights, bone hooks, and spear points. The presence of faunal remains throughout the archaeological record suggests a hunting economy that included both large and small mammals (Rosenthal et al. 2007).

The high frequency of mortars and pestles in delta area sites indicates a shift to a more intensive subsistence strategy based on the acorn as a dietary staple, or at least an intensification of the use of the mortar and pestle technology. However, the types of plant foods that the population was procuring do not change during this time period, simply the method used to process the resources. The increased efficiency in food processing may have allowed for a more sedentary lifestyle (Rosenthal et al. 2007:155). There is also archaeological evidence for the advent of other technologies such as cordage, twined basketry, basketry awls, simple pottery, and other baked clay objects, stone plummets, bird bone tubes, and shell beads in the Middle Archaic sites. The presence of exotic items, such as obsidian and shell ornaments, point to a complex exchange system with other native groups throughout California.

Lower Middle Period (Initial Upper Archaic) (2450 cal BP to AD 430)

The archaeological record of the Upper Archaic Period demonstrates a substantial shift in occupation, settlement, and artifact assemblages. It is suggested that this time period marks some of the most distinct representations of California's early occupation by prehistoric peoples. Assemblages change dramatically during this time period, particularly in the form of bead type changes represented in the archaeological record of the San Francisco and North Bay areas.

Split beveled and tiny saucer *Olivella* beads replaced the rectangular shell beads that were widely used over the preceding 3,000 years. Mortuaries that date to this period contain fewer grave goods, and cut *Olivella* beads are less common than spire-lopped *Olivella* beads (Milliken et al. 2007). Defined as the M1 Bead Horizon, artifact types of this period include: *Olivella* saucer beads, circular *Haliotis*

ornaments, new forms of bone tools (including those for coiled basketry), barbless fish spears, elk femur spatulas, tubes, and whistles. Stone net sinkers disappear from the archaeological record during this period.

The representative cultural pattern for the Initial Upper Archaic is the Berkeley Pattern. Spanning about 2,500 to 1,300 years ago, this pattern resembles earlier cultural ones, but shows an increase in larger and more frequent settlements across the landscape. Fredrickson (1973) defined the Berkeley Pattern by the economic adaptive strategies developed around the extensive and rich resources of the Bay Area during this time period. There were numerous marshes, tidal wetlands, streams, and inland grasslands and oak wooded areas that offered an abundant resource base, perhaps due to the slightly wetter period of prehistory during the late Holocene. Out of the Berkeley Pattern emerged larger occupation sites located near water sources, with the presence of projectile points and atlatls (Fredrickson 1989).

Berkeley Pattern assemblages generally show a decrease in the presence of milling slabs and handstones and a shift to the mortar-and-pestle technology, indicating an increased dependence on acorns as a staple, or again, an increased reliance on that particular technology. However, millingstone technology continues to be used in the North Bay region during this time (Milliken et al. 2007:115). While gathered resources gained importance during this period, the continued presence of projectile points and atlatls (spear-throwers) in the archaeological record indicates that hunting was still an important activity (Fredrickson 1973).

Artifact assemblages from this period are also noted for especially well developed bone tool industry, twined basketry, and such technological innovations as ribbon flaking of stone artifacts. Populations generally increased and status differentiation and social stratification is more prevalent in the artifact assemblages, as evidenced in the forms of grave goods and wealth items, such as shell beads and ornaments. Flexed burials replaced extended burials during this time. The Berkeley Pattern may represent the spread of ancestral Utians (proto-Miwok and Costonoans) from their hypothesized lower Sacramento Valley/Delta homeland to surrounding regions.

Upper Middle Period (Late Upper Archaic) (cal AD 430 to 1050)

The beginning of the Upper Middle Period is marked by another significant cultural disruption, as evidenced by trade network collapse and site abandonment. This precipitates a series of *Olivella* bead types with a relatively narrow chronological range, one supplanting the next through time, allowing for a clear chronological picture of the archaeological record. The following information is adapted from Milliken et al. (2007), and highlights the most recent findings regarding San Francisco Bay Area cultural chronology based on bead types.

- *M2:* New shapes of *Haliotis* pendants, ceremonial blades, fishtail charmstones, and mica ornaments appear.
    - M2a: The rough-edged, full saddle *Olivella* beads with very small perforations (marker for M2a) replace the *Olivella* saucer beads.
    - M2b: marked by mixed *Olivella* saddle beads.
- M3: mixed *Olivella* saddle beads replaced by small, square saddle *Olivella* beads "occasionally with small, poorly shaped *Olivella* saucer beads, often in off village single component cemeteries" (Milliken et al. 2007:116); single barbed bone fish spears, ear spools, and large mortars also appear in the archaeological record.

- M4: "de-evolution of saddle bead into a variety of wide and tall, bisymmetrical forms and distinctive *Haliotis* ornament styles, such as unperforated rectangles and perforated ovals" (Milliken et al. 2007:116). Most graves lack grave goods and there are few sites dated to the particular time period.

In addition, bone artifacts are represented in the Upper Middle Period and include a diverse assemblage of tools and other items. The relative importance of hunting is apparent, based on an increased volume of projectile points as compared to the previous period. There is a marked degree of social complexity and semi-permanent settlements become common. Complex, long-distance exchange networks develop during this period as well (Moratto 2004).

Initial Late Period (Lower Emergent) (cal AD 1050 to 1500)

According to Milliken et al. (2007), the Middle Period is defined by "collectors who buried their dead with diverse, numerous but fairly simple ornaments," whereas the Late Period concerns "collectors who invested large amounts of time in the creation of finely wrought wealth objects" (Milliken et al. 2007:116). This transition suggests a shift in use of time, and likely an increasingly sedentary nature of the prehistoric settlement patterns, along with the increased importance of ceremonialism and the idea of wealth distribution and status amongst the population.

The people who occupied Contra Costa County during this time practiced extensive elaboration of ceremonial and social organization, including the development of social stratification. Exchange networks became well established and proliferated. Local populations became more dependent on the acorn, as evidenced by the prevalence of mortars, pestles, and hopper mortars throughout the archaeological record.

Other important artifacts that are representative of this time period include smoking pipes, harpoons, baked clay composition of pottery vessels and figurines, coiled basketry, clamshell disks and pine nut beads, and the use of small projectile points, especially Gunther series points that denote adoption of the bow-and-arrow (Moratto 2004). This period is also represented by the presence of Bead Horizon L1, characterized by *Olivella* callus cup beads, banjo *Haliotis* ornaments, and flanged pipes, as well as the bow-and-arrow (Milliken et al. 2007).

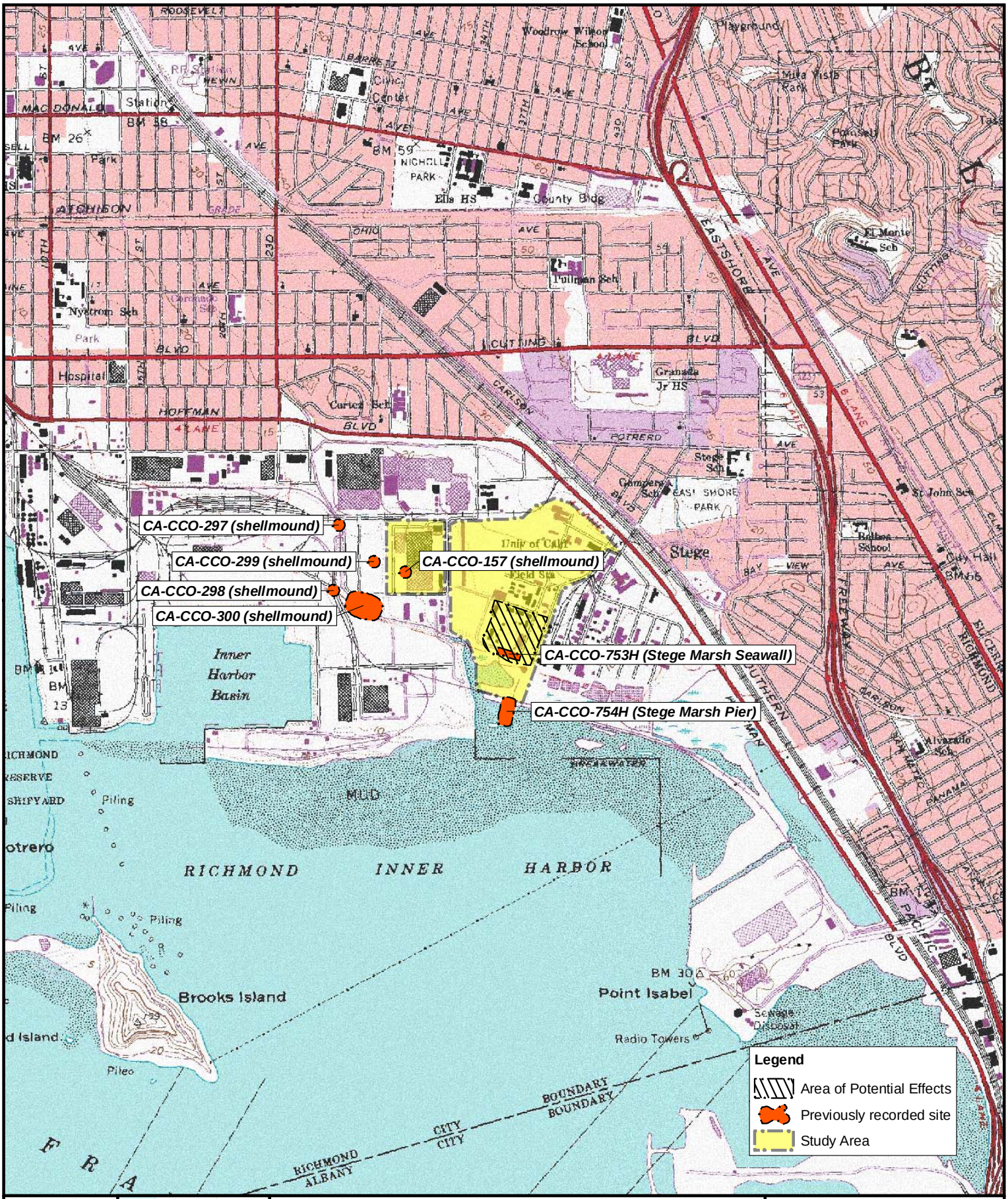
Terminal Late Period (cal AD 1500 to 1700)

Cultural adaptations grew more complex in terms of settlement patterns, indicating a shift to a more sedentary lifestyle. This was likely based on, or resulting from, a dynamic combination of population pressures, competition for resources, and population movements, which, in turn, led to an increase in ceremonialism, trade networks, technological change, and social stratification and organization. Some researchers suggest that increasing pressure on the region's carrying capacity, population size in relationship to abundance of resources, at the time of contact with European settlers was the reason behind the rapid increase in cultural complexity at the end of the Late Period (Milliken et al. 2007). In the archaeological record, this period is represented by the presence of callus-cupped *Olivellas,* replaced by clam shell disc beads and lipped beads, and larger amounts of spire-lopped O*livellas* than in previous time periods (Milliken et al. 2007).

Archaeology of the APE

In 1915, L. L. Loud originally recorded CA-CCO-157 (Loud's No. 299) as an approximately 350-foot wide by 250-foot long shellmound situated on the end of a slough around 800 feet from the San Francisco Bay's historic shoreline. What remains of the archaeological site is unknown and it is currently located underneath a warehouse and paved parking lot at 3200 Regatta Boulevard in

Richmond (Banks 1985a). This resource is located within the Study Area (Figure 6). In addition, there are four additional shellmounds located between 0.08 and 0.18 miles from the APE. These include: CCO-297, CCO-298, CCO-299, and CCO-300, also shown on Figure 6. These prehistoric shellmounds were all recorded within close proximity to the APE, along the historic shoreline by Nels Nelson in the early 20th century (Banks 1985a, 1985b, 1985c, 1985d, 1985e). These were prehistoric sites that generally demonstrated long periods of intense occupation, with an abundance of marine shellfish dietary debris, with human remains often associated with the sites, and served as long term habitation sites during the middle and late prehistoric periods. See the records search section below for a more detailed description of these resources.



0 1,000 2,000 3,000 4,000 ft

0 300 600 900 1,200 m

USGS 7.5' Quad: RICHMOND (1993)
Legal Description: T01N R04W Sec 19, 20

1:24,000
One In = 2,000 Ft

Figure 6
Previously Recorded Cultural Resources in the Project Vicinity Portions of the Richmond Properties

Contra Costa County, CA

ETHNOGRAPHIC CONTEXT

The Study Area is located within the area that is ethnographically attributed to the Ohlone (also known as Costanoan). The term "Costanoan" derives from the Spanish word Costaños or "coast people" and refers to an ethno-linguistic group of people that lived along the San Francisco peninsula before contact with European Americans. Ethnographic and ethnohistoric information about the Ohlone derives primarily from the accounts of early explorers and missionaries. The territory of the Ohlone is purported to have extended from the Central Coast Ranges between San Pablo Bay in the north and Monterey in the south. The Ohlone tribal territory boundary in the east is not precisely known but is understood to extend to the Mount Diablo Range (Kroeber 1925:462; Moratto 2004).

The Ohlone spoke a language considered to be one of the eight major subdivisions of the Miwok-Costanoan, as categorized by linguistics, which belonged to the Utian family within the Penutian language family (Shipley 1978:82-84). Linguistic evidence suggests that the Ohlone entered the San Francisco and Monterey Bay areas about 1500 cal BP (Levy 1978:486). The Ohlone were politically organized by tribelets, each having a designated territory. A tribelet consisted of one or more villages and camps in a territory designated by physiographic features. Tribelets generally had 200 to 250 members (Levy 1978:485; Margolin 1978:1). Each tribelet consisted of villages every three to five miles (as noted by early Spanish explorers) that contained an average of 60 to 90 persons (Milliken 1995:19). The current study area is located within the *Huchiun* tribelet ethnographic territory, where *Chochenyo/East Bay Costanoan* was the common spoken language (Levy 1978:485; Margolin 1978:2).

The acorn was among the most important food resources for Ohlone, who preferred tanbark oak, valley oak, and California black oak, all abundant in the area. The large stands of oak trees created a readily accessible staple. Acorns could be stored in granaries and used through the winter months. The acorns were ground into meal and leached to remove tannins. Other important food resources were buckeye nuts, which were leached and made into a mush, and the seeds of dock, gray pine, and tarweed, all of which were roasted in baskets with hot coals before being eaten. The Ohlone gathered berries and fruits including gooseberries, blackberries, madrone berries, and wild grapes along with root resources such as wild onion, cattail, and wild carrot (Levy 1978:491).

Shellfish and marine mammals were important resources in the Ohlone diet in general, particularly for coastal populations. Midden deposits found in shellmounds throughout the Bay Area attest to the importance of shellfish in the Ohlone diet. The Emeryville Shellmound (CA-ALA-309) is nearby, this was once a complex of mounds and was documented by Nels Nelson (1909); it is located approximately 2.5 miles south of the Study Area on the east shore of San Francisco Bay. Terrestrial mammals were also important to coastal and inland Ohlone populations including rabbits, black-tailed deer, tule elk and pronghorn sheep which were hunted and trapped using drive and snare methods. Hunting parties were communal, often bulk harvesting meat for immediate consumption or for winter storage for the various village groups (Lightfoot and Parrish 2009:212). Migratory waterfowl, particularly geese, ducks, and coots, were the most important avian resources and were captured with nets. Additionally, local quail were caught in traps. The Ohlone fished for salmon, sturgeon, and lampreys, and built tule balsas (rafts) to move about the waterways. The Ohlone traded with surrounding tribes such as the Miwok (to the northeast), and the Northern Valley Yokuts (to the east). Mussels, abalone shells, dried abalone, and salt were exchanged for piñon nuts with the Yokuts. *Olivella* shells were traded with the Sierra Miwok and bows with the Plains Miwok (Levy 1978:488).

Between 1770 and 1797, six missions were set up within the Ohlone territory (Margolin 1978:160). In 1770, the Ohlone population was estimated to be between 7,000 and 10,000 (Moratto 2004). Based on mission records, Milliken estimates that there were 2.5 people per square mile (Milliken et al. 1993:25). As a result of numerous stressors including the introduction of European diseases; the loss of traditional lifeways, including their settlement and subsistence practices; reduced birth rates; and

poor working and living conditions that they were forced to endure the Ohlone population dramatically and rapidly declined to fewer than 2,000 by 1832 (Milliken 1995). For native peoples who lived in tribelets, the loss of this many members would destabilize what little remained of their traditional social structure. By the time of secularization in 1834, there were no traditionally functioning tribal groups left within the project vicinity.

Since the 1980s, the modern Ohlone community has undergone a period of revitalization based on familial ties and former rancheria affiliations. Although they have yet to receive formal recognition from the federal government, the Ohlone are becoming increasingly organized as a political unit in the San Francisco Bay Area. Today, the Ohlone continue to live in and around Alameda and Contra Costa counties and despite more than a century of adversity, they continue to engage in traditional cultural practices and advocate for the preservation of their heritage.

HISTORIC CONTEXT

The historic context of the Study Area is influenced by four eras, including the Contact Period, Mission Period, Rancho Period, and American Period.

Contact Period (A.D. 1542 - 1769)

In 1542, Juan Sebastian Cabrillo was the first of the Europeans explorers to sail along the California coast. The goal of this expedition was to explore the new territory and to find suitable locations for establishing Franciscan missions; during this expedition they rediscovered the Bay of Monterey, described by sailors a hundred years earlier. Several accounts of this expedition exist including those of Fray Juan Crespi (Bolton 1971), Miguel Costansó (Browning 1992), and Pedro Fages (Priestley 1937). A Spanish expedition, led by Pedro Fages in 1772, reentered the San Francisco Bay Area returning from a southern expedition to Monterey. The explorers first saw the land that became Contra Costa County from San Francisco, and thus named the area "opposite coast" (Hoover et al. 1990).

Mission Period (A.D. 1769 – 1822)

The arrival of the Spanish and the subsequent establishment of the missions had a dramatic effect on native lifeways. The destruction of native culture resulted from the disruption of social systems, changes in subsistence and settlement patterns, the alteration of the landscape with the introduction of European plants and animals, and the devastation of Native American populations with the introduction of European diseases. The California missions of the San Francisco Bay Area that were established in the Ohlone territory are as follows: Mission San Francisco de Asis in 1776, Mission Santa Clara de Asis in 1777, Mission San José in 1797, Mission San Rafael Arcangel in 1817, and Mission San Francisco Solano in Sonoma in 1823. As the populations of Ohlone, who were originally brought to the Santa Clara de Asis, San Francisco de Asis, and San José missions, fled or died of disease, the Spanish were forced to search for replacement neophytes (Milliken 1995).

Rancho Period (A.D. 1822 – 1850)

In 1821, Mexico declared independence from Spain, and in 1822, California became a Mexican Territory. Following the secularization of the missions in 1834, representatives of the Mexican government distributed very large land grants to various individuals. Native Americans continued to work as laborers for new landowners (Beck and Haase 1977). During 1821 and 1846 when California was under the control of the Mexican Government, Contra Costa County was divided into the numerous ranchos, including Rancho San Pablo, Rancho San Ramón, Rancho El Sobrante de San Ramón, Rancho Sobrante, Rancho La Boca de la Cañada del Pinole, Rancho El Pinole, Rancho Los Medranos, Rancho Laguna de los Palos Colorados, and Rancho Arroyo de las Nueces y Bolbones

(Hoover et al. 1990). The current project area is located within Rancho San Pablo (Hatoff et al. 2003). A detailed description of the rancho is below:

Rancho San Pablo

Spain sought to solidify its claim to the territory by colonizing Alta California by encouraging settlement with large land grants. The closest land grant to the Study Area, Rancho San Pablo, was provisionally granted to Francisco Castro in 1823. Castro was born in Mexico and in 1800, relocated to Alta California where he served as a soldier for 13 years. In 1822, he became a member of the Governor's Council and acted as a *diputado*, or official representative, of the expedition led by Father Jose Altamira to the land north of the San Francisco Bay. The following year, he was provisionally granted Rancho San Pablo, where he lived until his death in 1831. His widow and eleven children inherited the estate and received official confirmation of the land grant in 1834 (Hoover et al. 1990).

American Period (A.D. 1850 to present)

The discovery of gold in the Sierra Nevada by Euro-americans ignited a major population increase in the northern half of California, as immigrants poured into the territory seeking gold and the opportunities it presented. The significant influx of people had a major impact on the environment and the remaining indigenous populations. Beginning in 1849, the Gold Rush created a shortage of ranch workers who rushed off to seek their fortunes. This loss of a ranch workforce, along with a huge increase in Euro-americans squatting on these lands, would later contribute to the disintegration of the Mexican land grants and eventual division and sale of land grant property.

Although rancho owners tried to maintain their property rights during the Gold Rush, by continuing to develop their cattle ranch industry, their lands were overrun by settlers or squatters as California ushered in the Gold Rush and ultimately and officially became a state in September 1850. The courts immediately reviewed Spanish and Mexican land grants, which were either confirmed or denied. Contra Costa became one of the state's original 27 counties in 1850 (Hoover et al. 1990). During the 1850s, the county grew rapidly resulting in the construction of roads, docks, railroads, canals, and shipping areas adjacent to the San Francisco Bay. In 1852, Castro divided the rancho into eight sections given to his heirs, who quickly sold the land to American settlers in the county. (Hatoff et al. 2003).

In 1876, the restaurateur Richard Stege purchased 600 acres of land within the former Rancho San Pablo. Stege established an estate on his new property, which included four frog ponds to raise red-legged frogs for restaurants in San Francisco, and a landing pier (located just south of the APE and dismantled in 2003) used by visitors to his estate and later by ships transporting grain to San Francisco (Hatoff et al. 2003).

Around the same time, chemical and explosive industries, including the Hercules Power Company and Stauffer Chemicals, began settling in the immediate vicinity. In 1880, Letts Oliver acquired the Stege property and established the California Cap Company to manufacture a new detonator, which he designed to be safer than those imported from Europe. The manufacturing plant featured over 150 buildings as well as trees to protect nearby residents in the event of an explosion. A wood seawall (located within the project vicinity and dismantled in 2003) was also constructed to serve as a wave barrier between the plant and the bay. The California Cap Company continued operations at the plant until 1948 (Hatoff et al. 2003).

In 1950, the University of California purchased the property from the California Cap Company and allowed the College of Engineering at the Berkeley campus to use it for off-site research. It renamed the property as the Richmond Field Station, remodeled existing buildings, and also constructed several new buildings to house administrative offices or specific research projects. The college also

filled in the area south of the seawall in order to construct a "hydrate pond" and a separate pond for sewage treatment research. (Hatoff et al. 2003). In 2002, the University of California conducted remediation of the shoreline to remove elevated concentrations of chemicals in the marsh sediments. The shoreline had been identified by the Regional Water Quality Control Board (RWQCB) as a high-priority "toxic hotspot" due to the release of mercury and pyrite cinders by the California Cap Company and adjacent manufacturing plants in the late 19th and early to mid-20th centuries. The above ground features of the cultural resources CA-CCO-754H (Stege Marsh Pier) and CA-CCO-753H (Stege Marsh Seawall) were removed during the remediation process, leaving remnants of these resources in place. These resources were evaluated and recommended ineligible for listing in the NRHP and CRHR (Hatoff et al. 2003). The University continues to own and operate the research facility (Hatoff et al. 2003).

4.0 PREFIELD RESEARCH AND CONSULTATION METHODS AND RESULTS

The methods used to conduct the records search, historic map review, and pedestrian survey for this inventory, and the results of those efforts are described in detail below.

RECORDS SEARCH METHODS

A GANDA cultural resource specialist conducted a records search at the Northwest Information Center (NWIC) of the California Historical Resources Information System (CHRIS) at Sonoma State University, Rohnert Park, on January 16, 2013 (File No. 12-0713). The NWIC is a repository of all cultural resources site records, previously conducted cultural resources investigations, and historic information concerning cultural resources for 16 counties, including Contra Costa County. The records search was conducted to compile information regarding the locations of previously recorded archaeological sites and previously conducted studies within a 0.25-mile radius of the Study Area which encompasses the APE. In addition, this information was used to assess the archaeological sensitivity of the Study Area and the APE. The following sources were consulted during the records search:

- NWIC base map: United States Geological Survey (USGS) 7.5-minute series topographic quadrangle for Richmond (1993).
- Survey reports from previous cultural resources investigations and cultural resources site records to identify previously recorded archaeological sites located within a 0.25-mile radius of the Study Area and the APE.
- California Office of Historic Preservation (OHP) resources, including the *California Inventory of Historic Resources* (1976), the *OHP Archaeological Determinations of Eligibility* for Contra Costa County (2012a), and the *OHP Historic Properties Directory* for Contra Costa County (2012b), which combines cultural resources listed as California Points of Historic Interest, listed as California Historical Landmarks, and listed in or determined eligible for listing in the NRHP or the CRHR.

RECORDS SEARCH RESULTS

Cultural Resources Investigations

The records search indicates that 29 cultural resources investigations have been completed within a 0.25-mile radius of the Study Area and the APE, four of which have been completed within the APE (Table 1).

Table 1. Previous Cultural Resource Investigations Located within the APE.

Study No.	Author/Date	Investigation Type	Associated Cultural Resources Recorded within the APE
S-02442	Banks 1980	Intensive level archaeological survey with limited testing excavation	None
S-11762	Holman 1989a	Intensive level archaeological survey	None

Study No.	Author/Date	Investigation Type	Associated Cultural Resources Recorded within the APE
S-11763	Holman 1989b	Built Environment reconnaissance survey	Several buildings over 45 years old were identified during the field survey but were not recorded on DPR 523 forms or evaluated for listing in the NRHP
S-26851	Hatoff et al. 2003	Archaeological monitoring	Two cultural resources were identified within the APE during the field survey: CA-CCO-754H/ P-07-002555 (Stege Marsh Pier/Richmond Field Station Pier/California Cap Company Pier) CA-CCO-753H/ P-07-002591 (Stege Marsh Seawall)

The following discussion provides information regarding the cultural resource investigations conducted within the APE and the cultural resources identified:

S-02442

Conducted in 1980 (Banks 1980), this archaeological survey covered a six acre parcel that included the Study Area and the APE. It consisted of a pedestrian survey of the parcel, the examination of three geotechnical auger borings that had been drilled to a depth of 30-60 feet before the survey began, and the drilling of two new hand-auger units. The location of the three previously-drilled augers is unknown and did not result in the discovery of cultural resources. The two new hand-auger units conducted by archaeologists, were located within the Study Area but outside the APE and were excavated to a depth of approximately 55 centimeters (Auger Unit #1) and approximately 105 centimeters (Auger Unit #2). This investigation did not result in the identification of cultural resources (Banks 1980).

S-11762

This archaeological survey, conducted in 1989, encompassed both the Study Area and the APE. The Study Area and the APE were surveyed using 20-foot (or less) transects, and the ground surface, including two existing trenches, was visually inspected. The survey did not result in the identification of cultural resources (Holman 1989a).

S-11763

Conducted in 1989, this reconnaissance field survey included the Study Area and the APE for the purpose of identifying built environment resources over 45 years old. Several buildings were identified, but they were not recorded on DPR 523 forms or evaluated for listing in the NRHP (Holman 1989b).

S-26851

Archaeological monitoring was conducted in 2003 within the southern portion of the APE. The monitoring resulted in the identification of one cultural resource, CA-CCO-753H (Stege Marsh Seawall) within the APE. Subsurface portions of CA-CCO-753H may still be present and buried to the west of the 2004 excavation. However, this resource was evaluated and recommended ineligible for listing in the NRHP and CRHR (Hatoff et al. 2003).

Cultural Resources

As a result of the 29 cultural resources investigations conducted within 0.25 mile of the APE, seven cultural resources, including five prehistoric shellmounds and a historic-period pier and seawall, were recorded. One of these cultural resources, CA-CCO-157 (Loud's No. 299) is located within the Study Area and several others are located within close proximity to the Study Area (Table 2) (Figure 6). Subsurface remnants of CA-CCO-753H (Stege Marsh Seawall) are located within the APE but have been evaluated and recommended as ineligible for listing in the NRHP and CRHR.

Table **2**. Previously Recorded Cultural Resources Located within 0.25 Miles of the APE.

Trinomial/ Primary No.	Resource Name	Resource Type/Age	Proximity to the APE and Survey Area	NRHP Eligibility Status
CA-CCO-157/ P-07-000099	Loud's No. 299	prehistoric shellmound	Within the Study Area, adjacent to the APE	Not evaluated
CA-CCO-297/ P-07-000174	Nelson's No. 297	prehistoric shellmound	Outside the APE, approx. 0.16 mile to the west	Not evaluated
CA-CCO-298/ P-07-000175	Nelson's No. 298/Loud's No. 298	prehistoric shellmound	Outside the Study Area and APE, approx. 0.18 mile to the west	Not evaluated
CA-CCO-299/ P-07-000176	Nelson's No. 299/Loud's No. 297	prehistoric shellmound	Outside the Study Area and APE, approx. 0.08 mile to the west	Not evaluated
CA-CCO-300/ P-07-000177	Nelson's No. 300/Loud's No. 300	prehistoric shellmound	Outside the Study Area and APE, approx. 0.10 mile to the west	Not evaluated
CA-CCO-754H/ P-07-002555	Stege Marsh Pier/Richmond Field Station Pier/California Cap Company Pier	Wood pier (late 19th or early 20th century)	Outside the Study Area and APE, approx. 50 feet to the south	Not evaluated
CA-CCO-753H/ P-07-002591	Stege Marsh Seawall	Seawall (late 19th or early 20th century)	Remnants located within the APE	Recommended ineligible

The following discussion provides information regarding the known resources located within the Study Area and the APE:

CA-CCO-157 (Loud's No. 299)
In 1915, L. L. Loud originally recorded this resource as an approximate 350-foot wide by 250-foot long shellmound situated on the end of a slough around 800 feet from the San Francisco Bay's historic shoreline. What remains of this resource is currently located underneath a warehouse and paved parking lot at 3200 Regatta Boulevard in Richmond (Banks 1985a). This resource is located within the Study Area but outside of the APE.

CA-CCO-753H (Stege Marsh Seawall)
Constructed in the late 19th or early 20th centuries, this segment of the Stege Marsh Seawall consists of an approximate 18-foot long wood beam mounted in place by two sets of round wood poles. Seventeen 1-foot by 3-inch wood planks form the back of the seawall. According to the monitoring report (S-26851), the other portion of the seawall has been dismantled (Lee 2002a). This resource was located within the Study Area and the APE, and subsurface portions of it may still be present and buried. This resource was evaluated and recommended ineligible for listing in the NRHP and CRHR (Hatoff et al. 2003).

HISTORIC MAP REVIEW

Historic maps showing features such as towns, railways, wagon roads, creeks, rivers, power lines, and reclamation and irrigation districts were reviewed in order to provide additional information to assess the sensitivity for the presence of historic-period resources within the Study Area and the APE. Historic maps were available at various online archives, such as the David Rumsey Map Collection and Calisphere. Results of the historic map review depict a historic period road system and railroad spurs within the Study Area and the APE. These roads and railroad are mapped on the 1947, 1959, and 1968 Richmond USGS topographic maps. These historic roads appear to be associated with the development of the explosive manufacturing plant in the late 19th or early- to mid-20th centuries and will be addressed as a part of the built environment analysis (Tetra Tech 2013a).

GEOARCHAEOLOGICAL ANALYSIS

Background research included a review of geology maps for archaeological and environmental information regarding the geology underlying the Study Area and the APE (Figure 5). This information was used to assess the sensitivity of the APE for buried archaeological resources, along with an understanding of the distribution and environmental setting of archaeological sites recorded nearby. Figure 5 illustrates that the APE is underlain primarily by Holocene aged alluvial deposits that were once along the San Francisco Bay shoreline. In addition, due to the proximity of the former bay shoreline, abundance of natural marine and estuarine resources, and the documented prehistoric shellmounds recorded within and adjacent to the Study Area, there is a clear sensitivity of the Study Area and APE for the presence of buried and at or near surface prehistoric archaeological sites.

NATIVE AMERICAN CONSULTATION

As part of the consultation process with Native American organizations and individuals, GANDA archaeologist Cassidy DeBaker, M.A., contacted the Native American Heritage Commission (NAHC) on January 24, 2013. DeBaker requested information about sacred lands that may be within the Study Area and APE and a list of interested Native American groups and individuals for Alameda County (Appendix A). To date, a response has not been received from the NAHC.

5.0 FIELD METHODS AND RESULTS

SURVEY METHODS

On January 24, 2013, archaeologist Kruger Frank, B.A., conducted a pedestrian survey of the approximately 16-acre APE, within the larger Study Area (Figure 3). The survey location was identified on an aerial map provided by Tetra Tech. Approximately 70 percent of the 16 acres is developed, consisting of buildings, roads, parking lots, and a large stock pile of soil. The remaining 30 percent of land consists of a large grassy field, lawns, landscaping, dirt driveways/parking lots, and wetlands. A small southern portion of the APE was inaccessible, because it was located within a fenced area marked with signs for hazardous waste and habitat restoration areas. K. Frank used conventional survey methods adapted to accommodate the undeveloped areas of the surrounding environment. K. Frank surveyed all land that was not paved or developed using two to five meter transects, roughly north to south. Some areas were spot-checked with a trowel, and gopher holes and recent ground disturbances were thoroughly inspected. The ground visibility was between 5 to 10 percent in the undeveloped portions of the APE, and the soil consisted of fill with the presence of some native black silty loam. K. Frank used a sub-meter accurate Trimble GXT hand held Global Positioning System (GPS) unit to take control points in the APE and to map the location of one isolated historic period bottle and two stands of Eucalyptus trees identified during the survey. In addition, K. Frank documented the APE using a digital camera.

SURVEY RESULTS

As a result of the field survey, no previously recorded or newly identified prehistoric archaeological resources were observed. Remnants of the previously recorded historic period resource within the APE, CA-CCO-753H (Stege Marsh Seawall) were not relocated. In addition, this area was inaccessible due to fact that it is located in the fenced area marked as hazardous waste and habitat restoration. The survey did result in the identification of two previously unrecorded historic period resources, including two stands of Eucalyptus trees, GANDA-622-01 (Figure 7), and one isolated bottle, GANDA-ISO-622-01 (
Figure 8), which were identified within the APE and are described below. DPR 523 forms have been prepared for these resources and are presented in Appendix B.

<u>GANDA 622-01 (Eucalyptus Stands 1 and 2)</u>
This landscape feature consists of two historic period Eucalyptus stands located within the APE (Figure 7). Eucalyptus Stand 1 is located on the east side of the APE, along the east side of S. 46th Street (Egret Way). Eucalyptus Stand 2 is located on the northwest side of the APE, east of Avocet Way. According to the technical report for the Richmond Field Station Remediation Project (S-26851), Richard Stege purchased 600 acres of land and established an estate in 1876. Around the same time, chemical and explosive companies also began buying land in the area and constructing manufacturing plants. In 1880, the California Cap Company was established at the Stege property, and trees were planted to serve as a buffer between the manufacturing facility and nearby residents (Hatoff et al. 2003). It is possible that the Eucalyptus stands are the same trees planted in the 1880s. The University purchased the property in 1950s and reused many of the existing buildings (Hatoff et al. 2003). It also may have retained the Eucalyptus stands.

Figure 7. View south toward Eucalyptus Stand 1 along Egret Way (left) and view northeast toward Eucalyptus Stand 2 from Avocet Way (right).

GANDA ISO-622-01

This isolated resource consists of a late 19th to early 20th century complete aqua whiskey bottle, which was identified in the southern portion of the APE, on the south side of Building 110 (Figure 8). The bottle was not collected during the field survey.

Figure 8. Photograph of GANDA ISO-622-01.

6.0 FINDINGS STATEMENT

As per the requirements of Section 106 of the NHPA and 36 CFR 800.4 and CEQA [Title 14 CCR 15064.5], this report presents the results of an archaeological inventory of the Study Area and APE. This investigation resulted in the identification of two newly identified historic period resources within the APE: 1) GANDA-622-01 (Eucalyptus Stands 1 and 2), which are likely associated with extant historic period buildings; and 2) GANDA-ISO-622-01, an isolated historic period bottle. It is recommended that GANDA-622-01 (Eucalyptus Stands 1 and 2) be evaluated for its potential eligibility for listing in the NRHP in conjunction with the extant historic structures as these landscape features are associated with those buildings and part of the overall historic landscape of the APE. As an isolated artifact that lacks association within the larger historic context of the APE, this resource is not potentially eligible for listing in the NRHP.

No prehistoric archaeological resources have been identified within the APE. However, much of the ground surface within the APE is obscured by historic and modern development. In the Study Area, there is one previously recorded prehistoric shellmound that is also currently obscured by buildings. In addition, there are three other previously recorded prehistoric shellmounds recorded within adjacent to the Study Area, and the geoarchaeological analysis and environmental setting of the APE and Study Area indicate that the APE has a very high sensitivity for buried, surface, or near surface prehistoric resources. Prior to ground disturbance within the APE, it is recommended that a testing program be conducted to complete the identification of prehistoric resources within the horizontal and vertical APE. In addition, based on the results of the background research, understanding of the historic use of the APE, and the identification of historic period materials and landscape features within the APE, there appears to be sensitivity for the presence of historic period archaeological resources, but not the degree that additional identification efforts are recommended.

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2012 http://alabamamaps.ua.edu/historicalmaps/us_states/california/topos/15index.htm (last accessed in February 2013).

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U. S. Climate Data
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Appendix A

Native American Correspondence

GARCIA AND ASSOCIATES
1 SAUNDERS AVENUE
SAN ANSELMO, CA 94960
PHONE 415.458.5803
FAX 415.458.5829

January 24, 2013

Native American Heritage Commission
915 Capitol Mall, Room 364
Sacramento, CA 95814
(916) 653-4082 (office)
(916) 657-5390 (fax)
nahc@pacbell.net

Subject: Cultural Resources Study for the Richmond Field Station

Dear Native American Heritage Commission,

Garcia and Associates (GANDA) is conducting a cultural resources investigation for the Richmond Field Station Project in Contra Costa County to determine if the project might affect any cultural resources. Please review the Sacred Lands File for any Native American cultural resources that may be within or adjacent to the project area. The project area is located in Sections 19 and 20, Township 01 North, Range 04 West of the Richmond (1993) CA 7.5 minute USGS Quadrangle (please see attached map).

We also request a list of Native American individuals and organizations that may have knowledge of cultural resources in the project area. If you have any questions, please contact me at the address and phone number above or via email (cdebaker@garciaandassociates.com). I look forward to hearing from you.

Thank you.

Sincerely,

Cassidy DeBaker, Archaeologist
415.458.5803 office
415.250.1687 cell
Garcia and Associates

Attachments (1)

GANDA

Appendix B

Department of Parks and Recreation (DPR) 523 Forms

State of California - The Resources Agency **Primary #**
DEPARTMENT OF PARKS AND RECREATION **HRI #**

PRIMARY RECORD

Trinomial:
NRHP Status Code

Other Listings
Review Code **Reviewer** **Date**

Page 1 **of** 6 ***Resource Name or #:** GANDA 622-01 (Eucalyptus Stands 1 and 2)

P1. Other Identifier:

***P2. Location:** ☒ **Not for Publication** ☐ **Unrestricted** ***a. County** Contra Costa

***b. USGS 7.5' Quad** Richmond, Calif. **Date** 1995 **T**3S **; R**5W **;** SE ¼ NW ¼ and SW ¼ NW ¼ **of Sec** 20; Mount Diablo **B.M.**

c. Address 1301 South 46th Street **City** Richmond **Zip** 94804

d. UTM: Zone 10N; *NAD 83:* 558553mE/4196376mN (north end of Stand 1) 558380mE/4196466mN (north end of Stand 2)

e. Other Locational Data: From the entrance station of the Berkeley Field Station on Seaver Avenue (Owl Way), continue east on Seaver Avenue for 700 feet until reaching South 46th Street (Egret Way). To reach Stand 1, make a left and continue south down South 46th Street for approximately 0.30 mile and stop at the intersection of Lark Way (Commodore Drive) and South 46th Street. To reach Stand 2, continue west (right) on Lark Way for approximately 560 feet and stop at Seaver Avenue. From here continue on foot south for approximately 100 feet.

***P3a. Description:** This historic-period resource consists of two stands of Eucalyptus trees (Stand 1 and Stand 2), which are located in the northeast and northwest portions of the project area. Stand 1 is located in the northeast portion of the project area starting on the south side of Lark Way (Commodore Drive) and continuing more than 700 feet along the east side of South 46th Street (Egret Way). Stand 2 is located in the northwest portion of the project area also starting on the south side of Lark Way (Commodore Drive) and continuing more than 270 feet south parallel to Avocet Way. Both tree stands represent landscape features that are likely associated with the California Cap Company.

***P3b. Resource Attributes:** AH3. Landscaping/orchards

***P4. Resources Present:** ☐Building ☐Structure ☐Object ☒Site ☐District ☐Element of District ☐Other (Isolates, etc.)

P5a. Photograph:

P5b. Description of Photo:
Overview of the northern extent of Eucalyptus Stand 1, facing south along South 46th Street (Egret Way).

***P6. Date Constructed/Age and Sources:** ☒Historic ☐Prehistoric ☐Both

***P7. Owner and Address:**
University of California, Berkeley
Berkeley, CA 94720

***P8. Recorded by:**
Kruger Frank
Garcia and Associates (GANDA)
1 Saunders Avenue
San Anselmo, CA 94960

***P9. Date Recorded:** January 24, 2013

***P10. Survey Type:** Pedestrian Survey

***P11. Report Citation:**
Garcia and Associates (GANDA). Draft Cultural Resources Inventory and Evaluation Report for the Richmond Bay Campus Project, Richmond, Contra Costa County, California. Prepared for Tetra Tech. February 2013.

***Attachments:** ☐NONE ☒Location Map ☐Sketch Map ☒Continuation Sheet ☐Building, Structure, and Object Record ☒Archaeological Record ☐District Record ☐Linear Feature Record ☐Milling Station Record ☐Rock Art Record ☐Artifact Record ☐Photograph Record ☐ Other

ARCHAEOLOGICAL SITE RECORD

 ***Resource Name or #:** GANDA 622-01 (Eucalyptus Stands 1 and 2)

***A1. Dimensions:** Tree Stand 1: **a. Length** 770 feet (N-S) × **b. Width** 30 feet (E-W)
Tree Stand 2: **a. Length** 300 feet (N-S) × **b. Width** 30 feet (E-W)

Method of Measurement: ☐ Paced ☐ Taped ☐ Visual estimate ☒ Other: GPS data collected with a Trimble Geo XT.

Method of Determination: ☐ Artifacts ☒ Features ☐ Soil ☐Vegetation ☐ Topography
☐ Cut bank ☐ Animal burrow ☐ Excavation ☐Property boundary ☐ Other (Explain):

Reliability of Determination: ☒ High ☐ Medium ☐ Low Explain:

Limitations: ☒ Restricted access ☒Paved/built over ☒ Site limits incompletely defined
☐ Disturbances ☐ Vegetation ☐ Other (Explain):

A2. Depth: ☒None ☐ Unknown Method of Determination: Monitored excavation.

***A3. Human Remains:** ☐ Present ☐ Absent ☒Possible ☐Unknown (Explain):

***A4. Features:**

Tree Stand 1: This historic-period landscape feature consists of approximately 250 mature eucalyptus trees that are located on intersection of South 46th Street (Egret Way) and Lark Way. The stand of eucalyptus trees are planted in three rows and start on the south side of Lark Way (Commodore Drive) and continue south on the east side of South 46th Street for approximately 800 feet. The overall width of the tree rows are approximately 30 feet. Most of the trees are greater than 4 feet wide and approximately 100 feet tall.

Tree Stand 2: This historic-period landscape feature consists of approximately 100 mature eucalyptus trees that are located east of Building 276 and run parallel north-south along Avocet Way. The stand of eucalyptus trees are planted in three rows and is approximately 30 feet wide. The overall length of the Eucalyptus Stand 2 is approximately 300 feet. Most of the trees are greater than 4 feet wide and are approximately 100 feet tall.

***A5. Cultural Constituents:** No artifacts were noted.

***A6. Were Specimens Collected?** ☒ No ☐ Yes

***A7. Site Condition:** ☐Good ☒ Fair ☐ Poor:

***A8. Nearest Water:** San Francisco Bay is approximately 200 meters south of Stand 1.

A9. Elevation: 5.6 meters amsl.

A10. Environmental Setting: The features are located in a highly industrialized area that is located on the former mash lands of the San Francisco Bay. The surrounding environment consists of industrial and commercial buildings and other built environment features, such as sidewalks, driveways, and roads.

A11. Historical Information: The two stands of eucalyptus trees are likely associated with the California Cap Company, which acquired the property in 1880. It built a manufacturing plant with over 150 buildings as well as trees to protect nearby residents in the event of an explosion. In 1950, the University of California (UC) purchased the property from the California Cap Company and allowed the College of Engineering at the UC Berkeley campus to use it for off-site research. It renamed the property as the Richmond Field Station, remodeled existing buildings, and also constructed several new buildings to house administrative offices or specific research projects (Hatoff et al. 2003). It is possible that the eucalyptus stands are the same trees planted in the 1880s. Both stands of trees are parallel to roads that may have replaced earlier railroad spurs, which can be identified on the 1947 Richmond, California topo map (USGS 1947).

***A12. Age:** ☐ Prehistoric ☐ Protohistoric ☐ 1542-1769 ☐ 1769-1848 ☒ 1848-1880 ☒ 1880-1914 ☐ 1914-1945 ☐ Post 1945 ☐ Undetermined

A13. Interpretations: Based on the overall size of the eucalyptus trees in both stands, it is more than likely that the trees are more than 100 years old and likely associated with the California Cap Company.

A14. Remarks: None

A15. References:

Hatoff, Brian, Christopher Lee, and Jessica Kusz
2003 Richmond Field Station Remediation Project—Subunit 2A, Cultural Resources Monitoring Program for 2002, Technical Report. Prepared by URS Corporation. Prepared for University of California, Berkeley (S-26851).

United States Geological Survey (USGS)
1947 USGS *Richmond, California* 7.5-minute topographic quadrangle.

A16. Photographs:
Original Media/Negatives Kept at: Garcia and Associates, San Anselmo office.

***A17. Form Prepared by:** Kruger Frank **Date:** January 24, 2013
Affiliation and Address: Garcia and Associates, 1 Saunders Avenue, San Anselmo, CA 94960

***Map Name:** *Richmond, California*, USGS 7.5-minute topographic quadrangle ***Scale:** 1:24000 ***Date of Map:** 1993

Additional Photographs:

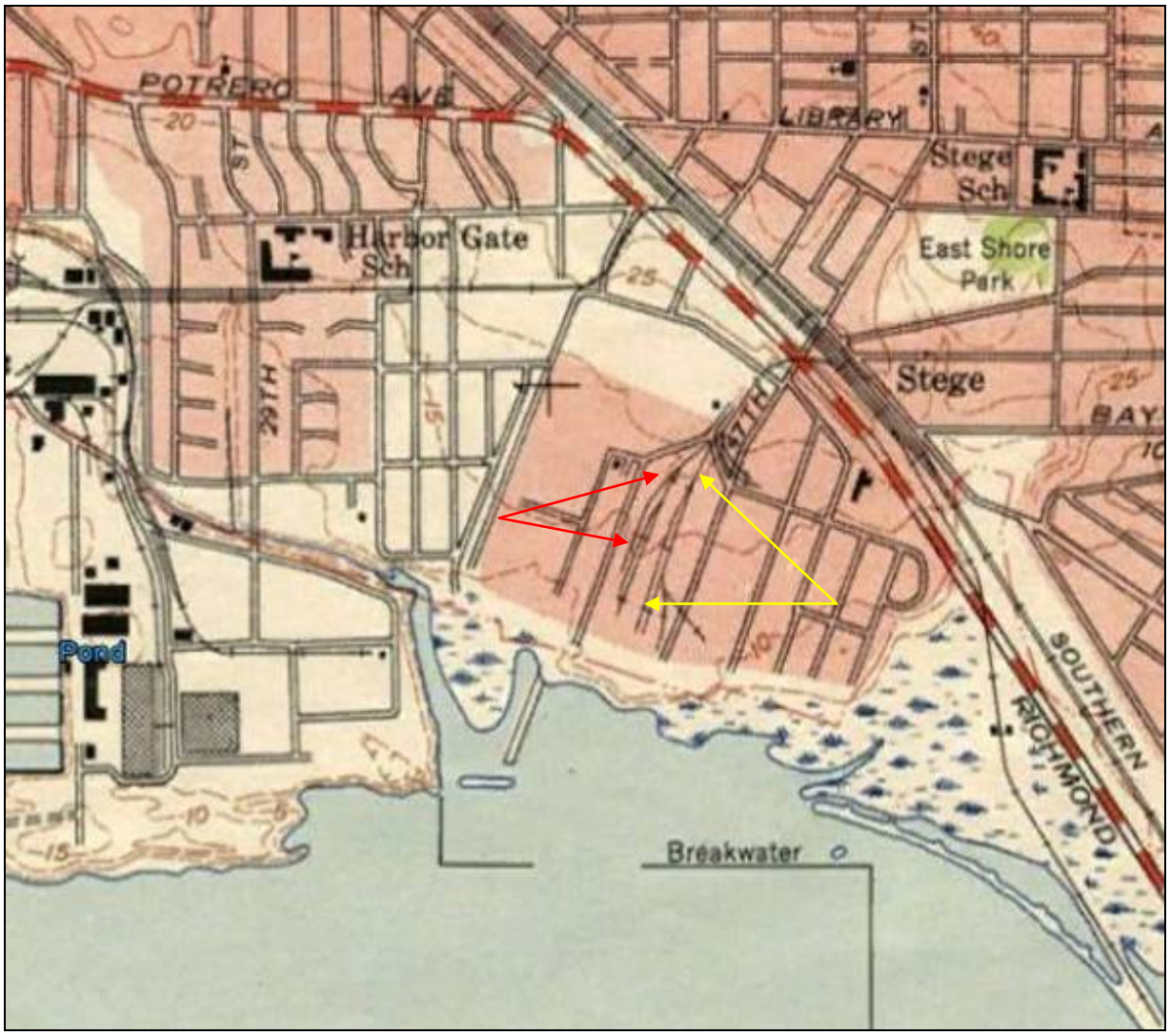
Overview of Stand 1, facing north on South 46th Street (Egret Way).

Close-up of relative size of eucalyptus trees at Stand 1, facing south.

.

Overview of Stand 2 facing south from Lark Way (Commodore Drive).

Overview of Stand 2 facing north.



Detail from the 1947 Richmond, California, 7.5-minute topographic map showing the approximate location of Stand 1 (yellow arrows) and Stand 2 (red arrows) in relation to the non-extant railroad spurs.

Aerial map depicting GANDA 622-01 (Eucalyptus Stands 1 and 2).

State of California - The Resources Agency
DEPARTMENT OF PARKS AND RECREATION

PRIMARY RECORD

Primary #
HRI #
Trinomial:
NRHP Status Code
Other Listings
Review Code Reviewer Date

Page 1 **of** 3 ***Resource Name or #:** GANDA ISO-622-01

P1. Other Identifier:

***P2. Location:** ☒ **Not for Publication** ☐ **Unrestricted** ***a. County** Contra Costa

***b. USGS 7.5' Quad** Richmond, Calif. **Date** 1993 **T1N ; R**4W **; SW ¼ NW ¼ of Sec** 20 **B.M.** Mount Diablo

c. Address 1301 South 46th Street **City** Richmond **Zip** 94804

d. UTM: Zone 10N; *NAD 83:* 558472mE/4196303mN

e. Other Locational Data: From the entrance station of the Berkeley Field Station on Seaver Avenue (Owl Way), continue east on Seaver Avenue for 700 feet until reaching South 46th Street (Egret Way). Make a left and continue south down South 46th Street for approximately 0.40 mile. Park in front of Building 102 and follow the sidewalk to Building 110 to the west. The isolate is located on the south side of Building 110 at base of the wood fence.

***P3a. Description:** This historic-period resource consists of an isolated aqua whiskey bottle, which was identified along the east side of a wood fence between Building 102 and Building 110. The bottle exhibits a tooled whiskey finish that is chipped slightly and still retains the original cork. The body of the bottle exhibits numerous air bubbles and waves. The base of the bottle exhibits a slight kick-up and no maker mark. The bottle was likely manufactured in a turn mold, because there is no evidence of mold seams. The overall measurement of the bottle is 12 inches in height by 3 inches wide. The base is 2 5/8 inches wide. The bottle is likely from the late 19th century to the early 20th century, which would fit into the early days of operations of the California Cap Company.

***P3b. Resource Attributes:** AH4. (trash scatter)

***P4. Resources Present:** ☐Building ☐Structure ☐Object ☐Site ☐District ☐Element of District ☒Other (Isolates, etc.)

P5a. Photograph:

P5b. Description of Photo:
Overview of isolate location, facing west.

***P6. Date Constructed/Age and Sources:** ☒Historic ☐Prehistoric ☐Both
Likely manufactured during the late 19th century to the early 20th century

***P7. Owner and Address:**
University of California, Berkeley
Berkeley, CA 94720

***P8. Recorded by:**
Kruger Frank
Garcia and Associates (GANDA)
1 Saunders Avenue
San Anselmo, CA 94960

***P9. Date Recorded:** January 24, 2013

***P10. Survey Type:** Pedestrian Survey

***P11. Report Citation:**
Garcia and Associates (GANDA). Draft Cultural Resources Inventory and Evaluation Report for the Richmond Bay Campus Project, Richmond, Contra Costa County, California. Prepared for Tetra Tech. February 2013.

***Attachments:** ☐NONE ☒Location Map ☐Sketch Map ☒Continuation Sheet ☐Building, Structure, and Object Record ☐Archaeological Record ☐District Record ☐Linear Feature Record ☐Milling Station Record ☐Rock Art Record ☐Artifact Record ☐Photograph Record ☐ Other

State of California — The Resources Agency DEPARTMENT OF PARKS AND RECREATION **LOCATION MAP**	Primary # HRI# Trinomial

Page 2 **of** 3 ***Resource Name or #:** GANDA ISO-622-01

***Map Name:** *Richmond, California*, USGS 7.5-minute topographic quadrangle ***Scale:** 1:24000 ***Date of Map:** 1993

Additional Photographs:

Detail of the aqua whiskey bottle.

Detail of the bottle neck.

Detail of the tooled whiskey finish and view of cork closure.

Detail of the wavy glass and air bubbles on the body and view of slight kick-up on base.

Historic Properties Survey Report for Portions of the Richmond Field Station Richmond, California

June 2013

Prepared for:

University of California

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1. SUMMARY

Tetra Tech, Inc. conducted historical evaluations of the 25 buildings[1] in the proposed "Phase 1" area of the Richmond Field Station during January 2013 and of an additional 9 buildings in the area of potential effects (APE) in April 2013. Of these, 32 buildings were evaluated in terms of their eligibility for listing in the National Register of Historic Places (NRHP) and the California Register of Historical Resources (CRHR) and for their eligibility for listing as a historic district. Two of the buildings in the APE are not yet of historic age (45 years under CEQA and 50 years for the NRHP); so Tetra Tech recorded these buildings on DPR 523A forms, but did not evaluate them for historic significance. The evaluation was done in accordance with Section 106 of the National Historic Preservation Act and the implementing regulations found in 36 Code of Federal Regulations (CFR) Part 800, and in accordance with Section 15064.5(a)-(b) of the California Environmental Quality Act (CEQA) Guidelines applying the criteria outlined in Section 5024.1 of the California Public Resources Code. Tetra Tech, Inc. prepared this Historic Properties Survey Report (HPSR) to document the evaluation of the 25 buildings in the Phase 1 footprint and an additional 7 buildings in the larger APE.

This report does not include the study of pre-historic or historic archaeological resources in or near the project area; a separate cultural resource inventory report has been prepared to identify archaeological resources.

The results of the survey indicate that 32 of the 34 buildings do not meet the eligibility criteria for listing in the NRHP or the CRHR and should not be considered historic properties or historic resources either individually or as a historic district. Buildings 150 and 175 should be considered individually eligible for listing under NRHP Criterion A and CRHR Criterion 1 for their association with the California Cap Company and the period of explosives innovation and production in the East Bay. Although both buildings are associated with the California Cap Company, two buildings do not possess a concentration of buildings, structures, or objects sufficient to constitute a historic district.

[1] These buildings are within a parcel proposed for development. There are an additional 59 buildings at the Richmond Field Station, some of which are of historic age and may be eligible for listing in the National Register of Historic Place or the California Register of Historical Resources.

2. PROJECT DESCRIPTION

2.1 PROJECT LOCATION

The Richmond Field Station is adjacent to San Francisco Bay in the City of Richmond in Contra Costa County (Figure 1). The project area is in the southern portion of the Richmond Field Station (Figure 2).

2.2 PROPOSED PROJECT ACTIVITIES

The US Department of Energy (DOE) proposes to relocate and consolidate some of its off-site Lawrence Berkeley National Laboratory (LBNL) research activities to a new 110,000 to 150,000 gross-square-foot facility that DOE would construct on the 16-acre Phase 1 portion of the Richmond Field Station. DOE may also choose to occupy additional facilities that may be constructed by others at approximately the same time as the DOE building construction. Construction would occur over 4 years from 2014-2018.

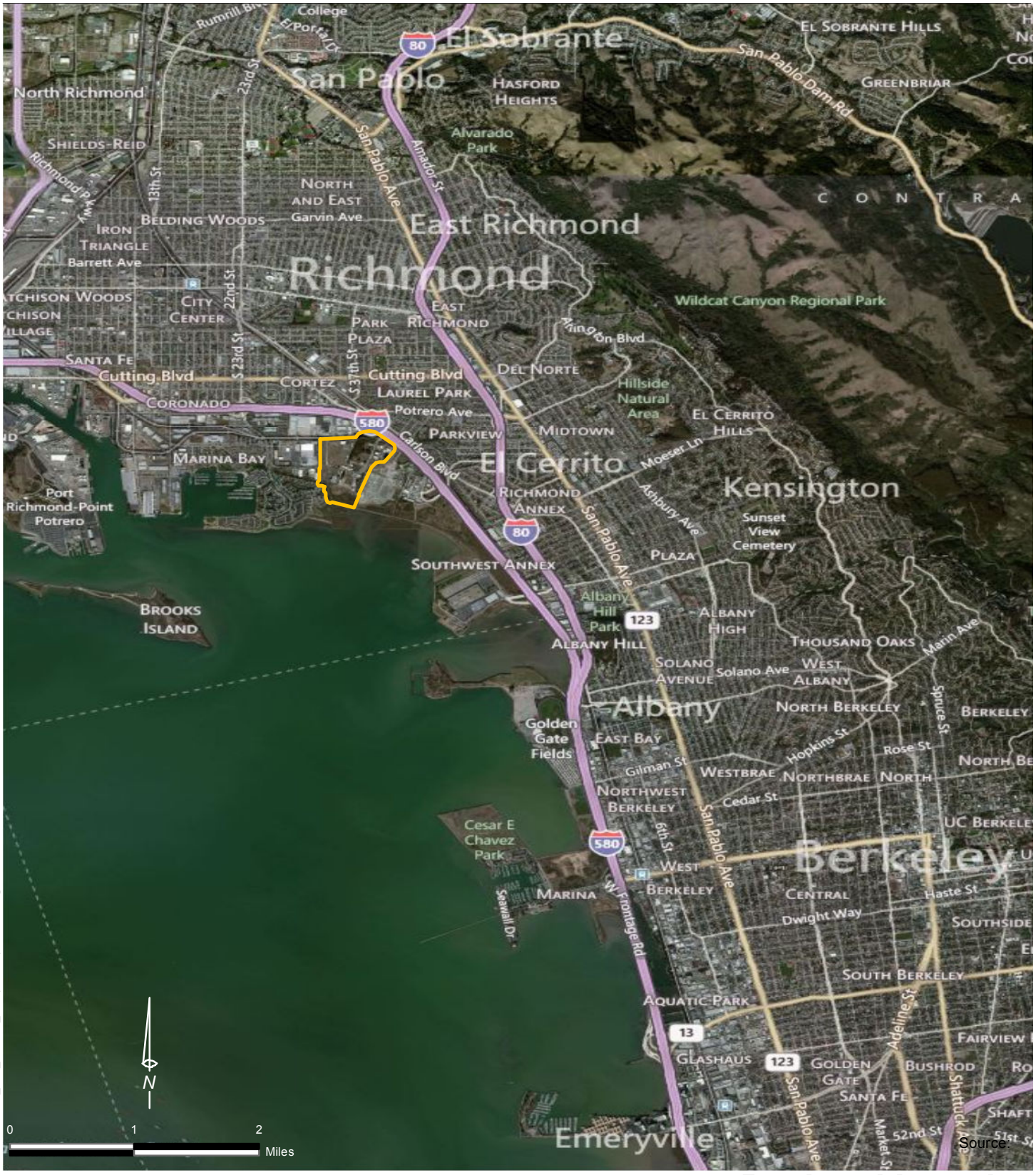
Once constructed, research at these new facilities would initially focus on cleaner biofuel development processes; an advanced understanding of the genomics of plants, microbes, and microbial communities; production of non-petroleum based essential materials and chemicals; advanced diagnostic equipment and techniques for bioscience; industrial process development; and cancer research. Existing research programs at the Richmond Field Station in sustainable transportation and earthquake engineering, among others, would continue.

Prior to construction, the 25 existing structures in the Phase 1 area, totaling approximately 107,000 gross square feet (gsf), would be demolished. Construction activities would include rerouting utilities, demolishing buildings, removing trees, landscaping, earthwork, installing utilities and stormwater infrastructure, constructing roads and parking lots, and constructing three new facilities totaling approximately 600,000 gsf. These buildings would include one three-story facility with 110,000 to 150,000 gsf, one two-story facility with 110,000 to 150,000 gsf, and one three- to four-story facility with up to 300,000 gsf.

2.3 RESEARCH METHOD

On January 4, 2013, Tetra Tech Historians/Architectural Historians inventoried and photographed the 25 buildings that are in the Phase 1 footprint. Tetra Tech researched specific buildings and the land use history of the Richmond Field Station at several repositories including the Contra Costa Historical Society archive, the Doe Memorial Library, the Earth Sciences and Map Library at UC Berkeley, and the Oakland Public Library's Oakland History Room.

On April 30, Tetra Tech's Historians/Architectural Historians inventoried and photographed the nine APE buildings across Lark Drive from the 25 buildings



R:\NEW\28511_LBL_Second_Campus\Maps\PPD\\RegionalLocation.mxd

Source:

Regional Location

Legend

Richmond Field Station

Richmond, California

TETRA TECH

Figure 1

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Project Area

Project Area

Richmond, California

TETRA TECH

Figure 2

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

mentioned above. Seven of the nine buildings were recorded and evaluated for their historic significance. Two of the buildings, Buildings 198 and 201, have modern construction dates and were not evaluated for their historic significance.

Tetra Tech identified and prepared a historic context and identified themes under which each of the buildings would be evaluated under the CRHR and NRHP criteria on California Department of Parks and Recreation (DPR) 523 forms; the latter criteria applied because properties listed on or eligible for listing in the NRHP are automatically eligible for listing in the CRHR.

2.4 PAST HISTORIC EVALUATIONS

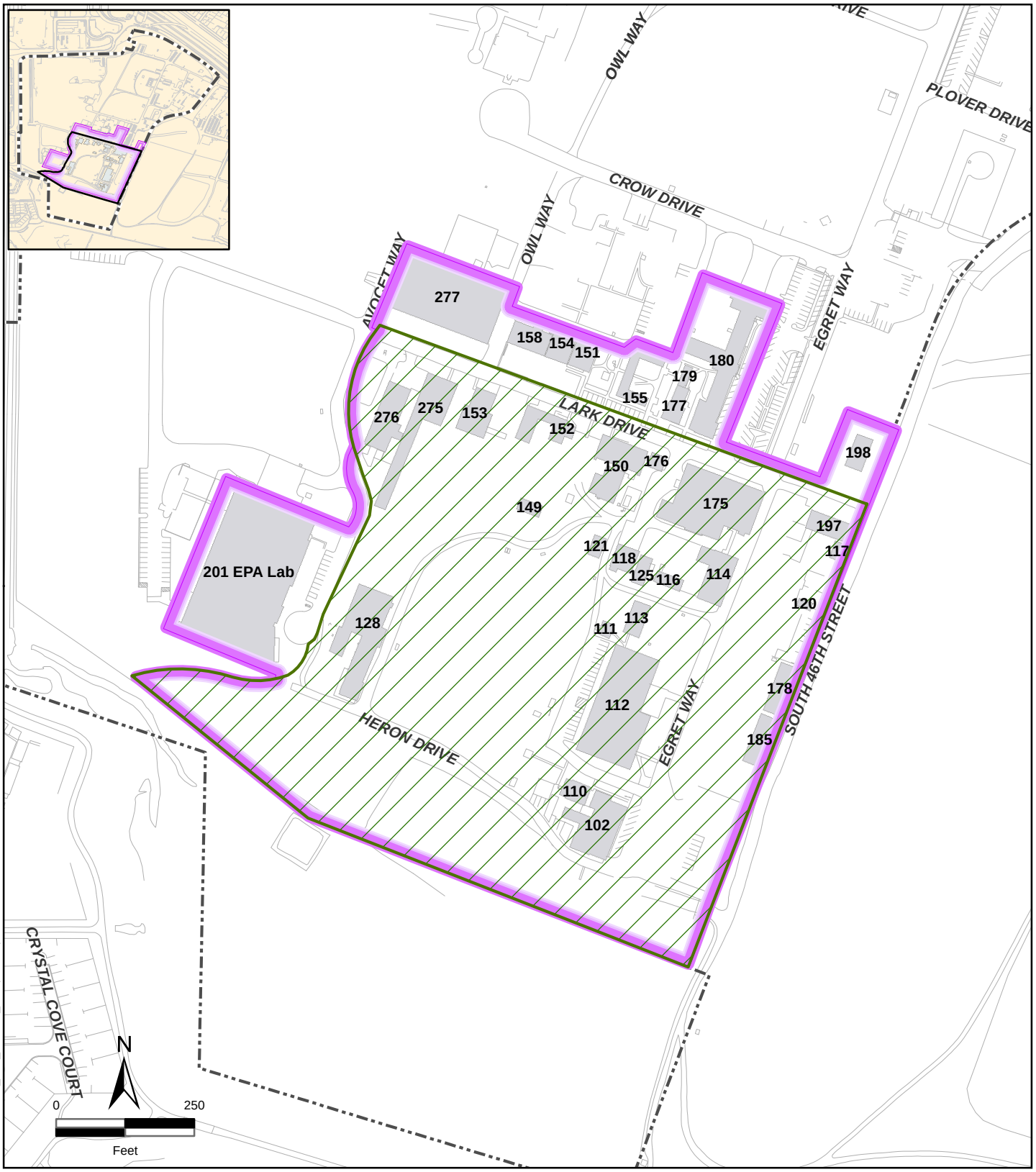
The Contra Costa County Historic Resources Inventory of 1976, updated in 1989 and 2010, lists the "California Cap Works" at 33rd Avenue and Hoffman Boulevard in Richmond as a structure of merit. This address is not within the "Phase 1" footprint, and the address and listing do not specify which building or structure at this address is included in the inventory. Contra Costa County Historical Landmarks Committee and the City of Richmond Planning Division staff explained that this inventory was conducted by local historical societies in 1976 to determine important local historical places, but that no formal evaluations were conducted for the California Cap Works buildings at 33rd Avenue and Hoffman Boulevard.[2] Listing in this inventory does not prescribe any protection to the buildings and structures listed and does not qualify them as historical resources included in a local register of historical resources, as defined in subsection 5020.1(k) of the Public Resources Code.

Holman and Associates surveyed the Richmond Field Station for cultural resources in 1989 as part of an Environmental Impact Report (Holman and Moser 1991). The boundaries for the Holman and Associates survey differed from the boundaries prescribed for this survey and Holman and Moser did not evaluate all the buildings in the current survey population using NRHP or CRHR criteria. The report simply identified that, at that time, the two buildings were over 50 years old.

2.5 AREA OF POTENTIAL EFFECTS

DOE, with assistance from Tetra Tech, established the direct APE (the area that would be directly impacted by proposed project activities) as the 16-acre project area that includes the 25 buildings to be demolished. The direct APE is bounded by South 46th Street, along Lark Drive, Avocet Way, and Heron Drive, as shown in Figure 3. The indirect APE includes the nine buildings to the north and northeast of Lark Drive and the EPA Laboratory building (Building 201) on Avocet Way. The proposed project could have indirect effects on these buildings.

[2] Christine Louie, Contra Costa County Historical Landmarks Committee personal communication with Kara Brunzell, Tetra Tech, Inc. March 11, 2013; Hector Rojas, City of Richmond Planning Division, personal communication with Kara Brunzell, Tetra Tech, Inc. March 11, 2013.



Historical Architectural Area of Potential Effects

DirectAreaPotentialEffects
Indirect Area of Potential Effects
Richmond Field Station Boundary
Road or Other Landscape Feature
Buildings

Richmond, California

TETRA TECH

Figure 3

Because Building 198 (constructed in 1981) and Building 201 (constructed in 1992) have not yet reached the 45-year (CRHR listing) or 50-year (NRHP listing) recommended age for eligibility, they were not evaluated for historic significance, but were recorded on DPR 523 A forms. Figure 3 shows the entire APE for historical architectural resources for the project. Table 1 lists the buildings in the direct APE, and those within the indirect APE are presented in Table 2.

Table 1
Buildings in the Direct APE

Building Number	Year Built	NRHP or CRHR Eligibility Finding
102	circa 1860	ineligible
110	circa 1910s	ineligible
111	1987	ineligible
112	1964	ineligible
113	1982	ineligible
114	circa 1930	ineligible
116	unknown	ineligible
117	unknown	ineligible
118	circa 1930s	ineligible
120	1967	ineligible
121	1982	ineligible
125	circa 1930	ineligible
128	circa 1930	ineligible
149	1982	ineligible
150	circa 1910	eligible
152	circa 1930s	ineligible
153	1959	ineligible
163	circa 1930/1963	ineligible
175	circa 1910	eligible
176	circa 1930s	ineligible
178	unknown	ineligible
185	unknown	ineligible
197	1975	ineligible
275	1956	ineligible
276	1956	ineligible

Table 2
Buildings in the Indirect APE

Building Number	Year Built	NRHP or CRHR Eligibility Finding
151	1961	ineligible
154	1958	ineligible
155	1953	ineligible
158	circa 1957	ineligible
177	circa 1920	ineligible
180	circa 1920	ineligible
198*	1981	ineligible
201*	1992	ineligible
277	1966	ineligible

*Buildings 198 and 201 are in the indirect APE but were not of historic age (45 years or older) at the time of the survey.

3. SURVEY POPULATION

3.1 DESCRIPTION OF THE BUILDINGS IN THE PHASE 1 FOOTPRINT (DIRECT APE)

3.1.1 Building 102

Building 102 is near the southern edge of the Richmond Field Station campus at the intersection of Heron Drive and Egret Way with its primary façade facing southeast. The 6,737 square-foot building is single story with an irregular plan. It was constructed circa 1860 and is currently used for research. The building has been altered since its original construction.

Building 102 was originally a produce warehouse with a rectangular plan at the corner of Heron Drive and Egret Way. When the Tonite Powder and California Cap companies were constructed along the waterfront in 1877, the warehouse was a crucial safety barrier between explosive powder and detonators. Agriculture continued to be an important local activity after the establishment of the explosive companies, and through the 1880s produce was stored in Building 102, along with explosives.[3] As the Tonite and California Cap Companies grew, less space was used for agricultural items, and the building was used entirely for California Cap Company products. By 1912, the company had its can factory and its warehouse in the building.[4] The California Cap Company labeled the building as Building 30. The California Cap Company constructed additional space on the northwest side of the building during the 1930s. During World War II, the building housed an assembly line for incendiary delayed-action bombs.[5]

After UC Berkeley's Department of Engineering took over the site in 1950, the Sanitary Engineering Research Laboratory (SERL) centered activities in and around the building and relabeled the Building 102. Professor H.B. Gotaas was in charge of SERL research during the early 1950s. Projects in the building included studies on composting, incineration, water reclamation, algae symbiosis, saltwater intrusion, and radioactive waste disposal.[6] Building 102 also housed SERL's library and administrative offices. The Department of Engineering altered the interior of the building to suit its purposes, and by the mid-1950s it housed "an unusually well-equipped chemistry and biology laboratory".[7]

Historic photographs indicate that the original building was side gabled, with its primary façade on Egret Way. The University made additions on the building four times after 1950, including construction of an addition projecting from the primary façade that has since been removed.[8] Alterations to the façade appear to have been made during the 1970s, when a flat roof replaced the original gabled roof over the

[3] Roland Oliver, "Recollections of Early Industries in Stege," August 7, 1959, p. 1.
[4] Sanborn Insurance Maps, Stege, California. 1912.
[5] Oliver, p. 1.
[6] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House," May 28, 1952, p. 1.
[7] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection," undated, p. 7.
[8] Shackleton, 2013.

southeast wing of the building (Photographs 1 and 2). Facades on Egret and Heron Drive were altered with the replacement of stucco siding instead of wood. Windows are aluminum sashes. In 2013, the building uses include storage, a bioengineering office, and wet chemistry laboratory.

Photograph 1: Building 102, circa 1954, camera facing west.
On file at the Richmond Field Station archives

Photograph 2: Building 102, circa 1970, camera facing west.
On file at the Richmond Field Station archives

The majority of the building is topped with a flat roof, while other elements of the building's rear are topped with shed roofs. The main (southeast) façade features a broad eave overhang with large exposed roof rafters. There are several large plain columns along this elevation. Many of these columns show signs of moderate to severe deterioration. The building's walls are sided with stucco with wood trim and with horizontal wood siding. Fenestration is aluminum sliding sashes and double-hung, multi-light, wood-frame sashes. Three entrances on the primary elevation are at grade through metal swinging doors; two have windows. Another elevation features a wood paneled door with a window.

Photograph 3: Building 102
January 4, 2013, camera facing southwest

The building currently reflects the many changes of use and alterations performed over the years in its irregular footprint and multiple types of siding and fenestration (Photographs 4 and 5).

Photograph 4: Building 102, January 4, 2013, camera facing north

Photograph 5: Building 102, January 4, 2013, camera facing southwest

3.1.2 Building 110

Building 110 is near the southern edge of Richmond Field Station campus adjacent to Building 102 (Photograph 6). The vernacular building does not strongly express a particular architecture style. Constructed circa the 1910s, the building is 1,325 square feet, single story, with a rectangular plan and topped by a shallow pitch, front gabled roof. Its primary elevation faces southeast. Its moderate eaves feature exposed rafter tails on its northeast and southwest elevations. The walls are clad in horizontal wood siding. Fenestration is original, multi-light, double-hung, wood sashes. An original paneled wood entry door is centered in the southwest elevation, sheltered by a recessed entry porch and accessed by a set of wooden stairs. Plain entablature adorns the door and windows surrounding the otherwise unornamented building. An addition at the rear (northwest) of the building is topped by a shed roof. Its rear entrance is a wood paneled door with a window. This door is sheltered by a small awning and accessed by a set of wooden stairs. The building is surrounded by grassy areas, and access to the rear of the building is currently blocked by a wood fence to the south and a chain link fence to the north.

Building 110 was constructed by the California Cap Company circa the 1910s. The building was originally several hundred yards to the northeast of its current location, along Egret Way.[9] It was used as a research laboratory by the California Cap Company and labeled Building 65.[10]

After UC Berkeley's SERL took over the site in 1950, its activities were concentrated in the southeast section of the Richmond Field Station. Historic aerial photographs show that Building 110 was moved to its current location adjacent to Building 102 circa 1960 and was used for research using radioisotopes. [11] After it was moved, Building 110 housed laboratories and offices for SERL's successor, (EEHSL).[12] The building continued to be used for offices until 2008, but it is currently vacant.[13]

[9] University of California, Berkley, "Draft Environmental Impact Report, Proposed U.S. Environmental Protection Agency, Region IX Laboratory at the University of California's Richmond Field Station," Prepared by University of California, Berkeley Planning, Design and Construction Department, July 1991, p. 307.
[10] University of California, Berkeley, 2008, p.
[11] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call," Regional Oral History Office, University of California, Berkeley, 1974, p. 71.
[12] Shackelton, 2013.
[13] University of California, Berkeley, 2008, p. 196.

Photograph 6: Building 110, January 4, 2013, camera facing south

3.1.3 Building 111

Building 111 is in the southern portion of the Richmond Field Station (Photograph 7). The utilitarian building does not express any particular architectural style. It is 507 square feet and was constructed in 1987. It is single story and rectangular in plan. The building is topped by a flat roof and constructed of concrete masonry units. It lacks fenestration, and its entrances are industrial-type metal doors on its northwest and southeast elevations.

Building 111 appears to have been constructed by UC Berkeley in 1987 on the site of an older building.[14] The land was the location of a storage shed for the California Cap Company "Building 148," that was removed prior to the construction of Building 111 that was constructed for hazardous materials storage.[15] The Watershed Project, a non-profit group whose offices are at the Richmond Field Station, has used the building for storage for the past several years.[16] The building is not of a historic age, as it was constructed 26 years ago.

[14] University of California, Berkeley, 2008, p. 196.
[15] University of California, Berkeley, 2008, p. 13.
[16] Shackleton, 2013.

Photograph 7: Building 111, January 4, 2013, camera facing northeast

3.1.4 Building 112

Building 112 is in the southern portion of the Richmond Field Station (Photograph 8). The rectangular, single-story, 16,949 square-foot building was constructed in 1964.

The building is topped with a flat roof. Its southeast (primary) and northwest (rear) elevations feature a broad eave overhang with large exposed roof rafters. The roof is supported by large plain columns. The walls are sided in stucco with wood trim. Primary fenestration is fixed and awning metal sashes, with vinyl replacement windows at the rear elevation. The primary entrance is a recessed glazed door with a transom and surround.

The building features landscaped areas in the front southeast side elevation that include mature trees along Egret Way. It is identified as the Center for Tissue Bioengineering. A small parking area is adjacent to its rear (northwest) elevation.

Building 112 was constructed in 1964 on the site of seven former California Cap Company buildings.[17] It is in the southeastern portion of the Richmond Field Station, where the early SERL activities were centered. The large building originally housed offices, classrooms, and laboratories.[18] It housed a wet chemistry laboratory as late as 2008, though at that time it was being phased out.[19] It is currently devoted to bioengineering and public health offices.[20]

[17] University of California, Berkeley, 2008, p. 149.
[18] University of California, Berkeley, 2008, p. 13.
[19] University of California, Berkeley, 2008, p. 25.
[20] Shackleton, 2013.

Photograph 8, Building 112, January 4, 2013, camera facing north

3.1.5 Building 113

Building 113 is in the southern portion of the Richmond Field Station. It is a 1,800 square-foot prefabricated building, constructed in 1982 (Photograph 9). It is single story and rectangular in plan.

The building is topped with a very shallow pitched gable roof with large vents in the gables. Its walls are corrugated steel and lack fenestration. An industrial metal entrance door is centered in its southwest elevation and its northwest elevation features a large roll-up door. The building has large vents in the walls near the ground. It is surrounded by a grassy area and shrubbery.

Building 113 was constructed in 1982 as a storage and support facility for SERL. The prefabricated steel building was assembled by Richmond Field Station maintenance workers, who also built its slab foundation.[21] Its use has continued unaltered. The building is 31 years old.

[21] University of California, Berkeley, File "Building 113," located in vertical files in Room 148, Richmond Field Station.

Photograph 9, Building 113, January 4, 2013, camera facing southeast

3.1.6 Building 114

Building 114 is in the southern portion of the Richmond Field Station on the west side of Egret Road (Photograph 10). Its primary façade faces northeast; it is an L-shaped, single story, with a one-and-one-half story wing, 4,523 square-foot building constructed circa 1930.

The one-and-one-half story building is topped with a front gabled roof that ties into a shed roof section at its southeast elevation. Rafter tails and purlins are exposed at the eaves. The walls and roof are of corrugated metal. Most of the fenestration is multi-light, fixed, wood sashes. The main entrance, centered in the northeast elevation, has a wood paneled and replacement industrial door, both with windows. There is a large sliding door at the east end of the elevation. The doors are accessed by a concrete loading dock that has a set of wooden stairs in front of the main entrance.

A single story, shed roof addition projects from the northwest end of the building. It features a large sliding door that faces northeast. Building 114, originally labeled "Building 81" was constructed circa 1930 by the California Cap Company or the Pacific Cartridge Company. It was adjacent to the Pacific Cartridge Company's factory and was a warehouse for the cartridges produced there. The original building was rectangular in plan, oriented along Heron Drive. After UC Berkeley purchased the property in 1950, it used the warehouse to store building materials for use in building maintenance on the property.[22] Aerial photographs show that the University constructed an addition at the northwest end of the building circa 1955. The building is currently used for the storage of building materials.

[22] Shackleton, 2013.

Photograph 10: Building 114, January 4, 2013, camera facing west

3.1.7 Building 116

Building 116 is in the southern portion of the Richmond Field Station (Photograph 11). It is 967 square feet and was moved to its present location in 1964. The single story building is a rectangular, Butler Company prefabricated building topped with a front gabled roof. The walls and roof are corrugated metal. Fenestration is multi-light, fixed metal sashes, some of which are wire sashes. The entrance at the south end of the southeast elevation is a paneled wood door with a window.

Building 116 was originally constructed on the UC Berkeley campus by the US Air Force. Its original construction date is unknown, but by 1961 it had outlived its purpose and the UC Regents decided to raze it. SERL had the building relocated to the Richmond Field Station at the end of 1961.[23] It has been used throughout its lifetime as a support and storage area.

[23] University of California, Berkeley, File "Building 116," located in vertical files in Room 148, Richmond Field Station.

Photograph 11: Building 116, January 4, 2013, camera facing west

3.1.8 Building 117

Building 117 is along the southeastern border of the Richmond Field Station (Photograph 12). It is a single story and rectangular in plan.

The building is topped with a front gabled roof that has exposed wood rafter tails and purlins at the eaves. The walls and roof are corrugated metal. Fenestration is fixed wood sashes. The entrance at the north end of the northwest elevation is double paneled wood doors with windows.

Building 117's construction date is unknown. Aerial photographs show it was moved to its present location circa 1990. Its materials indicate that it was constructed prior to 1950 during the California Cap Company era, but research failed to reveal its original use and location. It was used as a maintenance shop in the 1990s and is currently used for storage and support.[24]

[24] University of California, Berkeley, 2008, p. 196.

Photograph 12: Building 117, January 4, 2013, camera facing east

3.1.9 Building 118

Building 118 is in the southern portion of the Richmond Field Station (Photograph 13). It is west of Egret Way and adjacent to Building 125 with its primary façade facing northeast. The utilitarian building does not express any particular architectural style. It is 1,708 square feet and was constructed prior to 1940. It is a single story building with a rectangular plan.

The building is topped with a very shallow pitched roof with minimal eave overhang. The walls are clad in roof paper. Fenestration is a single multi-light, fixed wood sash adjacent to the primary entrance, and a single aluminum sliding sash at the rear (southwest) elevation. The primary entrance, at the east end of the northeast elevation, is a wood paneled door with a window. A large metal roll up door is centered in the façade.

The secondary entrance is sliding doors at the south end of the northwest elevation. A low shed roofed addition at the rear corner of the building has another wood paneled door, and a southwest facing window.

Building 118, originally labeled "Building 149," was constructed circa the 1930s by the California Cap Company. The building was constructed to house the fuel oil boiler for the plant. After UC Berkeley purchased the property in 1950, the building was used as a fire test research area and maintenance shop. Fire safety research studies were done at Richmond Field Station to determine the safety of a variety of products including plastics and airplane restrooms.[25] Building 118 also housed the plumbing shop for the Richmond Field Station until 2009. It is currently used as an art facility for graduate

[25] University of California, Berkeley, 2008, p. 14.

students.[26] The wood siding has been covered with roof paper. A small addition at the southwest corner was constructed in the modern period. Dates for these alterations are unknown.

Photograph 13: Building 118, January 4, 2013, camera facing southwest

3.1.10 Building 120

Building 120 is along the southeastern border of the Richmond Field Station (Photograph 14). It is set back from Egret Way adjacent to building 117. The utilitarian building does not express any architectural style. It is 269 square feet and was constructed in 1967. It is single story and rectangular in plan.

The building is topped with a shed roof. The walls and roof are corrugated metal, and the building lacks fenestration. The only entrances to the building are large openings on its northeast elevation that are covered with a metal construction fence.

This building was constructed in 1967. During the 1960s and 1970s, an incinerator burned garbage at this location.[27] Aerial photographs show that Building 120 was moved to its present location circa 1990. Research failed to reveal the building's original location. It was used as a solvent storage shed in the 1990s. Currently, drums containing waste petroleum products are stored in the building.[28]

[26] Shackleton, 2013.
[27] Shackleton, 2013.
[28] University of California, Berkeley, 2008, p. 28.

Photograph 14: Building 120, January 4, 2013, camera facing south

3.1.11 Building 121

Building 121 is in the southern portion of the Richmond Field Station (Photograph 15). The utilitarian building does not express any architectural style. It is 728 square feet and was constructed in 1982. It is single story and rectangular in plan.

The building is topped with a front gabled, fiberglass roof, with exposed rafter tails at the eaves. The walls are corrugated metal. It lacks fenestration. The only opening is a roll up garage door on the northeast elevation.

Building 121 was constructed circa 1970, as shown by aerial photographs. It was constructed as a garage for the storage of lawn equipment. The roll up garage door was added at an unknown date. The UC Berkeley Solar Powered Vehicle Club began using it for storage circa 2009.[29]

[29] Shackleton, 2013.

Photograph 15: Building 121, January 4, 2013, camera facing west

3.1.12 Building 125

Building 125 is in the southern portion of the Richmond Field Station (Photograph 16). It is west of Egret Way and between to Building 116 and Building 118 with its primary façade facing northeast. The vernacular building does not express any particular architectural style. It is 1,024 square feet and was constructed prior to 1940. It is single story and rectangular in plan.

The building is topped with a front gabled roof, and purlins are exposed at the minimal eaves on the front (northeast) and rear (southwest) elevations. Both gables are adorned with simple, decorative, stickwork trusses. The walls and roof are corrugated metal. Fenestration throughout the building is multi- light, wood sashes. The wide primary entrance is fitted with a flush door and reached by a wooden ramp leading to a small deck at the front of the building. The rear (southwest) door is flush, and accessed by a set of wooden steps.

Building 125, originally labeled "Building 24," was constructed circa 1930 by the California Cap Company. It was adjacent to the plant's mercury fulminate production facility (near Building 102) and was used as an alcohol warehouse. After UC Berkeley purchased the property in 1950, the building was used as a composting facility.[30] During the 1960s SERL used the building for a laboratory and shop. It was moved to its current location as part of an environmental remediation project in 1998. It is currently used as a bioengineering research facility.[31]

[30] University of California, Berkeley, 2008, p. 196.
[31] Shackleton, 2013.

Photograph 17: Building 125, January 4, 2013, camera facing west

3.1.13 Building 128

Building 128 is in the southwestern portion of the Richmond Field Station, along Heron Drive, adjacent to the Environmental Protection Agency building (Photographs 18 and 19). The vernacular building does not clearly express any particular architectural style. It is 10,287 square feet, constructed circa 1930, single story, and has an irregular plan.

The building is topped with a shallow, pitched, side-gabled roof. The primary façade, that faces southeast, features a partial width entry porch and several projecting bays. The building walls are sided in horizontal wood siding. Fenestration is a combination of original, multi- light wood and replacement aluminum sashes. A paneled entry door with windows is accessed by wooden stairs that lead to the porch. At the rear of this section of the building, are seven bays separated by poured concrete walls that project past the walls and above the roof. There are two rectangular plan sections at the northwest end of the primary wing. The smaller section, at the west end of the building, is topped with a shed roof. The larger section, to the north, has a very shallow, pitched, gabled roof. Both sections are accessed by large replacement roll up doors at their southwest ends.

Building 128, originally labeled "Building 4b," was constructed circa 1930 by the California Cap Company.[32] The original building consisted of what is today the southeast wing of the building and was used as a press house. The press house was where gunpowder was compressed into cakes using weights. There were several other small buildings in the vicinity that were also press houses. The heavy concrete walls at the rear of the original building are reinforced concrete blast walls, intended to limit damage in case of explosion. After UC Berkeley purchased the property in the 1950s, the University added two warehouse additions to the building. The first was the

[32] University of California, Berkeley, 2008, p. 199.

northwest section of the building, built circa 1950.[33] The smaller west section was added in 1974.[34] The building housed internal combustion laboratories and was used for detonation research. Rocket engine tests using model rockets were among the modes of research conducted in Building 128.[35] By 1980, Building 128 was altered to its current irregular footprint. During the 1980s, large machinery was installed for research into automated recycling.[36] The building is currently used as a research facility.

Photograph 18: Building 128, January 4, 2013 camera facing northeast

Photograph 19: Building 128, January 4, 2013, camera facing northeast

[33] Shackleton, 2013.
[34] University of California, Berkeley, File "Building 128," located in vertical files in Room 148, Richmond Field Station.
[35] University of California, Berkeley, File "Building 128," located in vertical files in Room 148, Richmond Field Station.
[36] Shackleton, 2013.

3.1.14 Building 149

Building 149 is in the southern portion of the Richmond Field Station (Photograph 20). Its primary façade faces southeast; it is 720 square feet and was constructed in 1982. It is single story and rectangular in plan.

The building is topped with a front gabled roof, with shallow eaves and exposed rafters on the southwest and northeast elevations. The building is clad in plain and vertical groove plywood. Fenestration is vinyl sashes. The primary entrance, on the southeast elevation, is a flush, at-grade door. A similar door is near the rear of the southwest elevation. The southeast elevation features a flush double door.

Building 149 was constructed by UC Berkeley in 1982. Originally, it was used for water technology research. It has also been used for solar research. Between 1992 and 1998, it was used as hang glider storage. It is currently being used by the UC Berkeley Concrete Canoe Club.[37] It is not of historic age, as it was constructed 31 years ago.

Photograph 20: Building 149, January 4, 2013, camera facing north

3.1.15 Building 150

Building 150 is in the southern portion of the Richmond Field Station (Photograph 21). Its primary façade faces northeast along Lark Drive. It is 5,410 square feet and was constructed in approximately 1910.

[37] Shackleton, 2013.

Photograph 21: Building 150, January 4, 2013, camera facing south

The building is single story and rectangular in plan, with additions to the rear (southwest) side. The building is topped with a shallow-pitched, side gabled roof with shallow eaves and exposed shaped wood rafter tails and purlins. Many of the original features remain and the building continues to convey original use as a shop with its sets of industrial, metal-frame, multi-light sashes, walls sided in board formed concrete, and low, open configuration.

The main entrance is centered in the primary elevation and features original flush wood double doors with multi-light windows and transoms. A concrete loading dock in front of these doors is accessed by a set of wooden stairs at its east end and a ramp at its west end.

The northwest elevation features a large roll up metal door. The rear (southwest) elevation of the building lacks the overhanging eaves with their decorative rafter tails that are found on the front and sides of the building. Fenestration at the rear is original, metal-frame, multi-light, industrial sashes.

A separate rectangular-plan addition is perpendicular to the main section of the building, at its rear (Photograph 22). It was added in 1946. This addition is topped with a shallow, pitched, gabled roof lower than the main building's roof with an eave overhang and rafter tail treatment mimicking that of the street-facing façade. Fenestration on this addition is multi-light, hung, wood sashes. A flush-mounted wood door is the entrance on the southwest elevation. It is sheltered by a shed roofed awning and accessed by a wooden staircase. An addition on the northwest side of the rear building has an even lower shed roof. The walls are clad in corrugated metal. Fenestration at this addition is horizontal sliding sashes, and the entrance is a large wood sliding door.

Photograph 22: Building 150, January 4, 2013, camera facing northwest

The California Cap Company constructed Building 150 circa 1910. The building was known as "Building 66a" and used for wire insulating. The addition at the southeast end of the building, known as "Building 66," was also constructed during the California Cap Company era. Aerial photographs show that it had been constructed by 1946. It was used for wire saturating.[38] Insulated wires were an essential element of the fuse-type blasting caps manufactured by the California Cap Company. Wire saturating was one step in the process of manufacturing insulated wire.

After UC Berkeley purchased the property in 1950, the Division of Mechanical Engineering was housed in Building 150. During the 1950s, Associate Dean E. D. Howe supervised Fluid Mechanics Test Facilities in the building.[39] Over the years the building was used as a petroleum studies facility, a machine shop, and a laboratory for UCSF.[40] Building 150 is currently used as a student art facility.

3.1.16 Building 152

Building 152 is in the southern portion of the Richmond Field Station (Photograph 23). It is on the south side of Lark Drive adjacent to Building 150, with its primary façade facing northeast. The vernacular building does not strongly express any particular architecture style. It is two stories and has an irregular plan, is 4,201 square feet, and was constructed prior to 1940.

[38] Sanborn Map, Richmond, 1949.
[39] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection," undated, p.2.
[40] University of California, Berkeley, 2008, p. 196.

The building consists of two front gabled wings facing the street, joined by a wing that runs parallel to the street. The roof is sheathed in composition shingles. The building is clad in a combination of horizontal wood, vertical board-and-batten, and asbestos siding. Fenestration also varies, and includes vinyl replacement windows and multi-light, double hung wood sashes. An entrance at the east gable is fitted with a flush wood door and accessed by a wood deck with stairs at one end and a ramp at the other. A similar entrance at the west gable is accessed by a concrete loading dock and stairs. A single story addition at the northwest end of the building features a hipped roof covered in corrugated metal. Multi- light, fixed, wood sashes have been painted over on its southeast elevation. The entrance at the northeast elevation is a large wood sliding door with a wood paneled door adjacent to it.

A rear entrance is toward the southwest corner of the west gable, facing the inside of the "U" formed by the building's wings. It is a flush mounted wood door that is accessed via a set of wooden stairs. The west gable is several feet longer than the east gable at the rear of the building. A small gable roofed shed is to the rear of the building adjacent to its southeast corner.

Building 152 was constructed by the California Cap Company circa the 1930s. It was originally three connected buildings referred to as "Building 59," Building 60," and "Building 142". Wooden boxes were assembled and other carpentry tasks performed in "Building 59," while "Building 60" was the packing house. "Building 142" was for sawdust storage and a restroom.[41] After UC Berkeley purchased the property in 1950 the building was used for salt water research and storage. A Mineral Dressing laboratory was installed by the Department of Mineral Technology in the late 1950s, but it appears not to have been used.[42] By 1980 the building was being used primarily for storage.[43] In the 1990s Building 152 began to house graduate student Art Practice, the current use of the building.[44]

[41] University of California, Berkeley, 2008, p. 200, 202.
[42] University of California, Berkeley, File "Building 152," located in vertical files in Room 148, Richmond Field Station.
[43] University of California, Berkeley, File "Building 152," located in vertical files in Room 148, Richmond Field Station.
[44] Shackleton, 2013.

Photograph 23: Building 152, January 4, 2013, camera facing west

3.1.17 Building 153

Building 153 is in the southern portion of the Richmond Field Station. It is on the south side of Lark Drive adjacent to Building 152, with its primary façade facing northeast (Photograph 24). The vernacular building does not strongly express any particular architecture style. It is single story and rectangular in plan, 2,731 square feet, and was constructed in 1959.

The front section of the building is flat roofed. The walls are covered in stucco, and fenestration is multi-light fixed sashes. The northeast elevation lacks fenestration, but has two entry doors and two large swinging double doors. All doors are wood paneled with windows. A rear addition to the building is topped with both a flat roof and a shed roof section. An entrance at the rear of the southeast elevation is a large sliding door.

Building 153 was constructed by UC Berkeley in 1959. It was used as a modeling shop and for salt water research.[45] The Naval Architecture Department used the building for ship design over the years.[46] In 1958, the department of Nuclear Engineering was looking for space for gamma-shielding experiments, and may have moved into Building 153 for a time.[47] Aerial photography indicates that the addition at the rear (southeast) of the building was constructed in approximately 1975. It is currently used as a research facility and a shop.

[45] University of California, Berkeley, 2008, p. 196.
[46] Shackleton, 2013.
[47] University of California, Berkeley, File "Building 153," located in vertical files in Room 148, Richmond Field Station.

Photograph 25: Building 153, January 4, 2013, camera facing west

3.1.18 Building 163

Building 163 is at the southeastern edge of the Richmond Field Station (Photograph 26). The primary façades of this L-shaped building face northwest and southwest. The vernacular building does not strongly express any particular architecture style. It is single story and 6,430 square feet. The building was constructed prior to 1940.

Both wings of the building have front gabled roofs covered with composition shingles. The walls are clad in horizontal wood siding; a portion of the walls is covered with stucco. Fenestration is aluminum replacement sashes. The primary entrance is a paneled, southeast-facing, wood door. It is accessed by a concrete ramp. Other entrances are centered in each gable end and are flush wood doors. The northwest entrance is accessed by concrete steps. The southwest entrance is accessed by a set of wooden steps and sheltered by a shed roof over the entry. There is a similar entrance on the rear (southeast) elevation.

Building 163 was created when two buildings were pieced together at this location in 1996. It is two California Cap Company buildings originally constructed circa 1930. They were connected with a new section at the corner of the "L" to create Building 1963. Its site overlaps with the footprint of the U.S. Briquette Company plant and William Letts Oliver's American Lucol Company. Aerial photographs indicate that the U.S. Briquette buildings were demolished circa the 1960s after UC Berkeley took over the site. Ergonomic studies, seeking to prevent chronic disorders of the upper extremities, have been conducted in the building since the 1990s.[48] Building 163 houses offices and continues to be used as a research facility.

[48] Shackleton, 2013.

Photograph 26: Building 163, January 4, 2013, camera facing east

3.1.19 Building 175

Building 175 is in the southern portion of the Richmond Field Station at the intersection of Lark Drive and Egret Way (Photograph 27). Its primary façade faces northeast along Lark Drive. It is 16,502 square feet and was constructed in approximately 1910.

The building is single story and rectangular in plan, with additions to the rear (southwest) side. The building is topped with a shallow, pitched-side, gabled roof with shallow eaves and exposed, shaped-wood rafter tails and purlins. Many of the building's original features remain, and the building continues to convey its original use as a shop with its, walls sided in board formed concrete, and low, open configuration. Fenestration is aluminum replacement windows and small aluminum sliding sashes. The east door has been replaced with a modern glass door.

Photograph 27: Building 175, January 4, 2013, camera facing south

A large, projecting, two-story addition at the southwestern end of the building is topped with a shed roof, its walls are clad in corrugated metal. Fenestration is both multiple pane fixed windows and vinyl replacement windows. A shed roof covers an open area at the center of the rear elevation adjacent to the corrugated addition. Double paneled wood doors with windows are at the center of the façade. A raised concrete ramp leads to these doors.

Historic maps and documents show that the building that is now Building 175 was constructed in 1910, when the California Cap Company and Pacific Cartridge Company were operating simultaneously. When in use for the Pacific Cartridge Company, Building 175 was numbered both "Building 75" and "Building 76" and was the primary production facility for Pacific Cartridge. The building appears to have been used as a cartridge loading facility during the early years, where powder was loaded into shells.[49] It also housed a small office, a vault, and cleaning and annealing rooms.[50] (Metal cartridges were strengthened through heat treating, or annealing.) Both the Pacific Cartridge Company and the California Cap Company were administered from the office in Building 175 (Photograph 28 and 29). By 1916, the company was producing cartridge shells in the building, but no longer loading powder there.[51] Pacific Cartridge Company was absorbed by the California Cap Company circa 1920. The 1949 Sanborn map shows the same uses for the Building 175 but lists only California Cap on the property.[52]

[49] Sanborn Map, Stege, 1912.
[50] Sanborn Map, Stege, 1912.
[51] Sanborn Map, Richmond, 1916.
[52] Sanborn Map, Richmond, 1949.

Photograph 28: Building 175, circa 1910, from Bancroft Library's Oliver Family Photograph Collection, labeled "Exterior California Cap Company office, California"

Photograph 29: Building 175, circa 1910, from Bancroft Library's Oliver Family Photograph Collection, labeled "Pacific Cartridge Co. Exterior – Stege, Calif."

After UC Berkeley purchased the property in 1950, this building continued to house an office and hazardous chemical storage area.[53] Building 175 was the Richmond Field Station's primary facility for maintenance and administration.[54] During the early 1950s, the Department of Engineering's machine shop was also in Building 175, fabricating experimental equipment for research. By 1952, a new high-speed wind tunnel for research was being assembled in the building.[55] The University made piecemeal additions to the rear (southwest) of the building beginning in the 1950s. By 1966, Building 175 reached its current footprint and housed machine, carpenter, and welding shops, and an office.[56] The University removed the original wood frame windows and replaced them with aluminum sashes in 1969.[57] The building continued to be considered important, as indicated by a 1977 letter arguing for "one of the most important buildings at the Station and if it were lost the program impact could be catastrophic, inasmuch that the Station operations would most likely come to a halt."[58] It continued to house maintenance operations until approximately 2008, when, in spite of the building's former importance, it was left vacant. It remained vacant until 2012, when the UC Bindery moved into the building.[59]

3.1.20 Building 176

Building 176 is in the southern portion of the Richmond Field Station between Building 175 and Building 150 (Photograph 30). Its primary façade faces northeast, along Lark Drive. The vernacular building does not strongly express any particular architecture style. It is single story and square in plan, 672 square feet, and was constructed prior to 1940.

The building is topped with a front gabled roof, with a large vent on the gable ridge. The building's walls are reinforced concrete covered in stucco. The building lacks fenestration. Its only opening is a flush metal door with a small window on the primary (northeast) elevation, accessed by a sloping concrete walkway that leads from the street.

The California Cap Company constructed Building 176 circa the 1930s. It was originally referred to as "Building 73" and was used by the plant as a warehouse. After UC Berkeley purchased the property in 1950, it continued to use the building for storage. Although the building was retrofitted as an animal lab, it was never used for that purpose. In 1998, it was renovated for the use of a private company named Stratacor that works on topical anti-insect solutions.[60]

[53] University of California, Berkeley, 2008, p. 197
[54] University of California, Berkeley, 2008, p. 20.
[55] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House," May 28, 1952, p. 3.
[56] Sanborn Map, Richmond, 1966.
[57] University of California, Berkeley, File "Building 175," located in vertical files in Room 148, Richmond Field Station.
[58] University of California, Berkeley, File "Building 175," located in vertical files in Room 148, Richmond Field Station.
[59] Shackleton, 2013.
[60] Shackleton, 2013.

Photograph 30: Building 176, January 4, 2013, camera facing south

3.1.21 Building 178

Building 178 is along the southeastern border of the Richmond Field Station (Photograph 31). It is set back from Egret Way to the east adjacent to building 185. Its primary façade faces northwest. The utilitarian building does not strongly express any particular architecture style. It is single story, rectangular in plan, 3,950 square feet, and was constructed prior to 1940.

The building is topped with a side gabled roof. Its roof and walls are clad in corrugated metal. Fenestration is both aluminum sliding sashes and multiple light wood sashes. There are three entryways on the primary (northwest) elevation. Entrances at the north end and the center of the elevation are metal double doors with windows. The south entrance is a single metal door with a window. At either end of the building the entrances are accessed by sets of wooden stairs. A similar door is at the north end of the rear (southeast) elevation.

Building 178 appears to have been moved to this location circa 1990. Although UC Berkeley property records and building materials suggest a build date prior to 1950, Building 178 does not appear on aerial photographs of this location until the 1990s. Research has not uncovered its original use or location. Building 178 housed the California Conservation Corps until circa 1999, after which it served as an electrical shop and a warehouse. It is currently used for Art Practice Studies.[61]

[61] Shackleton, 2013.

Photograph 31: Building 178, January 4, 2013, camera facing northeast

3.1.22 Building 185

Building 185 is along the southeastern border of the Richmond Field Station (Photograph 32). It is set back from Egret Way to the east adjacent to building 178. Its primary façade faces northwest. The utilitarian building does not strongly express any particular architecture style. It is single story, rectangular in plan, 3,165 square feet, and constructed prior to 1940.

The building is topped with a side gabled roof. Its roof and walls are clad in corrugated metal and it lacks fenestration. Entryways, at either end of the primary (northeast) elevation, are flush wood doors. The south door is accessed by a set of wooden stairs. Another entryway is at the north end of the rear (southwest) elevation.

Building 185 appears to have been moved to this location circa 1990. Although UC Berkeley property records and building materials suggest a build date prior to 1950, Building 185 does not appear on aerial photographs of this location until the 1990s. Research has not uncovered its original use or location. The building has been a support facility since the 1990s.

Photograph 32: Building 185, January 4, 2013, camera facing northeast

3.1.23 Building 197

Building 197 is along the southeastern border of the Richmond Field Station (Photograph 33). It is set back from Egret Way to the east adjacent to building 117. Its primary façade faces northeast. The utilitarian building does not strongly express any particular architecture style. It is single story, rectangular in plan, 2,419 square feet, and constructed in 1975.

The building is topped with a very shallow-pitched, side-gabled roof. Its roof and walls are clad in corrugated metal. Fenestration is an aluminum sliding sash. Three large open bays provide access to the northern end of the primary (northeast) elevation. A large metal roll up door is at its southern end. The entrance at the south end of the northwest elevation is a flush metal door.

UC Berkeley constructed Building 197 in 1975. It has been used for support and heavy vehicle storage since its construction. Drums containing waste petroleum products are stored in the building.[62] The building is not of historic age as it is 38 years old.

[62] University of California, Berkeley, 2008, p. 28.

Photograph 33: Building 197, January 4, 2013, camera facing southeast

3.1.24 Building 275

Building 275 is in the southern portion of the Richmond Field Station. It is on the south side of Lark Drive between Building 153 and Building 276, with its primary façade facing northeast (Photograph 34). The vernacular building does not strongly express any particular architecture style. It is single story, irregular in plan, 7,914 square feet, and was constructed in 1956.

The front portion of the building, adjacent to Lark Drive, is topped with a flat roof featuring a broad eave overhang with large exposed roof members. The walls are sided in smooth stucco with vertical wood trim. Fenestration is fixed and awning metal sashes. The entrance is a flush door with a window at the east end of the primary (northeast) elevation.

An older, front-gabled building, with its front gable visible behind the flat roof, is joined to the rear of the main section of the building. Its roof and walls are clad in corrugated metal. Fenestration is multiple light fixed metal sashes. This older section of the building has no entryways.

UC Berkeley constructed building 275 in 1956. Originally, it consisted of the long narrow section currently the southwest wing of the building. It was used as a laboratory for hydraulic and coastal engineering and to test ship hull designs.[63] The facility included a towing tank for experiments. Historic aerial photographs indicate that the front (northeast) portion of the building along Lark Drive was constructed in 1966. The building currently houses offices.

[63] University of California, Berkeley, 2008, p. 14.

Photograph 34: Building 275, January 4, 2013, camera facing west

3.1.25 Building 276

Building 276 is in the southern portion of the Richmond Field Station. It is on the south side of Lark Drive adjacent to Building 276, with its primary façade facing northeast (Photograph 35). UC Berkeley constructed this building in 1956. The utilitarian building does not strongly express any particular architecture style. It is single story and rectangular in plan.

The building is topped with a front-gabled roof. Its walls are corrugated metal. Fenestration is multi-light metal sashes. The main entryway is through a flush metal industrial door. A shed roofed addition projects from the rear elevation of the building.

Photograph 35: Building 276, January 4, 2013, camera facing southwest

3.2 DESCRIPTION OF THE BUILDINGS ADJACENT TO THE PHASE 1 FOOTPRINT (INDIRECT APE)

3.2.1 Building 151

Building 151 is in the southern portion of the Richmond Field Station. It is on the north side of Lark Drive, with its primary façade facing southwest (Photograph 36). This rectangular plan 2,629 square-foot building is a Soule Steel Company prefabricated building, topped with a front gabled roof. Vents are at each gable end. The walls and roof are corrugated metal. Fenestration consists of multi-light, metal sashes. There is also a small aluminum frame window in the center of the primary façade. The main entrance consists of a metal industrial door with a glass insert at the east end. This entrance is sheltered by a metal awning and accessed by a very gradual concrete ramp that runs across the main façade of the building. The rear of the building, at the northeast, contains an overhead mounted sliding door. In 1965, a 1,600 square-foot addition was constructed on the north end of the building.

Photograph 36: Building 155, April 30, 2013, camera facing northeast

3.2.2 Building 154

Building 154 is in the southern portion of the Richmond Field Station. It is on the north side of Lark Drive between Buildings 158 and 151, with its primary façade facing southwest (Photograph 37). The 2,731 square-foot building has a rectangular footprint and is a prefabricated Dudley Steel Building topped with a front gabled roof. The walls and roof are corrugated metal. Primary fenestration consists of multi-light metal sashes. A metal industrial door with a glass insert is centered in its southwest elevation and is the main entrance. This entrance is sheltered by a metal awning and accessed by concrete stairs and a ramp. The rear of the building contains an overhead-mounted sliding door. In 1965, a 1,600 square-foot addition was constructed on the north end of the building. Photograph 38 shows the building in the 1960s.

Photograph 37: Building 154, April 30, 2013, camera facing northeast

Photograph 38, Building 154 at center between Buildings 158 and 151,circa 1965,camera facing northwest

3.2.3 Building 155

Building 155 is in the southern portion of the Richmond Field Station. It is on the north side of Lark Drive between Buildings 151 and 177 (Photograph 39). The vernacular building does not strongly express a particular architecture style. It has 1,896 square feet and one story, with an irregular "U" plan. It was constructed in 1953 by combining three buildings dating from the 1920s.

The building consists of two side gabled wings joined by a wing that runs perpendicular to the street, forming a "U" shape. The roof is sheathed in replacement composition shingles, its walls clad in horizontal wood siding. Fenestration throughout the building consists of fixed, square, wood frame windows. The windows are not original and were likely replaced during the 1950s. A paneled wood door reached by a set of wooden stairs is centered in the gable end of the southwest wing, which is the closest to Lark Drive. The southwest elevation of the northeast wing features a similar entrance. A third entrance, centered in the connecting wing and faces southeast, is fitted with a modern door and accessed by a concrete ramp.

Construction of Building 155 was pieced together from former California Cap Company Buildings, "Building 64", "Building 67", and "Building 92". The California Cap Company constructed these three buildings circa 1920.[64] The buildings were originally used for waterproofing and assembling by the California Cap Company.[65] In 1953, the University appears to have turned "Building 67" perpendicular to its original position to form a connecting wing in a single "U" shaped building. In addition to joining the three buildings, the University replaced original siding and original windows on all three buildings. At first, the southwest wing adjacent to Lark Drive was labeled Building 155, and the northeast (rear) wing was labeled Building 157. At some point, all three wings became known as Building 155.[66] In 1977, a concrete foundation was installed under the building.[67]

Photograph 39: Building 155, April 30, 2013, camera facing north

[64] University of California, Berkeley, File "Building 155," located in vertical files in Room 148, Richmond Field Station.
[65] University of California, Berkeley, 2008, p. 200 – 204.
[66] Sanborn Map, 1966.
[67] Scott Shackleton, University of California, Berkeley, Personal communication with Julia Mates, Tetra Tech 2013.

3.2.4 Building 158

Building 158 is in the southern portion of the Richmond Field Station. It is on the north side of Lark Drive, with its primary façade facing southwest (Photograph 40). The 3,343 square-foot building is a rectangular, prefabricated building topped with a front gabled roof. It features shallow eaves with exposed rafters and exposed steel purlins. The walls and roof are corrugated metal. Fenestration consists of multi-light metal sashes and replacement sliding sashes. An overhead-mounted, sliding, metal door is centered in its southwest elevation. An entrance fitted with a single metal industrial door with a glass insert is adjacent to the large door to the east. This entrance is sheltered by a metal awning and accessed at grade.

Photograph 40: Building 158, April 30, 2013, camera facing northeast

3.2.5 Building 177

Building 177 is in the southern portion of the Richmond Field Station. It is on the north side of Lark Drive, with its primary façade facing southwest (Photograph 41). The vernacular building does not strongly express any particular architectural style. It is a 2,969 square-foot, two-story building with a modified rectangular plan. It is topped by a front gabled roof; its walls are clad in horizontal wood siding. A decorative octagonal vent is centered in the front gable. Fenestration consists of replacement vinyl sashes. The building's main façade is centered in the southwest elevation and features a full width, hipped roof porch.

The two-story main wing of Building 177 is connected to a small, single-story building at the rear, the former Building 179. The single story gable at the rear (northeast) of the building features decorative stickwork at the eaves. An exterior industrial-style staircase leads to the rear portion of the main wing's second floor (Photograph 42).

Originally constructed circa 1920, Building 177 was known as “Building 72” during the California Cap Company era. “Building 72” consisted of the two-story main wing of what is today Building 177, and is depicted on Sanborn Maps as a “Rest Room.” A separate one story building to the rear, “Building 131,” was also labeled as “Women’s Rest Room” and a “Water Closet” on historic maps.

By the time the University took over the property in 1950, Building 177 had small additions added onto its facade and had become somewhat dilapidated. The University renovated the building in 1953, removing some of the additions and changing the shed roofed entry porch to a small gable roof. By 1966, Building 177 was being used as a maintenance shop. California Cap Company “Building 131” at the rear was renumbered Building 179 and continued to be used as a restroom until it was joined to Building 177. Although Building 179 is still shown on maps of the Richmond Field Station, the rear portion of the building is currently labeled Building 177. Photograph 43 shows the building as it appeared in the 1950s.

Photograph 41: Building 177, April 30, 2013, camera facing north

Photograph 42: rear of two story portion of Building 177 showing exterior stairs,January 4, 2013, camera facing southwest

Photograph 43: Building 177, (background), 1952, camera facing east

3.2.6 Building 180

Building 180 is in the southern portion of the Richmond Field Station. It is on the north side of Lark Drive, and its primary façade faces southwest (Photograph 44). The vernacular building does not strongly express any particular architectural style. It has 11,008 square feet, is single-story, and has an irregular plan. It is topped with a cross gabled roof. The primary fenestration consists of aluminum replacement sliding and awning sashes. The main entrance is centered in the southeast elevation (Photograph 45). Its aluminum framed glass door is sheltered by a flat roofed entry porch and accessed by concrete steps.

Building 180 was constructed piecemeal, combining several buildings, over decades from about the 1920s through the 1930s. As a result, the building has multiple types of wall cladding, including two sizes of brick, horizontal wood siding, and vertical groove plywood. A small two-story wing at the northeast corner of the building contains multi-light wood sash windows that have been painted over.

During the California Cap Company era, the five connected buildings that comprise what is now Building 180 were devoted to manufacturing. "Building 44," which became the south half of Building 180's main wing, was devoted to plugging, soldering, and concaving (Photograph 5) when originally used by the California Cap Company. Wire cutting was done in "Building 185," which became the small two-story wing at the north end of the building (Photograph 4). The north half of the building's main wing was "Building 170," where plugging was done for the company. "Building 171," currently the west wing of Building 180, was a match head manufacturing area. "Building 172" is at the center of Building 180's main wing and was originally an office. Concrete blast walls on either side of the office protected the space from the explosives handled in Buildings 44 and 170.[68]

After the University took over and renumbered the five buildings, the space Building 180 now stands on was used for photography work and offices. Most of the building's windows were replaced with aluminum sashes sometime during the 1980s. In 1982, restrooms and a conference room were installed in Building 180. The new restroom facility served the Sea Water Conversion complex which, prior to 1982, did not have plumbed indoor toilets.[69] It is currently used as offices.

[68] Sanborn Maps, 1949.
[69] University of California, Berkeley, File "Building 180," located in vertical files in Room 148, Richmond Field Station.

Photograph 44: Building 180, April 30, 2013, camera facing northeast

Photograph 45: Building 180, April 30, 2013, camera facing west

3.2.7 Building 198

Building 198 is in the southern portion of the Richmond Field Station across Lark Drive from Building 197 (Photograph 46). It is an 1,800 square-foot, rectangular plan, prefabricated building, topped with a very shallow pitched, gable roof with vents in the gables. Its walls and roof are corrugated steel and the building lacks fenestration. A

large metal roll-up door is centered in its northwest elevation, while its southwest elevation features a metal industrial entrance door at grade.

Photograph 46: Building 198, April 30, 2013, camera facing northeast

3.2.8 Building 201

Building 201 is in the southwestern portion of the Richmond Field Station, along Avocet Way, on a 3.5-acre parcel. It is a single-story building and houses the U.S. Environmental Protection Agency's Region IX laboratory and office building. The building has 46,000 square feet and is a tilt-up building that is ornamented through with reveals and indentations in the tilt-up panels, with sculpting. Covered trellises surround the building's walkways, and the main entrance features a modern glass enclosure. It was constructed in 1992.

3.2.9 Building 277

Building 277 is in the southern portion of the Richmond Field Station. It is on the north side of Lark Drive, with its primary façade facing northwest (Photograph 47). It is 21,426 square feet and was constructed circa 1966. The single-story building is a rectangular plan, prefabricated building topped with a front gabled roof. The walls and roof are corrugated metal. Fenestration consists of metal sash windows that appear to have been repurposed from a vehicle. Its primary entrance is in the northwest elevation, which faces Avocet Way. A metal industrial entry door is set inside a large sliding door. Building 277 was constructed as a model basin building for salinity intrusion study. It has been used throughout its life for storage.

Photograph 47: Building 277, April 30, 2013, camera facing east

3.3 HISTORIC BACKGROUND OF RICHMOND FIELD STATION

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay at the confluence of the Sacramento and San Joaquin rivers.[70] Though subsequent Spanish expeditions passed through the region, the Spanish do not appear to have settled in the present-day City of Richmond area during the Mission Period of 1769 through 1833.

In the 1820s and 1830s, the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[71] Americans began farming in Contra Costa County in the late 1830s, and by 1882, two-thirds of the cultivated land in the county was devoted to wheat production.[72]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[73] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho

[70] Mildred B. Hoover,, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.
[71] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.
[72] J.P. Munro-Fraser, *History of Contra Costa County, California,* W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.
[73] Evan Griffins, "Early History of Richmond," December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

San Pablo and the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years, the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[74] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, a widow, in 1870.[75] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century, several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[76] The City of Richmond incorporated in 1905, and by 1917, it was already the largest city in Contra Costa County.[77] The town of Stege was eventually absorbed into Richmond as the latter grew.

3.4 HISTORIC CONTEXTS

3.4.1 The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in the 1860s, inventing first a detonator and then a blasting cap. In 1867, he invented dynamite, safer, cheaper, and more powerful than nitroglycerine that had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[78]

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew, explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its close proximity to the harbor, yet remote enough from population centers. The narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[79]

During the 1870s, chemical and explosives manufacturers began opening near what would eventually become the City of Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877, on the Stege ranch. Soon, San Francisco explosives companies followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to the Atlas Powder Company. The California

[74] Roland Oliver, "Recollections of Early Industries in Stege," August 7, 1959, p. 1.
[75] Munro-Fraser, p. 675.
[76] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.
[77] Hulanski p. 288.
[78] Ida Mae Purcell, *History of Contra Costa County,* The Gillick Press, Berkeley, California" 1940, p. 645 – 646.
[79] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area,* University of California, Berkeley: 1964, p. 27.

Powder Works soon followed, building a new factory in Hercules, named for the brand under which the company sold its powder.[80] The Vulcan Powder Works and Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902, California had only one powder factory outside Contra Costa and Alameda counties.[81]

3.4.2 The California Cap Company

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory that was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[82] William Letts Oliver and his wife Carrie lived in Oakland, from about 1880, until Oliver's death in 1918.[83] The couple eventually had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[84] In addition to his various professional activities, William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the early twentieth century. He was an avid amateur photographer throughout his lifetime; UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[85]

William Letts Oliver initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[86] As early as 1870, European explosive companies were experimenting with nitrated guncotton, and, by 1875, it was manufactured in England under the name "tonite."[87] By 1877, Oliver had left Chile and was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock needed an explosive to complete the tunnel that would remain stable at the high temperatures underground, and Oliver was able to solve the problem by substituting tonite for more volatile compounds.[88]

[80] Purcell, p. 646.
[81] Richmond Record, "Contra Costa County: Under the Vitascope," Richmond:1902.
[82] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry," Vol. 1, No. 7, November 1922, p. 222.
[83] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.
[84] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.
[85] Online Archive of California, "Guide to the Oliver Family Photograph Collection," UC Berkeley:2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.
[86] Blasting Cap Industry," Vol. 1, No. 7, November 1922, p. 222.
[87] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889," E. & F. N. Spon, London: 1890, p. 95.
[88] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry," Vol. 1, No. 7, November 1922, p. 222.

The California Cap Company

In 1877, William Letts Oliver was inspired by his success with tonite to leave mining and establish the Tonite Powder Company, on a portion of the former Stege Ranch.[89] In the 1870s, all blasting caps in the United States had to be imported from Europe. Not only were they expensive, but the timing of deliveries was uncertain, creating business difficulties for the powder plant. Oliver was determined to create his own caps to protect the tonite factory business. He experimented until he came up with a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter founded the California Cap Company. It was adjacent to the Tonite Powder Company, and was a parcel carved out of the southern portion of Stege Ranch.[90] California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[91] The California Cap Company was on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

The Tonite and California Cap factories, the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[92] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882, at the nearby Vulcan Powder Company caused 11 deaths and destroyed the plant.[93] Between 1882 and 1918, the Hercules and Atlas plants suffered numerous explosions that destroyed plant buildings and killed 64 workers.[94] Despite its focus on safety, the California Cap Company also had accidents. Two of its Chinese workers were killed in 1917, when one of them dropped a tray of caps. In 1941, an explosion caused a fire and critically injured a worker.[95]

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888, he formed the American Lucol Company adjacent to the California Cap Company property.[96] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[97] The factory was dismantled and relocated to New Jersey circa 1900.[98] In 1903, the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field

[89] Oliver, p. 1.
[90] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry," Vol. 1, No. 7, November 1922, p. 222.
[91] Nilda Rego, "Enterprising Stege lost all and died without a penny," Time Out, March 27, 1994, p. 2, column 4.
[92] Oliver, p. 1.
[93] Munro-Fraser, p. 424.
[94] Purcell, p. 648.
[95] Contra Costa County Standard, "Stege Powder Plant Blast; One Near Death," June 6, 1941, p. 1A.
[96] Oliver, p. 1.
[97] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913*, Dewey Publishing Company: 1913, p. 327.
[98] Oliver, p. 1.

station property.[99] Later known as the U.S. Briquette Company, the plant appears to have operated at this location until at least 1917.[100] The U.S. Briquette Company operated an explosive manufacturing plant at what is now the Richmond Field Station, but its buildings were demolished sometime in the 1960s.[101]

The Oliver family aggressively promoted their products through advertising and publishing. The California Cap Company sponsored or published articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing and a selling point in advertisements.[102] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century, the powder's explosive properties were considered comparable to the finest English products.[103] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family became benefactors of the university, and in 1917, the California Cap Company donated substantial amounts of their products to the College of Mining, including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[104]

Eventually, the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[105] By 1916, there were at least a dozen buildings on the site. When Oliver died in 1918, his son Roland Oliver took over as president of California Cap Company. By 1922, Roland's brother Leslie Oliver was assistant manager of the plant and Edwin Letts Oliver was a director.[106] Roland Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[107]

During the 1920s, the California Cap Company was granted patents on some of its inventions, including Albert Leslie Oliver's invention of an improved electric blasting cap. One of the improvements with Oliver's blasting cap is that the flame or sparks emitted by the fuse portion of the igniter would not come in contact with the explosive charge.[108] In 1925, Edward Barnes of the California Cap Company patented a new method of manufacturing fulminate of mercury. Traditional mercury fulminating,

[99] Oliver, p. 2.
[100] Hulanksi, p. 354.
[101] University of California, Berkeley (UC Berkeley),1973. *Sanitary Engineering Research Laboratory News Quarterly,* Volume XXIII, No. 2. Richmond, California. April
[102] Halbert Powers Gillette, *Rock Excavation:Methods and Cost,* M.C. Clark, New York: 1904, x.
[103] Manual Eissler, *A Handbook on Modern Explosives,* Crosby, Lockwood & son, London: 1897, p. 117.
[104] University of California, *The University of California Chronicle,* University of California Press, January, 1917, p. 92.
[105] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.
[106] Pacific Mining News, p.222.
[107] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11; for photographs of the California Cap Company's cap test, cap containers, fuses, and tools please see the Tulane University's Digital Media website: http://lunaweb.giza.tulane.edu/luna/servlet/view/search/?&q=california cap company.
[108] United States Patent Office, Albert Leslie Oliver, of Oakland, California, Assignor to California Cap Company of Oakland, California, a Corporation, Electric Blasting Cap, Application Filed January 27, 1920, Patented May 17, 1921, 1,878,269.

which had remained virtually unchanged since 1800, was limited to small quantities due to the volatility of gasses released by the reactions. Barnes's new process removed and condensed the volatile gasses, which allowed for the safe manufacture of much larger quantities of fulminate of mercury.[109]

During the late nineteenth and early twentieth century, the California Cap Company was one of the most important local employers.[110] As the twentieth century progressed, more heavy industry came to Contra Costa County, and by 1940, the county was second only to Los Angeles in overall industrial production.[111] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II, California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[112] The California Cap Company could not survive the transition to a peacetime economy, and by 1949, the plant was closed and the Oliver family was looking for a buyer.

3.4.3 University Research/Richmond Field Station

After World War II, UC Berkeley's Engineering Department needed an off-campus location to do experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were doing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They wanted a location that was not too remote, and The University purchased the California Cap Company from the Oliver family, for the use of the Engineering Department, in 1950.[113]

The Richmond Field Station has been the location of research overseen by numerous UC Berkeley departments over the years. The SERL was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and researched pollution control and disposal of solid and liquid waste.[114] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[115]

At first the Department of Engineering used the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[116] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the Cap Company era and have been repurposed for the University's use. The university constructed new buildings as funds became available, and by the mid-

[109] United States Patent Office, Edward A. Barnes of Oakland, California, Assignor to California Cap Company, of Oakland, California, A Corporation of California, Method of Manufacturing Fulminate of Mercury, Application Filed on April 13, 1922, Serial no. 548, 921,Patented January 13, 1925, 1,523,339,
[110] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California," Regional Oral History Office, University of California, Berkeley, 1990, p. 21.
[111] Purcell, p. 649.
[112] Oliver, p. 1.
[113] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call," Regional Oral History Office, University of California, Berkeley, 1974, p. 70.
[114] University of California, Berkeley, 2008, p. 13.
[115] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House," May 28, 1952, p. 3 – 4.
[116] McGauhey, p. 71.

1950s, five new buildings had been completed at the Richmond Field Station.[117] By the 1970s, the department had done many experiments at the Richmond Field Station that could not have been performed on the main campus.

The Richmond Field Station has been the location of research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to do research at the site. SERL focused primarily on sewage treatment technology and researched pollution control and disposal of solid and liquid waste.[118] Other early projects at the field station included heat transfer and cyclic stress research.[119]

Another laboratory that used the Richmond Field Station was the Sea Water Conversion Laboratory (SWCL). In 1952, Congress created and funded the Office of Saline Water in order to encourage desalination studies as a solution to water shortages.[120] In response, UC Berkeley Mechanical Engineering professor Everett D. Howe formed the SWCL at the Richmond Field Station in 1958.[121]

Building 154 was constructed circa 1957 for SWCL research, and the program continued to expand under Howe's direction for the next decade. SWCL eventually encompassed most of the buildings on the north side of Lark Drive, including Buildings 151, 155, 158, 177, and 180.[122]

In 2013, the Richmond Field Station continues to accommodate UC Berkeley's engineering research projects that cannot be done on the main campus and other space-intensive adjuncts to the University. SERL was eventually renamed, and is currently known as the Environmental Engineering and Health Sciences Laboratory (EEHSL). EEHSL has continued its presence at the Richmond Field Station into the twenty-first century, operating indoor and outdoor laboratories throughout the site.[123] The Northern Research Library Facility, the Asbestos Information Center, and the Earthquake Resource Center are among the University facilities at the site.[124] The Richmond Field Station also has non-UC tenants that include the EPA Region 9 Laboratory in Building 201.[125]

[117] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection," undated, p. 3.
[118] University of California, Berkeley, 2008, p. 13.
[119] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3–4.
[120] Heather Cooley, Peter H. Gleick, and Gary Wolff, "Desalination, With a Grain of Salt: A California Perspective," Pacific Institute, Oakland, California: 2006, p.11.
[121] University of California (System) Academic Senate, "1991, University of California: In Memoriam," 1991, Internet website: http://texts.cdlib.org/view?docId=hb4t1nb2bd&doc.view=frames&chunk.id=div00031&toc.depth=1&toc.id=.
[122] University of California, Berkeley, Files "Building 151", "Building 154", "Building 158", "Building 177", and "Building 180," located in vertical files in Room 148, Richmond Field Station.
[123] University of California, Berkeley, 2008, p. 13.
[124] University of California, Berkeley, 2008, p. 16 – 17.
[125] University of California, Berkeley, 2008, p. 21.

4. EVALUATION OF SIGNIFICANCE

The criteria for identifying historical resources under CEQA are in Section 15064.5(a)(2)-(3) of the CEQA Guidelines, according to the criteria outlined in Section 5024.1 of the California Public Resources Code. According to this code, properties listed in or formally determined eligible for listing in the NRHP are automatically eligible for listing in the CRHR. The CRHR criteria are largely based on the NRHP criteria, which are codified in 36 CFR Part 60 and explained in guidelines published by the Keeper of the National Register.[126]

Eligibility for listing on either the NRHP or the CRHR rests on both significance and integrity. A property must have both factors to be considered eligible. Loss of integrity, if sufficiently great, would overwhelm the historical significance of a resource and render it ineligible. Likewise, a resource can have complete integrity, but if it lacks significance, it must also be considered ineligible. The application of the four criteria and the definition of integrity are discussed below.

4.1 CRITERIA OF SIGNIFICANCE

Properties may be significant at the local, state, or national level.

4.1.1 National Register of Historic Places

National historical significance is judged in part by applying NRHP Criteria A through D:

- Criterion A: Association with events or trends significant to the broad patterns of our history;
- Criterion B: Association with the lives of significant individuals;
- Criterion C: A property that embodies the distinctive characteristics of a type, period, or method of construction that represents the work of a master or that possesses high artistic values;
- Criterion D: Has yielded or is likely to yield information important to history or prehistory.[127]

Properties that are less than 50 years old may also be evaluated under Criteria Consideration G:

- Criterion G: Properties that have achieved significance within the past 50 years. The National Register Criteria for Evaluation exclude properties that achieved significance within the past 50 years unless they are of exceptional importance.

[126] The most widely accepted guidelines are contained in the U.S. Department of Interior, National Park Service, "How to Apply the National Register Criteria for Evaluation," *National Register Bulletin 15* (Washington D.C.: US Government Printing, 1991, revised 1995 through 2002).
[127] Criterion D is largely applied to archaeological sites, so is not used in evaluating most historic architectural resources.

> Fifty years is a general estimate of the time needed to develop historical perspective and to evaluate significance. This consideration guards against the listing of properties of passing contemporary interest and ensures that the NRHP is a list of truly historic places.[128]

The NRHP definition of integrity is determined through applying seven factors to the historical resource: location, design, setting, workmanship, materials, feeling, and association. These criteria can be roughly grouped into the following types of integrity considerations:

- Location and setting relate to the relationship between the property and its environment;
- Design, materials, and workmanship, as they apply to historic buildings, relate to construction methods and architectural details; and
- Feeling and association, the least objective of the seven criteria, pertain to the overall ability of the property to convey a sense of the historical tie and place where it was constructed.

4.1.2 California Register of Historical Resources

The criteria for assessing a property for listing in the CRHR closely parallel those of the NRHP. CEQA requires consideration of the possible impacts on and the evaluation of historic resources using the criteria in the CRHR. Each resource must be assessed to determine whether it meets any of the criteria below, paraphrased as:

- Criterion 1: Resources associated with important events that made a significant contribution to broad patterns of our history;
- Criterion 2: Resources associated with the lives of persons important to our past;
- Criterion 3: Resources that embody the distinctive characteristics of a type, period, or method of construction, or represents the work of a master;
- Criterion 4: Resources that yielded, or may be likely to yield, information important in prehistory or history.[129]

The CRHR definition of integrity, and its special considerations for certain properties, is slightly different than that for the NRHP. Integrity is defined as "the authenticity of an historical resource's physical identity evidenced by the survival of characteristics that existed during the resource's period of significance." The CRHR further states that

[128] The most widely accepted guidelines are in the US Department of the Interior, National Park Service, "Guidelines for Applying the National Register Criteria for Evaluation," *National Register Bulletin 15* (Washington DC: US Government Printing, 1991, revised 1995 through 2002).

[129] California Code of Regulations, Sections 4850 through 4858; Office of Historic Preservation, Instructions for Nominating Historical Resources to the California Register of Historical Resources, August, 1997; as was the case with NRHP Criterion D, Criterion 4 is largely applied to archaeological sites, so is not used in evaluating most historic architectural resources.

eligible resources must "retain enough of their historic character or appearance to be recognizable as historical resources and to convey the reasons for their significance," and the CRHR lists the same seven aspects of integrity used for evaluating properties under the NRHP criteria. The CRHR's special considerations for certain property types are limited to: 1) moved buildings, structures, or objects; 2) historical resources achieving significance within the past 50 years; and 3) reconstructed buildings.

4.2 HISTORIC EVALUATION OF BUILDINGS IN THE DIRECT APE

The California Cap Company in its heyday comprised 150 buildings on its expansive site. The University took possession of the property in 1950, initially using the existing buildings for engineering laboratories. As time passed, UC Berkeley began altering the property to suit its changing needs. Over its seven decades of ownership, the University repurposed, remodeled, moved, or demolished almost all of the buildings left behind by the California Cap Company. The University altered the property by constructing a number of new buildings. The Richmond Field Station as a whole, therefore, does not retain sufficient integrity to be listed in the NRHP or the CRHR or as a historic district.

Despite the scope of the alterations to the property, a handful of buildings have been retained from the California Cap Company period. Three of these, Buildings 102, 150, and 175, were determined, through this report, to be historically significant. Despite meeting eligibility under Criterion A/1, Building 102 has been repeatedly altered over the decades and no longer retains sufficient integrity to be eligible for listing in the NRHP or the CRHR. Only Buildings 150 and 175 have retained sufficient integrity to be individually eligible for listing.

4.2.1 Building 102

Criterion A/1: Building 102 meets Criterion A/1 for its association with events significant to national, state, and local history. It is the oldest building on the Richmond Field Station, dating to the property's ranching era. The manufacturing activities that took place in Building 102 were central to the production processes of the California Cap Company, the first blasting cap company in the United States. The company also manufactured bombs in the building that were used against the Japanese during World War II.

Criterion B/2: Because this building is associated with important individuals significant to our past, it meets this criterion. Building 102 is the oldest of the extant buildings at the Richmond Field Station, and, therefore, it is the most notably associated with California Cap Company founder William Letts Oliver. Oliver was a significant figure in the history of explosives manufacture, responsible for the invention of a high-heat explosive named "Tonite", and the first manufacturer of blasting caps in the United States. Building 102 is

the only California Cap Company building specifically discussed in a document created in 1959 by William Letts Oliver's son Roland Oliver.[130]

Criterion C/3: The building does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values. Building 102 is a utilitarian building constructed piecemeal over many decades, so the building is not eligible to the NRHP for its architecture and does not meet this criterion.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard. As a result, it does not meet this criterion.

Despite meeting Criteria A/1 and B/2 due to Building 102's association with the California Cap Company and William Letts Oliver, the building's integrity has suffered due to repeated alterations. Only its location has remained unchanged, and its historic integrity of setting, design, materials, workmanship, feeling, and association has all been compromised. As demonstrated by a comparison of historic and contemporary photographs (Photograph 1, Photograph 2, and Photograph 3) of the building, extensive alterations to the primary façade of Building 102 have rendered it virtually indistinguishable from buildings constructed in the late twentieth century. These alterations, which include replacement of exterior siding, replacement of windows, alterations to the size of window openings, a modification of the roof from gabled to flat, and other changes, have drastically impaired the building's ability to convey historic significance. Therefore, the building is not eligible for the NRHP or the CRHR.

4.2.2 Building 110

Criterion A/1: No particular association was found between Building 110 and events significant to national, state, or local history. Although the California Cap Company was the first blasting cap manufacturer in the United States there is no indication that the research that took place in Building 110 was central to the development of the plant or its technical processes, so the building does not meet this criterion and is not eligible for inclusion in the NRHP or CRHR for historical significance.

Criterion B/2: Building 110 dates from the period when William Letts Oliver and his son Roland Oliver were making important breakthroughs in the explosives industry. However, no particular association has been found between the building and members of the Oliver family, or with other important individuals significant to our past, so the building does not meet this criterion and is not eligible for the NRHP or CRHR for association with important individuals.

Criterion C/3: The building does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important

[130] Oliver, p.1.

creative individual or possess high artistic values. Building 102 is a vernacular building of a type commonly constructed from the late nineteenth to the early twentieth century, so the building is not eligible under this criterion.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard and does not meet this criterion.

Building 110 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.3 Building 111

Criteria A/1 and B/2: Building 111 does not meet these criteria for listing in NRHP or CRHR because it lacks historical significance. The structure has been a storage facility throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons.

Criterion C/3: The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction. As a result, it does not meet this criterion.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard. As a result, this building does not meet this criterion.

Criterion G: As a storage facility, Building 111 does not meet the standard of exceptional importance required for properties under 50 years old to be eligible to the NRHP.

Building 111 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.4 Building 112

Criteria A/1 and B/2: Building 112 does not meet the criteria for listing in NRHP or CRHR because it lacks historical significance. The structure has served various functions throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons.

Criterion C/3: The simple building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Building 112 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.5 Building 113

Criteria A/1 and B/2: Building 113 does not meet the criteria for listing in NRHP or CRHR because it lacks historical significance. The structure has been a storage facility throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons.

Criterion C/3: The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Criterion G: As a storage facility, Building 113 does not meet the standard of exceptional importance required for properties less than 50 years old to be eligible to the NRHP.

Building 113 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.6 Building 114

Criteria A/1 and B/2: Building 114 does not meet the criteria for listing in NRHP or CRHR because it lacks historical significance. The structure has primarily been used for storage throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons.

Criterion C/3: The simple building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Building 114 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.7 Building 116

Criteria A/1 and B/2: Building 116 does not meet the criteria for listing in NRHP or CRHR because it lacks historical significance. The structure has primarily been used for storage throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons.

Criterion C/3: The utilitarian prefabricated building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Building 116 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.8 Building 117

Criteria A/1 and B/2: Building 117 does not meet the criteria for listing in NRHP or CRHR because it lacks historical significance. The structure has had various functions throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons.

Criterion C/3: The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Building 117 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.9 Building 118

Criteria A/1 and B/2: Building 118 does not meet the criteria for listing in NRHP or CRHR because it lacks historical significance. The structure has had various functions throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons.

Criterion C/3: The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Building 118 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.10 Building 120

Criteria A/1 and B/2: Building 120 does not meet the criteria for listing in NRHP or CRHR because it lacks historical significance. The structure has been used for storage throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons.

Criterion C/3: The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Building 120 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.11 Building 121

Criteria A/1 and B/2: Building 121 does not meet the criteria for listing in the NRHP or CRHR because it lacks historical significance. The structure has been used for vehicle storage throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons.

Criterion C/3: The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Building 121 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.12 Building 125

Criterion A/1: No particular association was found between the Building 125 and events significant to national, state, or local history. Although the California Cap Company was the first blasting cap manufacturer in the United States there is no indication that Building 125, a warehouse building, was central to the development of the plant or its technical processes, so the building is not eligible for inclusion in the NRHP or CRHR for historical significance.

Criterion B/2: Although William Letts Oliver and his son Roland Oliver were significant in the history of the explosives industry, no particular association was found between the Oliver family and the building. It lacks the strength of association

necessary to be considered historically significant in relation to any particular persons (Criteria B/2).

Criterion C/3: The building does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values (Criterion C/3). Building 125 is a vernacular building of a type commonly constructed from the late nineteenth to the early twentieth century, so the building is not eligible to the NRHP for its architecture.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard (Criterion D/4).

Building 125 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.13 Building 128

Criterion A/1: Building 128 does not meet the criteria for listing in the NRHP or CRHR because it lacks historical significance. Although the California Cap Company was the first blasting cap manufacturer in the United States there is no indication that Building 128, as a press house, was central to the development of the plant and its technical processes. It has had a variety of uses over its lifetime, so it lacks the strength of association to be considered historically significant in relation to any particular events in national, state, or local history to (Criterion A/1).

Criterion B/2: Although William Letts Oliver and his son Roland Oliver were significant in the history of the explosives industry, no particular association was found between the Oliver family and the building. It lacks the strength of association necessary to be considered historically significant in relation to any particular persons.

Criterion C/3: Building 128 was constructed in a utilitarian style, with materials commonly used in industrial structures during the early twentieth century. Alterations were done and additions were constructed over the years in response to changing needs. It does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Building 128 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.14 Building 149

Criteria A/1 and B/2: Building 149 does not meet the criteria for listing in NRHP or CRHR because it lacks historical significance. The structure has been used for a variety of purposes throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons.

Criterion C/3: The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Criterion G: As a storage facility, Building 149 does not meet the standard of exceptional importance required for properties less than 50 years old to be eligible to the NRHP.

Building 149 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.15 Building 150

Criterion A/1: Building 150 meets Criterion A/1 because it is associated with the early explosives industry in the United States. The California Cap company was the oldest blasting manufacturer in the East Bay. Blasting caps, or detonators, were an important safety innovation, invented only a few years before California Cap was opened.[131] Several other explosives factories were opened in Contra Costa County after the Tonite Powder and California Cap companies, and from the 1880s into the twentieth century, the East Bay produced most of the explosives products in California. High-explosive powder and blasting caps were essential to mining, road-building, and other economically important activities in California. These factories also produced munitions that were used during wartime. The manufacturing activities in Building 150, specifically wire insulating and wire saturating, were central to the production processes of the California Cap Company, the first blasting cap company in the United States. Insulated wire was required for blasting caps, one of the primary products of the plant. Building 150 is closely associated with Building 175, the California Cap Company's primary building.

Criterion B/2: Although William Letts Oliver and his son Roland Oliver were significant in the history of the explosives industry, no particular association was found between the Oliver family and the building, so it lacks the strength of association necessary to be considered historically significant in relation to any particular persons.

[131] A detonator is a small explosive charge that ignites a larger charge, allowing for the use of a more stable and thus safer type of explosive.

Criterion C/3: The building does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values. Building 150 is a simple industrial building, so it is not eligible to the NRHP or CRHR for its architecture.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Eligibility for listing in either the NRHP or the CRHR rests on significance and integrity. A property must have both factors to be considered eligible. Loss of integrity, if sufficiently great, would overwhelm the historical significance of a resource and render it ineligible. Integrity of a historic resource is measured by applying seven factors: location, design, setting, workmanship, materials, feeling, and association. Building 150 has retained a sufficient level of integrity in all measures. Although the building has undergone alterations, these changes have not compromised its historic integrity. Additional square footage at the rear of the building is not visible from the street, leaving the primary façade's ability to convey its historic significance intact. Furthermore, the main addition to Building 150 was constructed to complement the primary volume of the building in 1946, within the period of significance (1910-1949) for the California Cap Company. Therefore, Building 150 continues to convey its historic significance as a California Cap Company manufacturing facility.

4.2.16 Building 152

Criterion A/1: No particular association was found between the Building 152 and events significant to national, state, or local history. Although the California Cap Company was the first blasting cap manufacturer in the United States there is no indication that the activities that took place in Building 152 were central to the development of the plant or its technical processes. The building has been used for a variety of purposes throughout its lifetime, so the building is not eligible for inclusion in the NRHP or CRHR under this criterion.

Criterion B/2: Although William Letts Oliver and his son Roland Oliver were significant in the history of the explosives industry, no particular association was found between the Oliver family and the building., so it lacks the strength of association necessary to be considered historically significant in relation to any particular persons.

Criterion C/3: The building does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values. Building 152 is a vernacular building of a type that was commonly constructed from the late nineteenth to the early twentieth century, so the building is not eligible to the NRHP or CRHR under this criterion.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Building 152 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.17 Building 153

Criteria A/1 and B/2: Building 153 does not meet the criteria for listing in NRHP or CRHR because it lacks historical significance. The structure has been used for a variety of purposes throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons.

Criterion C/3: The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Building 153 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.18 Building 163

Criteria A/1 and B/2: Building 163 does not meet the criteria for listing in NRHP or CRHR because it lacks historical significance. The structure has been used for research throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons.

Criterion C/3: The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Criterion G: As a research facility Building 163 does not meet the standard of exceptional importance required for properties less than 50 years old to be eligible to the NRHP.

Building 163 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.19 Building 175

Criterion A/1: Building 175 meets Criterion A/1 because it is associated with the early explosives industry in the United States, as it was part of the first blasting cap company in the United States. The California Cap company was also the oldest blasting manufacturer in the East Bay area. Blasting caps, or detonators, were an important safety innovation, invented only a few years before California Cap was opened.[132] Several other explosives factories were opened in Contra Costa County after the Tonite Powder and California Cap companies, and from the 1880s into the twentieth century, the East Bay produced most of the explosives products in California. High-explosive powder and blasting caps were essential to mining, road-building, and other economically important activities in California. These factories also produced munitions that were used during wartime.

The manufacturing activities in Building 175, specifically cartridge loading and cartridge production, were central to the production processes of the Pacific Cartridge Company and the California Cap Company. Building 175 was one of the plant's primary manufacturing buildings in the 1910s. The company was administered from the office in the building. The building is at what was the geographical center of the plant between 1900 and the 1940s, and it is featured in historic photographs as the Pacific Cartridge and the California Cap Company's primary building.

Criterion B/2: Although William Letts Oliver and his son Roland Oliver were significant in the history of the explosives industry, no particular association was found between the Oliver family, the architect or builder, or any person associated with the building, so it lacks the strength of association necessary to be considered historically significant in relation to any particular persons under Criterion B/2.

Criterion C/3: The building does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values. Building 175 is an industrial building with little ornamentation, so it is not eligible to the NRHP or CRHR under this criterion.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Eligibility for listing on either the NRHP or the CRHR rests on significance and integrity. A property must have both factors to be considered eligible. Loss of integrity, if sufficiently great, would overwhelm the historical significance of a resource and render it ineligible. Integrity of a historic resource is measured by applying seven factors: location, design, setting, workmanship, materials, feeling, and association. Building 175 retains a

[132] A detonator is a small explosive charge that ignites a larger charge, allowing for the use of a more stable and thus safer type of explosive.

sufficient level of integrity in all measures. Although the building has undergone alterations, including the additional square footage constructed at the rear of the building, this addition is not visible from the street, leaving the primary façade intact. The replacement of the original wood frame sashes affects the building's integrity of design and materials. However, as demonstrated by a comparison of photographs taken in 2013 (Photograph 27) and ca. 1910 (Photograph 28), Building 175 is easily recognizable from historic photographs from the California Cap Company era. Despite some alterations, the building retains its ability to convey its significance as the company's historic administration building, and thus retains sufficient integrity to be considered eligible.

4.2.20 Building 176

Criteria A/1 and B/2: Building 176 does not meet the criteria for listing in NRHP or CRHR because it lacks historical significance. The structure has been used for storage throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons.

Criterion C/3: The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Building 176 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.21 Building 178

Criteria A/1 and B/2: Building 178 does not meet the criteria for listing in the NRHP or CRHR because it lacks historical significance. The structure has had a variety of uses throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons.

Criterion C/3: The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Criterion G: As a multiple use building, Building 178 does not meet the standard of exceptional importance required for properties less than 50 years old to be eligible to the NRHP (Criterion G).

Building 178 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.22 Building 185

Criteria A/1 and B/2: Building 185 does not meet the criteria for listing in NRHP or CRHR because it lacks historical significance. The structure has been used for a variety of purposes throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons.

Criterion C/3: The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Criterion G: As a multiple use building, Building 185 does not meet the standard of exceptional importance required for properties less than 50 years old to be eligible to the NRHP under this criterion.

Building 185 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.23 Building 197

Criteria A/1 and B/2: Building 197 does not meet the criteria for listing in NRHP or CRHR because it lacks historical significance. The structure has had a variety of uses throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons.

Criterion C/3: The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Criterion G: As a storage facility, Building 197 does not meet the standard of exceptional importance required for properties less than 50 years old to be eligible under this criterion.

Building 197 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.24 Building 275

Criteria A/1 and B/2: Building 275 does not meet the criteria for listing in NRHP or CRHR because it lacks historical significance. The structure has been used for research throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons.

Criterion C/3: The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Building 275 does not meet the significance criteria for listing in the NRHP or CRHR.

4.2.25 Building 276

Criterion A/1 and B/2: Building 276 does not meet the criteria for listing in the NRHP or CRHR because it lacks historical significance. The structure has been used for research throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events (Criterion A/1 or persons B/2).

Criteria C/3 and D/4: The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard (Criterion D/4).

Building 276 does not meet the significance criteria for listing in the NRHP or CRHR.

4.3 HISTORIC EVALUATION OF BUILDINGS IN THE INDIRECT APE

The buildings over 45 years old adjacent to the Phase 1 footprint, in the indirect APE, were evaluated for their historic significance and determined ineligible for listing in the NRHP or CRHR.

4.3.1 Building 151

Criterion A/1 and B/2: Building 151 does not meet the criteria for listing in NRHP or CRHR under Criterion A/1 because it lacks historical significance. The historical record does not indicate that Building 151 was important in local, state, or national events or trends. While academic research is important to anyone directly involved in the field, the historical record must show that the research or studies had a significant

impact on historical events and trends. The SWCL and Building 151 are not significant in this regard (Criterion A/1). None of the persons associated with Building 151 had a significant impact on local, state, or national history. Therefore, the building lacks the strength of association necessary to be considered historically significant in relation to any particular persons (Criterion B/2).

Criterion C/3 and D/4: Building 151 lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction and is a simple, prefabricated building (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information; however, this building is not a principal source of important information in this regard (Criterion D/4).

Building 151 does not meet the significance criteria for listing in the NRHP or CRHR.

4.3.2 Building 154

Criterion A/1 and B/2: Building 154 does not meet the criteria for listing in NRHP or CRHR under Criterion A/1 because it lacks historical significance. The historical record does not indicate that Building 154 was important in local, state, or national events or trends. While academic research is important to anyone directly involved in that field, in order to be eligible for the NRHP or CRHR, the historical record must show that the research or studies had a significant impact on historical events and trends. The SWCL and Building 154 are not significant in this regard. None of the persons associated with Building 154 had a significant impact on local, state, or national history. Therefore, the building lacks the strength of association necessary to be considered historically significant in relation to any particular persons (Criterion B/2).

Criterion C/3 and D/4: Building 154 lacks any identifiable architectural stylistic design and is a simple prefabricated building. It does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information; however, this building is not a principal source of important information in this regard (Criterion D/4).

Building 154 does not meet the significance criteria for listing in the NRHP or CRHR.

4.3.3 Building 155

Criterion A/1 and B/2: although the Olivers were significant in the history of the explosives industry, no particular association was found between the Oliver family and Building 155. Although the structure was used for University research by Professor Howe and others throughout its lifetime, none of the available historical evidence suggests that the building has association with persons important to the development of the desalination field. Academic research is important to those working directly in that

specific field, however none of the persons associated with Building 155 had a significant impact on local, state, or national history. The building lacks the strength of association necessary to be considered historically significant in relation to any particular persons (Criterion B/2).

Criterion C/3 and D/4: the building does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values. Building 155 is a vernacular building of a type that was commonly constructed in the early twentieth century. It has been heavily altered over the years since the University took possession in 1950, so the building is not eligible for the NRHP or CRHR for its architecture (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information; however, this building is not a principal source of important information (Criterion D/4).

Building 155 does not meet the significance criteria for listing in the NRHP or CRHR.

4.3.4 Building 158

Criterion A/1 and B/2: Building 158 does not meet the criteria for listing in the NRHP or CRHR under Criterion A/1 because it lacks historical significance. The historical record does not indicate that Building 158 was important in local, state, or national events or trends. While academic research is important to anyone directly involved in the field, the historical record must show that the research or studies had a significant impact on historical events and trends in order to be eligible for the NRHP or CRHR. Building 158 is not significant in this regard (Criterion A/1). Although the structure was used for University research by Professor Howe and others throughout its lifetime, none of the available evidence suggests that the building has association with persons important to the development of the desalination field. None of the persons associated with Building 158 have had a significant impact on local, state, or national history. Therefore, the building lacks the strength of association necessary to be considered historically significant in relation to any particular persons (Criterion B/2).

Criterion C/3 and D/4: Building 158 lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information; however, this building is not a principal source of important information in this regard (Criterion D/4).

Building 158 does not meet the significance criteria for listing in the NRHP or CRHR.

4.3.5 Building 177

Criterion A/1 and B/2: no association was found between Building 177 and events significant to national, state, or local history (Criterion A/1). Although the California Cap Company was the first blasting cap manufacturer in the United States, there is no

indication that the activities that took place in Building 177 were central to the development of the plant or its technical processes. Academic research took place in the building after the University took over the property, and while academic research is important to anyone directly involved in the field, the historical record must show that the research or studies had a significant impact on historical events and trends in order to merit eligibility in the NRHP or CRHR. The historical record does not indicate that Building 177 is eligible in this regard under Criterion A/1. Although the Olivers were significant in the history of the explosives industry, no particular association was found between the Oliver family and the building. Although Building 177 was used for University research by Professor Howe and others throughout its lifetime, none of the available evidence suggests that the building has association with persons important to the development of the desalination field. As stated, academic research is important to those working directly in that specific field; however, none of the persons associated with Building 177 had a significant impact on local, state, or national history. Therefore, the building lacks the strength of association necessary to be considered historically significant in relation to any particular persons (Criterion B/2).

Criterion C/3 and D/4: the building does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values. Building 177 is a vernacular building of a type that was commonly constructed in the early twentieth century. It has been heavily altered over the years since the University took possession in 1950, and the building is not eligible for listing in the NRHP or CRHR for its architecture (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information; however, this building is not a principal source of important information in this regard (Criterion D/4).

Building 177 does not meet the significance criteria for listing in the NRHP or CRHR

4.3.6 Building 180

Criterion A/1 and B/2: no association was found between Building 180 and events significant to national, state, or local history (Criterion A/1). Although the California Cap Company was the first blasting cap manufacturer in the United States, there is no indication that the activities that took place in Building 180 were central to the development of the plant or its technical processes. The building is not eligible for inclusion in the NRHP or CRHR for historical significance (Criterion A/1). Although the Olivers were significant in the history of the explosives industry, no particular association was found between the Oliver family and the building. The building was used for University research by Professor Howe and others throughout its lifetime; however, none of the available historical evidence suggests that the building has association with persons important to local, state, or national history. None of the persons associated with Building 180 have the strength of association necessary to be considered eligible under Criterion B/2.

Criterion C/3 and D/4: the building does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values. Building 180 is a combination of five buildings joined to make one building complex and has alteration dates from 1930 through 1950. The building is not eligible for the NRHP or CRHR for its architecture (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information; however, this building is not a principal source of important information in this regard (Criterion D/4).

Building 180 does not meet the significance criteria for listing in the NRHP or CRHR.

4.3.7 Building 277

Criterion A/1 and B/2: Building 277 does not meet the criteria for listing in NRHP or CRHR because it lacks historical significance. The structure has primarily been used for storage throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 and B/2).

Criterion C/3 and D/4: the utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information (Criterion D/4).

Building 277 does not meet the significance criteria for listing in the NRHP or CRHR.

4.4 PERIOD OF SIGNIFICANCE FOR ANY ELIGIBLE RESOURCES

The California Cap Company operated on the site from 1877 – 1949. Although its most innovative products have been created during the nineteenth century, the plant produced cartridges during World War I and incendiary bombs during World War II. Prior to World War II, it was one of the most important local employers in Richmond. Buildings 150 and 175 were constructed in 1910 and used for the California Cap Company until 1949, when the Cap Company ceased production. The period of significance for these buildings is from their construction in 1910 until 1949, when they were no longer used for the explosives industry.

5. CONCLUSION

This report concludes that there are two buildings, Buildings 150 and 175, which are eligible for listing in the NRHP and the CRHR for their association with the California Cap Company. These two buildings could be significantly adversely impacted by demolition, alteration, removal, or a change in their historic setting. Any future projects should be analyzed to ensure that these buildings are not significantly impacted, and if there is a significant adverse impact, mitigation measures should be implemented to reduce that impact.

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7. PREPARER'S QUALIFICATIONS

Tetra Tech Historian/Architectural Historian Kara Brunzell meets the history and architectural history professional qualifications, as outlined by the federal government in Title 36, Code of Federal Regulations, Part 61. She has an MA in History/Public History from California State University, Sacramento.

Tetra Tech Historian/Architectural Historian Julia Mates meets the history and architectural history professional qualifications, as outlined by the federal government in Title 36, Code of Federal Regulations, Part 61. She has an MA in History/Public History from California State University, Sacramento.

APPENDIX A

DPR 523 FORMS

BUILDINGS IN THE DIRECT APE

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 102

P1. Other Identifier: Richmond Field Station Building 102

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; _Diablo____ **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558491 mE/ 4196289 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate) Assessor Parcel Number

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 102 is near the southern edge of the Richmond Field Station campus. It is situated at the intersection of Heron Drive and Egret Way with its primary façade facing southeast. The 6,737 square foot building is single story with an irregular plan. It was constructed circa 1860 and is currently used for research. The building has been altered over its lifetime.

Originally, Building 102 was a produce warehouse with a rectangular plan at the corner of Heron Drive and Egret Way. When the Tonite Powder and California Cap companies were constructed along the waterfront in 1877 the warehouse served as a crucial safety barrier between explosive powder and detonators. (See Continuation Sheet)
***P3b. Resource Attributes:** (List attributes and codes) HP15: Educational building, HP39: Other

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1 camera facing west, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Circa 1860s

***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804

***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** January 4, 2013

***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

B1. Historic Name: California Cap Company Building 30

B2. Common Name: Building 102

B3. Original Use: Produce warehouse B4. Present Use: Research

***B5. Architectural Style:** Vernacular

***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed circa 1860; 1877: Converted from warehouse to explosives manufacturing facility; Circa 1930: Additions to rear of building; Circa 1950: Further additions to rear of building; Circa 1970s: Façade renovation, flat roof installed

***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____

***B8. Related Features:** _____

B9. Architect: Unknown b. Builder: Unknown

***B10. Significance: Theme** History **Area** Richmond Field Station

Period of Significance 1877 - 1949 **Property Type** industrial **Applicable Criteria** 1/A

(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 102 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet)

B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:**

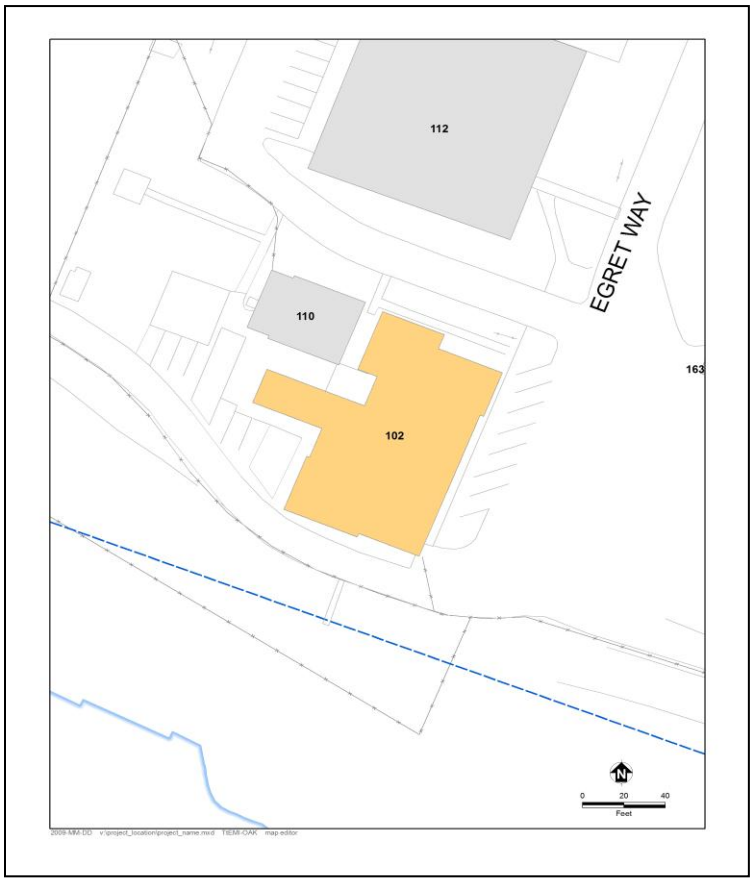
(See Footnotes)

B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



P3a. Description (continued)

Agriculture continued to be an important local activity after the establishment of the plants, and through the 1880s produce was stored in the warehouse along with explosives.[1] As the Tonite and California Cap Companies grew they crowded out agriculture, and the building was taken over by California Cap. By 1912 the company had its can factory as well as its warehouse in the building.[2] The California Cap Company referred to the building as Building 30. The California Cap Company constructed additional space on the northwest side of the building during the 1930s. During World War II the building housed an assembly line for incendiary delayed action bombs.[3]

After UC Berkeley's Department of Engineering took over the site in 1950 Sanitary Engineering Research Laboratory (SERL) activities were centered in and around Building 102. Professor H.B. Gotaas was in charge of SERL research during the early 1950s. Projects included both studies on composting, incineration, water reclamation, algae symbiosis, saltwater intrusion, and radioactive waste disposal.[4] In addition to laboratories, Building 102 housed SERL's library and administrative offices. The Department altered the interior of the building to suit its purposes, and by the mid-1950s it housed "an unusually well-equipped chemistry and biology laboratory".[5]

Historic photographs indicate that the original building was side gabled, with its primary façade on Egret Way. The University made additions on the building four times after 1950, including construction of an addition projecting from the primary façade that has since been removed (Photograph 2 and Photograph 3).[6] Alterations to the façade appear to have been made during the 1970s, when a flat roof replaced the original gabled roof over the southeast wing of the building. Facades on Egret and Heron Drive were altered with the replacement of stucco siding instead of wood and aluminum sash windows. In 2013 the building uses include storage, a bioengineering offices, and wet chemistry laboratory.

The primary volume of the building, which is adjacent to the corner of Heron Drive and Egret Way, is topped with a flat roof. Sections of the building to the rear are topped with shed roofs. The primary (southeast) façade features a broad eave overhang with large exposed roof members. The roof beams rest on large plain columns. (Many of these columns show signs of moderate to severe deterioration). The building is clad in both stucco with wood trim and horizontal wood siding. Fenestration consists of a combination of aluminum sliding sashes and double-hung, multi-light, wood frame sashes. Three entryways on the primary elevation are at grade through metal industrial-type doors, two of which have windows. Another elevation features a wood paneled door with a window.

The building currently reflects the many changes of use and alterations performed over the years in its irregular footprint and multiple types of siding and fenestration (Photograph 4 and Photograph 5).

[1] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p.1.
[2] Sanborn Insurance Maps, Stege, California. 1912.
[3] Oliver, p. 1.
[4] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 1.
[5] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 7.
[6] Scott Shackleton, University of California, Berkeley, Personal communication with Julia Mates, Tetra Tech 2013.

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[7] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[8] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[9]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[10] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[11] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[12] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[13] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[14] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is

[7] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[8] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[9] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[10] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[11] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[12] J.P. Munro-Fraser, p. 675.

[13] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[14] Hulanski p. 288.

B10. Significance (continued)

today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[15]

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its proximity to the harbor yet remote from population centers. In addition, the narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[16]

During the 1870s chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch. The San Francisco explosives companies soon followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to the Atlas Powder Company. The California Powder Works soon followed, building a new factory in Hercules, which was named for the brand under which the company sold its powder.[17] The Vulcan Powder Works and Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902 California had only one powder factory outside Contra Costa and Alameda counties.[18]

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory, which was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[19] William Letts Oliver and his wife Carrie lived in Oakland, from about 1880 until Oliver's death in 1918.[20] The couple eventually had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[21] In addition his various professional activities William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the early twentieth century. An avid amateur photographer throughout his lifetime, UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[22]

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[15] Ida Mae Purcell, *History of Contra Costa County*, The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

[16] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area,* University of California, Berkeley: 1964, p. 27.

[17] Purcell, p. 646.

[18] Richmond Record, "Contra Costa County: Under the Vitascope", Richmond:1902.

[19] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

[20] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

[21] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

[22] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley: 2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

B10. Significance (continued)

William Letts Oliver initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[23] As early as 1870, European explosive companies were experimenting with nitrated guncotton in and by 1875 it was manufactured in England under the name "tonite."[24] By 1877 Oliver had left Chile and was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock needed an explosive that would remain stable at the high temperatures underground to complete the tunnel, and Oliver was able to solve the problem by substituting tonite for more volatile compounds.[25]

The California Cap Company

In 1877 William Letts Oliver was inspired by his success with tonite to leave mining and establish the Tonite Powder Company, on a portion of the former Stege Ranch.[26] In the 1870s all blasting caps in the United States had to be imported from Europe. Not only were they expensive, but the timing of deliveries was uncertain, creating business difficulties for the powder plant. Oliver was determined to create his own caps in order to protect the tonite factory business. He experimented until he came up with a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter founded the California Cap Company. It was located adjacent to the Tonite Powder Company a 160 acre parcel carved out of the southern portion of Stege Ranch.[27] California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[28] The California Cap Company was located on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

The Tonite and California Cap factories, which were the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[29] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882 at the nearby Vulcan Powder Company caused 11 deaths and destroyed the plant.[30] Between 1882 and 1918 the Hercules and Atlas plants suffered numerous explosions which destroyed plant buildings and killed a total of 64 workers.[31] Despite its focus on safety, the California Cap Company had accidents as well. Two of its Chinese workers were killed in 1917 when one of them dropped a tray of caps. In 1941 an explosion caused a fire and critically injured a worker.[32]

[23] Pacific Mining News, p. 222.
[24] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.
[25] Pacific Mining News, p. 222.
[26] Oliver, p. 1.
[27] Pacific Mining News, p. 222.
[28] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.
[29] Oliver, p. 1.
[30] Munro-Fraser, p. 424.
[31] Purcell, p. 648.
[32] Contra Costa County Standard, "Stege Powder Plant Blast; One Near Death", June 6, 1941, p. 1A.

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888 he formed the American Lucol Company adjacent to the California Cap Company property.[33] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[34] The factory was dismantled and relocated to New Jersey circa 1900.[35] In 1903 the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field station property.[36] Later known as the U.S. Briquette Company, the plant appears to have operated at this location until at least 1917.[37] The U.S. Briquette Company buildings were demolished sometime in the 1960s.

The Oliver family aggressively promoted their products both through advertising and publishing. The California Cap Company sponsored or published both articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing as well as a selling point in advertisements.[38] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century the powder's explosive properties were considered comparable to the finest English products.[39] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family also became benefactors of the university, and in 1917 the California Cap Company donated substantial amounts of their products to the College of Mining including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[40]

Eventually the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[41] By 1916 there were at least a dozen buildings on the site. When Oliver died in 1918 his son Roland Oliver took over as president of California Cap Company. By 1922 Roland's brother Leslie Oliver was assistant manager of the plant and Edwin Letts Oliver was a director.[42] Roland Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[43]

During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[44] As the twentieth century progressed more heavy industry came to Contra Costa County, and by

[33] Oliver, p. 1.

[34] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913*, Dewey Publishing Company: 1913, p. 327.

[35] Oliver, p. 1.

[36] Oliver, p. 2.

[37] Hulanksi, p. 354.

[38] Halbert Powers Gillette, *Rock Excavation:Methods and Cost*, M.C. Clark, New York: 1904, x.

[39] Manual Eissler, *A Handbook on Modern Explosives*, Crosby, Lockwood & son, London: 1897, p. 117.

[40] University of California, *The University of California Chronicle*, University of California Press, January, 1917, p. 92.

[41] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.

[42] Pacific Mining News, p.222.

[43] University of California, Berkeley, *Current Conditions Report*, Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

[44] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

B10. Significance (continued)

1940 the county was second only to Los Angeles in overall industrial production.[45] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[46] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[47]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[48] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[49]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[50] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[51] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Building 102

Building 102 was constructed in the 1860s as a produce warehouse. The agricultural products of the Quilfelt-Stege and San Pablo ranches were stored here before being shipped to San Francisco via the adjacent wharf. During the California Cap Company era the building was used as a can factory and bomb production facility as well as a warehouse.

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[45] Purcell, p. 649.

[46] Oliver, p. 1.

[47] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[48] University of California, Berkeley, 2008, p. 13.

[49] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[50] McGauhey, p. 71.

[51] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

After UC Berkeley took over the site activities at Building 102 included storage, a chemical laboratory, and office space. The building was also used for SERL research activities, which included the use of chemicals and radioisotopes during research activities.[52]

Evaluation

Building 102 appears to meet the criteria for listing in the NHRP/CRHR because it is associated with events significant to national, state, and local history (Criterion A/1). It is the oldest building on the Richmond Field Station, dating to the property's ranching era. The manufacturing activities that took place in Building 102 were central to the production processes of the California Cap Company, the first blasting cap company in the United States. The company also manufactured bombs that were used against the Japanese during World War II in the building.

In addition, the building is associated with important individuals significant to our past (Criterion B/2). Building 102 is the oldest of the extant buildings at the Richmond Field Station, and therefore the most notably associated with California Cap Company founder William Letts Oliver. Oliver was a significant figure in the history of explosives manufacture, responsible for the invention of a high-heat explosive named Tonite as well as the first manufacturer of blasting caps in the United States. Building 102 is the only California Cap Company building specifically discussed in a document created in 1959 by William Letts Oliver's son Roland Oliver.[53]

The building does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values (Criterion C/3). Building 102 is a utilitarian building that was constructed piecemeal over a period of many decades. Therefore the building is not eligible to the NHRP for its architecture.

In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

Eligibility for listing on either the NRHP rests on significance and integrity. A property must have both factors to be considered eligible. Loss of integrity, if sufficiently great, would overwhelm the historical significance of a resource and render it ineligible. Despite Building 102's historical significance for the California Cap Company period, the building's integrity has suffered due to repeated alterations. Only its location has remained unchanged over the years, and its integrity of setting, design, materials, workmanship, feeling, and association have all been compromised. Therefore the building is not eligible for the NHRP or the CRHR. Although Building 102 has been found ineligible due to loss of integrity, because of its historical significance it may warrant special attention in the planning process.

[52] University of California, Berkeley, 2008, p. 25.
[53] Oliver, p.1.

Photographs:

Photograph 2: Building 102, circa 1954

Photograph 3: Building 102, circa 1970

Photograph 4: Building 102, January 4, 2013, camera facing northwest

Photograph 5: Building 102, January 4, 2013, camera facing west

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ **Reviewer** _____ **Date** _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 110

P1. Other Identifier: Richmond Field Station Building 110

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558477 mE/ 4196309 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 110 is near the southern edge of Richmond Field Station campus adjacent to Building 102. The vernacular building does not strongly express a particular architecture style. Constructed circa the 1910s, the building is 1,325 square feet, single story, with a rectangular plan and topped by a shallow pitch, front gabled roof. Its primary elevation faces southeast. Its moderate eaves feature exposed rafter tails on its northeast and southwest elevations. (See Continuation Sheet)

***P3b. Resource Attributes:** (List attributes and codes) HP15: Educational building, HP39: Other

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Southeast and northeast façades of building, camera facing west, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Circa 1910

***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804

***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** January 4, 2013

***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

B1. Historic Name: California Cap Company Building 65
B2. Common Name: Building 110
B3. Original Use: Research Laboratory B4. Present Use: Vacant
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed circa 1910
***B7. Moved?** ☐**No** ☒ **Yes** ☐ **Unknown** **Date:** circa 1960 **Original Location:** adjacent to Egret Way
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 110 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet)

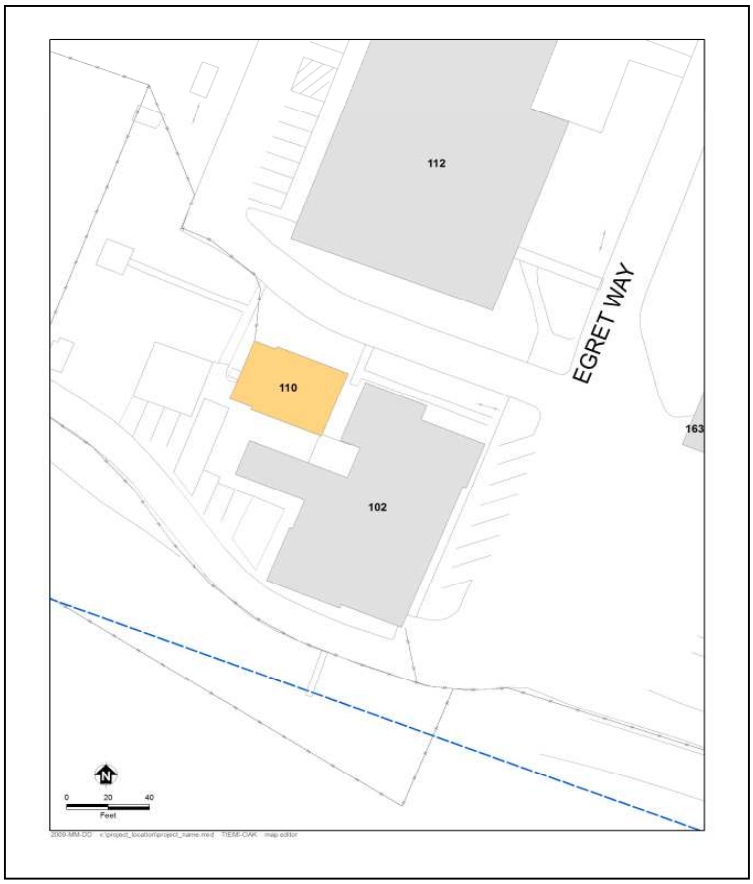
B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See Footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



P3a. Description (continued)

The walls are clad in horizontal wood siding. Fenestration is original, multi- light, double-hung wood sashes. An original paneled wood entry door is centered in the southwest elevation. sheltered by a recessed entry porch and accessed by a set of wooden stairs. Plain entablature adorns the door and window surrounds throughout the otherwise unornamented building. An addition at the rear (northwest) of the building is topped by a shed roof. Its rear entrance is a wood paneled door with a window. This door is sheltered by a small awning and accessed by a set of wooden stairs. The building is surrounded by grassy areas, and access to the rear of the building is currently blocked by a wood fence to the south and a chain link fence to the north.

Building 110 was constructed by the California Cap Company circa the 1910s. The building was originally several hundred yards to the northeast of its current location, along Egret Way.[1] It was used as a research laboratory by the California Cap Company and labeled Building 65.[2]

After UC Berkeley's SERL took over the site in 1950 its activities were concentrated in the southeast section of the Richmond Field Station. Historic aerial photographs show that Building 110 was moved to its current location adjacent to Building 102 circa 1960 and was used for research using radioisotopes. [3] After it was moved, Building 110 housed laboratories and offices for SERL's successor, (EEHSL).[4] The building continued to be used for offices until 2008, but it is currently vacant.[5]

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[6] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[7] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[8]

[1] University of California, Berkley, "Draft Environmental Impact Report, Proposed U.S. Environmental Protection Agency, Region IX Laboratory at the University of California's Richmond Field Station," Prepared by University of California, Berkeley Planning, Design and Construction Department, July 1991, p. 307.

[2] University of California, Berkeley, 2008, p.

[3] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call," Regional Oral History Office, University of California, Berkeley, 1974, p. 71.

[4] Shackelton, 2013.

[5] University of California, Berkeley, 2008, p. 196.

[6] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[7] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[8] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

B10. Significance (continued)

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[9] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[10] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[11] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[12] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[13] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[14]

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its proximity to the harbor yet remote from population centers. In addition, the narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[15]

During the 1870s chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch. The San Francisco explosives companies soon followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to

[9] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[10] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[11] J.P. Munro-Fraser, p. 675.

[12] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[13] Hulanski p. 288.

[14] Ida Mae Purcell, *History of Contra Costa County*, The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

[15] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area*, University of California, Berkeley: 1964, p. 27.

B10. Significance (continued)

the Atlas Powder Company. The California Powder Works soon followed, building a new factory in Hercules, which was named for the brand under which the company sold its powder.[16] The Vulcan Powder Works and Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902 California had only one powder factory outside Contra Costa and Alameda counties.[17]

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory, which was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[18] William Letts Oliver and his wife Carrie lived in Oakland, from about 1880 until Oliver's death in 1918.[19] The couple eventually had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[20] In addition his various professional activities William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the early twentieth century. An avid amateur photographer throughout his lifetime, UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[21]

William Letts Oliver initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[22] As early as 1870, European explosive companies were experimenting with nitrated guncotton in and by 1875 it was manufactured in England under the name "tonite."[23] By 1877 Oliver had left Chile and was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock needed an explosive that would remain stable at the high temperatures underground to complete the tunnel, and Oliver was able to solve the problem by substituting tonite for more volatile compounds.[24]

The California Cap Company

In 1877 William Letts Oliver was inspired by his success with tonite to leave mining and establish the Tonite Powder Company, on a portion of the former Stege Ranch.[25] In the 1870s all blasting caps in the United States

[16] Purcell, p. 646.

[17] Richmond Record, "Contra Costa County: Under the Vitascope", Richmond:1902.

[18] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

[19] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

[20] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

[21] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley: 2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

[22] Pacific Mining News, p. 222.

[23] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.

[24] Pacific Mining News, p. 222.

[25] Oliver, p. 1.

B10. Significance (continued)

had to be imported from Europe. Not only were they expensive, but the timing of deliveries was uncertain, creating business difficulties for the powder plant. Oliver was determined to create his own caps in order to

protect the tonite factory business. He experimented until he came up with a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter founded the California Cap Company. It was located adjacent to the Tonite Powder Company a 160 acre parcel carved out of the southern portion of Stege Ranch.[26] California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[27] The California Cap Company was located on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

The Tonite and California Cap factories, which were the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[28] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882 at the nearby Vulcan Powder Company caused 11 deaths and destroyed the plant.[29] Between 1882 and 1918 the Hercules and Atlas plants suffered numerous explosions which destroyed plant buildings and killed a total of 64 workers.[30] Despite its focus on safety, the California Cap Company had accidents as well. Two of its Chinese workers were killed in 1917 when one of them dropped a tray of caps. In 1941 an explosion caused a fire and critically injured a worker.[31]

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888 he formed the American Lucol Company adjacent to the California Cap Company property.[32] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[33] The factory was dismantled and relocated to New Jersey circa 1900.[34] In 1903 the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field station property.[35] Later known as the U.S. Briquette Company, the plant appears to have operated at this location until at least 1917.[36] The U.S. Briquette Company buildings were demolished sometime in the 1960s.

[26] Pacific Mining News, p. 222.
[27] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.
[28] Oliver, p. 1.
[29] Munro-Fraser, p. 424.
[30] Purcell, p. 648.
[31] Contra Costa County Standard, "Stege Powder Plant Blast; One Near Death", June 6, 1941, p. 1A.
[32] Oliver, p. 1.
[33] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913*, Dewey Publishing Company: 1913, p. 327.
[34] Oliver, p. 1.
[35] Oliver, p. 2.
[36] Hulanksi, p. 354.

B10. Significance (continued)

The Oliver family aggressively promoted their products both through advertising and publishing. The California Cap Company sponsored or published both articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing as well as a selling point in advertisements.[37] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century the powder's explosive properties were considered comparable to the finest English products.[38] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family also became benefactors of the university, and in 1917 the California Cap Company donated substantial amounts of their products to the College of Mining including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[39]

Eventually the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[40] By 1916 there were at least a dozen buildings on the site. When Oliver died in 1918 his son Roland Oliver took over as president of California Cap Company. By 1922 Roland's brother Leslie Oliver was assistant manager of the plant and Edwin Letts Oliver was a director.[41] Roland Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[42]

During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[43] As the twentieth century progressed more heavy industry came to Contra Costa County, and by 1940 the county was second only to Los Angeles in overall industrial production.[44] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[45] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a

[37] Halbert Powers Gillette, *Rock Excavation:Methods and Cost,* M.C. Clark, New York: 1904, x.

[38] Manual Eissler, *A Handbook on Modern Explosives,* Crosby, Lockwood & son, London: 1897, p. 117.

[39] University of California, *The University of California Chronicle,* University of California Press, January, 1917, p. 92.

[40] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.

[41] Pacific Mining News, p.222.

[42] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

[43] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

[44] Purcell, p. 649.

[45] Oliver, p. 1.

B10. Significance (continued)

crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[46]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[47] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[48]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[49] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[50] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Building 110

Building 110 was constructed by the California Cap Company circa 1910. The building was originally located several hundred yards to the northeast of its current location, along Egret Way.[51] It was used as a research laboratory by the California Cap Company and located adjacent to the plant's mercury fulminating area. It was labeled "Building 65".[52]

After UC Berkeley's Sanitary Engineering Research Laboratory (SERL) took over the site in 1950 its activities were concentrated in the southeast section of the Richmond Field Station. In the early 1950s Building 110 housed algae symbiosis research.[53] Historic aerial photographs demonstrate that Building 110 was moved to its current location adjacent to Building 102 circa 1960. After it was moved Building 110 housed laboratories and offices for SERL's successor the Environmental Engineering and Health Sciences Laboratory (EEHSL).[54] The building continued to be used for offices until at least 2008, but it is currently vacant.[55]

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[46] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[47] University of California, Berkeley, 2008, p. 13.

[48] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[49] McGauhey, p. 71.

[50] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

[51] University of California, Berkley, "Draft Environmental Impact Report, Proposed U.S. Environmental Protection Agency, Region IX Laboratory at the University of California's Richmond Field Station", Prepared by University of California, Berkeley Planning, Design and Construction Department, July 1991, p. 307.

[52] University of California, Berkeley, 2008, p.

[53] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 7.

[54] Shackelton, 2013.

Evaluation

The following provides an evaluation of Building 110 under each NRHP/CRHR criteria.

No particular association was found between the Building 110 and events significant to national, state, or local history (Criterion A/1). Although the California Cap Company was the first blasting cap manufacturer in the United States there is no indication that the research that took place in Building 110 was central to the development of the plant or its technical processes. Therefore the building is not eligible for inclusion in the NRHP for historical significance

Building 110 dates from the period when William Letts Oliver and his son Roland Oliver were making important breakthroughs in the explosives industry. However, no particular association has been found between the building and members of the Oliver family, or with other important individuals significant to our past (Criterion B/2). Therefore the building is not eligible under to the NRHP for association with important individuals.

The building does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values (Criterion C/3). Building 102 is a vernacular building of a type that was commonly constructed from the late nineteenth to the early twentieth century. Therefore the building is not eligible to the NHRP for its architecture.

In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

[55] University of California, Berkeley, 2008, p. 196.

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 111

P1. Other Identifier: Richmond Field Station Building 111

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558491 mE/ 4196401 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 111 is in the southern portion of the Richmond Field Station. The utilitarian building does not express any particular architectural style. It is 507 square feet and was constructed in 1987. It is single story and rectangular in plan. The building is topped by a flat roof and constructed of concrete masonry units. It lacks fenestration, and its entrances are industrial-type metal doors on its northwest and southeast elevations.

***P3b. Resource Attributes:** (List attributes and codes) HP4: Ancillary Building

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Northwest and northeast facades of building, camera facing southeast, December 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
1987/UC Berkeley records

***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804

***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** January 4, 2013

***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

B1. Historic Name: _____
B2. Common Name: Building 111
B3. Original Use: Storage B4. Present Use: Storage
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed in 1987
***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 111 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet.)

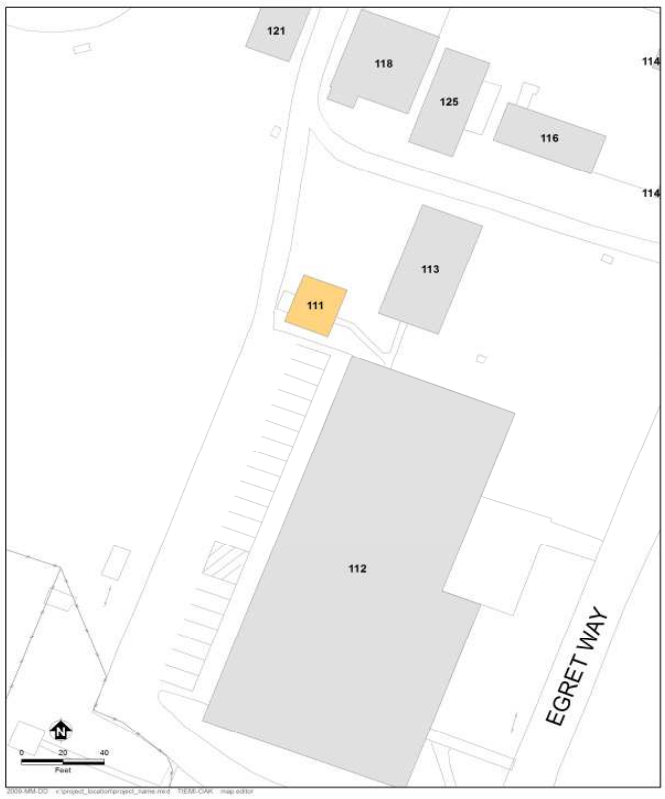
B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See Footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[1] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[2] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[3]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[4] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[5] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[6] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[7] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[8] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is

[1] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[2] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[3] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[4] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[5] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[6] J.P. Munro-Fraser, p. 675.

[7] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[8] Hulanski p. 288.

B10. Significance (continued)

today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[9]

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its proximity to the harbor yet remote from population centers. In addition, the narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[10]

During the 1870s chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch. The San Francisco explosives companies soon followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to the Atlas Powder Company. The California Powder Works soon followed, building a new factory in Hercules, which was named for the brand under which the company sold its powder.[11] The Vulcan Powder Works and Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902 California had only one powder factory outside Contra Costa and Alameda counties.[12]

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory, which was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[13] William Letts Oliver and his wife Carrie lived in Oakland, from about 1880 until Oliver's death in 1918.[14] The couple eventually had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[15] In addition his various professional activities William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the early twentieth century. An avid amateur photographer throughout his lifetime, UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[16]

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[9] Ida Mae Purcell, *History of Contra Costa County,* The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

[10] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area,* University of California, Berkeley: 1964, p. 27.

[11] Purcell, p. 646.

[12] Richmond Record, "Contra Costa County: Under the Vitascope", Richmond:1902.

[13] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

[14] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

[15] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

[16] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley: 2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

B10. Significance (continued)

William Letts Oliver initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[17] As early as 1870, European explosive companies were experimenting with nitrated guncotton in and by 1875 it was manufactured in England under the name "tonite."[18] By 1877 Oliver had left Chile and was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock needed an explosive that would remain stable at the high temperatures underground to complete the tunnel, and Oliver was able to solve the problem by substituting tonite for more volatile compounds.[19]

The California Cap Company

In 1877 William Letts Oliver was inspired by his success with tonite to leave mining and establish the Tonite Powder Company, on a portion of the former Stege Ranch.[20] In the 1870s all blasting caps in the United States had to be imported from Europe. Not only were they expensive, but the timing of deliveries was uncertain, creating business difficulties for the powder plant. Oliver was determined to create his own caps in order to protect the tonite factory business. He experimented until he came up with a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter founded the California Cap Company. It was located adjacent to the Tonite Powder Company a 160 acre parcel carved out of the southern portion of Stege Ranch.[21] California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[22] The California Cap Company was located on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

The Tonite and California Cap factories, which were the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[23] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882 at the nearby Vulcan Powder Company caused 11 deaths and destroyed the plant.[24] Between 1882 and 1918 the Hercules and Atlas plants suffered numerous explosions which destroyed plant buildings and killed a total of 64 workers.[25] Despite its focus on safety, the California Cap Company had accidents as well. Two of its Chinese workers were killed in 1917 when one of them dropped a tray of caps. In 1941 an explosion caused a fire and critically injured a worker.[26]

[17] Pacific Mining News, p. 222.
[18] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.
[19] Pacific Mining News, p. 222.
[20] Oliver, p. 1.
[21] Pacific Mining News, p. 222.
[22] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.
[23] Oliver, p. 1.
[24] Munro-Fraser, p. 424.
[25] Purcell, p. 648.
[26] Contra Costa County Standard, "Stege Powder Plant Blast; One Near Death", June 6, 1941, p. 1A.

B10. Significance (continued)

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888 he formed the American Lucol Company adjacent to the California Cap Company property.[27] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[28] The factory was dismantled and relocated to New Jersey circa 1900.[29] In 1903 the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field station property.[30] Later known as the U.S. Briquette Company, the plant appears to have operated at this location until at least 1917.[31] The U.S. Briquette Company buildings were demolished sometime in the 1960s.

The Oliver family aggressively promoted their products both through advertising and publishing. The California Cap Company sponsored or published both articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing as well as a selling point in advertisements.[32] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century the powder's explosive properties were considered comparable to the finest English products.[33] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family also became benefactors of the university, and in 1917 the California Cap Company donated substantial amounts of their products to the College of Mining including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[34]

Eventually the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[35] By 1916 there were at least a dozen buildings on the site. When Oliver died in 1918 his son Roland Oliver took over as president of California Cap Company. By 1922 Roland's brother Leslie Oliver was assistant manager of the plant and Edwin Letts Oliver was a director.[36] Roland Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[37]

[27] Oliver, p. 1.
[28] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913,* Dewey Publishing Company: 1913, p. 327.
[29] Oliver, p. 1.
[30] Oliver, p. 2.
[31] Hulanksi, p. 354.
[32] Halbert Powers Gillette, *Rock Excavation:Methods and Cost,* M.C. Clark, New York: 1904, x.
[33] Manual Eissler, *A Handbook on Modern Explosives,* Crosby, Lockwood & son, London: 1897, p. 117.
[34] University of California, *The University of California Chronicle,* University of California Press, January, 1917, p. 92.
[35] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915,* Oakland, California: 1915.
[36] Pacific Mining News, p.222.
[37] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

B10. Significance (continued)

During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[38] As the twentieth century progressed more heavy industry came to Contra Costa County, and by 1940 the county was second only to Los Angeles in overall industrial production.[39] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[40] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[41]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[42] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[43]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[44] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[45] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Building 111

[38] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

[39] Purcell, p. 649.

[40] Oliver, p. 1.

[41] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[42] University of California, Berkeley, 2008, p. 13.

[43] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[44] McGauhey, p. 71.

[45] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

Building 111 appears to have been constructed by UC Berkeley in 1987 on the site of an older building.[46] The site seems to have housed a storage shed, California Cap Company "Building 148", prior to the construction of Building 111. It was constructed for hazardous materials storage.[47] The Watershed Project, a non-profit group whose offices are at the Richmond Field Station, has used the building for storage for the past several years.[48] The building is not of a historic age, as it was constructed 26 years ago.

Evaluation

The following provides an evaluation of Building 111 under each NRHP/CRHR criteria.

Building 111 does not appear to meet the criteria for listing in National Register of Historic Places because it lacks historical significance. The structure has served as a storage facility throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 and B/2).

The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

As a storage facility Building 111 does not meet the standard of exceptional importance required for properties under 50 years old to be eligible to the NHRP (Criterion G).

[46] University of California, Berkeley, 2008, p. 196.

[47] University of California, Berkeley, 2008, p. 13.

[48] Scott Shackleton, University of California, Berkeley, Personal communication with Julia Mates, Tetra Tech, 2013.

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ **Reviewer** _____ **Date** _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 112

P1. Other Identifier: Richmond Field Station Building 112

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5' Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558500 mE/ 4196357 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 112 is in the southern portion of the Richmond Field Station. The rectangular, single-story, 16,949 square-foot building was constructed in 1964.

The building is topped with a flat roof. Its southeast (primary) and northwest (rear) elevations feature a broad eave overhang with large exposed roof rafters. The roof is supported by large plain columns. The walls are sided in stucco with wood trim. Primary fenestration is fixed and awning metal sashes, with vinyl replacement windows at the rear elevation. The primary entrance is a recessed glazed door with a transom and surround.
(See Continuation Sheet)

***P3b. Resource Attributes:** (List attributes and codes) HP15: Educational building, HP39: Other

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Southwest and southeast facades of building, camera facing north, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
1964/UC Berkeley records

***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804

***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** January 4, 2013

***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

B1. Historic Name: _____
B2. Common Name: Building 112
B3. Original Use: Office B4. Present Use: Office
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed in 1964
***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 112 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet.)

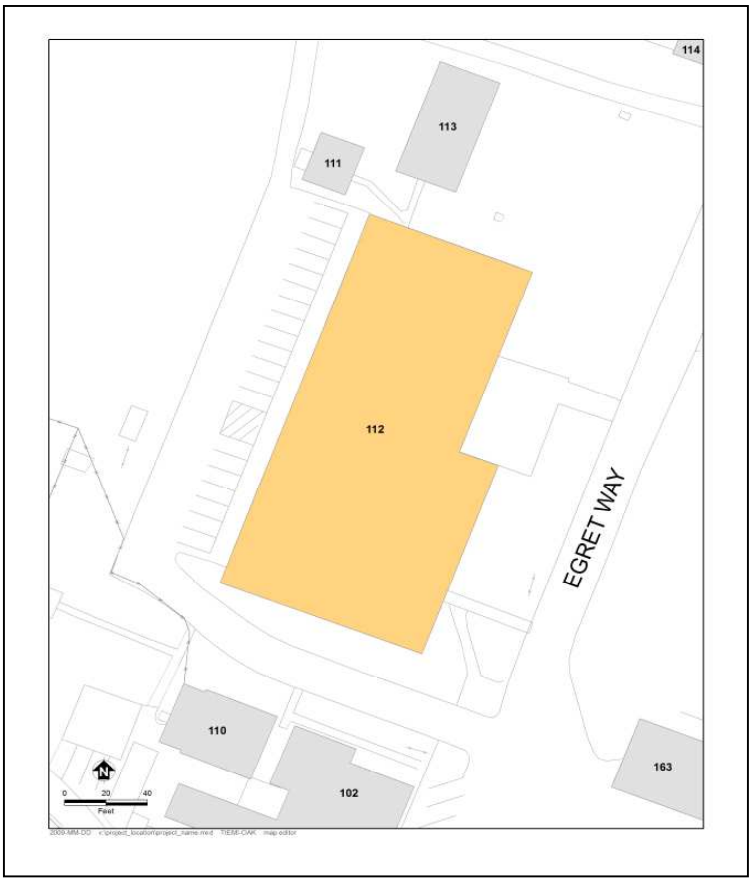
B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See Footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



P3a. Description (continued)

The building features landscaped areas in the front southeast side elevation that include mature trees along Egret Way. It is identified as the Center for Tissue Bioengineering. A small parking area is adjacent to its rear (northwest) elevation.

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[1] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[2] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[3]

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Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer,

[1] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[2] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[3] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[4] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[5] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[6] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 675.

[7] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[8] Hulanski p. 288.

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[9] Ida Mae Purcell, *History of Contra Costa County,* The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

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[14] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

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[16] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley:2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

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[24] Munro-Fraser, p. 424.

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During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[38] As the twentieth century progressed more heavy industry came to Contra Costa County, and by

[27] Oliver, p. 1.
[28] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913*, Dewey Publishing Company: 1913, p. 327.
[29] Oliver, p. 1.
[30] Oliver, p. 2.
[31] Hulanksi, p. 354.
[32] Halbert Powers Gillette, *Rock Excavation:Methods and Cost,* M.C. Clark, New York: 1904, x.
[33] Manual Eissler, *A Handbook on Modern Explosives*, Crosby, Lockwood & son, London: 1897, p. 117.
[34] University of California, *The University of California Chronicle*, University of California Press, January, 1917, p. 92.
[35] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.
[36] Pacific Mining News, p.222.
[37] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.
[38] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

1940 the county was second only to Los Angeles in overall industrial production.[39] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[40] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[41]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[42] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[43]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[44] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[45] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.[46]

Building 112

Building 112 was constructed in 1964 on the site of seven former California Cap Company buildings.[47] It is in the southeastern portion of the Richmond Field Station, where the early SERL activities were centered. The large building originally housed offices, classrooms, and laboratories.[48] It housed a wet chemistry laboratory as late as

[39] Purcell, p. 649.

[40] Oliver, p. 1.

[41] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[42] University of California, Berkeley, 2008, p. 13.

[43] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[44] McGauhey, p. 71.

[45] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

[46] University of California, Berkeley, 2008, p. 21.

[47] University of California, Berkeley, 2008, p. 149.

[48] University of California, Berkeley, 2008, p. 13.

2008, though at that time it was being phased out of use.[49] It is currently devoted to bioengineering and public health offices.[50]

Evaluation

The following provides an evaluation of Building 112 under each NRHP/CRHR criteria.

Building 112 does not appear to meet the criteria for listing in NRHP/CRHR because it lacks historical significance. The structure has served various functions throughout its lifetime and as such lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 and B/2).

The simple building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

[49] University of California, Berkeley, 2008, p. 25.

[50] Shackleton, 2013.

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 113

P1. Other Identifier: Richmond Field Station Building 113

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558507 mE/ 4196406 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 113 is in the southern portion of the Richmond Field Station. It is a 1,800 square foot prefabricated building, constructed in 1982. It is single story and rectangular in plan.
The building is topped with a very shallow pitched gable roof with large vents in the gables. Its walls are corrugated steel and lack fenestration. An industrial metal entrance door is centered in its southwest elevation and its northwest elevation features a large roll-up door. The building has large vents in the walls near the ground. It is surrounded by a grassy area and shrubbery. (See Continuation Sheet)

***P3b. Resource Attributes:** (List attributes and codes) HP4: Ancillary Building

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Northeast and northwest facades of building, camera facing south, January 4, 2012.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
1981/UC Berkeley records
***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804
***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612
***P9. Date Recorded:** January 4, 2013
***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

***NRHP Status Code** 6Z

***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 113

B1. Historic Name: _____
B2. Common Name: Building 113
B3. Original Use: Storage B4. Present Use: Storage
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed in 1982
***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 113 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet.)

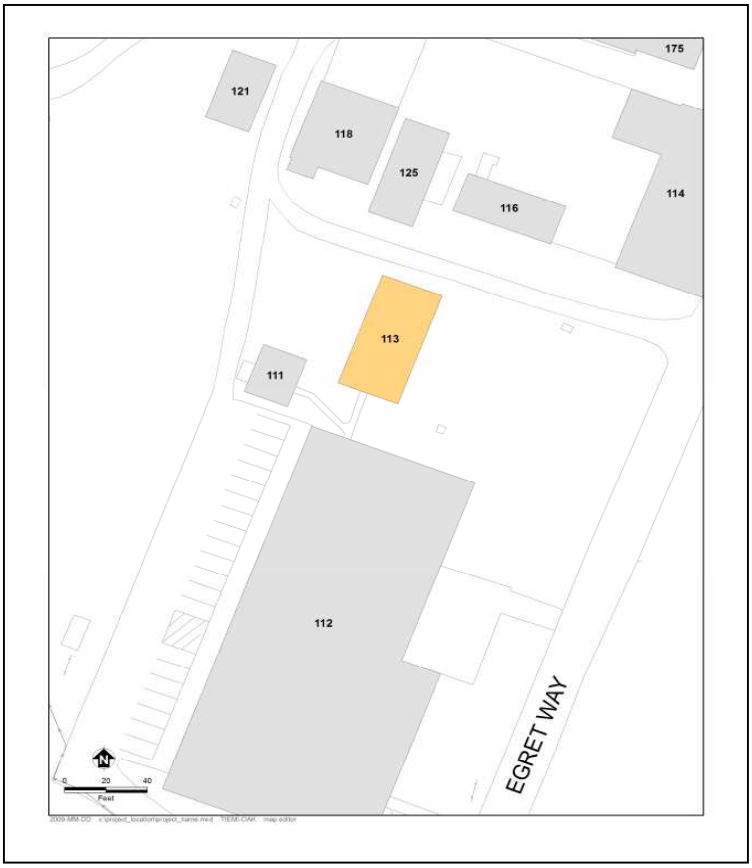
B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



P3a. Description (continued)

Building 113 was constructed in 1982 as a storage and support facility for SERL. The prefabricated steel building appears to have been assembled by Richmond Field Station maintenance workers, who also built its slab foundation.[1] Its use has continued unaltered. The building is not of historic age as it is 31 years old.

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[2] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[3] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[4]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[5] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[6] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[7] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[8] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[9] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer,

[1] University of California, Berkeley, File "Building 113," located in vertical files in Room 148, Richmond Field Station.

[2] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[3] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[4] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[5] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[6] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[7] J.P. Munro-Fraser, p. 675.

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During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[39] As the twentieth century progressed more heavy industry came to Contra Costa County, and by 1940 the county was second only to Los Angeles in overall industrial production.[40] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action

[29] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913*, Dewey Publishing Company: 1913, p. 327.
[30] Oliver, p. 1.
[31] Oliver, p. 2.
[32] Hulanksi, p. 354.
[33] Halbert Powers Gillette, *Rock Excavation:Methods and Cost*, M.C. Clark, New York: 1904, x.
[34] Manual Eissler, *A Handbook on Modern Explosives*, Crosby, Lockwood & son, London: 1897, p. 117.
[35] University of California, *The University of California Chronicle*, University of California Press, January, 1917, p. 92.
[36] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.
[37] Pacific Mining News, p.222.
[38] University of California, Berkeley, *Current Conditions Report*, Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.
[39] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.
[40] Purcell, p. 649.

incendiary bombs that were used against Japan.[41] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[42]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[43] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[44]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[45] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[46] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Evaluation

The following provides an evaluation of Building 113 under each NRHP/CRHR criteria.

Building 113 does not appear to meet the criteria for listing in NRHP/CRHR because it lacks historical significance. The structure has served as a storage facility throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 and B/2).

The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

[41] Oliver, p. 1.

[42] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[43] University of California, Berkeley, 2008, p. 13.

[44] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[45] McGauhey, p. 71.

[46] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

As a storage facility, Building 113 does not meet the standard of exceptional importance required for properties under 50 years old to be eligible to the NHRP (Criterion G).

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 114

P1. Other Identifier: Richmond Field Station Building 114

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558551 mE/ 4196433 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 114 is in the southern portion of the Richmond Field Station on the west side of Egret Road. Its primary façade faces northeast; it is an L-shaped, single story, with a one-and-one-half story wing, 4,523 square foot building constructed circa 1930. The one-and-one-half story of the building is topped with a front gabled roof that ties into a shed roof section at its southeast. Rafter tails and purlins are exposed at the eaves. The walls and roof are of corrugated metal. Most of the fenestration is multi-light, fixed, wood sashes. The main entrance, centered in the northeast elevation, has a wood paneled and replacement industrial door, both with windows. There is a large sliding door at the east end of the elevation. The doors are accessed by a concrete loading dock that has a set of wooden stairs in front of the main entrance. (See Continuation Sheet)
***P3b. Resource Attributes:** (List attributes and codes) HP4: Ancillary Building

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Northeast facade of building, camera facing west, January 4, 2013
***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Circa the 1930s/Sanborn maps
***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804
***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612
***P9. Date Recorded:** January 4, 2013
***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

B1. Historic Name: California Cap Company Building 81
B2. Common Name: Building 114
B3. Original Use: Unknown B4. Present Use: Storage
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed circa 1930s
Circa 1955: northwest addition constructed
***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 114 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet.)

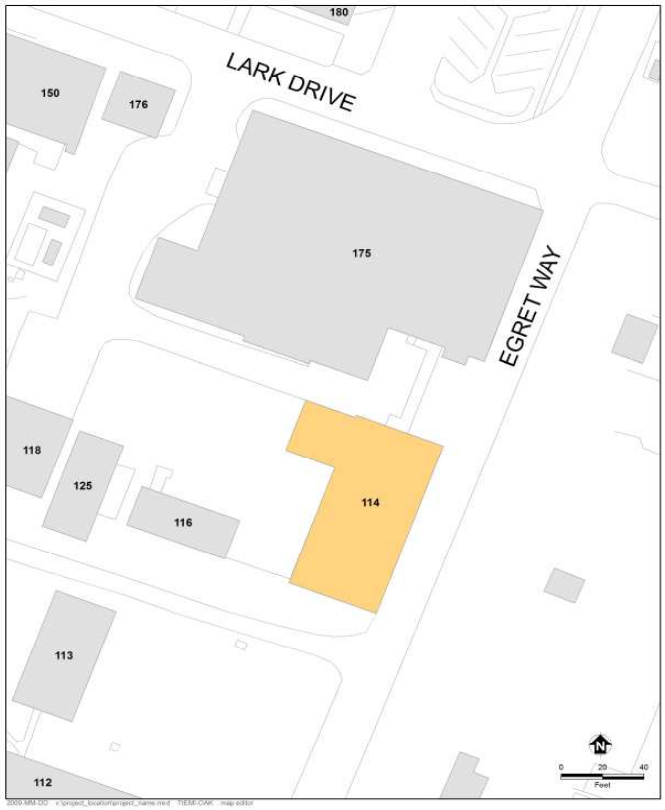
B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See Footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



P3a. Description (continued)

A single story, shed roof addition projects from the northwest end of the building. It features a large sliding door that faces northeast. A large opening on the southeast elevation appears to be sealed from the interior.

Building 114, originally labeled "Building 81" was constructed circa 1930 by the California Cap Company or the Pacific Cartridge Company. It was adjacent to the Pacific Cartridge Company's factory and was a warehouse for the cartridges produced there. The original building was rectangular in plan, oriented along Heron Drive. After UC Berkeley purchased the property in 1950, it used the warehouse to store building materials for use in building maintenance on the property.[1] Aerial photographs show that the University constructed an addition at the northwest end of the building circa 1955. The building is currently used for building maintenance equipment.

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[2] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[3] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[4]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[5] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[6] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[7] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were

[1] Shackleton, 2013.

[2] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[3] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[4] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[5] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[6] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[7] J.P. Munro-Fraser, p. 675.

operating from portions of the Stege Ranch.[8] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[9] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[10]

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its proximity to the harbor yet remote from population centers. In addition, the narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[11]

During the 1870s chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch. The San Francisco explosives companies soon followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to the Atlas Powder Company. The California Powder Works soon followed, building a new factory in Hercules, which was named for the brand under which the company sold its powder.[12] The Vulcan Powder Works and Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902 California had only one powder factory outside Contra Costa and Alameda counties.[13]

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory, which was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[14] William Letts Oliver and his wife Carrie lived in Oakland, from about 1880 until Oliver's death in 1918.[15] The couple eventually

[8] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[9] Hulanski p. 288.

[10] Ida Mae Purcell, *History of Contra Costa County*, The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

[11] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area*, University of California, Berkeley: 1964, p. 27.

[12] Purcell, p. 646.

[13] Richmond Record, "Contra Costa County: Under the Vitascope", Richmond:1902.

[14] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

[15] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[16] In addition his various professional activities William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the early twentieth century. An avid amateur photographer throughout his lifetime, UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[17]

William Letts Oliver initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[18] As early as 1870, European explosive companies were experimenting with nitrated guncotton in and by 1875 it was manufactured in England under the name "tonite."[19] By 1877 Oliver had left Chile and was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock needed an explosive that would remain stable at the high temperatures underground to complete the tunnel, and Oliver was able to solve the problem by substituting tonite for more volatile compounds.[20]

The California Cap Company

In 1877 William Letts Oliver was inspired by his success with tonite to leave mining and establish the Tonite Powder Company, on a portion of the former Stege Ranch.[21] In the 1870s all blasting caps in the United States had to be imported from Europe. Not only were they expensive, but the timing of deliveries was uncertain, creating business difficulties for the powder plant. Oliver was determined to create his own caps in order to protect the tonite factory business. He experimented until he came up with a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter founded the California Cap Company. It was located adjacent to the Tonite Powder Company a 160 acre parcel carved out of the southern portion of Stege Ranch.[22] California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[23] The California Cap Company was located on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

The Tonite and California Cap factories, which were the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[24] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882 at the nearby Vulcan Powder Company caused 11 deaths and destroyed the plant.[25] Between 1882 and 1918 the Hercules and Atlas plants suffered numerous

[16] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

[17] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley: 2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

[18] Pacific Mining News, p. 222.

[19] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.

[20] Pacific Mining News, p. 222.

[21] Oliver, p. 1.

[22] Pacific Mining News, p. 222.

[23] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.

[24] Oliver, p. 1.

[25] Munro-Fraser, p. 424.

explosions which destroyed plant buildings and killed a total of 64 workers.[26] Despite its focus on safety, the California Cap Company had accidents as well. Two of its Chinese workers were killed in 1917 when one of them dropped a tray of caps. In 1941 an explosion caused a fire and critically injured a worker.[27]

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888 he formed the American Lucol Company adjacent to the California Cap Company property.[28] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[29] The factory was dismantled and relocated to New Jersey circa 1900.[30] In 1903 the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field station property.[31] Later known as the U.S. Briquette Company, the plant appears to have operated at this location until at least 1917.[32] The U.S. Briquette Company buildings were demolished sometime in the 1960s.

The Oliver family aggressively promoted their products both through advertising and publishing. The California Cap Company sponsored or published both articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing as well as a selling point in advertisements.[33] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century the powder's explosive properties were considered comparable to the finest English products.[34] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family also became benefactors of the university, and in 1917 the California Cap Company donated substantial amounts of their products to the College of Mining including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[35]

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[26] Purcell, p. 648.

[27] Contra Costa County Standard, "Stege Powder Plant Blast; One Near Death", June 6, 1941, p. 1A.

[28] Oliver, p. 1.

[29] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913,* Dewey Publishing Company: 1913, p. 327.

[30] Oliver, p. 1.

[31] Oliver, p. 2.

[32] Hulanksi, p. 354.

[33] Halbert Powers Gillette, *Rock Excavation:Methods and Cost,* M.C. Clark, New York: 1904, x.

[34] Manual Eissler, *A Handbook on Modern Explosives,* Crosby, Lockwood & son, London: 1897, p. 117.

[35] University of California, *The University of California Chronicle,* University of California Press, January, 1917, p. 92.

[36] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915,* Oakland, California: 1915.

[37] Pacific Mining News, p.222.

[38] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

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At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[45] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[46] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Evaluation

The following provides an evaluation of Building 114 under each NRHP/CRHR criteria.

[39] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

[40] Purcell, p. 649.

[41] Oliver, p. 1.

[42] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[43] University of California, Berkeley, 2008, p. 13.

[44] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[45] McGauhey, p. 71.

[46] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

Building 114 does not appear to meet the criteria for listing in NRHP/CRHR because it lacks historical significance. The structure has primarily been used for storage throughout its lifetime and as such lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 and B/2).

The simple building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 116

P1. Other Identifier: Richmond Field Station Building 116

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5' Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; _Diablo_____ **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558525 mE/ 4196427 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 116 is in the southern portion of the Richmond Field Station. It is 967 square feet and was moved to its present location in 1964. The single story building is a rectangular, Butler Company prefabricated building topped with a front gabled roof. The walls and roof are corrugated metal. Fenestration is multi-light, fixed metal sashes, some of which are wire sashes. The entrance at the south end of the southeast elevation is a paneled wood door with a window. (See Continuation Sheet)

***P3b. Resource Attributes:** (List attributes and codes) HP4: Ancillary Building

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Southeast and northeast facades of building, camera facing southwest, January 4, 2013
***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Unknown
***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804
***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612
***P9. Date Recorded:** January 4, 2013
***P10. Survey Type:** (Describe) Intensive
***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

***NRHP Status Code** 6Z

***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 116

B1. Historic Name: _____
B2. Common Name: Building 116
B3. Original Use: Shop B4. Present Use: Shop
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Unknown
***B7. Moved?** ☐ **No** ☒ **Yes** ☐ **Unknown** **Date:** 1961 **Original Location:** UCB Campus
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 116 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet.)

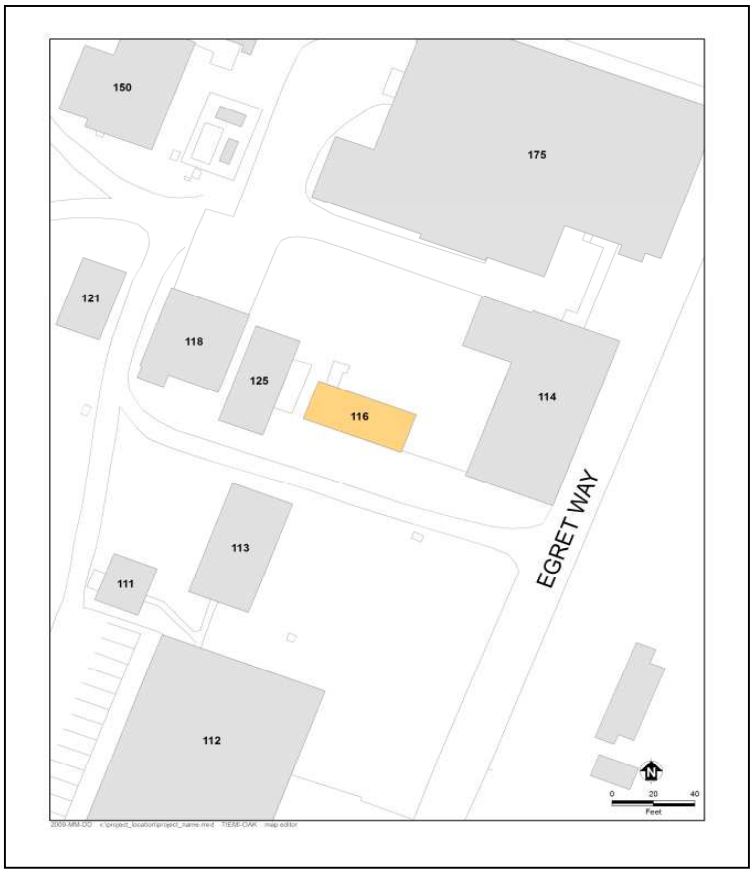
B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See Footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



P3a. Description (continued)

Building 116 was originally constructed on the UC Berkeley campus by the US Air Force. Its original construction date is unknown, but by 1961 it had outlived its purpose and the UC Regents decided to raze it. SERL had the building relocated to the Richmond Field Station at the end of 1961.[1] It has been used throughout its lifetime as a support and storage area.

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[2] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[3] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[4]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[5] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[6] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[7] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[8] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[9] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

[1] University of California, Berkeley, File "Building 116," located in vertical files in Room 148, Richmond Field Station.

[2] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[3] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[4] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[5] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[6] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[7] J.P. Munro-Fraser, p. 675.

[8] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[9] Hulanski p. 288.

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[10]

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its proximity to the harbor yet remote from population centers. In addition, the narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[11]

During the 1870s chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch. The San Francisco explosives companies soon followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to the Atlas Powder Company. The California Powder Works soon followed, building a new factory in Hercules, which was named for the brand under which the company sold its powder.[12] The Vulcan Powder Works and Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902 California had only one powder factory outside Contra Costa and Alameda counties.[13]

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory, which was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[14] William Letts Oliver and his wife Carrie lived in Oakland, from about 1880 until Oliver's death in 1918.[15] The couple eventually had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[16] In addition his various professional activities William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the

[10] Ida Mae Purcell, *History of Contra Costa County*, The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

[11] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area*, University of California, Berkeley: 1964, p. 27.

[12] Purcell, p. 646.

[13] Richmond Record, "Contra Costa County: Under the Vitascope", Richmond:1902.

[14] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

[15] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

[16] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

early twentieth century. An avid amateur photographer throughout his lifetime, UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[17]

William Letts Oliver initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[18] As early as 1870, European explosive companies were experimenting with nitrated guncotton in and by 1875 it was manufactured in England under the name "tonite."[19] By 1877 Oliver had left Chile and was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock needed an explosive that would remain stable at the high temperatures underground to complete the tunnel, and Oliver was able to solve the problem by substituting tonite for more volatile compounds.[20]

The California Cap Company

In 1877 William Letts Oliver was inspired by his success with tonite to leave mining and establish the Tonite Powder Company, on a portion of the former Stege Ranch.[21] In the 1870s all blasting caps in the United States had to be imported from Europe. Not only were they expensive, but the timing of deliveries was uncertain, creating business difficulties for the powder plant. Oliver was determined to create his own caps in order to protect the tonite factory business. He experimented until he came up with a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter founded the California Cap Company. It was located adjacent to the Tonite Powder Company a 160 acre parcel carved out of the southern portion of Stege Ranch.[22] California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[23] The California Cap Company was located on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

The Tonite and California Cap factories, which were the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[24] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882 at the nearby Vulcan Powder Company caused 11 deaths and destroyed the plant.[25] Between 1882 and 1918 the Hercules and Atlas plants suffered numerous explosions which destroyed plant buildings and killed a total of 64 workers.[26] Despite its focus on safety, the California Cap Company had accidents as well. Two of its Chinese workers were killed in 1917 when one of them dropped a tray of caps. In 1941 an explosion caused a fire and critically injured a worker.[27]

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[17] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley: 2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

[18] Pacific Mining News, p. 222.

[19] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.

[20] Pacific Mining News, p. 222.

[21] Oliver, p. 1.

[22] Pacific Mining News, p. 222.

[23] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.

[24] Oliver, p. 1.

[25] Munro-Fraser, p. 424.

[26] Purcell, p. 648.

[27] Contra Costa County Standard, "Stege Powder Plant Blast; One Near Death", June 6, 1941, p. 1A.

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888 he formed the American Lucol Company adjacent to the California Cap Company property.[28] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[29] The factory was dismantled and relocated to New Jersey circa 1900.[30] In 1903 the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field station property.[31] Later known as the U.S. Briquette Company, the plant appears to have operated at this location until at least 1917.[32] The U.S. Briquette Company buildings were demolished sometime in the 1960s.

The Oliver family aggressively promoted their products both through advertising and publishing. The California Cap Company sponsored or published both articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing as well as a selling point in advertisements.[33] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century the powder's explosive properties were considered comparable to the finest English products.[34] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family also became benefactors of the university, and in 1917 the California Cap Company donated substantial amounts of their products to the College of Mining including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[35]

Eventually the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[36] By 1916 there were at least a dozen buildings on the site. When Oliver died in 1918 his son Roland Oliver took over as president of California Cap Company. By 1922 Roland's brother Leslie Oliver was assistant manager of the plant and Edwin Letts Oliver was a director.[37] Roland Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[38]

During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[39] As the twentieth century progressed more heavy industry came to Contra Costa County, and by

[28] Oliver, p. 1.
[29] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913*, Dewey Publishing Company: 1913, p. 327.
[30] Oliver, p. 1.
[31] Oliver, p. 2.
[32] Hulanksi, p. 354.
[33] Halbert Powers Gillette, *Rock Excavation:Methods and Cost*, M.C. Clark, New York: 1904, x.
[34] Manual Eissler, *A Handbook on Modern Explosives*, Crosby, Lockwood & son, London: 1897, p. 117.
[35] University of California, *The University of California Chronicle*, University of California Press, January, 1917, p. 92.
[36] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.
[37] Pacific Mining News, p.222.
[38] University of California, Berkeley, *Current Conditions Report*, Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.
[39] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

1940 the county was second only to Los Angeles in overall industrial production.[40] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[41] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[42]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[43] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[44]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[45] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[46] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Evaluation

The following provides an evaluation of Building 116 under each NRHP/CRHR criteria.

Building 116 does not appear to meet the criteria for listing in NRHP/CRHR because it lacks historical significance. The structure has primarily been used for storage throughout its lifetime and as such lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 and B/2).

[40] Purcell, p. 649.

[41] Oliver, p. 1.

[42] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[43] University of California, Berkeley, 2008, p. 13.

[44] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[45] McGauhey, p. 71.

[46] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

The utilitarian prefabricated building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 117

P1. Other Identifier: Richmond Field Station Building 117

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)

***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**

c. Address _____ City _____ Zip_____

d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558618 mE/ 4196446 mN

e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)

Building 117 is along the southeastern border of the Richmond Field Station. It is a single story and rectangular in plan. The building is topped with a front gabled roof that has exposed wood rafter tails and purlins at the eaves. The walls and roof are corrugated metal. Fenestration is fixed wood sashes. The entrance at the north end of the northwest elevation is double paneled wood doors with windows. Building 117's construction date is unknown. Aerial photographs show it was moved to its present location circa 1990. Its materials indicate that it was constructed prior to 1950 during the California Cap Company era, but research failed to reveal its original use and location. It was used as a maintenance shop in the 1990s and is currently used for storage and support.

***P3b. Resource Attributes:** (List attributes and codes) HP4: Ancillary Building

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Northwest and southwest facades of building, camera facing west, January 4, 2013

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Unknown

***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804

***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** January 4, 2013

***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

BUILDING, STRUCTURE, AND OBJECT RECORD

***NRHP Status Code** 6Z

***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 117

B1. Historic Name: _____

B2. Common Name: Building 117

B3. Original Use: Unknown B4. Present Use: Storage

***B5. Architectural Style:** Vernacular

***B6. Construction History:** (Construction date, alteration, and date of alterations) Construction date unknown, moved circa 1990

***B7. Moved?** ☐ **No** ☒ **Yes** ☐ **Unknown** **Date:** 1990 **Original Location:** Unknown

***B8. Related Features:** _____

B9. Architect: Unknown b. Builder: Unknown

***B10. Significance: Theme** N/A **Area** N/A

Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A

(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 117 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR).

B11. Additional Resource Attributes: (List attributes and codes)

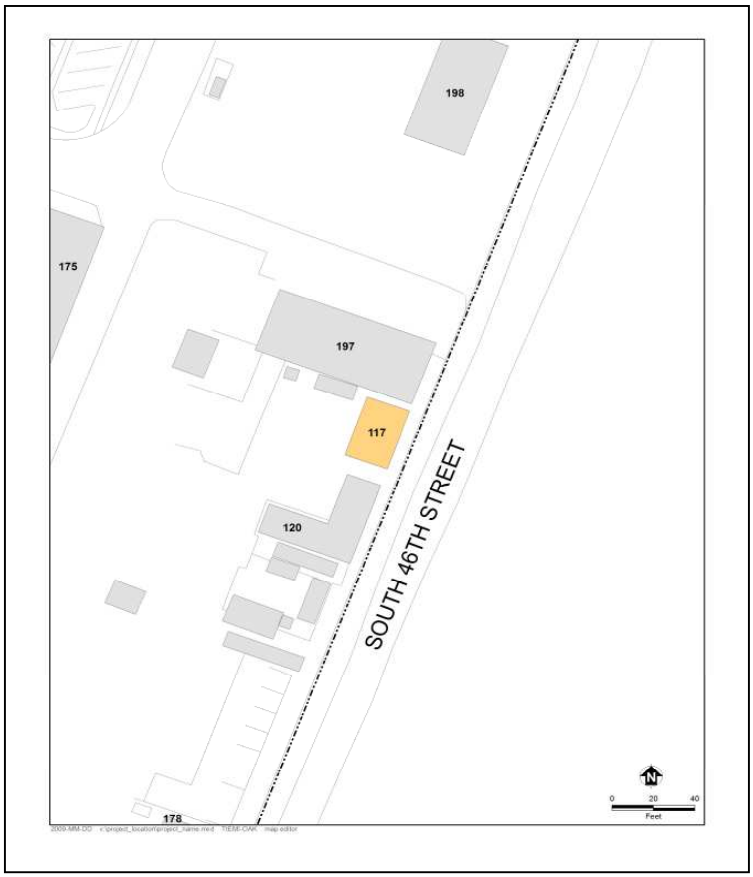
***B12. References:** See Footnotes

B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



B10. Significance (continued)

Historic Context

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[13] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

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[18] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.

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The California Cap Company

In 1877 William Letts Oliver was inspired by his success with tonite to leave mining and establish the Tonite Powder Company, on a portion of the former Stege Ranch.[20] In the 1870s all blasting caps in the United States had to be imported from Europe. Not only were they expensive, but the timing of deliveries was uncertain, creating business difficulties for the powder plant. Oliver was determined to create his own caps in order to protect the tonite factory business. He experimented until he came up with a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter founded the California Cap Company. It was located adjacent to the Tonite Powder Company a 160 acre parcel carved out of the southern portion of Stege Ranch.[21] California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[22] The California Cap Company was located on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

The Tonite and California Cap factories, which were the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[23] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882 at the nearby Vulcan Powder Company caused 11 deaths and destroyed the plant.[24] Between 1882 and 1918 the Hercules and Atlas plants suffered numerous explosions which destroyed plant buildings and killed a total of 64 workers.[25] Despite its focus on safety, the California Cap Company had accidents as well. Two of its Chinese workers were killed in 1917 when one of them dropped a tray of caps. In 1941 an explosion caused a fire and critically injured a worker.[26]

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888 he formed the American Lucol Company adjacent to the California Cap Company property.[27] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[28] The factory was dismantled and relocated to New Jersey circa 1900.[29] In 1903 the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field station property.[30] Later known as the U.S. Briquette Company, the plant appears to have

[19] Pacific Mining News, p. 222.
[20] Oliver, p. 1.
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[23] Oliver, p. 1.
[24] Munro-Fraser, p. 424.
[25] Purcell, p. 648.
[26] Contra Costa County Standard, "Stege Powder Plant Blast; One Near Death", June 6, 1941, p. 1A.
[27] Oliver, p. 1.
[28] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913*, Dewey Publishing Company: 1913, p. 327.
[29] Oliver, p. 1.
[30] Oliver, p. 2.

operated at this location until at least 1917.[31] The U.S. Briquette Company buildings were demolished sometime in the 1960s.

The Oliver family aggressively promoted their products both through advertising and publishing. The California Cap Company sponsored or published both articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing as well as a selling point in advertisements.[32] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century the powder's explosive properties were considered comparable to the finest English products.[33] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family also became benefactors of the university, and in 1917 the California Cap Company donated substantial amounts of their products to the College of Mining including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[34]

Eventually the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[35] By 1916 there were at least a dozen buildings on the site. When Oliver died in 1918 his son Roland Oliver took over as president of California Cap Company. By 1922 Roland's brother Leslie Oliver was assistant manager of the plant and Edwin Letts Oliver was a director.[36] Roland Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[37]

During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[38] As the twentieth century progressed more heavy industry came to Contra Costa County, and by 1940 the county was second only to Los Angeles in overall industrial production.[39] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[40] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the

[31] Hulanksi, p. 354.

[32] Halbert Powers Gillette, *Rock Excavation:Methods and Cost,* M.C. Clark, New York: 1904, x.

[33] Manual Eissler, *A Handbook on Modern Explosives,* Crosby, Lockwood & son, London: 1897, p. 117.

[34] University of California, *The University of California Chronicle,* University of California Press, January, 1917, p. 92.

[35] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.

[36] Pacific Mining News, p.222.

[37] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

[38] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

[39] Purcell, p. 649.

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department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[41]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[42] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[43]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[44] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[45] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Evaluation

The following provides an evaluation of Building 117 under each NRHP/CRHR criteria.

Building 117 does not appear to meet the criteria for listing in NHRP/CRHR because it lacks historical significance. The structure has served various functions throughout its lifetime and as such lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 and B/2).

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[42] University of California, Berkeley, 2008, p. 13.

[43] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[44] McGauhey, p. 71.

[45] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 118

P1. Other Identifier: Richmond Field Station Building 118

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5' Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558500 mE/ 4196438 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 118 is in the southern portion of the Richmond Field Station. It is west of Egret Way and adjacent to Building 125 with its primary façade facing northeast. The utilitarian building does not express any particular architectural style. It is 1,708 square feet and was constructed prior to 1940. It is a single story building with a rectangular plan. (See Continuation Sheet)
***P3b. Resource Attributes:** (List attributes and codes) HP4: Ancillary Building

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Southeast and northeast facades of building, camera facing west, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Circa 1930s/UC Berkeley records
***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804
***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612
***P9. Date Recorded:** January 4, 2013
***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

B1. Historic Name: California Cap Company Building 149
B2. Common Name: Building 118
B3. Original Use: Fuel Oil Boiler B4. Present Use: Art practice
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed circa 1930s, dates of alterations unknown
***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 118 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet.)

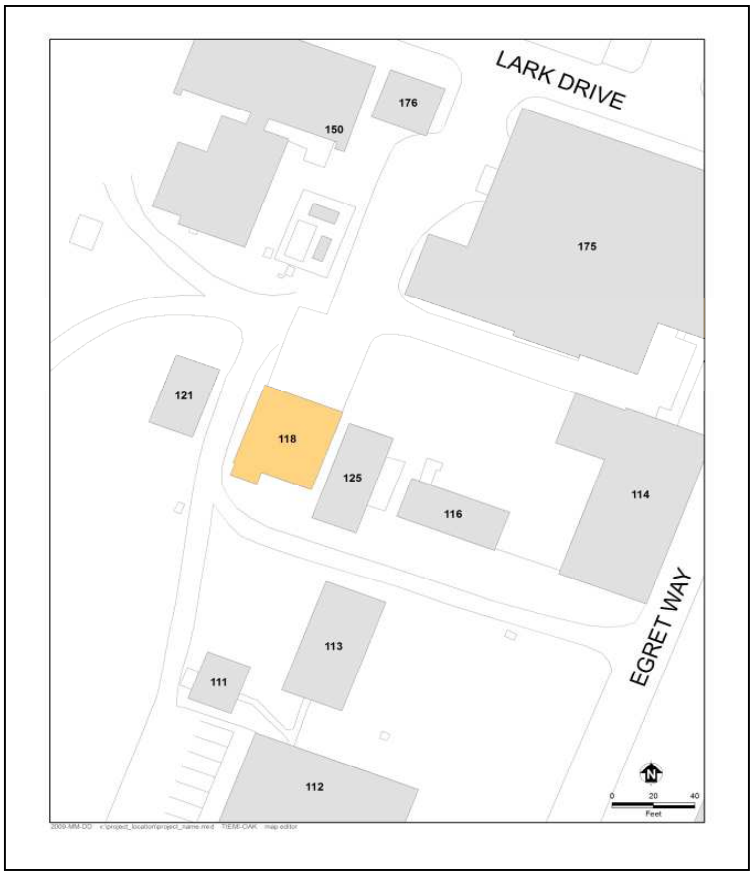
B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See Footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



P3a. Description (continued)

The building is topped with a very shallow pitched roof with minimal eave overhang. The walls are clad in roof paper. Fenestration is a single multi-light, fixed wood sash adjacent to the primary entrance, and a single aluminum sliding sash at the rear (southwest) elevation. The primary entrance, at the east end of the northeast elevation, is a wood paneled door with a window. A large metal roll up door is centered in the façade.

The secondary entrance is sliding doors at the south end of the northwest elevation. A low shed roofed addition at the rear corner of the building has another wood paneled door, and a southwest facing window.

Building 118, originally labeled "Building 149" was constructed circa the 1930s by the California Cap Company. The building was constructed to house the fuel oil boiler for the plant. After UC Berkeley purchased the property in 1950, the building was used as a fire test research area and maintenance shop. Fire safety research studies were done at Richmond Field Station to determine the safety of a variety of products including plastics and airplane restrooms.[1] Building 118 also housed the plumbing shop for the Richmond Field Station until 2009. It is currently used as an art facility for graduate students.[2] The wood siding has been covered with roof paper. A small addition at the southwest corner was constructed in the modern period. Dates for these alterations are unknown.

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[3] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[4] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[5]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[6] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[7] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields

[1] University of California, Berkeley, 2008, p. 14.

[2] Shackleton, 2013.

[3] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[4] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[5] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[6] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[7] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[8] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[9] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[10] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[11]

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its proximity to the harbor yet remote from population centers. In addition, the narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[12]

During the 1870s chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch. The San Francisco explosives companies soon followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to the Atlas Powder Company. The California Powder Works soon followed, building a new factory in Hercules, which was named for the brand under which the company sold its powder.[13] The Vulcan Powder Works and Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902 California had only one powder factory outside Contra Costa and Alameda counties.[14]

William Letts Oliver

[8] J.P. Munro-Fraser, p. 675.

[9] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[10] Hulanski p. 288.

[11] Ida Mae Purcell, *History of Contra Costa County*, The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

[12] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area*, University of California, Berkeley: 1964, p. 27.

[13] Purcell, p. 646.

[14] Richmond Record, "Contra Costa County: Under the Vitascope", Richmond:1902.

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory, which was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[15] William Letts Oliver and his wife Carrie lived in Oakland, from about 1880 until Oliver's death in 1918.[16] The couple eventually had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[17] In addition his various professional activities William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the early twentieth century. An avid amateur photographer throughout his lifetime, UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[18]

William Letts Oliver initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[19] As early as 1870, European explosive companies were experimenting with nitrated guncotton in and by 1875 it was manufactured in England under the name "tonite."[20] By 1877 Oliver had left Chile and was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock needed an explosive that would remain stable at the high temperatures underground to complete the tunnel, and Oliver was able to solve the problem by substituting tonite for more volatile compounds.[21]

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[15] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

[16] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

[17] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

[18] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley: 2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

[19] Pacific Mining News, p. 222.

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[21] Pacific Mining News, p. 222.

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[25] Oliver, p. 1.
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[30] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913*, Dewey Publishing Company: 1913, p. 327.
[31] Oliver, p. 1.
[32] Oliver, p. 2.
[33] Hulanksi, p. 354.
[34] Halbert Powers Gillette, *Rock Excavation:Methods and Cost*, M.C. Clark, New York: 1904, x.
[35] Manual Eissler, *A Handbook on Modern Explosives*, Crosby, Lockwood & son, London: 1897, p. 117.
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[41] Purcell, p. 649.

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[44] University of California, Berkeley, 2008, p. 13.

[45] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[46] McGauhey, p. 71.

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[47] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 120

P1. Other Identifier: Richmond Field Station Building 120

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; _Diablo____ **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558606 mE/ 4196431 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 120 is along the southeastern border of the Richmond Field Station. It is set back from Egret Way adjacent to building 117. The utilitarian building does not express any architectural style. It is 269 square feet and was constructed in 1967. It is single story and rectangular in plan. The building is topped with a shed roof. The walls and roof are corrugated metal, and the building lacks fenestration. The only entrances to the building are large openings on its northeast elevation that are covered with a metal construction fence.

***P3b. Resource Attributes:** (List attributes and codes) HP4: Ancillary Building

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Northeast and northwest facades of building, camera facing east, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
1967/UC Berkeley records

***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804

***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** January 4, 2013

***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

B1. Historic Name: _____
B2. Common Name: Building 120
B3. Original Use: Unknown B4. Present Use: Storage
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed in 1967
***B7. Moved?** ☐ **No** ☒ **Yes** ☐ **Unknown** **Date:** circa 1990 **Original Location:** Unknown
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 120 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet.)

B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See Footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)

P3a. Description (continued)

This building was constructed in 1967. During the 1960s and 1970s an incinerator burned garbage at this location.[1] Aerial photographs show that Building 120 was moved to its present location circa 1990. Research failed to reveal the building's original location. It was used as a solvent storage shed in the 1990s. Currently, drums containing waste petroleum products are stored in the building.[2]

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[3] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[4] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[5]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[6] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[7] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[8] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[9] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[10] Stege was eventually absorbed into Richmond as the latter grew.

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[1] Shackleton, 2013.

[2] University of California, Berkeley, 2008, p. 28.

[3] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[4] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[5] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[6] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[7] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[8] J.P. Munro-Fraser, p. 675.

[9] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[10] Hulanski p. 288.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[11]

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its proximity to the harbor yet remote from population centers. In addition, the narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[12]

During the 1870s chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch. The San Francisco explosives companies soon followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to the Atlas Powder Company. The California Powder Works soon followed, building a new factory in Hercules, which was named for the brand under which the company sold its powder.[13] The Vulcan Powder Works and Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902 California had only one powder factory outside Contra Costa and Alameda counties.[14]

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory, which was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[15] William Letts Oliver and his wife Carrie lived in Oakland, from about 1880 until Oliver's death in 1918.[16] The couple eventually had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[17] In addition his various professional activities William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the

[11] Ida Mae Purcell, *History of Contra Costa County*, The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

[12] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area*, University of California, Berkeley: 1964, p. 27.

[13] Purcell, p. 646.

[14] Richmond Record, "Contra Costa County: Under the Vitascope", Richmond:1902.

[15] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

[16] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

[17] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

early twentieth century. An avid amateur photographer throughout his lifetime, UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[18]

William Letts Oliver initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[19] As early as 1870, European explosive companies were experimenting with nitrated guncotton in and by 1875 it was manufactured in England under the name "tonite."[20] By 1877 Oliver had left Chile and was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock needed an explosive that would remain stable at the high temperatures underground to complete the tunnel, and Oliver was able to solve the problem by substituting tonite for more volatile compounds.[21]

The California Cap Company

In 1877 William Letts Oliver was inspired by his success with tonite to leave mining and establish the Tonite Powder Company, on a portion of the former Stege Ranch.[22] In the 1870s all blasting caps in the United States had to be imported from Europe. Not only were they expensive, but the timing of deliveries was uncertain, creating business difficulties for the powder plant. Oliver was determined to create his own caps in order to protect the tonite factory business. He experimented until he came up with a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter founded the California Cap Company. It was located adjacent to the Tonite Powder Company a 160 acre parcel carved out of the southern portion of Stege Ranch.[23] California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[24] The California Cap Company was located on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

The Tonite and California Cap factories, which were the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[25] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882 at the nearby Vulcan Powder Company caused 11 deaths and destroyed the plant.[26] Between 1882 and 1918 the Hercules and Atlas plants suffered numerous explosions which destroyed plant buildings and killed a total of 64 workers.[27] Despite its focus on safety, the California Cap Company had accidents as well. Two of its Chinese workers were killed in 1917 when one of them dropped a tray of caps. In 1941 an explosion caused a fire and critically injured a worker.[28]

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[18] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley: 2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

[19] Pacific Mining News, p. 222.

[20] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.

[21] Pacific Mining News, p. 222.

[22] Oliver, p. 1.

[23] Pacific Mining News, p. 222.

[24] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.

[25] Oliver, p. 1.

[26] Munro-Fraser, p. 424.

[27] Purcell, p. 648.

[28] Contra Costa County Standard, "Stege Powder Plant Blast; One Near Death", June 6, 1941, p. 1A.

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888 he formed the American Lucol Company adjacent to the California Cap Company property.[29] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[30] The factory was dismantled and relocated to New Jersey circa 1900.[31] In 1903 the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field station property.[32] Later known as the U.S. Briquette Company, the plant appears to have operated at this location until at least 1917.[33] The U.S. Briquette Company buildings were demolished sometime in the 1960s.

The Oliver family aggressively promoted their products both through advertising and publishing. The California Cap Company sponsored or published both articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing as well as a selling point in advertisements.[34] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century the powder's explosive properties were considered comparable to the finest English products.[35] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family also became benefactors of the university, and in 1917 the California Cap Company donated substantial amounts of their products to the College of Mining including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[36]

Eventually the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[37] By 1916 there were at least a dozen buildings on the site. When Oliver died in 1918 his son Roland Oliver took over as president of California Cap Company. By 1922 Roland's brother Leslie Oliver was assistant manager of the plant and Edwin Letts Oliver was a director.[38] Roland Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[39]

During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[40] As the twentieth century progressed more heavy industry came to Contra Costa County, and by

[29] Oliver, p. 1.
[30] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913*, Dewey Publishing Company: 1913, p. 327.
[31] Oliver, p. 1.
[32] Oliver, p. 2.
[33] Hulanksi, p. 354.
[34] Halbert Powers Gillette, *Rock Excavation:Methods and Cost*, M.C. Clark, New York: 1904, x.
[35] Manual Eissler, *A Handbook on Modern Explosives*, Crosby, Lockwood & son, London: 1897, p. 117.
[36] University of California, *The University of California Chronicle*, University of California Press, January, 1917, p. 92.
[37] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.
[38] Pacific Mining News, p.222.
[39] University of California, Berkeley, *Current Conditions Report*, Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.
[40] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

1940 the county was second only to Los Angeles in overall industrial production.[41] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[42] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[43]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[44] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[45]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[46] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[47] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Evaluation

The following provides an evaluation of Building 120 under each NRHP/CRHR criteria.

Building 120 does not appear to meet the criteria for listing in NRHP/CRHR because it lacks historical significance. The structure has been used for storage throughout its lifetime and as such lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 and B/2).

[41] Purcell, p. 649.

[42] Oliver, p. 1.

[43] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[44] University of California, Berkeley, 2008, p. 13.

[45] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[46] McGauhey, p. 71.

[47] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 121

P1. Other Identifier: Richmond Field Station Building 121

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558484 mE/ 4196446 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 121 is in the southern portion of the Richmond Field Station. The utilitarian building does not express any architectural style. It is 728 square feet and was constructed in 1982. It is single story and rectangular in plan. The building is topped with a front gabled roof, with exposed rafter tails at the eaves. The walls and roof are corrugated metal. It lacks fenestration. The only opening is a roll up garage door on the northeast elevation. Building 121 was constructed circa 1970, as shown by aerial photographs. It was constructed as a garage for the storage of lawn equipment. The roll up garage door was added at an unknown date. The UC Berkeley Solar Powered Vehicle Club began using it for storage circa 2009.

***P3b. Resource Attributes:** (List attributes and codes) HP4: Ancillary Building

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Northeast and northwest facades of building, camera facing southwest, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Circa 1970/Aerial photographs

***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804

***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** January 4, 2013

***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

B1. Historic Name: _____
B2. Common Name: Building 121
B3. Original Use: Storage B4. Present Use: Storage
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed circa 1970
***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 121 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet.)

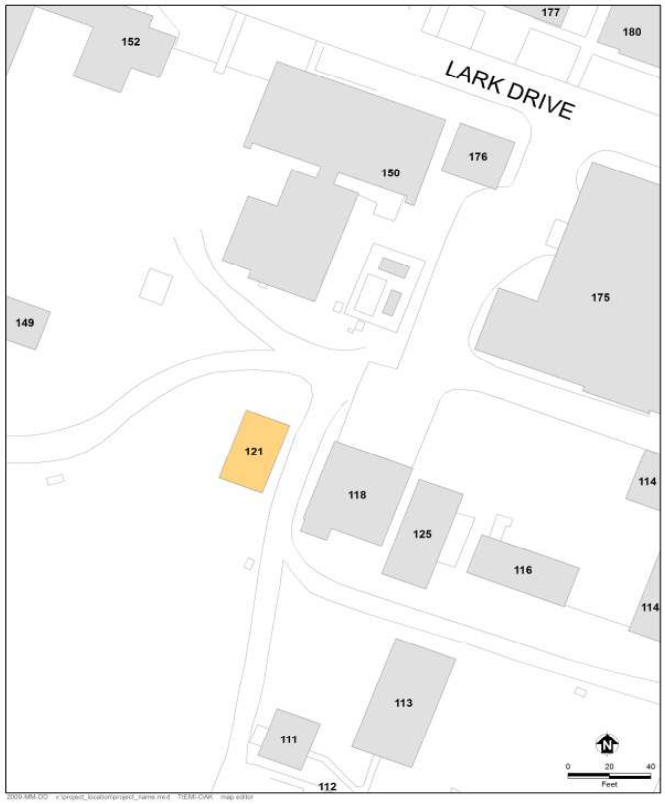
B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See Footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[1] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[2] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[3]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[4] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[5] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[6] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[7] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[8] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[9]

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[1] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[2] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[3] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[4] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[5] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[6] J.P. Munro-Fraser, p. 675.

[7] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[8] Hulanski p. 288.

[9] Ida Mae Purcell, *History of Contra Costa County*, The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

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William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory, which was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[13] William Letts Oliver and his wife Carrie lived in Oakland, from about 1880 until Oliver's death in 1918.[14] The couple eventually had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[15] In addition his various professional activities William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the early twentieth century. An avid amateur photographer throughout his lifetime, UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[16]

William Letts Oliver initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[17] As early as 1870, European explosive companies were experimenting with nitrated guncotton in and by 1875 it was manufactured in England under the name "tonite."[18] By 1877 Oliver had left Chile and was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock

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[14] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

[15] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

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The California Cap Company

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The Tonite and California Cap factories, which were the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[23] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882 at the nearby Vulcan Powder Company caused 11 deaths and destroyed the plant.[24] Between 1882 and 1918 the Hercules and Atlas plants suffered numerous explosions which destroyed plant buildings and killed a total of 64 workers.[25] Despite its focus on safety, the California Cap Company had accidents as well. Two of its Chinese workers were killed in 1917 when one of them dropped a tray of caps. In 1941 an explosion caused a fire and critically injured a worker.[26]

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888 he formed the American Lucol Company adjacent to the California Cap Company property.[27] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[28] The factory was dismantled and relocated to New Jersey circa 1900.[29] In 1903 the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field station property.[30] Later known as the U.S. Briquette Company, the plant appears to have

[19] Pacific Mining News, p. 222.
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[28] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913*, Dewey Publishing Company: 1913, p. 327.
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[30] Oliver, p. 2.

operated at this location until at least 1917.[31] The U.S. Briquette Company buildings were demolished sometime in the 1960s.

The Oliver family aggressively promoted their products both through advertising and publishing. The California Cap Company sponsored or published both articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing as well as a selling point in advertisements.[32] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century the powder's explosive properties were considered comparable to the finest English products.[33] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family also became benefactors of the university, and in 1917 the California Cap Company donated substantial amounts of their products to the College of Mining including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[34]

Eventually the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[35] By 1916 there were at least a dozen buildings on the site. When Oliver died in 1918 his son Roland Oliver took over as president of California Cap Company. By 1922 Roland's brother Leslie Oliver was assistant manager of the plant and Edwin Letts Oliver was a director.[36] Roland Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[37]

During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[38] As the twentieth century progressed more heavy industry came to Contra Costa County, and by 1940 the county was second only to Los Angeles in overall industrial production.[39] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[40] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the

[31] Hulanksi, p. 354.

[32] Halbert Powers Gillette, *Rock Excavation:Methods and Cost,* M.C. Clark, New York: 1904, x.

[33] Manual Eissler, *A Handbook on Modern Explosives,* Crosby, Lockwood & son, London: 1897, p. 117.

[34] University of California, *The University of California Chronicle,* University of California Press, January, 1917, p. 92.

[35] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.

[36] Pacific Mining News, p.222.

[37] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

[38] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

[39] Purcell, p. 649.

[40] Oliver, p. 1.

department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[41]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[42] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[43]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[44] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[45] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Evaluation

The following provides an evaluation of Building 121 under each NRHP/CRHR criteria.

Building 121 does not appear to meet the criteria for listing in NRHP/CRHR because it lacks historical significance. The structure has been used for vehicle storage throughout its lifetime and as such lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 and B/2).

The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

Criterion G: As a vehicle storage facility, Building 121 does not meet the standard of exceptional importance required for properties less than 50 years old to be eligible to the NHRP.

[41] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[42] University of California, Berkeley, 2008, p. 13.

[43] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[44] McGauhey, p. 71.

[45] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 125

P1. Other Identifier: Richmond Field Station Building 125

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted**

***a. County** Contra Costa

and (P2b and P2c or P2d. Attach a Location Map as necessary.)

***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**

c. Address _____ City _____ Zip_____

d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558509 mE/ 4196433 mN

e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)

Building 125 is in the southern portion of the Richmond Field Station. It is west of Egret Way and between to Building 116 and Building 118 with its primary façade facing northeast. The vernacular building does not express any particular architectural style. It is 1,024 square feet and was constructed prior to 1940. It is single story and rectangular in plan. (See continuation sheet)

***P3b. Resource Attributes:** (List attributes and codes) HP4: Ancillary Building

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Northeast and southeast facades of building, camera facing southwest, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Circa 1930s/UC Berkeley records

***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804

***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** January 4, 2013

***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

B1. Historic Name: California Cap Company Building 24
B2. Common Name: Building 125
B3. Original Use: Storage B4. Present Use: Storage
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed circa 1930
***B7. Moved?** ☐ **No** ☒ **Yes** ☐ **Unknown** **Date:** 1998 **Original Location:** Building 102 area
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 125 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet.)

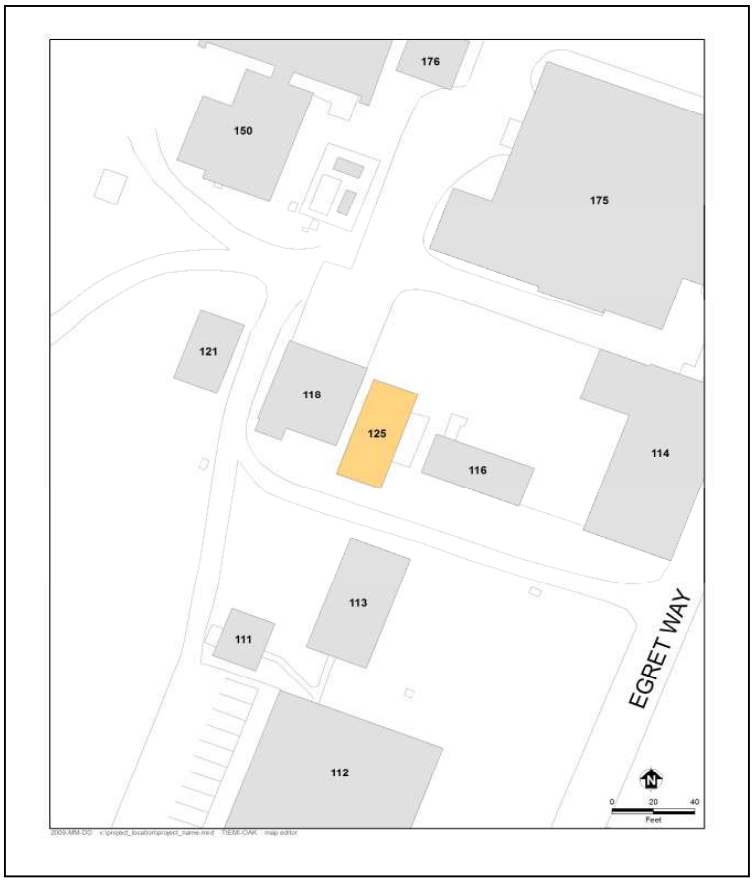
B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See Footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



*P3a. Description: (continued)

The building is topped with a front gabled roof, and purlins are exposed at the minimal eaves on the front (northeast) and rear (southwest) elevations. Both gables are adorned with simple, decorative, stickwork trusses. The walls and roof are corrugated metal. Fenestration throughout the building is multi- light, wood sashes. The wide primary entrance is fitted with a flush door and reached by a wooden ramp leading to a small deck at the front of the building. The rear (southwest) door is flush, and accessed by a set of wooden stairs.

Building 125, originally labeled "Building 24," was constructed circa 1930 by the California Cap Company. It was adjacent to the plant's mercury fulminate production facility (near Building 102) and was used as an alcohol warehouse. After UC Berkeley purchased the property in 1950 the building was initially used as a composting facility.[1] During the 1960s SERL used the building for a laboratory and shop. It was moved to its current location as part of an environmental remediation project in 1998. It is currently used as a bioengineering research facility.[2]

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[3] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[4] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[5]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[6] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[7] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[8] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's

[1] University of California, Berkeley, 2008, p. 196.

[2] Shackleton, 2013.

[3] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[4] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[5] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[6] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[7] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[8] J.P. Munro-Fraser, p. 675.

holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[9] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[10] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[11]

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its proximity to the harbor yet remote from population centers. In addition, the narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[12]

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[9] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[10] Hulanski p. 288.

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[30] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913,* Dewey Publishing Company: 1913, p. 327.
[31] Oliver, p. 1.
[32] Oliver, p. 2.
[33] Hulanksi, p. 354.
[34] Halbert Powers Gillette, *Rock Excavation:Methods and Cost,* M.C. Clark, New York: 1904, x.
[35] Manual Eissler, *A Handbook on Modern Explosives,* Crosby, Lockwood & son, London: 1897, p. 117.
[36] University of California, *The University of California Chronicle,* University of California Press, January, 1917, p. 92.
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[38] Pacific Mining News, p.222.

Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[39]

During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[40] As the twentieth century progressed more heavy industry came to Contra Costa County, and by 1940 the county was second only to Los Angeles in overall industrial production.[41] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[42] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[43]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[44] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[45]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[46] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[47] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

[39] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

[40] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

[41] Purcell, p. 649.

[42] Oliver, p. 1.

[43] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[44] University of California, Berkeley, 2008, p. 13.

[45] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[46] McGauhey, p. 71.

[47] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

Evaluation

The following provides an evaluation of Building 125 under each NRHP/CRHR criteria.

No particular association was found between the Building 125 and events significant to national, state, or local history (Criterion A/1) Although the California Cap Company was the first blasting cap manufacturer in the United States there is no indication that Building 125, a warehouse building, was central to the development of the plant or its technical processes. Therefore the building is not eligible for inclusion in the NRHP/CRHR for historical significance.

Although William Letts Oliver and his son Roland Oliver were significant in the history of the explosives industry, no particular association was found between the Oliver family and the building. Therefore it lacks the strength of association necessary to be considered historically significant in relation to any particular persons (Criteria B/2).

The building does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values (Criterion C/3). Building 125 is a vernacular building of a type that was commonly constructed from the late nineteenth to the early twentieth century and is not located in its original location. Therefore the building is not eligible to the NHRP for its architecture.

In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 128

P1. Other Identifier: Richmond Field Station Building 128

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558356 mE/ 4196398 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 128 is in the southwestern portion of the Richmond Field Station, along Heron Drive, adjacent to the Environmental Protection Agency building. The vernacular building does not clearly express any particular architectural style. It is 10,287 square feet, constructed circa 1930, single story, and has an irregular plan.

The building is topped with a shallow, pitched, side-gabled roof. The primary façade, that faces southeast, features a partial width entry porch and several projecting bays. The building walls are sided in horizontal wood siding. Fenestration is a combination of original, multi- light wood and replacement aluminum sashes. (See Continuation Sheet)

***P3b. Resource Attributes:** (List attributes and codes) HP8: Industrial building

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Northwest and southwest facades of building, camera facing northeast, January 4, 2013.
***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Circa the 1930s/Sanborn maps
***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804
***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612
***P9. Date Recorded:** January 4, 2013
***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

***NRHP Status Code** 6Z

***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 128

B1. Historic Name: California Cap Company Building 4b
B2. Common Name: Building 128
B3. Original Use: Manufacturing B4. Present Use: Storage/Research
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed circa the 1930s; northwest section added Circa 1960s; west section added Circa 1970s.
***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 128 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet.)

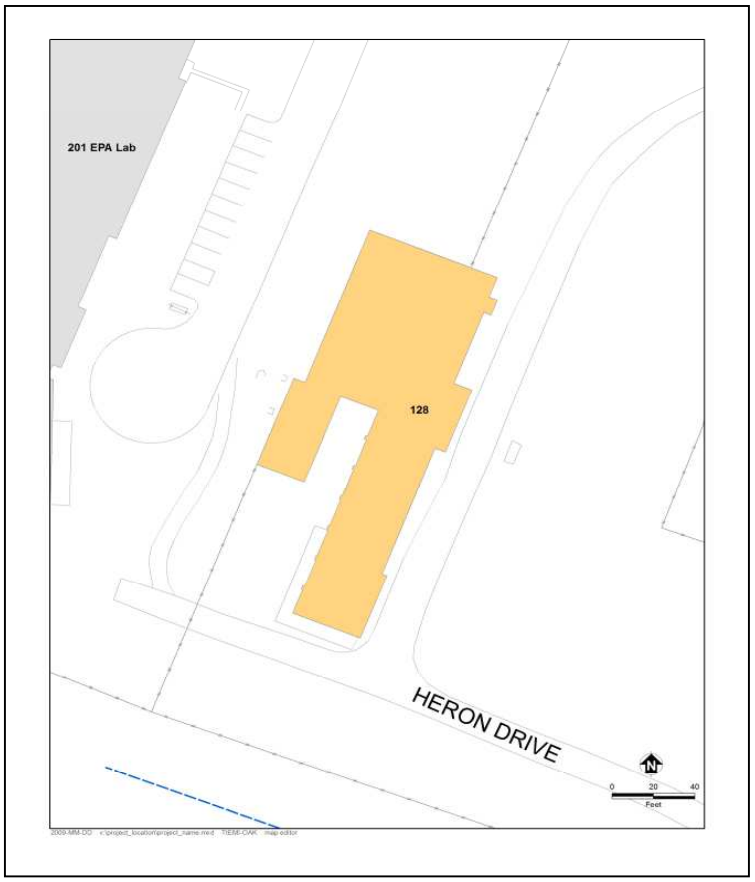
B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See Footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



P3a. Description (continued)

A paneled entry door with windows is accessed by wooden stairs that lead to the porch. At the rear of this section of the building, are seven bays separated by poured concrete walls that project past the walls and above the roof. There are two rectangular plan sections at the northwest end of the primary wing. The smaller section, at the west end of the building, is topped with a shed roof. The larger section, to the north, has a very shallow, pitched, gabled roof. Both sections are accessed by large replacement roll up doors at their southwest ends.

Building 128, originally labeled "Building 4b," was constructed circa 1930 by the California Cap Company.[1] The original building consisted of what is today the southeast wing of the building and was used as a press house. The press house was where gunpowder was compressed into cakes using weights. There were several other small buildings in the vicinity that were also press houses. The heavy concrete walls at the rear of the original building are reinforced concrete blast walls, intended to limit damage in case of explosion. After UC Berkeley purchased the property in the 1950s, the University added two warehouse additions to the building. The first was the northwest section of the building, built circa 1950.[2] The smaller west section was added in 1974.[3] The building housed internal combustion laboratories and was used for detonation research. Rocket engine tests using model rockets were among the modes of research conducted in Building 128.[4] By 1980 Building 128 was altered to its current irregular footprint. During the 1980s, large machinery was installed for research into automated recycling.[5] The building is currently used as a research facility.

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[6] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[7] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[8]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[9] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco

[1] University of California, Berkeley, 2008, p. 199.

[2] Shackleton, 2013.

[3] University of California, Berkeley, File "Building 128," located in vertical files in Room 148, Richmond Field Station.

[4] University of California, Berkeley, File "Building 128," located in vertical files in Room 148, Richmond Field Station.

[5] Shackleton, 2013.

[6] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[7] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[8] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[9] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[10] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[11] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[12] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[13] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[14]

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its proximity to the harbor yet remote from population centers. In addition, the narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[15]

During the 1870s chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch. The San Francisco explosives companies soon followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to the Atlas Powder Company. The California Powder Works soon followed, building a new factory in Hercules, which was named for the brand under which the company sold its powder.[16] The Vulcan Powder Works and Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902 California had only one powder factory outside Contra Costa and Alameda counties.[17]

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[10] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[11] J.P. Munro-Fraser, p. 675.

[12] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[13] Hulanski p. 288.

[14] Ida Mae Purcell, *History of Contra Costa County*, The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

[15] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area*, University of California, Berkeley: 1964, p. 27.

[16] Purcell, p. 646.

[17] Richmond Record, "Contra Costa County: Under the Vitascope", Richmond:1902.

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory, which was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[18] William Letts Oliver and his wife Carrie lived in Oakland, from about 1880 until Oliver's death in 1918.[19] The couple eventually had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[20] In addition his various professional activities William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the early twentieth century. An avid amateur photographer throughout his lifetime, UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[21]

William Letts Oliver initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[22] As early as 1870, European explosive companies were experimenting with nitrated guncotton in and by 1875 it was manufactured in England under the name "tonite."[23] By 1877 Oliver had left Chile and was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock needed an explosive that would remain stable at the high temperatures underground to complete the tunnel, and Oliver was able to solve the problem by substituting tonite for more volatile compounds.[24]

The California Cap Company

In 1877 William Letts Oliver was inspired by his success with tonite to leave mining and establish the Tonite Powder Company, on a portion of the former Stege Ranch.[25] In the 1870s all blasting caps in the United States had to be imported from Europe. Not only were they expensive, but the timing of deliveries was uncertain, creating business difficulties for the powder plant. Oliver was determined to create his own caps in order to protect the tonite factory business. He experimented until he came up with a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter founded the California Cap Company. It was located adjacent to the Tonite Powder Company a 160 acre parcel carved out of the southern portion of Stege Ranch.[26] California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[27] The California Cap Company was located on the parcel that is currently the Richmond Field

[18] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

[19] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

[20] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

[21] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley: 2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

[22] Pacific Mining News, p. 222.

[23] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.

[24] Pacific Mining News, p. 222.

[25] Oliver, p. 1.

[26] Pacific Mining News, p. 222.

[27] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.

Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

The Tonite and California Cap factories, which were the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[28] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882 at the nearby Vulcan Powder Company caused 11 deaths and destroyed the plant.[29] Between 1882 and 1918 the Hercules and Atlas plants suffered numerous explosions which destroyed plant buildings and killed a total of 64 workers.[30] Despite its focus on safety, the California Cap Company had accidents as well. Two of its Chinese workers were killed in 1917 when one of them dropped a tray of caps. In 1941 an explosion caused a fire and critically injured a worker.[31]

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888 he formed the American Lucol Company adjacent to the California Cap Company property.[32] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[33] The factory was dismantled and relocated to New Jersey circa 1900.[34] In 1903 the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field station property.[35] Later known as the U.S. Briquette Company, the plant appears to have operated at this location until at least 1917.[36] The U.S. Briquette Company buildings were demolished sometime in the 1960s.

The Oliver family aggressively promoted their products both through advertising and publishing. The California Cap Company sponsored or published both articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing as well as a selling point in advertisements.[37] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century the powder's explosive properties were considered comparable to the finest English products.[38] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family also became benefactors of the university, and in 1917 the California Cap Company donated substantial amounts of their products to the College of Mining including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[39]

[28] Oliver, p. 1.
[29] Munro-Fraser, p. 424.
[30] Purcell, p. 648.
[31] Contra Costa County Standard, "Stege Powder Plant Blast; One Near Death", June 6, 1941, p. 1A.
[32] Oliver, p. 1.
[33] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913,* Dewey Publishing Company: 1913, p. 327.
[34] Oliver, p. 1.
[35] Oliver, p. 2.
[36] Hulanksi, p. 354.
[37] Halbert Powers Gillette, *Rock Excavation:Methods and Cost,* M.C. Clark, New York: 1904, x.
[38] Manual Eissler, *A Handbook on Modern Explosives,* Crosby, Lockwood & son, London: 1897, p. 117.
[39] University of California, *The University of California Chronicle,* University of California Press, January, 1917, p. 92.

Eventually the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[40] By 1916 there were at least a dozen buildings on the site. When Oliver died in 1918 his son Roland Oliver took over as president of California Cap Company. By 1922 Roland's brother Leslie Oliver was assistant manager of the plant and Edwin Letts Oliver was a director.[41] Roland Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[42]

During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[43] As the twentieth century progressed more heavy industry came to Contra Costa County, and by 1940 the county was second only to Los Angeles in overall industrial production.[44] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[45] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[46]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[47] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[48]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[49] The current Buildings 102, 110, 118, 128, 150,

[40] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.

[41] Pacific Mining News, p.222.

[42] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

[43] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

[44] Purcell, p. 649.

[45] Oliver, p. 1.

[46] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[47] University of California, Berkeley, 2008, p. 13.

[48] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[49] McGauhey, p. 71.

152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[50] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Evaluation

The following provides an evaluation of Building 128 under each NRHP/CRHR criteria.

Building 128 does not appear to meet the criteria for listing in the NHRP/CRHR because it lacks historical significance Although the California Cap Company was the first blasting cap manufacturer in the United States there is no indication that Building 128, as a press house, was central to the development of the plant and its technical processes. In addition, it has been used for a variety of purposes over its lifetime. Therefore it lacks the strength of association to be considered historically significant in relation to any particular events in national, state, or local history to (Criterion A/1).

Although William Letts Oliver and his son Roland Oliver were significant in the history of the explosives industry, no particular association was found between the Oliver family and the building. Therefore it lacks the strength of association necessary to be considered historically significant in relation to any particular persons (Criteria B/2).

Building 128 was constructed in a utilitarian style, with materials commonly used in industrial structures during the early twentieth century. In addition, alterations were performed on the building and additions were constructed over the years in response to changing needs. Therefore it does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values (Criterion C/3).

In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

[50] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 149

P1. Other Identifier: Richmond Field Station Building 149

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5' Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; _Diablo____ **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558448 mE/ 4196467 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 149 is in the southern portion of the Richmond Field Station. Its primary façade faces southeast; it is 720 square feet and was constructed in 1982. It is single story and rectangular in plan.

The building is topped with a front gabled roof, with shallow eaves and exposed rafters on the southwest and northeast elevations. The building is clad in plain and vertical groove plywood. Fenestration is vinyl sashes. The primary entrance, on the southeast elevation, is a flush, at-grade door. A similar door is near the rear of the southwest elevation. The southeast elevation features a flush double door. (See Continuation Sheet)
***P3b. Resource Attributes:** (List attributes and codes) HP4: Ancillary Building

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Southwest and southeast facades of building, camera facing north, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
1982/UC Berkeley records
***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804
***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** January 4, 2013
***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

***NRHP Status Code** 6Z

***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 149

B1. Historic Name: _____
B2. Common Name: Building 149
B3. Original Use: Unknown B4. Present Use: Storage
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed in 1982
***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 149 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet.)

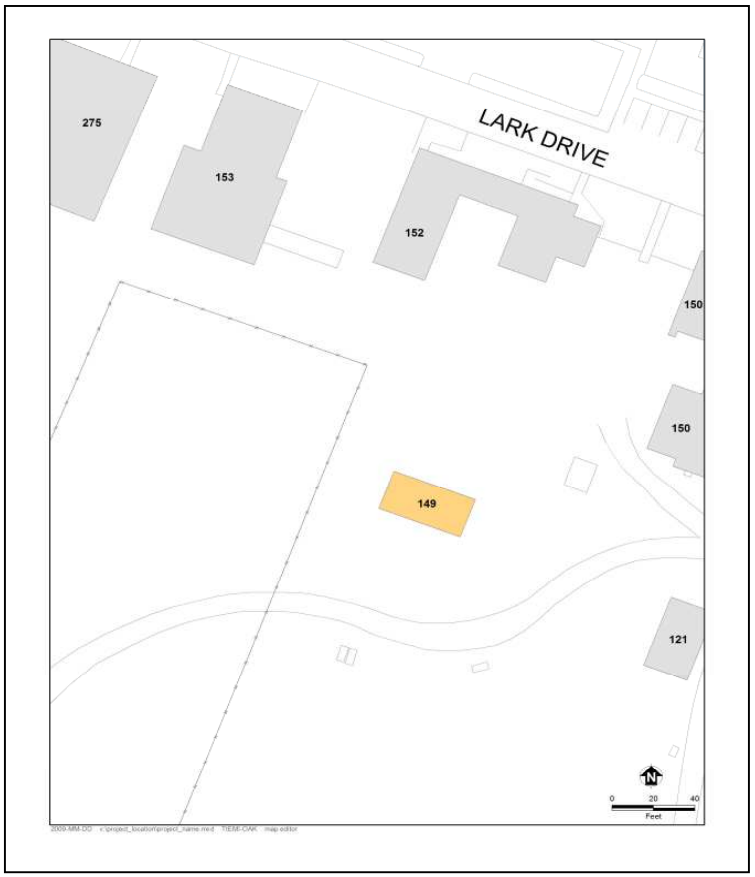
B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See Footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



P3a. Description (continued)

Building 149 was constructed by UC Berkeley in 1982. Originally it was used for water technology research. It has also been used for solar research. Between 1992 and 1998 it was used as hang glider storage. It is currently being used by the UC Berkeley Concrete Canoe Club.[1] It is not of historic age, as it was constructed 31 years ago.

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[2] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[3] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[4]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[5] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[6] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[7] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[8] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[9] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

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[1] Shackleton, 2013.

[2] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[3] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[4] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[5] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[6] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[7] J.P. Munro-Fraser, p. 675.

[8] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[9] Hulanski p. 288.

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[10]

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its proximity to the harbor yet remote from population centers. In addition, the narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[11]

During the 1870s chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch. The San Francisco explosives companies soon followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to the Atlas Powder Company. The California Powder Works soon followed, building a new factory in Hercules, which was named for the brand under which the company sold its powder.[12] The Vulcan Powder Works and Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902 California had only one powder factory outside Contra Costa and Alameda counties.[13]

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory, which was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[14] William Letts Oliver and his wife Carrie lived in Oakland, from about 1880 until Oliver's death in 1918.[15] The couple eventually had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[16] In addition his various professional activities William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the

[10] Ida Mae Purcell, *History of Contra Costa County*, The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

[11] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area*, University of California, Berkeley: 1964, p. 27.

[12] Purcell, p. 646.

[13] Richmond Record, "Contra Costa County: Under the Vitascope", Richmond:1902.

[14] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

[15] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

[16] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

early twentieth century. An avid amateur photographer throughout his lifetime, UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[17]

William Letts Oliver initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[18] As early as 1870, European explosive companies were experimenting with nitrated guncotton in and by 1875 it was manufactured in England under the name "tonite."[19] By 1877 Oliver had left Chile and was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock needed an explosive that would remain stable at the high temperatures underground to complete the tunnel, and Oliver was able to solve the problem by substituting tonite for more volatile compounds.[20]

The California Cap Company

In 1877 William Letts Oliver was inspired by his success with tonite to leave mining and establish the Tonite Powder Company, on a portion of the former Stege Ranch.[21] In the 1870s all blasting caps in the United States had to be imported from Europe. Not only were they expensive, but the timing of deliveries was uncertain, creating business difficulties for the powder plant. Oliver was determined to create his own caps in order to protect the tonite factory business. He experimented until he came up with a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter founded the California Cap Company. It was located adjacent to the Tonite Powder Company a 160 acre parcel carved out of the southern portion of Stege Ranch.[22] California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[23] The California Cap Company was located on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

The Tonite and California Cap factories, which were the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[24] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882 at the nearby Vulcan Powder Company caused 11 deaths and destroyed the plant.[25] Between 1882 and 1918 the Hercules and Atlas plants suffered numerous explosions which destroyed plant buildings and killed a total of 64 workers.[26] Despite its focus on safety, the California Cap Company had accidents as well. Two of its Chinese workers were killed in 1917 when one of them dropped a tray of caps. In 1941 an explosion caused a fire and critically injured a worker.[27]

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[17] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley: 2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

[18] Pacific Mining News, p. 222.

[19] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.

[20] Pacific Mining News, p. 222.

[21] Oliver, p. 1.

[22] Pacific Mining News, p. 222.

[23] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.

[24] Oliver, p. 1.

[25] Munro-Fraser, p. 424.

[26] Purcell, p. 648.

[27] Contra Costa County Standard, "Stege Powder Plant Blast; One Near Death", June 6, 1941, p. 1A.

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888 he formed the American Lucol Company adjacent to the California Cap Company property.[28] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[29] The factory was dismantled and relocated to New Jersey circa 1900.[30] In 1903 the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field station property.[31] Later known as the U.S. Briquette Company, the plant appears to have operated at this location until at least 1917.[32] The U.S. Briquette Company buildings were demolished sometime in the 1960s.

The Oliver family aggressively promoted their products both through advertising and publishing. The California Cap Company sponsored or published both articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing as well as a selling point in advertisements.[33] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century the powder's explosive properties were considered comparable to the finest English products.[34] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family also became benefactors of the university, and in 1917 the California Cap Company donated substantial amounts of their products to the College of Mining including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[35]

Eventually the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[36] By 1916 there were at least a dozen buildings on the site. When Oliver died in 1918 his son Roland Oliver took over as president of California Cap Company. By 1922 Roland's brother Leslie Oliver was assistant manager of the plant and Edwin Letts Oliver was a director.[37] Roland Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[38]

During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[39] As the twentieth century progressed more heavy industry came to Contra Costa County, and by

[28] Oliver, p. 1.
[29] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913*, Dewey Publishing Company: 1913, p. 327.
[30] Oliver, p. 1.
[31] Oliver, p. 2.
[32] Hulanksi, p. 354.
[33] Halbert Powers Gillette, *Rock Excavation:Methods and Cost,* M.C. Clark, New York: 1904, x.
[34] Manual Eissler, *A Handbook on Modern Explosives*, Crosby, Lockwood & son, London: 1897, p. 117.
[35] University of California, *The University of California Chronicle*, University of California Press, January, 1917, p. 92.
[36] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.
[37] Pacific Mining News, p.222.
[38] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.
[39] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

1940 the county was second only to Los Angeles in overall industrial production.[40] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[41] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[42]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[43] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[44]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[45] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[46] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Evaluation

The following provides an evaluation of Building 149 under each NRHP/CRHR criteria.

Building 149 does not appear to meet the criteria for listing in NRHP/CRHR because it lacks historical significance. The structure has been used for a variety of purposes throughout its lifetime and as such lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 and B/2).

[40] Purcell, p. 649.

[41] Oliver, p. 1.

[42] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[43] University of California, Berkeley, 2008, p. 13.

[44] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[45] McGauhey, p. 71.

[46] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

As a storage facility Building 149 does not meet the standard of exceptional importance required for properties under 50 years old to be eligible to the NHRP (Criterion G).

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 150

P1. Other Identifier: Richmond Field Station Building 150

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558497 mE/ 4196497 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 150 is in the southern portion of the Richmond Field Station. Its primary façade faces northeast along Lark Drive. It is 5,410 square feet and was constructed in approximately 1910. The building is single story and rectangular in plan, with additions to the rear (southwest) side. The building is topped with a shallow-pitched, side gabled roof with shallow eaves and exposed shaped wood rafter tails and purlins. Many of the original features remain and the building continues to convey original use as a shop with its sets of industrial, metal-frame, multi-light sashes, walls sided in board formed concrete, and low, open configuration.(See Continuation Sheet).

***P3b. Resource Attributes:** (List attributes and codes) HP15: Educational building

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Northeast and northwest facades of building, camera facing south, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Circa 1910/Sanborn maps
***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804
***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** January 4, 2013
***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

***NRHP Status Code** 3D

***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 150

B1. Historic Name: California Cap Company Building 66a

B2. Common Name: Building 150

B3. Original Use: Manufacturing B4. Present Use: Research

***B5. Architectural Style:** Vernacular

***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed circa 1910 for Californa Cap Company; additions constructed circa 1946.

***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____

***B8. Related Features:** _____

B9. Architect: Unknown b. Builder: Unknown

***B10. Significance: Theme** History **Area** Richmond Field Station

Period of Significance 1910 - 1949 **Property Type** Industrial **Applicable Criteria** A

(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 150 at Richmond Field Station appears to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and appears to meet the significance criteria as outlined in these guidelines. Therefore, the building is eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet)

B11. Additional Resource Attributes: (List attributes and codes)

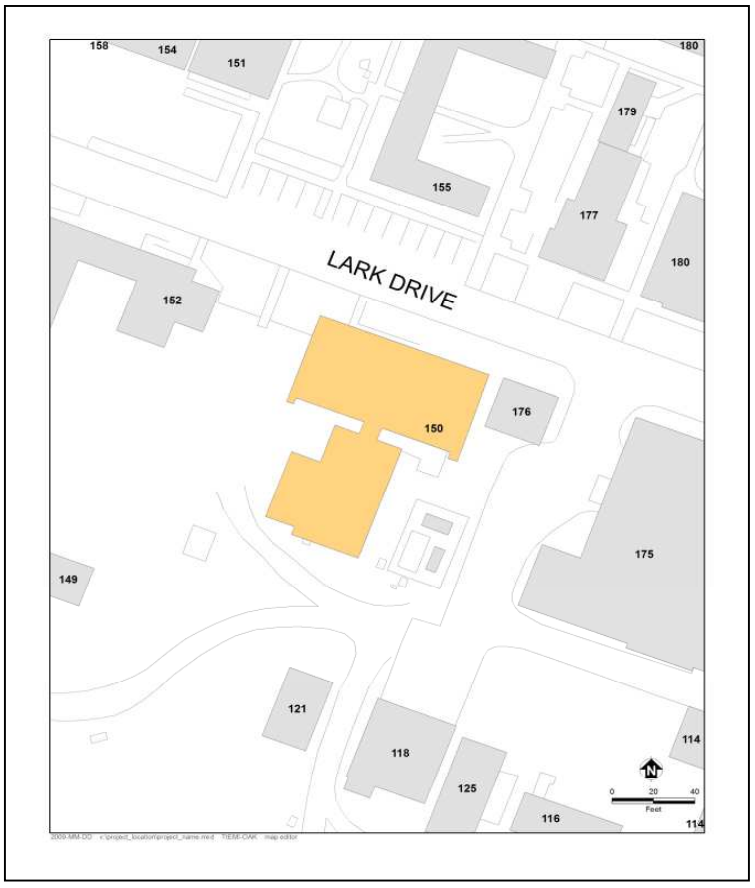
***B12. References:** See footnotes and continuation sheet

B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



P3a. Description (continued)

The main entrance is centered in the primary elevation and is original flush wood double doors with multi-light windows and transoms (Photograph 2). A concrete loading dock in front of these doors is accessed by a set of wooden stairs at its east end and a ramp at its west end.

The northwest elevation features a large roll up metal door. The rear (southwest) elevation of the building lacks the overhanging eaves with their decorative rafter tails that are found on the front and sides of the building. Fenestration at the rear is original, metal-frame, multi-light, industrial sashes.

Photograph 2: Building 150, January 4, 2013, camera facing south

A separate rectangular-plan addition is perpendicular to the main section of the building, at its rear (Photograph 3). It was added in 1946. This addition is topped with a shallow, pitched, gabled roof lower than the main building's roof with an eave overhang and rafter tail treatment mimicking that of the street-facing façade. Fenestration on this addition is multi-light, hung, wood sashes. A flush-mounted wood door is the entrance on the southwest elevation. It is sheltered by a shed roofed awning and accessed by a wooden staircase. An addition on the northwest side of the rear building has an even lower shed roof. The walls are clad in corrugated metal. Fenestration at this addition is horizontal sliding sashes, and the entrance is a large wood sliding door.

Photograph 3: Building 150, January 4, 2013, camera facing northwest

The California Cap Company constructed Building 150 circa 1910. The building was known as "Building 66a" and used for wire insulating. The addition at the southeast end of the building, known as "Building 66," was also constructed during the California Cap Company era. Aerial photographs show that it had been constructed by 1946. It was used for wire saturating.[1] Insulated wires were an essential element of the fuse-type blasting caps manufactured by the California Cap Company. Wire saturating was one step in the process of manufacturing insulated wire.

After UC Berkeley purchased the property in 1950, the Division of Mechanical Engineering was housed in Building 150. During the 1950s, Associate Dean E. D. Howe supervised Fluid Mechanics Test Facilities in the building.[2] Over the years the building was used as a petroleum studies facility, a machine shop, and a laboratory for UCSF.[3] Building 150 is currently used as an student art facility.

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[4] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native

[1] Sanborn Map, Richmond, 1949.

[2] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection," undated, p.2.

[3] University of California, Berkeley, 2008, p. 196.

[4] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[5] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[6]

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[5] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[6] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[7] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[8] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[9] J.P. Munro-Fraser, p. 675.

[10] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[11] Hulanski p. 288.

[12] Ida Mae Purcell, *History of Contra Costa County*, The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

[13] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area*, University of California, Berkeley: 1964, p. 27.

During the 1870s chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch. The San Francisco explosives companies soon followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to the Atlas Powder Company. The California Powder Works soon followed, building a new factory in Hercules, which was named for the brand under which the company sold its powder.[14] The Vulcan Powder Works and Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902 California had only one powder factory outside Contra Costa and Alameda counties.[15]

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory, which was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[16] William Letts Oliver and his wife Carrie lived in Oakland, from about 1880 until Oliver's death in 1918.[17] The couple eventually had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[18] In addition his various professional activities William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the early twentieth century. An avid amateur photographer throughout his lifetime, UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[19]

William Letts Oliver initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[20] As early as 1870, European explosive companies were experimenting with nitrated guncotton in and by 1875 it was manufactured in England under the name "tonite."[21] By 1877 Oliver had left Chile and was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock needed an explosive that would remain stable at the high temperatures underground to complete the tunnel, and Oliver was able to solve the problem by substituting tonite for more volatile compounds.[22]

The California Cap Company

In 1877 William Letts Oliver was inspired by his success with tonite to leave mining and establish the Tonite Powder Company, on a portion of the former Stege Ranch.[23] In the 1870s all blasting caps in the United States

[14] Purcell, p. 646.

[15] Richmond Record, "Contra Costa County: Under the Vitascope", Richmond:1902.

[16] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

[17] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

[18] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

[19] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley: 2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

[20] Pacific Mining News, p. 222.

[21] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.

[22] Pacific Mining News, p. 222.

[23] Oliver, p. 1.

had to be imported from Europe. Not only were they expensive, but the timing of deliveries was uncertain, creating business difficulties for the powder plant. Oliver was determined to create his own caps in order to protect the tonite factory business. He experimented until he came up with a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter founded the California Cap Company. It was located adjacent to the Tonite Powder Company a 160 acre parcel carved out of the southern portion of Stege Ranch.[24] California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[25] The California Cap Company was located on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

The Tonite and California Cap factories, which were the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[26] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882 at the nearby Vulcan Powder Company caused 11 deaths and destroyed the plant.[27] Between 1882 and 1918 the Hercules and Atlas plants suffered numerous explosions which destroyed plant buildings and killed a total of 64 workers.[28] Despite its focus on safety, the California Cap Company had accidents as well. Two of its Chinese workers were killed in 1917 when one of them dropped a tray of caps. In 1941 an explosion caused a fire and critically injured a worker.[29]

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888 he formed the American Lucol Company adjacent to the California Cap Company property.[30] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[31] The factory was dismantled and relocated to New Jersey circa 1900.[32] In 1903 the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field station property.[33] Later known as the U.S. Briquette Company, the plant appears to have operated at this location until at least 1917.[34] The U.S. Briquette Company buildings were demolished sometime in the 1960s.

The Oliver family aggressively promoted their products both through advertising and publishing. The California Cap Company sponsored or published both articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing as well as a selling point in

[24] Pacific Mining News, p. 222.
[25] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.
[26] Oliver, p. 1.
[27] Munro-Fraser, p. 424.
[28] Purcell, p. 648.
[29] Contra Costa County Standard, "Stege Powder Plant Blast; One Near Death", June 6, 1941, p. 1A.
[30] Oliver, p. 1.
[31] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913*, Dewey Publishing Company: 1913, p. 327.
[32] Oliver, p. 1.
[33] Oliver, p. 2.
[34] Hulanksi, p. 354.

advertisements.[35] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century the powder's explosive properties were considered comparable to the finest English products.[36] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family also became benefactors of the university, and in 1917 the California Cap Company donated substantial amounts of their products to the College of Mining including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[37]

Eventually the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[38] By 1916 there were at least a dozen buildings on the site. When Oliver died in 1918 his son Roland Oliver took over as president of California Cap Company. By 1922 Roland's brother Leslie Oliver was assistant manager of the plant and Edwin Letts Oliver was a director.[39] Roland Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[40]

During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[41] As the twentieth century progressed more heavy industry came to Contra Costa County, and by 1940 the county was second only to Los Angeles in overall industrial production.[42] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[43] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[44]

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[35] Halbert Powers Gillette, *Rock Excavation:Methods and Cost*, M.C. Clark, New York: 1904, x.

[36] Manual Eissler, *A Handbook on Modern Explosives*, Crosby, Lockwood & son, London: 1897, p. 117.

[37] University of California, *The University of California Chronicle*, University of California Press, January, 1917, p. 92.

[38] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.

[39] Pacific Mining News, p.222.

[40] University of California, Berkeley, *Current Conditions Report*, Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

[41] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

[42] Purcell, p. 649.

[43] Oliver, p. 1.

[44] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[45] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[46]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[47] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[48] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Evaluation

Criterion A/1: Building 150 appears to be eligible for listing in the NHRP/CRHR under Criterion A/1 because it is associated with the early explosives industry in the United States. The California Cap company was the oldest blasting manufacturer in the East Bay. Blasting caps, or detonators, were an important safety innovation, invented only a few years before California Cap was opened.[49] Several other explosives factories were opened in Contra Costa County after the Tonite Powder and California Cap companies, and from the 1880s into the twentieth century the East Bay produced most of the explosives products in California. High-explosive powder and blasting caps were essential to mining, road-building, and other economically important activities in California. These factories also produced munitions that were used during wartime. The manufacturing activities in Building 150, specifically wire insulating and wire saturating, were central to the production processes of the California Cap Company, the first blasting cap company in the United States. Insulated wire was required for blasting caps, one of the primary products of the plant. In addition, Building 150 is closely associated with Building 175, the California Cap Company's primary building.

Criterion B/2: Although William Letts Oliver and his son Roland Oliver were significant in the history of the explosives industry, no particular association was found between the Oliver family and the building, so it lacks the strength of association necessary to be considered historically significant in relation to any particular persons.

Criterion C/3: The building does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values. Building 150 is a simple industrial building, so it is not eligible to the NHRP/CRHR for its architecture.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Eligibility for listing on either the NRHP rests on significance and integrity. A property must have both factors to be considered eligible. Loss of integrity, if sufficiently great, would overwhelm the historical significance of a resource and render it ineligible. Integrity of a historic resource is measured by applying seven factors: location,

[45] University of California, Berkeley, 2008, p. 13.

[46] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[47] McGauhey, p. 71.

[48] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

[49] A detonator is a small explosive charge that ignites a larger charge, allowing for the use of a more stable and thus safer type of explosive.

design, setting, workmanship, materials, feeling, and association. Building 150 has retained a sufficient level of integrity in all measures. Although the building has undergone alterations, including the additional square footage constructed at the rear, these alterations have not compromised the historic integrity of the building. It continues to convey its historic significance as a California Cap Company manufacturing facility.

*B12. References (continued):

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State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 152

P1. Other Identifier: Richmond Field Station Building 152

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558495 mE/ 4196494 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 152 is in the southern portion of the Richmond Field Station. It is on the south side of Lark Drive adjacent to Building 150, with its primary façade facing northeast. The vernacular building does not strongly express any particular architecture style. It is two stories and has an irregular plan, is 4,201 square feet, and was constructed prior to 1940. (See Continuation Sheet)

***P3b. Resource Attributes:** (List attributes and codes) HP15: Educational building, HP39:Other

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Southeast and northeast facades of building, camera facing southwest, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Circa 1930s/UC Berkeley records

***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804

***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** January 4, 2013

***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

B1. Historic Name: California Cap Company Building 59, Building 60, and Building 142

B2. Common Name: Building 152

B3. Original Use: Box assembly/packing B4. Present Use: Art practice/storage

***B5. Architectural Style:** Vernacular

***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed circa the 1930s

***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____

***B8. Related Features:** _____

B9. Architect: Unknown b. Builder: Unknown

***B10. Significance: Theme** N/A **Area** N/A

Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A

(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 152 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet.)

B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See Footnotes

B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)

P3a. Description (continued)

The building consists of two front gabled wings facing the street, joined by a wing that runs parallel to the street. The roof is sheathed in composition shingles. The building is clad in a combination of horizontal wood, vertical board-and-batten, and asbestos siding. Fenestration also varies, and includes vinyl replacement windows and multi-light, double hung wood sashes. An entrance at the east gable is fitted with a flush wood door and accessed by a wood deck with stairs at one end and a ramp at the other. A similar entrance at the west gable is accessed by a concrete loading dock and stairs. A single story addition at the northwest end of the building features a hipped roof covered in corrugated metal. Multi- light, fixed, wood sashes have been painted over on its southeast elevation. The entrance at the northeast elevation is a large wood sliding door with a wood paneled door adjacent to it.

A rear entrance is toward the southwest corner of the west gable, facing the inside of the "U" formed by the building's wings. It is a flush mounted wood door that is accessed via a set of wooden stairs. The west gable is several feet longer than the east gable at the rear of the building. A small gable roofed shed is to the rear of the building adjacent to its southeast corner.

Building 152 was constructed by the California Cap Company circa the 1930s. It was originally three connected buildings referred to as "Building 59," Building 60," and "Building 142". Wooden boxes were assembled and other carpentry tasks performed in "Building 59," while "Building 60" was the packing house. "Building 142" was for sawdust storage and a restroom.[1] After UC Berkeley purchased the property in 1950 the building was used for salt water research and storage. A Mineral Dressing laboratory was installed by the Department of Mineral Technology in the late 1950s, but it appears not to have been used.[2] By 1980 the building was being used primarily for storage.[3] In the 1990s Building 152 began to house graduate student Art Practice, the current use of the building.[4]

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[5] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[6] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[7]

[1] University of California, Berkeley, 2008, p. 200, 202.

[2] University of California, Berkeley, File "Building 152," located in vertical files in Room 148, Richmond Field Station.

[3] University of California, Berkeley, File "Building 152," located in vertical files in Room 148, Richmond Field Station.

[4] Shackleton, 2013.

[5] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[6] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[7] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[8] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[9] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[10] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[11] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[12] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[13]

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its proximity to the harbor yet remote from population centers. In addition, the narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[14]

During the 1870s chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch. The San Francisco explosives companies soon followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to the Atlas Powder Company. The California Powder Works soon followed, building a new factory in Hercules, which was named for the brand under which the company sold its powder.[15] The Vulcan Powder Works and

[8] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[9] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[10] J.P. Munro-Fraser, p. 675.

[11] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[12] Hulanski p. 288.

[13] Ida Mae Purcell, *History of Contra Costa County*, The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

[14] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area,* University of California, Berkeley: 1964, p. 27.

[15] Purcell, p. 646.

Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902 California had only one powder factory outside Contra Costa and Alameda counties.[16]

William Letts Oliver

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The California Cap Company

In 1877 William Letts Oliver was inspired by his success with tonite to leave mining and establish the Tonite Powder Company, on a portion of the former Stege Ranch.[24] In the 1870s all blasting caps in the United States had to be imported from Europe. Not only were they expensive, but the timing of deliveries was uncertain, creating business difficulties for the powder plant. Oliver was determined to create his own caps in order to protect the tonite factory business. He experimented until he came up with a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter founded the California Cap Company. It was located adjacent to the Tonite Powder Company a 160 acre parcel carved out of the southern portion of Stege Ranch.[25] California Cap Company, which went on to operate on the site for nearly

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[18] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

[19] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

[20] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley: 2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

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seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[26] The California Cap Company was located on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

The Tonite and California Cap factories, which were the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[27] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882 at the nearby Vulcan Powder Company caused 11 deaths and destroyed the plant.[28] Between 1882 and 1918 the Hercules and Atlas plants suffered numerous explosions which destroyed plant buildings and killed a total of 64 workers.[29] Despite its focus on safety, the California Cap Company had accidents as well. Two of its Chinese workers were killed in 1917 when one of them dropped a tray of caps. In 1941 an explosion caused a fire and critically injured a worker.[30]

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888 he formed the American Lucol Company adjacent to the California Cap Company property.[31] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[32] The factory was dismantled and relocated to New Jersey circa 1900.[33] In 1903 the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field station property.[34] Later known as the U.S. Briquette Company, the plant appears to have operated at this location until at least 1917.[35] The U.S. Briquette Company buildings were demolished sometime in the 1960s.

The Oliver family aggressively promoted their products both through advertising and publishing. The California Cap Company sponsored or published both articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing as well as a selling point in advertisements.[36] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century the powder's explosive properties were considered comparable to the finest English products.[37] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family also became benefactors of the

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[27] Oliver, p. 1.
[28] Munro-Fraser, p. 424.
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[35] Hulanksi, p. 354.
[36] Halbert Powers Gillette, *Rock Excavation:Methods and Cost*, M.C. Clark, New York: 1904, x.
[37] Manual Eissler, *A Handbook on Modern Explosives*, Crosby, Lockwood & son, London: 1897, p. 117.

university, and in 1917 the California Cap Company donated substantial amounts of their products to the College of Mining including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[38]

Eventually the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[39] By 1916 there were at least a dozen buildings on the site. When Oliver died in 1918 his son Roland Oliver took over as president of California Cap Company. By 1922 Roland's brother Leslie Oliver was assistant manager of the plant and Edwin Letts Oliver was a director.[40] Roland Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[41]

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University Research/Richmond Field Station

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The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[46] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[47]

[38] University of California, *The University of California Chronicle*, University of California Press, January, 1917, p. 92.

[39] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.

[40] Pacific Mining News, p.222.

[41] University of California, Berkeley, *Current Conditions Report*, Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

[42] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

[43] Purcell, p. 649.

[44] Oliver, p. 1.

[45] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[46] University of California, Berkeley, 2008, p. 13.

[47] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[48] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[49] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Evaluation

The following provides an evaluation of Building 152 under each NRHP/CRHR criteria.

No particular association was found between the Building 152 and events significant to national, state, or local history (Criterion A/1). Although the California Cap Company was the first blasting cap manufacturer in the United States there is no indication that the activities that took place in Building 152 were central to the development of the plant or its technical processes. In addition, the building has been used for a variety of purposes throughout its lifetime. Therefore the building is not eligible for inclusion in the NRHP/CRHR for historical significance

Although William Letts Oliver and his son Roland Oliver were significant in the history of the explosives industry, no particular association was found between the Oliver family and the building. Therefore it lacks the strength of association necessary to be considered historically significant in relation to any particular persons (Criterion B/2).

The building does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values (Criterion C/3). Building 152 is a vernacular building of a type that was commonly constructed from the late nineteenth to the early twentieth century. Therefore the building is not eligible to the NHRP for its architecture.

In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

[48] McGauhey, p. 71.

[49] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 153

P1. Other Identifier: Richmond Field Station Building 153

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 409938 mE/ 4397486 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 153 is in the southern portion of the Richmond Field Station. It is on the south side of Lark Drive adjacent to Building 152, with its primary façade facing northeast. The vernacular building does not strongly express any particular architecture style. It is single story and rectangular in plan, 2,731 square feet, and was constructed in 1959. (See Continuation Sheet)

***P3b. Resource Attributes:** (List attributes and codes) HP15: Educational building; HP39: Other

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Southeast and northeast facades of building, camera facing southwest, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
1959/UC Berkeley records
***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804
***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612
***P9. Date Recorded:** January 4, 2013
***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.
***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record
☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record
☐ Other (list) _____

***NRHP Status Code** 6Z

***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 153

B1. Historic Name: _____
B2. Common Name: Building 153
B3. Original Use: Shop B4. Present Use: Shop
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed in 1956
***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 153 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet.)

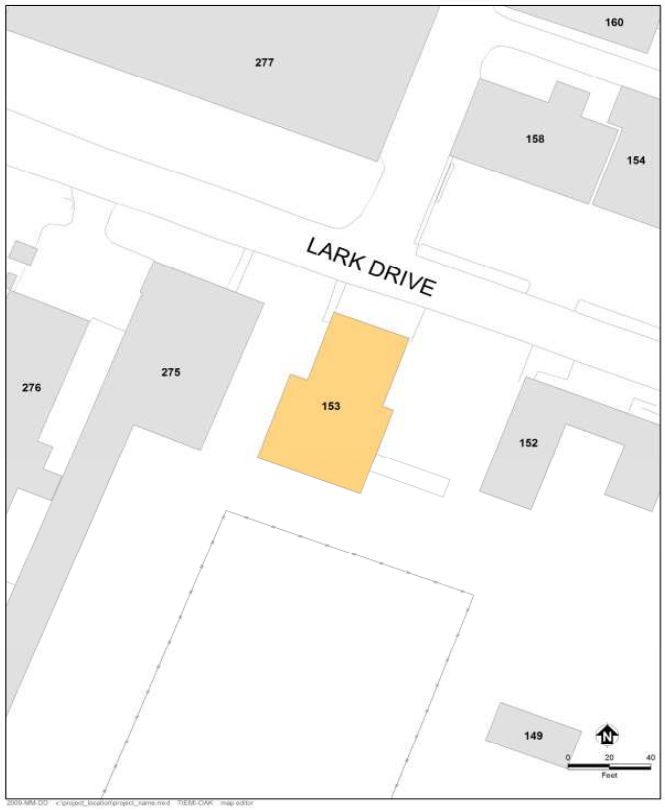
B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See Footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



P3a. Description (continued)

The front section of the building is flat roofed. The walls are covered in stucco, and fenestration is multi-light fixed sashes. The northeast elevation lacks fenestration, but has two entry doors and two large swinging double doors. All doors are wood paneled with windows. A rear addition to the building is topped with both a flat roof and a shed roof section. An entrance at the rear of the southeast elevation is a large sliding door.

Building 153 was constructed by UC Berkeley in 1959. It was used as a modeling shop and for salt water research.[1] The Naval Architecture Department used the building for ship design over the years.[2] In 1958 the department of Nuclear Engineering was looking for space for gamma-shielding experiments, and may have moved into Building 153 for a time.[3] Aerial photography indicates that the addition at the rear (southeast) of the building was constructed in approximately 1975. It is currently used as a research facility and a shop.

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[4] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[5] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[6]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[7] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[8] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[9] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United

[1] University of California, Berkeley, 2008, p. 196.

[2] Shackleton, 2013.

[3] University of California, Berkeley, File "Building 153," located in vertical files in Room 148, Richmond Field Station.

[4] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[5] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[6] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[7] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[8] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[9] J.P. Munro-Fraser, p. 675.

States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[10] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[11] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[12]

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its proximity to the harbor yet remote from population centers. In addition, the narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[13]

During the 1870s chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch. The San Francisco explosives companies soon followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to the Atlas Powder Company. The California Powder Works soon followed, building a new factory in Hercules, which was named for the brand under which the company sold its powder.[14] The Vulcan Powder Works and Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902 California had only one powder factory outside Contra Costa and Alameda counties.[15]

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory, which was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[16] William Letts

[10] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[11] Hulanski p. 288.

[12] Ida Mae Purcell, *History of Contra Costa County*, The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

[13] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area*, University of California, Berkeley: 1964, p. 27.

[14] Purcell, p. 646.

[15] Richmond Record, "Contra Costa County: Under the Vitascope", Richmond:1902.

[16] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

Oliver and his wife Carrie lived in Oakland, from about 1880 until Oliver's death in 1918.[17] The couple eventually had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[18] In addition his various professional activities William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the early twentieth century. An avid amateur photographer throughout his lifetime, UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[19]

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[25] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.

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[35] Halbert Powers Gillette, *Rock Excavation:Methods and Cost,* M.C. Clark, New York: 1904, x.
[36] Manual Eissler, *A Handbook on Modern Explosives,* Crosby, Lockwood & son, London: 1897, p. 117.
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After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[44]

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At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[47] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[48] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

The following provides an evaluation of Building 153 under each NRHP/CRHR criteria.

[40] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

[41] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

[42] Purcell, p. 649.

[43] Oliver, p. 1.

[44] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[45] University of California, Berkeley, 2008, p. 13.

[46] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[47] McGauhey, p. 71.

[48] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

Building 153 does not appear to meet the criteria for listing in NRHP/CRHR because it lacks historical significance. The structure has been used for a variety of purposes throughout its lifetime and as such lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 and B/2).

The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 163

P1. Other Identifier: Richmond Field Station Building 163

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558560 mE/ 4196300 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 163 is at the southeastern edge of the Richmond Field Station. The primary façades of this L-shaped building face northwest and southwest. The vernacular building does not strongly express any particular architecture style. It is single story and 6,430 square feet. The building was constructed prior to 1940.
Both wings of the building have front gabled roofs covered with composition shingles. The walls are clad in horizontal wood siding; a portion of the walls is covered with stucco. Fenestration is aluminum replacement sashes. The primary entrance is a paneled, southeast-facing, wood door. It is accessed by a concrete ramp. Other entrances are centered in each gable end and are flush wood doors. (See Continuation Sheet)
***P3b. Resource Attributes:** (List attributes and codes) HP15: Educational building; HP39: Other

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Northwest and southwest facades of building, camera facing northeast, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
1996/UC Berkeley records
***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804
***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** January 4, 2013
***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.
***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record
☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record
☐ Other (list) _____

B1. Historic Name: _____
B2. Common Name: Building 163
B3. Original Use: Research/offices B4. Present Use: Research/offices
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed in 1996
***B7. Moved?** ☐ **No** ☒ **Yes** ☐ **Unknown** **Date:** 1996 **Original Location:** A portion of Building 165
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 163 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet.)

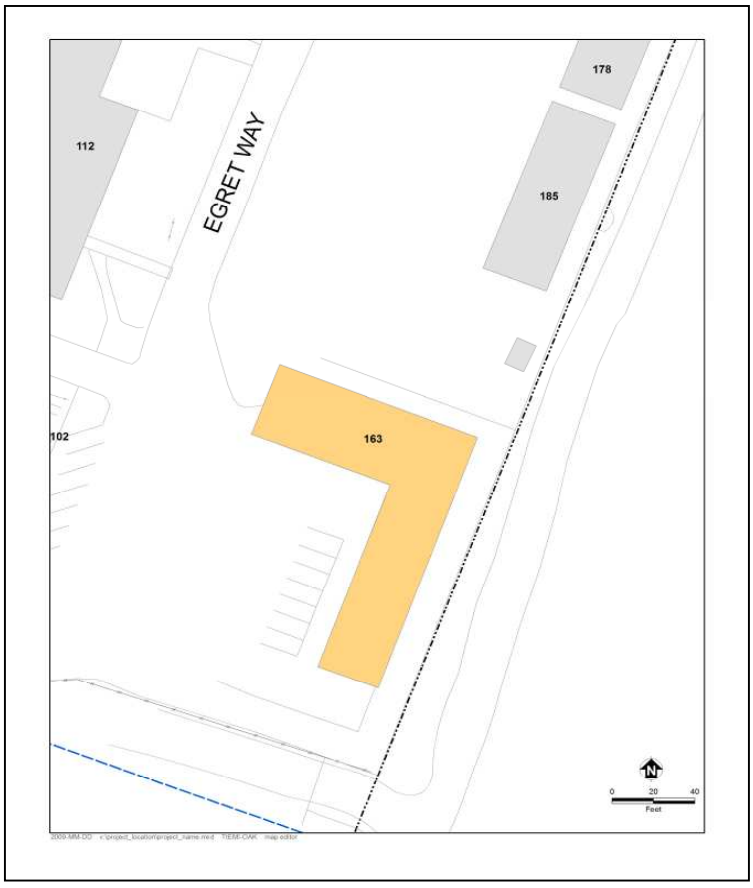
B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See Footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



P3a. Description (continued)

The northwest entrance is accessed by concrete steps. The southwest entrance is accessed by a set of wooden steps and sheltered by a shed roof over the entry. There is a similar entrance on the rear (southeast) elevation.

Building 163 was created when Building 165 and another building were moved and another addition added to it to create Building 163 at this location in 1996. The two buildings that were moved to form Building 163 was a California Cap Company building originally constructed circa 1930. They were connected with a new section at the corner of the "L" to create Building 1963. Its site overlaps with the footprint of the U.S. Briquette Company plant and William Letts Oliver's American Lucol Company. Aerial photographs indicate that the U.S. Briquette buildings were demolished circa the 1960s after UC Berkeley took over the site. Ergonomic studies, seeking to prevent chronic disorders of the upper extremities, have been done in the building since the 1990s.[1] Building 163 continues to be used as a research facility, and houses offices.

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[2] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[3] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[4]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[5] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[6] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[7] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were

[1] Shackleton, 2013.

[2] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[3] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[4] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[5] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[6] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[7] J.P. Munro-Fraser, p. 675.

operating from portions of the Stege Ranch.[8] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[9] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[10]

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its proximity to the harbor yet remote from population centers. In addition, the narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[11]

During the 1870s chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch. The San Francisco explosives companies soon followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to the Atlas Powder Company. The California Powder Works soon followed, building a new factory in Hercules, which was named for the brand under which the company sold its powder.[12] The Vulcan Powder Works and Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902 California had only one powder factory outside Contra Costa and Alameda counties.[13]

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory, which was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[14] William Letts Oliver and his wife Carrie lived in Oakland, from about 1880 until Oliver's death in 1918.[15] The couple eventually

[8] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[9] Hulanski p. 288.

[10] Ida Mae Purcell, *History of Contra Costa County*, The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

[11] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area*, University of California, Berkeley: 1964, p. 27.

[12] Purcell, p. 646.

[13] Richmond Record, "Contra Costa County: Under the Vitascope", Richmond:1902.

[14] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

[15] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[16] In addition his various professional activities William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the early twentieth century. An avid amateur photographer throughout his lifetime, UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[17]

William Letts Oliver initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[18] As early as 1870, European explosive companies were experimenting with nitrated guncotton in and by 1875 it was manufactured in England under the name "tonite."[19] By 1877 Oliver had left Chile and was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock needed an explosive that would remain stable at the high temperatures underground to complete the tunnel, and Oliver was able to solve the problem by substituting tonite for more volatile compounds.[20]

The California Cap Company

In 1877 William Letts Oliver was inspired by his success with tonite to leave mining and establish the Tonite Powder Company, on a portion of the former Stege Ranch.[21] In the 1870s all blasting caps in the United States had to be imported from Europe. Not only were they expensive, but the timing of deliveries was uncertain, creating business difficulties for the powder plant. Oliver was determined to create his own caps in order to protect the tonite factory business. He experimented until he came up with a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter founded the California Cap Company. It was located adjacent to the Tonite Powder Company a 160 acre parcel carved out of the southern portion of Stege Ranch.[22] California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[23] The California Cap Company was located on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

The Tonite and California Cap factories, which were the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[24] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882 at the nearby Vulcan Powder Company caused 11 deaths and destroyed the plant.[25] Between 1882 and 1918 the Hercules and Atlas plants suffered numerous

[16] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

[17] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley: 2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

[18] Pacific Mining News, p. 222.

[19] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.

[20] Pacific Mining News, p. 222.

[21] Oliver, p. 1.

[22] Pacific Mining News, p. 222.

[23] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.

[24] Oliver, p. 1.

[25] Munro-Fraser, p. 424.

explosions which destroyed plant buildings and killed a total of 64 workers.[26] Despite its focus on safety, the California Cap Company had accidents as well. Two of its Chinese workers were killed in 1917 when one of them dropped a tray of caps. In 1941 an explosion caused a fire and critically injured a worker.[27]

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888 he formed the American Lucol Company adjacent to the California Cap Company property.[28] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[29] The factory was dismantled and relocated to New Jersey circa 1900.[30] In 1903 the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field station property.[31] Later known as the U.S. Briquette Company, the plant appears to have operated at this location until at least 1917.[32] The U.S. Briquette Company buildings were demolished sometime in the 1960s.

The Oliver family aggressively promoted their products both through advertising and publishing. The California Cap Company sponsored or published both articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing as well as a selling point in advertisements.[33] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century the powder's explosive properties were considered comparable to the finest English products.[34] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family also became benefactors of the university, and in 1917 the California Cap Company donated substantial amounts of their products to the College of Mining including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[35]

Eventually the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[36] By 1916 there were at least a dozen buildings on the site. When Oliver died in 1918 his son Roland Oliver took over as president of California Cap Company. By 1922 Roland's brother Leslie Oliver was assistant manager of the plant and Edwin Letts Oliver was a director.[37] Roland Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[38]

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[26] Purcell, p. 648.

[27] Contra Costa County Standard, "Stege Powder Plant Blast; One Near Death", June 6, 1941, p. 1A.

[28] Oliver, p. 1.

[29] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913,* Dewey Publishing Company: 1913, p. 327.

[30] Oliver, p. 1.

[31] Oliver, p. 2.

[32] Hulanksi, p. 354.

[33] Halbert Powers Gillette, *Rock Excavation:Methods and Cost,* M.C. Clark, New York: 1904, x.

[34] Manual Eissler, *A Handbook on Modern Explosives,* Crosby, Lockwood & son, London: 1897, p. 117.

[35] University of California, *The University of California Chronicle,* University of California Press, January, 1917, p. 92.

[36] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915,* Oakland, California: 1915.

[37] Pacific Mining News, p.222.

[38] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[39] As the twentieth century progressed more heavy industry came to Contra Costa County, and by 1940 the county was second only to Los Angeles in overall industrial production.[40] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[41] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[42]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[43] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[44]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[45] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[46] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Evaluation

The following provides an evaluation of Building 163 under each NRHP/CRHR criteria.

[39] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

[40] Purcell, p. 649.

[41] Oliver, p. 1.

[42] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[43] University of California, Berkeley, 2008, p. 13.

[44] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[45] McGauhey, p. 71.

[46] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

Building 163 does not appear to meet the criteria for listing in National Register of Historic Places because it lacks historical significance. The structure has been used for research throughout its lifetime and as such lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 and B/2).

The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3) The building has been moved from its original location as part of two other buildings. In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

As a research facility Building 163 does not meet the standard of exceptional importance required for properties under 50 years old to be eligible to the NHRP (Criterion G).

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

Page 1 **of** 16 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 175

P1. Other Identifier: Richmond Field Station Building 175

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558547 mE/ 4196474 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 175 is in the southern portion of the Richmond Field Station at the intersection of Lark Drive and Egret Way. Its primary façade faces northeast, along Lark Drive. It is 16,502 square feet and was constructed in approximately 1910. The building is single story and rectangular in plan, with additions to the rear (southwest) side. The building is topped with a shallow, pitched-side, gabled roof with shallow eaves and exposed, shaped-wood rafter tails and purlins. (See Continuation Sheet)

***P3b. Resource Attributes:** (List attributes and codes) HP15: Educational building; HP4: Other

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Southeast and northeast facades of building, camera facing southwest, January 4, 2013
***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Circa 1910/Sanborn maps
***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804
***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612
***P9. Date Recorded:** January 4, 2013
***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none".) *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record
☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record
☐ Other (list) _____

B1. Historic Name: California Cap Company Building 75 & Building 76

B2. Common Name: Building 175

B3. Original Use: Manufacturing/office B4. Present Use: Shop/office

***B5. Architectural Style:** Vernacular

***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed circa 1910 for California Cap Company; rear addition constructed circa 1950s; wood sash windows replaced 1969

***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____

***B8. Related Features:** _____

B9. Architect: Unknown b. Builder: Unknown

***B10. Significance: Theme** History **Area** Richmond Field Station

Period of Significance 1910 - 1949 **Property Type** industrial **Applicable Criteria** A

(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 175 at Richmond Field Station appears to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and appears to meet the significance criteria as outlined in these guidelines. Therefore, the building is eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet)

B11. Additional Resource Attributes: (List attributes and codes)

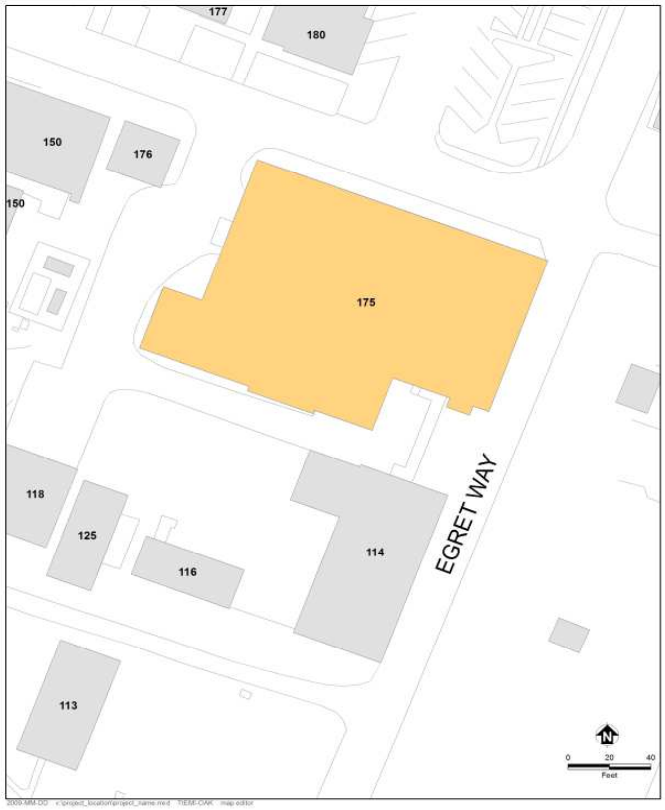
***B12. References:** See Footnotes and Continuation Sheet

B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



P3a. Description (continued)

Many of the building's original features remain, and the building continues to convey its original use as a shop with its, walls sided in board formed concrete, and low, open configuration. Fenestration is aluminum replacement windows and small aluminum sliding sashes. The east door has been replaced with a modern glass door.

Photograph 2: Building 175, January 4, 2013, camera facing south

A large, projecting, two-story addition at the southwestern end of the building is topped with a shed roof, its walls are clad in corrugated metal. Fenestration is both multiple pane fixed windows and vinyl replacement windows. A shed roof covers an open area at the center of the rear elevation adjacent to the corrugated addition. Double paneled wood doors with windows are at the center of the façade. A raised concrete ramp leads to these doors.
Historic maps and documents show that the building that is now Building 175 was constructed in 1910, when the California Cap Company and Pacific Cartridge Company were operating simultaneously. When in use for the Pacific Cartridge Company, Building 175 was numbered both "Building 75" and "Building 76" and was the primary production facility for Pacific Cartridge. The building appears to have been used as a cartridge loading facility during the early years, where powder was loaded into shells.[1] It also housed a small office, a vault, and cleaning and annealing rooms.[2] (Metal cartridges were strengthened through heat treating, or annealing.) Both the Pacific Cartridge Company and the California Cap Company were administered from the office in Building 175 (Photograph 3 and 4). By 1916 the company was producing cartridge shells in the building, but no longer loading

[1] Sanborn Map, Stege, 1912.
[2] Sanborn Map, Stege, 1912.

powder there.[3] Pacific Cartridge Company was absorbed by the California Cap Company circa 1920. The 1949 Sanborn map shows the same uses for the Building 175 but lists only California Cap on the property.[4]

Photograph 3: Building 175, circa 1910, from Bancroft Library's Oliver Family Photograph Collection, labeled "Exterior California Cap Company office, California"

[3] Sanborn Map, Richmond, 1916.
[4] Sanborn Map, Richmond, 1949.

Photograph 4: Building 175, circa 1910, from Bancroft Library's Oliver Family Photograph Collection, labeled "Pacific Cartridge Co. Exterior – Stege, Calif."

After UC Berkeley purchased the property in 1950, this building continued to house an office and hazardous chemical storage area.[5] Building 175 was the Richmond Field Station's primary facility for maintenance and administration.[6] During the early 1950s the Department of Engineering's machine shop was also in Building 175, fabricating experimental equipment for research. By 1952 a new high-speed wind tunnel for research was being assembled in the building.[7] The University made piecemeal additions to the rear (southwest) of the building beginning in the 1950s. By 1966 Building 175 reached its current footprint and housed machine, carpenter, and welding shops, and an office.[8] The University removed the original wood frame windows and replaced them with aluminum sashes in 1969.[9] The building continued to be considered important, as indicated by a 1977 letter arguing for "one of the most important buildings at the Station and if it were lost the program impact could be catastrophic, inasmuch that the Station operations would most likely come to a halt."[10] It continued to house maintenance operations until approximately 2008 when, in spite of the building's former importance, it was left vacant. It remained vacant until 2012 when the UC Bindery moved into the building.[11]

[5] University of California, Berkeley, 2008, p. 197
[6] University of California, Berkeley, 2008, p. 20.
[7] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House," May 28, 1952, p. 3.
[8] Sanborn Map, Richmond, 1966.
[9] University of California, Berkeley, File "Building 175," located in vertical files in Room 148, Richmond Field Station.
[10] University of California, Berkeley, File "Building 175," located in vertical files in Room 148, Richmond Field Station.
[11] Shackleton, 2013.

B10. Significance (continued)

Historic Contexts

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[12] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[13] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[14]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[15] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[16] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[17] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[18] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[19] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[20]

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[12] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[13] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[14] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[15] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[16] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[17] J.P. Munro-Fraser, p. 675.

[18] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[19] Hulanski p. 288.

[20] Ida Mae Purcell, *History of Contra Costa County*, The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its proximity to the harbor yet remote from population centers. In addition, the narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[21]

During the 1870s chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch. The San Francisco explosives companies soon followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to the Atlas Powder Company. The California Powder Works soon followed, building a new factory in Hercules, which was named for the brand under which the company sold its powder.[22] The Vulcan Powder Works and Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902 California had only one powder factory outside Contra Costa and Alameda counties.[23]

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory, which was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[24] William Letts Oliver and his wife Carrie lived in Oakland, from about 1880 until Oliver's death in 1918.[25] The couple eventually had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[26] In addition his various professional activities William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the early twentieth century. An avid amateur photographer throughout his lifetime, UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[27]

William Letts Oliver initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[28] As early as 1870, European explosive companies were experimenting with nitrated guncotton in and by 1875 it was manufactured in England under the name "tonite."[29] By 1877 Oliver had left Chile and was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock

[21] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area,* University of California, Berkeley: 1964, p. 27.

[22] Purcell, p. 646.

[23] Richmond Record, "Contra Costa County: Under the Vitascope", Richmond:1902.

[24] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

[25] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

[26] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

[27] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley: 2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

[28] Pacific Mining News, p. 222.

[29] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.

needed an explosive that would remain stable at the high temperatures underground to complete the tunnel, and Oliver was able to solve the problem by substituting tonite for more volatile compounds.[30]

The California Cap Company

In 1877 William Letts Oliver was inspired by his success with tonite to leave mining and establish the Tonite Powder Company, on a portion of the former Stege Ranch.[31] In the 1870s all blasting caps in the United States had to be imported from Europe. Not only were they expensive, but the timing of deliveries was uncertain, creating business difficulties for the powder plant. Oliver was determined to create his own caps in order to protect the tonite factory business. He experimented until he came up with a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter founded the California Cap Company. It was located adjacent to the Tonite Powder Company a 160 acre parcel carved out of the southern portion of Stege Ranch.[32] California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[33] The California Cap Company was located on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

The Tonite and California Cap factories, which were the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[34] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882 at the nearby Vulcan Powder Company caused 11 deaths and destroyed the plant.[35] Between 1882 and 1918 the Hercules and Atlas plants suffered numerous explosions which destroyed plant buildings and killed a total of 64 workers.[36] Despite its focus on safety, the California Cap Company had accidents as well. Two of its Chinese workers were killed in 1917 when one of them dropped a tray of caps. In 1941 an explosion caused a fire and critically injured a worker.[37]

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888 he formed the American Lucol Company adjacent to the California Cap Company property.[38] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[39] The factory was dismantled and relocated to New Jersey circa 1900.[40] In 1903 the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field station property.[41] Later known as the U.S. Briquette Company, the plant appears to have

[30] Pacific Mining News, p. 222.
[31] Oliver, p. 1.
[32] Pacific Mining News, p. 222.
[33] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.
[34] Oliver, p. 1.
[35] Munro-Fraser, p. 424.
[36] Purcell, p. 648.
[37] Contra Costa County Standard, "Stege Powder Plant Blast; One Near Death", June 6, 1941, p. 1A.
[38] Oliver, p. 1.
[39] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913*, Dewey Publishing Company: 1913, p. 327.
[40] Oliver, p. 1.
[41] Oliver, p. 2.

operated at this location until at least 1917.[42] The U.S. Briquette Company buildings were demolished sometime in the 1960s.

The Oliver family aggressively promoted their products both through advertising and publishing. The California Cap Company sponsored or published both articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing as well as a selling point in advertisements.[43] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century the powder's explosive properties were considered comparable to the finest English products.[44] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family also became benefactors of the university, and in 1917 the California Cap Company donated substantial amounts of their products to the College of Mining including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[45]

Eventually the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[46] By 1916 there were at least a dozen buildings on the site. When Oliver died in 1918 his son Roland Oliver took over as president of California Cap Company. By 1922 Roland's brother Leslie Oliver was assistant manager of the plant and Edwin Letts Oliver was a director.[47] Roland Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[48]

During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[49] As the twentieth century progressed more heavy industry came to Contra Costa County, and by 1940 the county was second only to Los Angeles in overall industrial production.[50] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[51] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the

[42] Hulanksi, p. 354.

[43] Halbert Powers Gillette, *Rock Excavation:Methods and Cost,* M.C. Clark, New York: 1904, x.

[44] Manual Eissler, *A Handbook on Modern Explosives,* Crosby, Lockwood & son, London: 1897, p. 117.

[45] University of California, *The University of California Chronicle,* University of California Press, January, 1917, p. 92.

[46] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.

[47] Pacific Mining News, p.222.

[48] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

[49] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

[50] Purcell, p. 649.

[51] Oliver, p. 1.

department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[52]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[53] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[54]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[55] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[56] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Evaluation

The following provides an evaluation of Building 175 under each NRHP and CRHR criteria. The property's period of significance is from 1910, when it was constructed, until it ceased to be used for the California Cap Company, in 1949.

Criterion A/1: Building 175 appears to be eligible for listing in the NHRP/CRHR under Criterion A/1 because it is associated with the early explosives industry in the United States, as it was part of the first blasting cap company in the United States. The California Cap company was also the oldest blasting manufacturer in the East Bay area. Blasting caps, or detonators, were an important safety innovation, invented only a few years before California Cap was opened.[57] Several other explosives factories were opened in Contra Costa County after the Tonite Powder and California Cap companies, and from the 1880s into the twentieth century the East Bay produced most of the explosives products in California. High-explosive powder and blasting caps were essential to mining, road-building, and other economically important activities in California. These factories also produced munitions that were used during wartime.

The manufacturing activities in Building 175, specifically cartridge loading and cartridge production, were central to the production processes of the Pacific Cartridge Company and the California Cap Company. Building 175 was one of the plant's primary manufacturing buildings in the 1910s. In addition, the company was administered from

[52] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[53] University of California, Berkeley, 2008, p. 13.

[54] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[55] McGauhey, p. 71.

[56] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

[57] A detonator is a small explosive charge that ignites a larger charge, allowing for the use of a more stable and thus safer type of explosive.

the office in the building. The building is at what was the geographical center of the plant between circa 1900 and 1940s, and is featured in historic photographs as the Pacific Cartridge and the California Cap Companies' primary building.

Criterion B/2: Although William Letts Oliver and his son Roland Oliver were significant in the history of the explosives industry, no particular association was found between the Oliver family, the architect or builder, or any person associated with the building, so it lacks the strength of association necessary to be considered historically significant in relation to any particular persons under Criterion B/2.

Criterion C/3: The building does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values (Criterion C). Building 175 is an industrial building with little ornamentation, so it is not eligible to the NHRP/CRHR under this criterion.

Criterion D/4: In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information in this regard.

Eligibility for listing on either the NRHP rests on significance and integrity. A property must have both factors to be considered eligible. Loss of integrity, if sufficiently great, would overwhelm the historical significance of a resource and render it ineligible. Integrity of a historic resource is measured by applying seven factors: location, design, setting, workmanship, materials, feeling, and association. Building 175 retains a sufficient level of integrity in all measures. Although the building has undergone alterations, including the additional square footage constructed at the rear of the building and the replacement of the original wood frame sashes, these alterations have not compromised the historic integrity of the building and Building 175, which continues to convey the its significance as a California Cap Company administration building.

*B12. References (continued):

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Photographs:

Photograph 2: Building 175, January 4, 2013, looking south

Photograph 3: Building 175, circa 1910, from Bancroft Library's Oliver Family Photograph Collection, labeled "Exterior California Cap Company office, California"

Photograph 4: Building 175, circa 1910, from Bancroft Library's Oliver Family Photograph Collection, labeled "Pacific Cartridge Co. Exterior – Stege, Calif."

Photograph 5: Workers outside Building 175 circa 1914,
Contra Costa County Historical Society collection

Photograph 6: Workers inside Building 175 circa 1914,
Contra Costa County Historical Society collection

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ **Reviewer** _____ **Date** _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 176

P1. Other Identifier: Richmond Field Station Building 176

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558516 mE/ 4196491 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 176 is in the southern portion of the Richmond Field Station between Building 175 and Building 150. Its primary façade faces northeast, along Lark Drive. The vernacular building does not strongly express any particular architecture style. It is single story and square in plan, 672 square feet, and was constructed prior to 1940.

***P3b. Resource Attributes:** (List attributes and codes) HP4: Ancillary Building

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Northwest and northeast facades of building, camera facing south, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Circa 1930/UC Berkeley records

***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804

***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** January 4, 2013

***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

B1. Historic Name: California Cap Company Building 73
B2. Common Name: Building 176
B3. Original Use: Unknown B4. Present Use: Research
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed circa 1930s
***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 176 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet.)

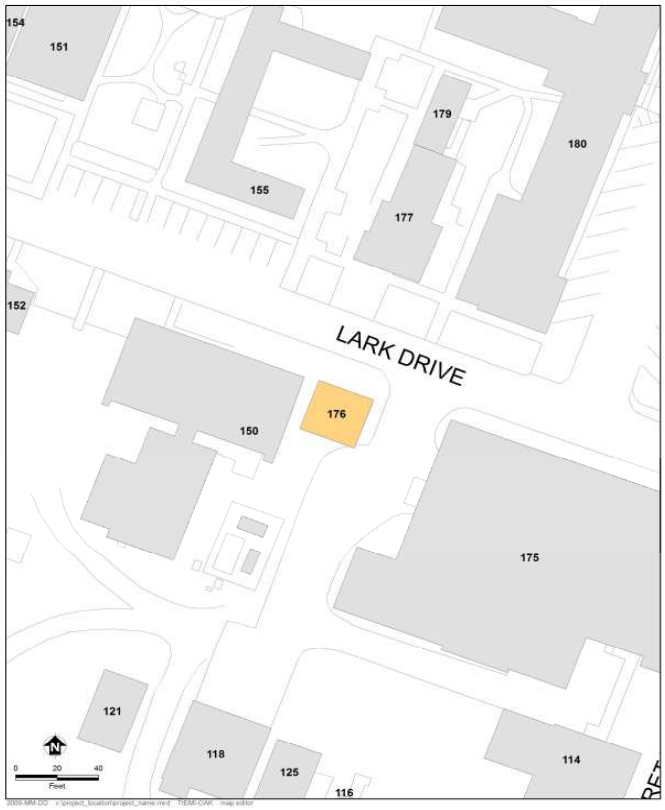
B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See Footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



P3a. Description (continued)

The building is topped with a front gabled roof, with a large vent on the gable ridge. The building's walls are reinforced concrete covered in stucco. The building lacks fenestration. Its only opening is a flush metal door with a small window on the primary (northeast) elevation, accessed by a sloping concrete walkway that leads from the street.

The California Cap Company constructed Building 176 circa the 1930s. It was originally referred to as "Building 73," and was used by the plant as a warehouse. After UC Berkeley purchased the property in 1950 it continued to use the building for storage. Although the building was retrofitted as an animal lab, it was never used for that purpose. In 1998 it was renovated for the use of a private company named Stratacor that works on topical anti-insect solutions.[1]

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[2] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[3] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[4]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[5] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[6] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[7] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were

[1] Shackleton, 2013.

[2] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[3] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[4] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[5] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[6] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[7] J.P. Munro-Fraser, p. 675.

operating from portions of the Stege Ranch.[8] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[9] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[10]

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its proximity to the harbor yet remote from population centers. In addition, the narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[11]

During the 1870s chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch. The San Francisco explosives companies soon followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to the Atlas Powder Company. The California Powder Works soon followed, building a new factory in Hercules, which was named for the brand under which the company sold its powder.[12] The Vulcan Powder Works and Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902 California had only one powder factory outside Contra Costa and Alameda counties.[13]

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory, which was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[14] William Letts Oliver and his wife Carrie lived in Oakland, from about 1880 until Oliver's death in 1918.[15] The couple eventually

[8] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[9] Hulanski p. 288.

[10] Ida Mae Purcell, *History of Contra Costa County*, The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

[11] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area*, University of California, Berkeley: 1964, p. 27.

[12] Purcell, p. 646.

[13] Richmond Record, "Contra Costa County: Under the Vitascope", Richmond:1902.

[14] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

[15] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[16] In addition his various professional activities William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the early twentieth century. An avid amateur photographer throughout his lifetime, UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[17]

William Letts Oliver initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[18] As early as 1870, European explosive companies were experimenting with nitrated guncotton in and by 1875 it was manufactured in England under the name "tonite."[19] By 1877 Oliver had left Chile and was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock needed an explosive that would remain stable at the high temperatures underground to complete the tunnel, and Oliver was able to solve the problem by substituting tonite for more volatile compounds.[20]

The California Cap Company

In 1877 William Letts Oliver was inspired by his success with tonite to leave mining and establish the Tonite Powder Company, on a portion of the former Stege Ranch.[21] In the 1870s all blasting caps in the United States had to be imported from Europe. Not only were they expensive, but the timing of deliveries was uncertain, creating business difficulties for the powder plant. Oliver was determined to create his own caps in order to protect the tonite factory business. He experimented until he came up with a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter founded the California Cap Company. It was located adjacent to the Tonite Powder Company a 160 acre parcel carved out of the southern portion of Stege Ranch.[22] California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[23] The California Cap Company was located on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

The Tonite and California Cap factories, which were the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[24] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882 at the nearby Vulcan Powder Company caused 11 deaths and destroyed the plant.[25] Between 1882 and 1918 the Hercules and Atlas plants suffered numerous

[16] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

[17] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley: 2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

[18] Pacific Mining News, p. 222.

[19] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.

[20] Pacific Mining News, p. 222.

[21] Oliver, p. 1.

[22] Pacific Mining News, p. 222.

[23] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.

[24] Oliver, p. 1.

[25] Munro-Fraser, p. 424.

explosions which destroyed plant buildings and killed a total of 64 workers.[26] Despite its focus on safety, the California Cap Company had accidents as well. Two of its Chinese workers were killed in 1917 when one of them dropped a tray of caps. In 1941 an explosion caused a fire and critically injured a worker.[27]

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888 he formed the American Lucol Company adjacent to the California Cap Company property.[28] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[29] The factory was dismantled and relocated to New Jersey circa 1900.[30] In 1903 the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field station property.[31] Later known as the U.S. Briquette Company, the plant appears to have operated at this location until at least 1917.[32] The U.S. Briquette Company buildings were demolished sometime in the 1960s.

The Oliver family aggressively promoted their products both through advertising and publishing. The California Cap Company sponsored or published both articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing as well as a selling point in advertisements.[33] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century the powder's explosive properties were considered comparable to the finest English products.[34] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family also became benefactors of the university, and in 1917 the California Cap Company donated substantial amounts of their products to the College of Mining including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[35]

Eventually the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[36] By 1916 there were at least a dozen buildings on the site. When Oliver died in 1918 his son Roland Oliver took over as president of California Cap Company. By 1922 Roland's brother Leslie Oliver was assistant manager of the plant and Edwin Letts Oliver was a director.[37] Roland Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[38]

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[26] Purcell, p. 648.

[27] Contra Costa County Standard, "Stege Powder Plant Blast; One Near Death", June 6, 1941, p. 1A.

[28] Oliver, p. 1.

[29] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913,* Dewey Publishing Company: 1913, p. 327.

[30] Oliver, p. 1.

[31] Oliver, p. 2.

[32] Hulanksi, p. 354.

[33] Halbert Powers Gillette, *Rock Excavation:Methods and Cost,* M.C. Clark, New York: 1904, x.

[34] Manual Eissler, *A Handbook on Modern Explosives,* Crosby, Lockwood & son, London: 1897, p. 117.

[35] University of California, *The University of California Chronicle,* University of California Press, January, 1917, p. 92.

[36] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915,* Oakland, California: 1915.

[37] Pacific Mining News, p.222.

[38] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[39] As the twentieth century progressed more heavy industry came to Contra Costa County, and by 1940 the county was second only to Los Angeles in overall industrial production.[40] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[41] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[42]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[43] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[44]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[45] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[46] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

[39] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

[40] Purcell, p. 649.

[41] Oliver, p. 1.

[42] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[43] University of California, Berkeley, 2008, p. 13.

[44] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[45] McGauhey, p. 71.

[46] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

Evaluation

The following provides an evaluation of Building 176 under each NRHP/CRHR criteria.

Building 176 does not appear to meet the criteria for listing in NRHP/CRHR because it lacks historical significance. The structure has been used for storage throughout its lifetime and as such lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 or B/2).

The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 178

P1. Other Identifier: Richmond Field Station Building 178

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558587 mE/ 4196368 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 178 is along the southeastern border of the Richmond Field Station. It is set back from Egret Way to the east adjacent to building 185. Its primary façade faces northwest. The utilitarian building does not strongly express any particular architecture style. It is single story, rectangular in plan, 3,950 square feet, and was constructed prior to 1940. The building is topped with a side gabled roof. Its roof and walls are clad in corrugated metal. Fenestration is both aluminum sliding sashes and multiple light wood sashes. There are three entryways on the primary (northwest) elevation. Entrances at the north end and the center of the elevation are metal double doors with windows. The south entrance is a single metal door with a window. At either end of the building the entrances are accessed by sets of wooden stairs. A similar door is at the north end of the rear (southeast) elevation. (See Continuation Sheet)

***P3b. Resource Attributes:** (List attributes and codes) HP4: Ancillary Building

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Northwest and southwest facades of building, camera facing east, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Unknown
***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804
***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612
***P9. Date Recorded:** January 4, 2013
***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.
***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record
☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record
☐ Other (list) _____

B1. Historic Name: _____
B2. Common Name: Building 178
B3. Original Use: Unknown B4. Present Use: Art practice
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Unknown
***B7. Moved?** ☐ **No** ☒ **Yes** ☐ **Unknown** **Date:** circa 1990 **Original Location:** Unknown
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 178 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources. (See Continuation Sheet.)

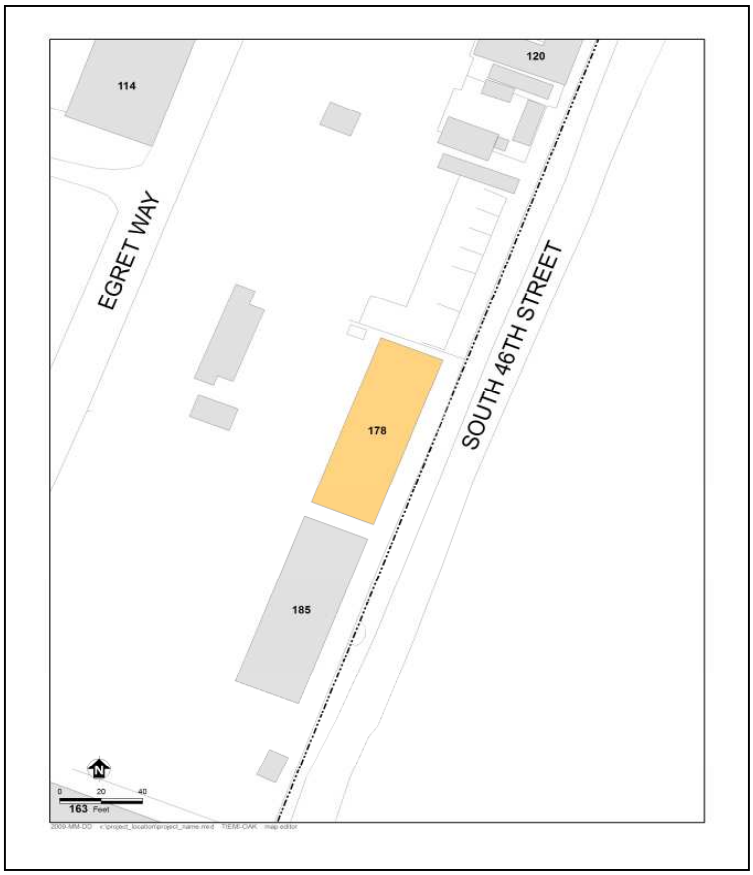
B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See Footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



P3a. Description (continued)

Building 178 appears to have been moved to this location circa 1990. Although UC Berkeley property records and building materials suggest a build date prior to 1950, Building 178 does not appear on aerial photographs of this location until the 1990s. Research has not uncovered its original use or location. Building 178 housed the California Conservation Corps until circa 1999, after which it served as an electrical shop and a warehouse. It is currently used for Art Practice Studies.[1]

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[2] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[3] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[4]

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[5] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[6] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[7] J.P. Munro-Fraser, p. 675.

[8] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[9] Hulanski p. 288.

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The Tonite and California Cap factories, which were the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[24] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882 at the nearby Vulcan Powder Company caused 11 deaths and destroyed the plant.[25] Between 1882 and 1918 the Hercules and Atlas plants suffered numerous explosions which destroyed plant buildings and killed a total of 64 workers.[26] Despite its focus on safety, the California Cap Company had accidents as well. Two of its Chinese workers were killed in 1917 when one of them dropped a tray of caps. In 1941 an explosion caused a fire and critically injured a worker.[27]

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[17] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley: 2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

[18] Pacific Mining News, p. 222.

[19] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.

[20] Pacific Mining News, p. 222.

[21] Oliver, p. 1.

[22] Pacific Mining News, p. 222.

[23] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.

[24] Oliver, p. 1.

[25] Munro-Fraser, p. 424.

[26] Purcell, p. 648.

[27] Contra Costa County Standard, "Stege Powder Plant Blast; One Near Death", June 6, 1941, p. 1A.

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888 he formed the American Lucol Company adjacent to the California Cap Company property.[28] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[29] The factory was dismantled and relocated to New Jersey circa 1900.[30] In 1903 the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field station property.[31] Later known as the U.S. Briquette Company, the plant appears to have operated at this location until at least 1917.[32] The U.S. Briquette Company buildings were demolished sometime in the 1960s.

The Oliver family aggressively promoted their products both through advertising and publishing. The California Cap Company sponsored or published both articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing as well as a selling point in advertisements.[33] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century the powder's explosive properties were considered comparable to the finest English products.[34] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family also became benefactors of the university, and in 1917 the California Cap Company donated substantial amounts of their products to the College of Mining including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[35]

Eventually the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[36] By 1916 there were at least a dozen buildings on the site. When Oliver died in 1918 his son Roland Oliver took over as president of California Cap Company. By 1922 Roland's brother Leslie Oliver was assistant manager of the plant and Edwin Letts Oliver was a director.[37] Roland Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[38]

During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[39] As the twentieth century progressed more heavy industry came to Contra Costa County, and by

[28] Oliver, p. 1.
[29] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913*, Dewey Publishing Company: 1913, p. 327.
[30] Oliver, p. 1.
[31] Oliver, p. 2.
[32] Hulanksi, p. 354.
[33] Halbert Powers Gillette, *Rock Excavation:Methods and Cost,* M.C. Clark, New York: 1904, x.
[34] Manual Eissler, *A Handbook on Modern Explosives*, Crosby, Lockwood & son, London: 1897, p. 117.
[35] University of California, *The University of California Chronicle*, University of California Press, January, 1917, p. 92.
[36] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.
[37] Pacific Mining News, p.222.
[38] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.
[39] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

1940 the county was second only to Los Angeles in overall industrial production.[40] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[41] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[42]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[43] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[44]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[45] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[46] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Evaluation

The following provides an evaluation of Building 178 under each NRHP/CRHR criteria.

Building 178 does not appear to meet the criteria for listing in NRHP/CRHR because it lacks historical significance. The structure has been used for a variety of purposes throughout its lifetime and as such lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 and B/2).

[40] Purcell, p. 649.

[41] Oliver, p. 1.

[42] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[43] University of California, Berkeley, 2008, p. 13.

[44] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[45] McGauhey, p. 71.

[46] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

As a multiple use building, Building 178 does not meet the standard of exceptional importance required for properties under 50 years old to be eligible to the NHRP (Criterion G).

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 185

P1. Other Identifier: Richmond Field Station Building 185

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558577 mE/ 4196342 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 185 is along the southeastern border of the Richmond Field Station. It is set back from Egret Way to the east adjacent to building 178. Its primary façade faces northwest. The utilitarian building does not strongly express any particular architecture style. It is single story, rectangular in plan, 3,165 square feet, and constructed prior to 1940. The building is topped with a side gabled roof. Its roof and walls are clad in corrugated metal and it lacks fenestration. Entryways, at either end of the primary (northeast) elevation, are flush wood doors. The south door is accessed by a set of wooden stairs. Another entryway is at the north end of the rear (southwest) elevation. Building 185 appears to have been moved to this location circa 1990. Although UC Berkeley property records and building materials suggest a build date prior to 1950, Building 185 does not appear on aerial photographs of this location until the 1990s. Research has not uncovered its original use or location. The building has been a support facility since the 1990s.

***P3b. Resource Attributes:** (List attributes and codes) HP4: Ancillary Building

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Northwest and southwest facades of building, camera facing east, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Unknown
***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804
***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612
***P9. Date Recorded:** January 4, 2013
***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.
***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record
☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record
☐ Other (list) _____

***NRHP Status Code** 6Z

***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 185

B1. Historic Name: _____
B2. Common Name: Building 185
B3. Original Use: Unknown B4. Present Use: Admistrative/Support
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Unknown
***B7. Moved?** ☐ **No** ☒ **Yes** ☐ **Unknown** **Date:** circa 1990 **Original Location:** Unknown
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 185 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet.)

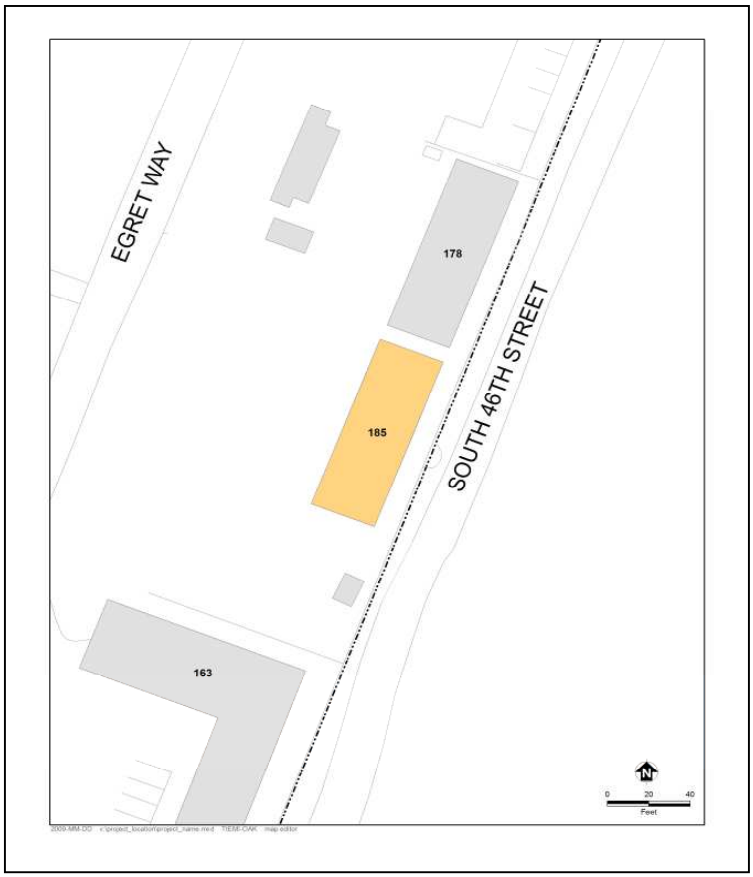
B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See Footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[1] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[2] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[3]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[4] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[5] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[6] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[7] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[8] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[9]

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[1] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[2] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[3] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[4] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[5] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[6] J.P. Munro-Fraser, p. 675.

[7] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[8] Hulanski p. 288.

[9] Ida Mae Purcell, *History of Contra Costa County*, The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its proximity to the harbor yet remote from population centers. In addition, the narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[10]

During the 1870s chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch. The San Francisco explosives companies soon followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to the Atlas Powder Company. The California Powder Works soon followed, building a new factory in Hercules, which was named for the brand under which the company sold its powder.[11] The Vulcan Powder Works and Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902 California had only one powder factory outside Contra Costa and Alameda counties.[12]

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory, which was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[13] William Letts Oliver and his wife Carrie lived in Oakland, from about 1880 until Oliver's death in 1918.[14] The couple eventually had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[15] In addition his various professional activities William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the early twentieth century. An avid amateur photographer throughout his lifetime, UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[16]

William Letts Oliver initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[17] As early as 1870, European explosive companies were experimenting with nitrated guncotton in and by 1875 it was manufactured in England under the name "tonite."[18] By 1877 Oliver had left Chile and was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock

[10] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area,* University of California, Berkeley: 1964, p. 27.

[11] Purcell, p. 646.

[12] Richmond Record, "Contra Costa County: Under the Vitascope", Richmond:1902.

[13] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

[14] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

[15] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

[16] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley: 2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

[17] Pacific Mining News, p. 222.

[18] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.

needed an explosive that would remain stable at the high temperatures underground to complete the tunnel, and Oliver was able to solve the problem by substituting tonite for more volatile compounds.[19]

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[27] Oliver, p. 1.
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[32] Halbert Powers Gillette, *Rock Excavation:Methods and Cost,* M.C. Clark, New York: 1904, x.

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[34] University of California, *The University of California Chronicle,* University of California Press, January, 1917, p. 92.

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[39] Purcell, p. 649.

[40] Oliver, p. 1.

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Evaluation

The following provides an evaluation of Building 185 under each NRHP/CRHR criteria.

Building 185 does not appear to meet the criteria for listing in NRHP/CRHR because it lacks historical significance. The structure has been used for a variety of purposes throughout its lifetime and as such lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 and B/2).

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[41] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[42] University of California, Berkeley, 2008, p. 13.

[43] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[44] McGauhey, p. 71.

[45] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 197

P1. Other Identifier: Richmond Field Station Building 197

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558614 mE/ 4196460 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 197 is along the southeastern border of the Richmond Field Station. It is set back from Egret Way to the east adjacent to building 117. Its primary façade faces northeast. The utilitarian building does not strongly express any particular architecture style. It is single story, rectangular in plan, 2,419 square feet, and constructed in 1975. The building is topped with a very shallow-pitched, side-gabled roof. Its roof and walls are clad in corrugated metal. Fenestration is an aluminum sliding sash. Three large open bays provide access to the northern end of the primary (northeast) elevation. A large metal roll up door is at its southern end. The entrance at the south end of the northwest elevation is a flush metal door. UC Berkeley constructed Building 197 in 1975. It has been used for support and heavy vehicle storage since its construction. In addition, drums containing waste petroleum products are stored in the building. The building is not of historic age as it is 38 years old.

***P3b. Resource Attributes:** (List attributes and codes) HP4: Ancillary Building

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Northwest and southwest facades of building, camera facing east, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
1975/UC Berkeley records
***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804
***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612
***P9. Date Recorded:** January 4, 2013
***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.
***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record
☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record
☐ Other (list) _____

B1. Historic Name: _____
B2. Common Name: Building 197
B3. Original Use: Vehicle Storage B4. Present Use: Vehicle Storage
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed in 1975
***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 197 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet)

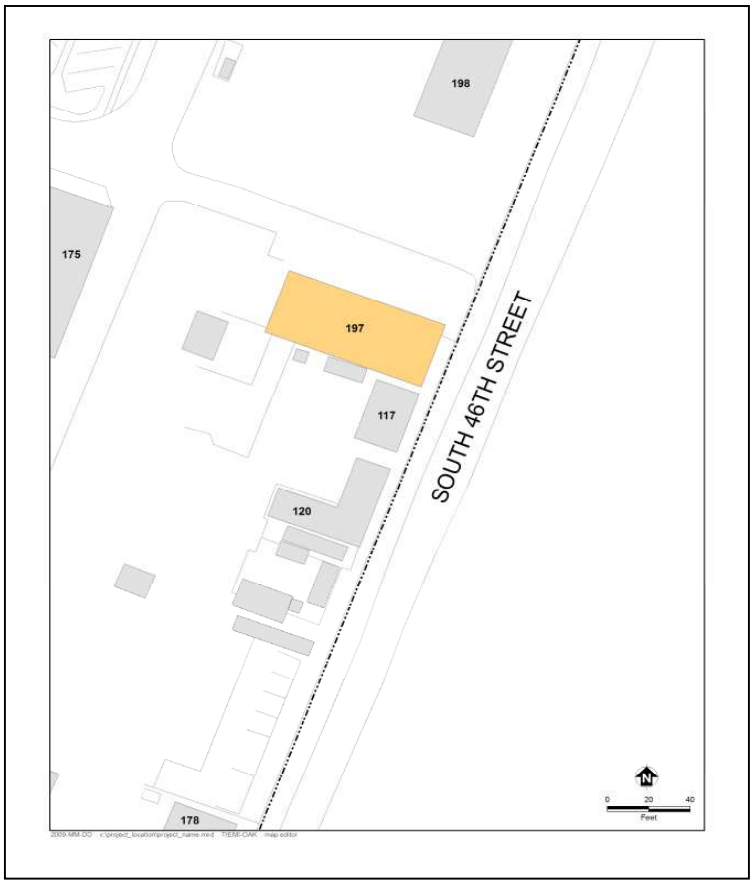
B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[1] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[2] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[3]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[4] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[5] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[6] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[7] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[8] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[9]

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[1] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[2] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[3] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[4] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[5] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[6] J.P. Munro-Fraser, p. 675.

[7] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[8] Hulanski p. 288.

[9] Ida Mae Purcell, *History of Contra Costa County*, The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its proximity to the harbor yet remote from population centers. In addition, the narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[10]

During the 1870s chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch. The San Francisco explosives companies soon followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to the Atlas Powder Company. The California Powder Works soon followed, building a new factory in Hercules, which was named for the brand under which the company sold its powder.[11] The Vulcan Powder Works and Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902 California had only one powder factory outside Contra Costa and Alameda counties.[12]

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory, which was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[13] William Letts Oliver and his wife Carrie lived in Oakland, from about 1880 until Oliver's death in 1918.[14] The couple eventually had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[15] In addition his various professional activities William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the early twentieth century. An avid amateur photographer throughout his lifetime, UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[16]

William Letts Oliver initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[17] As early as 1870, European explosive companies were experimenting with nitrated guncotton in and by 1875 it was manufactured in England under the name "tonite."[18] By 1877 Oliver had left

[10] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area,* University of California, Berkeley: 1964, p. 27.

[11] Purcell, p. 646.

[12] Richmond Record, "Contra Costa County: Under the Vitascope", Richmond:1902.

[13] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

[14] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

[15] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

[16] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley: 2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

[17] Pacific Mining News, p. 222.

[18] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.

Chile and was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock needed an explosive that would remain stable at the high temperatures underground to complete the tunnel, and Oliver was able to solve the problem by substituting tonite for more volatile compounds.[19]

The California Cap Company

In 1877 William Letts Oliver was inspired by his success with tonite to leave mining and establish the Tonite Powder Company, on a portion of the former Stege Ranch.[20] In the 1870s all blasting caps in the United States had to be imported from Europe. Not only were they expensive, but the timing of deliveries was uncertain, creating business difficulties for the powder plant. Oliver was determined to create his own caps in order to protect the tonite factory business. He experimented until he came up with a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter founded the California Cap Company. It was located adjacent to the Tonite Powder Company a 160 acre parcel carved out of the southern portion of Stege Ranch.[21] California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[22] The California Cap Company was located on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

The Tonite and California Cap factories, which were the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[23] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882 at the nearby Vulcan Powder Company caused 11 deaths and destroyed the plant.[24] Between 1882 and 1918 the Hercules and Atlas plants suffered numerous explosions which destroyed plant buildings and killed a total of 64 workers.[25] Despite its focus on safety, the California Cap Company had accidents as well. Two of its Chinese workers were killed in 1917 when one of them dropped a tray of caps. In 1941 an explosion caused a fire and critically injured a worker.[26]

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888 he formed the American Lucol Company adjacent to the California Cap Company property.[27] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[28] The factory was dismantled and relocated to New Jersey circa 1900.[29] In 1903 the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field station property.[30] Later known as the U.S. Briquette Company, the plant appears to have

[19] Pacific Mining News, p. 222.
[20] Oliver, p. 1.
[21] Pacific Mining News, p. 222.
[22] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.
[23] Oliver, p. 1.
[24] Munro-Fraser, p. 424.
[25] Purcell, p. 648.
[26] Contra Costa County Standard, "Stege Powder Plant Blast; One Near Death", June 6, 1941, p. 1A.
[27] Oliver, p. 1.
[28] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913*, Dewey Publishing Company: 1913, p. 327.
[29] Oliver, p. 1.

operated at this location until at least 1917.[31] The U.S. Briquette Company buildings were demolished sometime in the 1960s.

The Oliver family aggressively promoted their products both through advertising and publishing. The California Cap Company sponsored or published both articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing as well as a selling point in advertisements.[32] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century the powder's explosive properties were considered comparable to the finest English products.[33] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family also became benefactors of the university, and in 1917 the California Cap Company donated substantial amounts of their products to the College of Mining including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[34]

Eventually the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[35] By 1916 there were at least a dozen buildings on the site. When Oliver died in 1918 his son Roland Oliver took over as president of California Cap Company. By 1922 Roland's brother Leslie Oliver was assistant manager of the plant and Edwin Letts Oliver was a director.[36] Roland Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[37]

During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[38] As the twentieth century progressed more heavy industry came to Contra Costa County, and by 1940 the county was second only to Los Angeles in overall industrial production.[39] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[40] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

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[30] Oliver, p. 2.

[31] Hulanksi, p. 354.

[32] Halbert Powers Gillette, *Rock Excavation:Methods and Cost,* M.C. Clark, New York: 1904, x.

[33] Manual Eissler, *A Handbook on Modern Explosives,* Crosby, Lockwood & son, London: 1897, p. 117.

[34] University of California, *The University of California Chronicle,* University of California Press, January, 1917, p. 92.

[35] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.

[36] Pacific Mining News, p.222.

[37] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

[38] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

[39] Purcell, p. 649.

[40] Oliver, p. 1.

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[41]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[42] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[43]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[44] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[45] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Evaluation

The following provides an evaluation of Building 197 under each NRHP and CRHR criteria.

Building 197 does not appear to meet the criteria for listing in National Register of Historic Places because it lacks historical significance. The structure has been used for a variety of purposes throughout its lifetime and as such lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 and B/2).

The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

As a storage facility Building 197 does not meet the standard of exceptional importance required for properties under 50 years old to be eligible to the NHRP (Criterion G).

[41] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[42] University of California, Berkeley, 2008, p. 13.

[43] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[44] McGauhey, p. 71.

[45] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ **Reviewer** _____ **Date** _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 275

P1. Other Identifier: Richmond Field Station Building 275

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558393 mE/ 4196523 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 275 is in the southern portion of the Richmond Field Station. It is on the south side of Lark Drive between Building 153 and Building 276, with its primary façade facing northeast. The vernacular building does not strongly express any particular architecture style. It is single story, irregular in plan, 7,914 square feet, constructed in 1956. (See Continuation Sheet)

***P3b. Resource Attributes:** (List attributes and codes) HP15: Educational building; HP39: Other

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Northeast and southeast facades of building, camera facing southwest, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
1956/UC Berkeley records

***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804

***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** January 4, 2013

***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

B1. Historic Name: _____
B2. Common Name: Building 275
B3. Original Use: Research B4. Present Use: Research/offices
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed in 1956
1966: Addition constructed
***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 275 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet.)

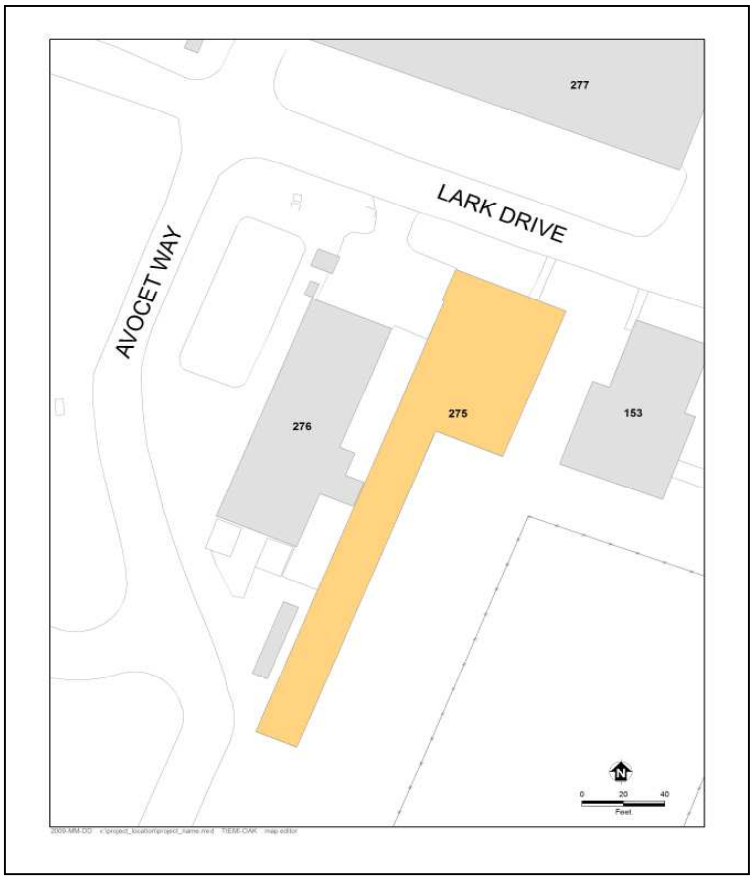
B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** See Footnotes
B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



P3a. Description (continued)

The front portion of the building, adjacent to Lark Drive, is topped with a flat roof featuring a broad eave overhang with large exposed roof members. The walls are sided in smooth stucco with vertical wood trim. Fenestration is fixed and awning metal sashes. The entrance is a flush door with a window at the east end of the primary (northeast) elevation.

An older, front-gabled building, with its front gable visible behind the flat roof, is joined to the rear of the main section of the building. Its roof and walls are clad in corrugated metal. Fenestration is multiple light fixed metal sashes. This older section of the building has no entryways.

UC Berkeley constructed building 275 in 1956. Originally it consisted of the long narrow section currently the southwest wing of the building. It was used as a laboratory for hydraulic and coastal engineering, and to test ship hull designs.[1] The facility included a towing tank for experiments. Historic aerial photographs indicate that the front (northeast) portion of the building along Lark Drive was constructed in 1966. The building currently houses offices.

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[2] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[3] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[4]

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[1] University of California, Berkeley, 2008, p. 14.

[2] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[3] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[4] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[5] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[6] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[7] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 675.

money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[8] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[9] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[10]

The nineteenth century explosives industry was extremely dangerous, and as San Francisco's population grew explosives manufacturers needed to relocate. Contra Costa County across the bay was attractive since it was accessible due to its proximity to the harbor yet remote from population centers. In addition, the narrow canyons of Contra Costa County, which terminate in small bays, provided a natural geographical defense against explosions by allowing factory design that placed water between different facets of explosives manufacturing.[11]

During the 1870s chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch. The San Francisco explosives companies soon followed those explosive companies across the bay to Contra Costa County. In 1880, Giant relocated to Point Pinole, changing its name to the Atlas Powder Company. The California Powder Works soon followed, building a new factory in Hercules, which was named for the brand under which the company sold its powder.[12] The Vulcan Powder Works and Judson Powder works also opened in the Stege Ranch area during this era, consolidating Contra Costa County's position as the cradle of the California explosives industry. The East Bay dominated California explosives manufacturing into the twentieth century. In 1902 California had only one powder factory outside Contra Costa and Alameda counties.[13]

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He attended the University of Edinburgh and became a mining engineer. After returning to Chile, Oliver ran an explosives factory, which was nationalized by the Chilean government in 1864. After the loss of his factory, Oliver left Chile for San Francisco.[14] William Letts

[8] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[9] Hulanski p. 288.

[10] Ida Mae Purcell, *History of Contra Costa County*, The Gillick Press, Berkeley, California" 1940, p. 645 – 646.

[11] James E. Vance, *Geography and Urban Evolution in the San Francisco Bay Area*, University of California, Berkeley: 1964, p. 27.

[12] Purcell, p. 646.

[13] Richmond Record, "Contra Costa County: Under the Vitascope", Richmond:1902.

[14] Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

Oliver and his wife Carrie lived in Oakland, from about 1880 until Oliver's death in 1918.[15] The couple eventually had six children together: Roland, Edwin, Caroline, Anita, William Harold, and Albert.[16] In addition his various professional activities William Letts Oliver was a yachtsman and an officer of the Bohemian Grove club in the early twentieth century. An avid amateur photographer throughout his lifetime, UC Berkeley's Bancroft Library has a collection of 2700 negatives and prints taken by Oliver and his son.[17]

William Letts Oliver initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[18] As early as 1870, European explosive companies were experimenting with nitrated guncotton in and by 1875 it was manufactured in England under the name "tonite."[19] By 1877 Oliver had left Chile and was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock needed an explosive that would remain stable at the high temperatures underground to complete the tunnel, and Oliver was able to solve the problem by substituting tonite for more volatile compounds.[20]

The California Cap Company

In 1877 William Letts Oliver was inspired by his success with tonite to leave mining and establish the Tonite Powder Company, on a portion of the former Stege Ranch.[21] In the 1870s all blasting caps in the United States had to be imported from Europe. Not only were they expensive, but the timing of deliveries was uncertain, creating business difficulties for the powder plant. Oliver was determined to create his own caps in order to protect the tonite factory business. He experimented until he came up with a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter founded the California Cap Company. It was located adjacent to the Tonite Powder Company a 160 acre parcel carved out of the southern portion of Stege Ranch.[22] California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[23] The California Cap Company was located on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

The Tonite and California Cap factories, which were the first of several gunpowder and chemical companies in the region, were separated by the Stege agricultural warehouse for safety.[24] The explosives industry during this era was an extremely dangerous one. A horrific explosion in 1882 at the nearby Vulcan Powder Company caused 11

[15] United States Census Bureau, Tenth Census of the United States, 1880, National Archives and Records Administration, Washington, D.C., San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.

[16] United States Census Bureau, Twelfth Census of the United States, 1900, National Archives and Records Administration, Washington, D.C., Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

[17] Online Archive of California, "Guide to the Oliver Family Photograph Collection", UC Berkeley:2009, website: http://www.oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/ accessed February, 2013.

[18] Pacific Mining News, p. 222.

[19] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.

[20] Pacific Mining News, p. 222.

[21] Oliver, p. 1.

[22] Pacific Mining News, p. 222.

[23] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.

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deaths and destroyed the plant.[25] Between 1882 and 1918 the Hercules and Atlas plants suffered numerous explosions which destroyed plant buildings and killed a total of 64 workers.[26] Despite its focus on safety, the California Cap Company had accidents as well. Two of its Chinese workers were killed in 1917 when one of them dropped a tray of caps. In 1941 an explosion caused a fire and critically injured a worker.[27]

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888 he formed the American Lucol Company adjacent to the California Cap Company property.[28] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station, at the approximate location of Building 163. Lucol manufactured a linseed oil substitute.[29] The factory was dismantled and relocated to New Jersey circa 1900.[30] In 1903 the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field station property.[31] Later known as the U.S. Briquette Company, the plant appears to have operated at this location until at least 1917.[32] The U.S. Briquette Company buildings were demolished sometime in the 1960s.

The Oliver family aggressively promoted their products both through advertising and publishing. The California Cap Company sponsored or published both articles and book-length treatises on the use of explosives. Safety was a key element of the company image, a topic of company-sponsored technical writing as well as a selling point in advertisements.[33] The Tonite Powder Company's product was known even outside the United States, and by the end of the nineteenth century the powder's explosive properties were considered comparable to the finest English products.[34] Oliver's sons Roland and Edwin Letts Oliver both graduated from UC Berkeley's College of Mining in 1900. Roland Oliver seems to have spent his entire career working in the family enterprises, while Edwin worked at California Cap between mining and other ventures. The Oliver family also became benefactors of the university, and in 1917 the California Cap Company donated substantial amounts of their products to the College of Mining including 500 electric detonators, 500 delayed action exploders, and 500 blasting caps.[35]

Eventually the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[36] By 1916 there were at least a dozen buildings on the site. When Oliver died in 1918 his son Roland Oliver took over as president of California Cap Company. By 1922 Roland's brother Leslie Oliver was assistant manager of the plant and Edwin Letts Oliver was a director.[37] Roland

[25] Munro-Fraser, p. 424.
[26] Purcell, p. 648.
[27] Contra Costa County Standard, "Stege Powder Plant Blast; One Near Death", June 6, 1941, p. 1A.
[28] Oliver, p. 1.
[29] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913,* Dewey Publishing Company: 1913, p. 327.
[30] Oliver, p. 1.
[31] Oliver, p. 2.
[32] Hulanksi, p. 354.
[33] Halbert Powers Gillette, *Rock Excavation:Methods and Cost,* M.C. Clark, New York: 1904, x.
[34] Manual Eissler, *A Handbook on Modern Explosives,* Crosby, Lockwood & son, London: 1897, p. 117.
[35] University of California, *The University of California Chronicle,* University of California Press, January, 1917, p. 92.
[36] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915,* Oakland, California: 1915.
[37] Pacific Mining News, p.222.

Oliver substantially expanded the California Cap Company after he took over as president. During this era the plant grew to include 150 buildings and a horse-drawn tram line.[38]

During the late nineteenth and early twentieth century the California Cap Company was one of the most important local employers.[39] As the twentieth century progressed more heavy industry came to Contra Costa County, and by 1940 the county was second only to Los Angeles in overall industrial production.[40] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II California Cap was able to stay open by producing delayed action incendiary bombs that were used against Japan.[41] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed and the Oliver family looking for a buyer.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[42]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[43] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[44]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[45] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[46] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Evaluation

[38] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

[39] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

[40] Purcell, p. 649.

[41] Oliver, p. 1.

[42] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[43] University of California, Berkeley, 2008, p. 13.

[44] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[45] McGauhey, p. 71.

[46] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

The following provides an evaluation of Building 275 under each NRHP/CRHR criteria.

Building 275 does not appear to meet the criteria for listing in NRHP/CRHR because it lacks historical significance. The structure has been used for research throughout its lifetime and as such lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 and B/2).

The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3). In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 276

P1. Other Identifier: Richmond Field Station Building 276

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 396633 mE/ 4396112 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 276 is in the southern portion of the Richmond Field Station. It is on the south side of Lark Drive adjacent to Building 276, with its primary façade facing northeast. The utilitarian building does not strongly express any particular architecture style. It is single story and rectangular in plan.

The building is topped with a front-gabled roof. Its walls are corrugated metal. Fenestration is multi-light metal sashes. The main entrance is through a flush metal industrial door. A shed roofed addition projects from the rear elevation of the building.

***P3b. Resource Attributes:** (List attributes and codes) HP4: Ancillary Building

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1: Northeast façade of building, camera facing south, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
1958
***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804
***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** January 4, 2013
***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station* prepared by Tetra Tech, Inc, 2013.
***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record
☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record
☐ Other (list) _____

B1. Historic Name: _____

B2. Common Name: Building 276

B3. Original Use: Research B4. Present Use: Research

***B5. Architectural Style:** Vernacular

***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed in 1958

***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____

***B8. Related Features:** _____

B9. Architect: Unknown b. Builder: Unknown

***B10. Significance: Theme** N/A **Area** N/A

Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A

(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 276 at Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet)

B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:**

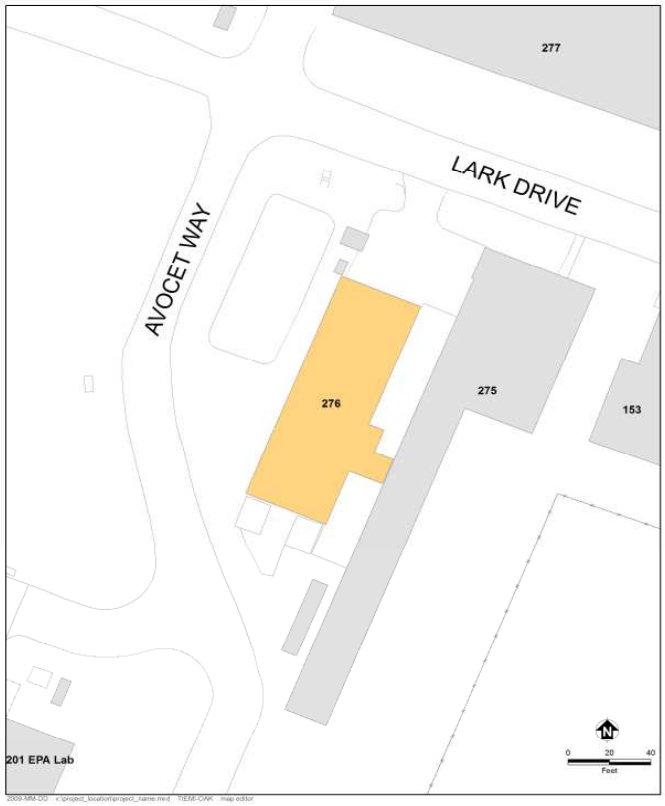
See Footnotes

B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** January 2013

(This space reserved for official comments.)



B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[1] Though subsequent Spanish expeditions passed through the region the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000 acre Rancho San Pablo to the Castros in 1823.[2] Americans began farming in Contra Costa County in the late 1830s, and by 1882 2/3 of the cultivated land in the county was devoted to wheat production.[3]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[4] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo as well as the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[5] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade. He married Minna Quilfelt, who was a widow, in 1870.[6] Minna Quilfelt Stege died in 1879, leaving the ranch to Stege and her daughter Edith. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Works, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[7] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[8] Stege was eventually absorbed into Richmond as the latter grew.

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Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867 he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive. Nobel licensed the Giant Powder Company to produce dynamite in California later that year. Giant was the first American company to produce dynamite, and its plant was initially located in Rock House Canyon, in what is today the City of San Francisco. The California Powder Works began manufacturing dynamite in the same area in 1869.[9]

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[1] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[2] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[3] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[4] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[5] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[6] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 675.

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[31] Hulanksi, p. 354.

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[33] Manual Eissler, *A Handbook on Modern Explosives,* Crosby, Lockwood & son, London: 1897, p. 117.

[34] University of California, *The University of California Chronicle,* University of California Press, January, 1917, p. 92.

[35] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.

[36] Pacific Mining News, p.222.

[37] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

[38] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

[39] Purcell, p. 649.

[40] Oliver, p. 1.

University Research/Richmond Field Station

After World War II UC Berkeley's Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O' Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. The University purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[41]

The Richmond Field Station has been the location of a research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[42] Other early projects at the field station included sea water distillation, heat transfer, and cyclic stress research.[43]

At first the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[44] The current Buildings 102, 110, 118, 128, 150, 152 175, and 176 all date to the cap company era and have been repurposed for the Richmond Field Station. They also constructed new buildings as funds became available, and by the mid-1950s five new buildings had been completed at the Richmond Field Station.[45] By the 1970s the department had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

Evaluation

Building 276 does not appear to meet the criteria for listing in NRHP/CRHR because it lacks historical significance. The structure has been used for research throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 and B/2).

The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3) Instead, it is a simple utilitarian building. In rare instances, buildings themselves can serve as sources of important information, however this building is not a principal source of important information in this regard (Criterion D/4).

*B12. References (continued):

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Clausen, Marguerite. "On the Waterfront: An Oral History of Richmond, California". Regional Oral History

[41] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[42] University of California, Berkeley, 2008, p. 13.

[43] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[44] McGauhey, p. 71.

[45] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

Office, University of California, Berkeley: 1990.

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McGauhey, P.H. "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call". Regional Oral History Office, University of California, Berkeley: 1974.

Munro-Fraser, J.P. *History of Contra Costa County, California*. W.A. Slocum & Co., San Francisco: 1882.

O'Brien, Morrough. Regional Oral History Office, University of California, Berkeley.

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Oliver, Roland. "Recollections of Early Industries in Stege". August 7, 1959. Located in ephemera file labeled "Stege" at Contra Costa County Historical Society.

Pacific Mining News, Supplement to Engineering & Mining Journal-Press, "Industrial Notes: Developing of the Blasting Cap Industry", Vol. 1, No. 7, November 1922, p. 222.

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Purcell, Ida Mae. *History of Contra Costa County.* The Gillick Press, Berkeley, California: 1940.

Rego, Nilda. "Enterprising Stege lost all and died without a penny". Time Out. March 27, 1994, p. 2, column 4.

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--------Stege, California. 1912.
--------Richmond, California. 1916.
--------Richmond, California. 1949.

San Francisco Chronicle. "EPA Signs Lab Lease in Richmond". June 19, 1991.

Shackleton, Scott. University of California, Berkeley. Personal communication with Julia Mates, Tetra Tech 2013.

United States Census Bureau.
--------Tenth Census of the United States, 1880. National Archives and Records Administration, Washington, D.C. San Francisco, California, Roll: 79, Film: 1254079, Page: 170B.
--------Twelfth Census of the United States, 1900. National Archives and Records Administration, Washington, D.C. Oakland Ward 3, Alameda, California, Roll: 82, Page: 13A.

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--------"Current Conditions Report." Prepared by Tetra Tech EM Inc. November 21, 2008.
--------"Draft Environmental Impact Report, Proposed U.S. Environmental Protection Agency, Region IX Laboratory at the University of California's Richmond Field Station". Prepared by University of California, Berkeley Planning, Design and Construction Department. July 1991.
---------Building files. Vertical files, Room 148. Richmond Field Station.

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BUILDINGS IN THE INDIRECT APE

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 151

P1. Other Identifier: Richmond Field Station Building 151

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond ___ **Date** 2013 **T** 1N ; **R** 4W; ___ **¼ of Sec** 20 ; Mt. Diablo **B.M.**
c. Address _____ City _____ Zip _____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558475 mE/ 4196552 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 151 is in the southern portion of the Richmond Field Station. It is on the north side of Lark Drive, with its primary façade facing southwest. This 2,629 square-foot building is rectangular in plan and is a Soule Steel Company prefabricated building, topped with a front gabled roof. Vents are located at each gable end. The walls and roof are corrugated metal. Fenestration consists of multi-light, metal sashes. There is also a small aluminum frame window in the center of the primary façade. The main entrance consists of a metal industrial door with a glass insert located at the east end. This entrance is sheltered by a metal awning and accessed by a very gradual concrete ramp that runs across the main façade of the building. The rear of the building, at the northeast, contains an overhead mounted sliding door (Photograph 2). In 1965, a 1,600 square-foot addition was constructed on the north end of the building.

***P3b. Resource Attributes:** (List attributes and codes) P39: Other

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1, camera facing northeast, April 30, 2013.
***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
1961/Richmond Field Station Building Files
***P7. Owner and Address:**
University of California, Berkeley
1301 South 46th Street
Richmond, California 94804
***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612
***P9. Date Recorded:** April 30, 2013
***P10. Survey Type:** (Describe) Intensive
***P11. Report Citation:** (Cite survey report and other sources, or enter "none.")

Historic Properties Survey Report for Portions of the Richmond Field Station, prepared by Tetra Tech, Inc., 2013.

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record
☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record
☐ Other (list) _____

***NRHP Status Code** 6Z

***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 151

B1. Historic Name: _____

B2. Common Name: Building 151

B3. Original Use: Research B4. Present Use: Research

***B5. Architectural Style:** Vernacular

***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed in 1961; additional 20 feet by 40 feet at each end of building, constructed 1965

***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____

***B8. Related Features:** _____

B9. Architect: Unknown b. Builder: Unknown

***B10. Significance: Theme** N/A **Area** N/A

Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A

(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 151 at the Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet)

B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:**

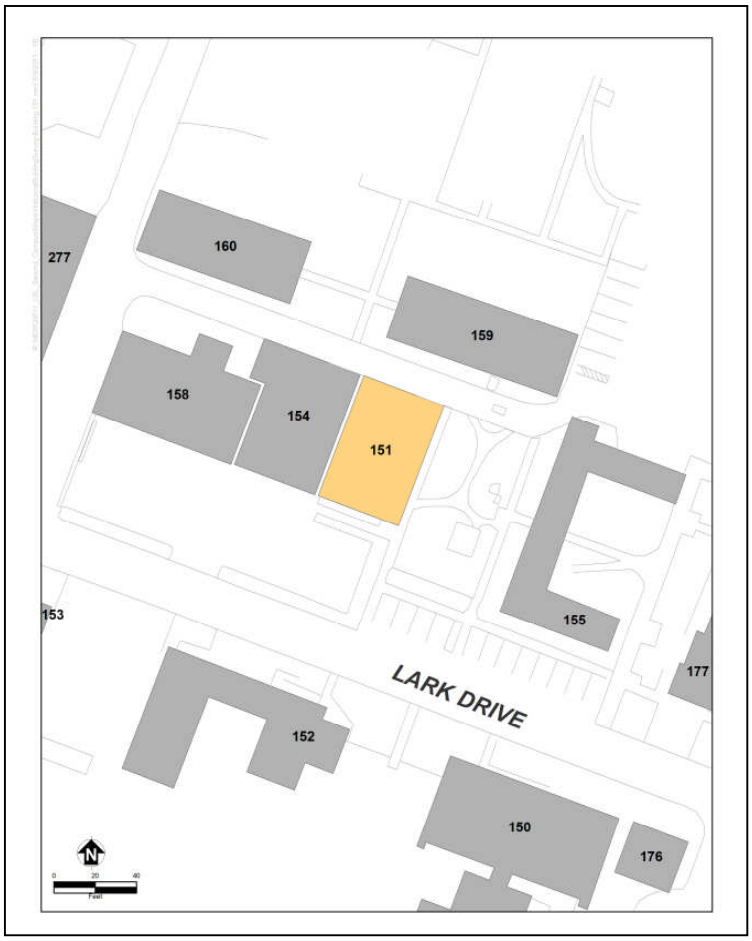
(See Footnotes)

B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** April 2013

(This space reserved for official comments.)



B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages came upon the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[1] Though subsequent Spanish expeditions passed through the region, the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s, the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000-acre Rancho San Pablo to the Castros in 1823.[2] Americans began farming in Contra Costa County in the late 1830s, and by 1882, two-thirds of the cultivated land in the county was devoted to wheat production.[3]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[4] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade, marrying Quilfelt and gaining title to her ranch. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century, several industries, including the California Cap Company, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[5] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County. Stege was eventually absorbed into Richmond as the latter grew.

William Letts Oliver established the Tonite Powder Company and California Cap Company on land purchased from the Stege Ranch in 1877. The California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. The company was operated by Oliver's sons after his death and survived through the end of World War II. By 1949, however, the plant was closed and for sale.

University Research/Richmond Field Station

After World War II, the University of California (UC) Berkeley Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O'Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited for use on a crowded campus. They also wanted a location that was not too remote. UC Berkeley

[1] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[2] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[3] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[4] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[5] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354: Hulanski p. 288.

B10. Significance (continued)

purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[6]

At first, the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[7] The buildings currently numbered 102, 110, 118, 128, 150, 152, 155, 175, 177, 176, and 180 all date to the California Cap Company era, and were repurposed for the Richmond Field Station. UC Berkeley constructed new buildings as funds became available, and by the mid-1950s, five new buildings had been completed at the Richmond Field Station.[8] By the 1970s, the Department of Engineering had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

The Richmond Field Station has been the location of research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology and also researched pollution control and disposal of solid and liquid waste.[9] Other early projects at the field station included heat transfer and cyclic stress research.[10]

Another laboratory that utilized Richmond Field Station was the Sea Water Conversion Laboratory (SWCL). In 1952, congress had created and funded the Office of Saline Water in order to encourage desalination studies as a solution to water shortages.[11] In response, UC Berkeley Mechanical Engineering professor Everett D. Howe formed the SWCL at the Richmond Field Station in 1958.[12]

Building 154 was constructed circa 1957, for SWCL research, and the program continued to expand under Howe's direction for the next decade. SWCL eventually encompassed most of the buildings on the north side of Lark Drive, including Buildings 151, 155, 158, 177, and 180.[13] Howe became the coordinator for Saline Water Conversion Projects throughout the UC system and authored several books on desalination before his retirement in 1968.[14] Although Howe has been referred to as a pioneer in the solar distillation of seawater, research has not

[6] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[7] McGauhey, p. 71.

[8] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

[9] University of California, Berkeley, 2008, p. 13.

[10] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[11] Heather Cooley, Peter H. Gleick, and Gary Wolff, "Desalination, With a Grain of Salt: A California Perspective," Pacific Institute, Oakland, California: 2006, p.11.

[12] University of California (System) Academic Senate, "1991, University of California: In Memoriam," 1991, Internet website: http://texts.cdlib.org/view?docId=hb4t1nb2bd&doc.view=frames&chunk.id=div00031&toc.depth=1&toc.id=.

[13] University of California, Berkeley, Files "Building 151", "Building 154", "Building 158", "Building 177", and "Building 180," located in vertical files in Room 148, Richmond Field Station.

[14] University of California (System) Academic Senate, "1991, University of California: In Memoriam," 1991, Internet website: http://texts.cdlib.org/view?docId=hb4t1nb2bd&doc.view=frames&chunk.id=div00031&toc.depth=1&toc.id=.

B10. Significance (continued)

revealed a significant lasting impact on desalination science resulting from his work.[15] Howe's primary contributions appear to have been administering and promoting desalination research. Breakthroughs such as reverse osmosis were developed by scientists at the University of California Los Angeles (UCLA) and the University of Florida. UCLA researchers also designed the pilot desalination plant in Coalinga, California, that went online in 1965, while Howe's role in that effort seems to have been limited to coordination.[16]

Professor Alan D.K. Laird became SWCL Director when Howe retired, a position he held until the laboratory was closed in 1987.[17] By 1978, SWCL encompassed twelve separate research projects. During this era, the cluster of buildings devoted to SWCL had grown to include Building 150 on the south side of Lark Drive, as well as the six buildings on the north side of the street. In 1978, Laird proposed a major capital improvement project involving 10,000 square feet of new construction.[18] In 1982, the Office of Saline Water was closed when the Reagan administration made broad cuts to funding for scientific research.[19] Professor Laird's proposed capital improvements were never constructed. Alan D.K. Laird does not seem to have been responsible for groundbreaking contributions to desalination science.

Building 151

Building 151 was constructed in 1961, in order to house expanded activities of the SWCL, which was operated next door in Building 154 by Professor Everett D. Howe. In 1965, a 1,600 square-foot addition was constructed on the north end of the building.[20] This building has also housed a solar materials laboratory in later years.[21] Building 151 is currently used for research.

Evaluation

Building 151 does not meet the criteria for listing in the NRHP or CRHR under Criterion A/1 because it lacks historical significance. The historical record does not indicate that Building 151 was important within local, state, or national events or trends. While academic research is important to anyone directly involved in the field, the historical record must show that the research or studies conducted had a significant impact on historical events and trends. The SWCL and Building 151 are not significant in this regard (Criterion A/1).

Although the structure was used for university research by Professor Howe and others throughout its lifetime, none of the available evidence suggests that the building has association with persons important to the

[15] Soteris A. Kalogirou, *Solar Engineering: Processes and Systems*, Academic Press, Burlington, MA: 2009, p. 31.

[16] Yorem Cohen and Julius Glater, "A Tribute to Sidney Loeb, the Pioneer of Reverse Osmosis Desalination Research," Water Technology Research Center, Chemical and Biomolecular Engineering Research, University of California, Los Angeles, December, 2009, p. 13.

[17] University of California (System) Academic Senate, "1996, University of California: In Memoriam," 1996, Internet website: http://texts.cdlib.org/view?docId=hb0z09n6nn&doc.view=frames&chunk.id=div00041&toc.depth=1&toc.id=.

[18] University of California, Berkeley, Files "Building 180," located in vertical files in Room 148, Richmond Field Station.

[19] Heather Cooley, Peter H. Gleick, and Gary Wolff, "Desalination, With a Grain of Salt: A California Perspective," Pacific Institute, Oakland, California: 2006, p.12.

[20] University of California, Berkeley, File "Building 151", located in vertical files in Room 148, Richmond Field Station.

[21] University of California, Berkeley, 2008, p. 196.

B10. Significance (continued)

development of the desalination field. Academic research is important to those working directly in that specific field; however, none of the persons associated with Building 151 had a significant impact on local, state, or national history. Therefore, the building lacks the strength of association necessary to be considered historically significant in relation to any particular persons (Criterion B/2).

Building 151 lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction and is a simple, prefabricated building (Criterion C/3).

In rare instances, buildings themselves can serve as sources of important information; however, this building is not a principal source of important information in this regard (Criterion D/4).

Building 151 does not meet the significance criteria for listing in the NRHP or CRHR.

Photograph 2: Building 151, April 30, 2013, camera facing southwest

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 154

P1. Other Identifier: Richmond Field Station Building 154

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond ___ **Date** 2013 **T** 1N ; **R** 4W; ___ **¼ of Sec** 20 ; Mt. Diablo **B.M.**
c. Address _____ City _____ Zip _____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558463 mE/ 4196555 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate) Assessor Parcel Number

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)

Building 154 is in the southern portion of the Richmond Field Station. It is on the north side of Lark Drive between Buildings 158 and 151, with its primary façade facing southwest. The 2,731 square-foot building has a rectangular footprint and is a prefabricated Dudley Steel Building topped with a front gabled roof. The walls and roof are corrugated metal. Primary fenestration consists of multi-light metal sashes. A metal industrial door with a glass insert is centered in its southwest elevation and serves as the main entrance. This entrance is sheltered by a metal awning and accessed by both concrete stairs and a ramp. The rear of the building contains an overhead-mounted, sliding door (Photograph 2). In 1965, a 1,600 square-foot addition was constructed on the north end of the building.

***P3b. Resource Attributes:** (List attributes and codes) HP39: Other

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1, camera facing northeast, April 30, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
1958/Richmond Field Station building files

***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804

***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** April 30, 2013

***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station, prepared by Tetra Tech, Inc., 2013.*

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

B1. Historic Name: _____
B2. Common Name: Building 154
B3. Original Use: Research B4. Present Use: Research
***B5. Architectural Style:** Vernacular
***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed 1958; Addition constructed 1965
***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____
***B8. Related Features:** _____
B9. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** N/A **Area** N/A
Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 154 at the Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet)

B11. Additional Resource Attributes: (List attributes and codes)

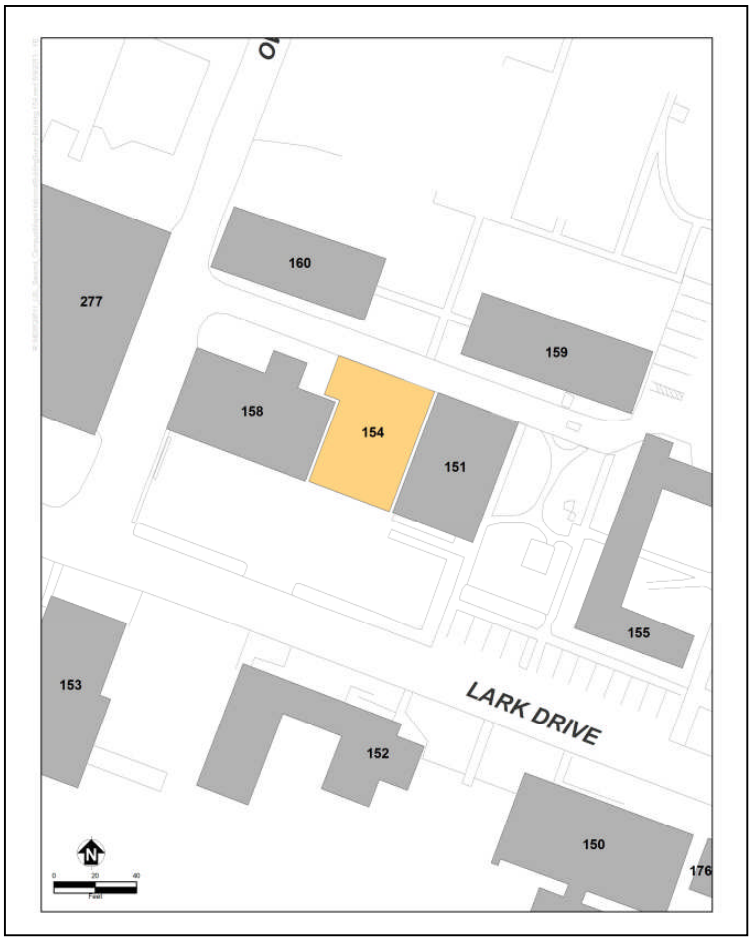
***B12. References:**
(See Footnotes)

B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** April 2013

(This space reserved for official comments.)



B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages came upon the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[1] Though subsequent Spanish expeditions passed through the region, the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s, the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000-acre Rancho San Pablo to the Castros in 1823.[2] Americans began farming in Contra Costa County in the late 1830s, and by 1882, two-thirds of the cultivated land in the county was devoted to wheat production.[3]

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After World War II, the University of California (UC) Berkeley Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O'Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited for use on a crowded campus. They also wanted a location that was not too remote. UC Berkeley

[1] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[2] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[3] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[4] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[5] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354: Hulanski p. 288.

B10. Significance (continued)

purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[6]

At first, the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[7] The buildings currently numbered 102, 110, 118, 128, 150, 152, 155, 175, 177, 176, and 180 all date to the California Cap Company era, and were repurposed for the Richmond Field Station. UC Berkeley also constructed new buildings as funds became available, and by the mid-1950s, five new buildings had been completed at the Richmond Field Station.[8] By the 1970s, the Department of Engineering had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

The Richmond Field Station has been the location of research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology and also researched pollution control and disposal of solid and liquid waste.[9] Other early projects at the field station included heat transfer and cyclic stress research.[10]

Another laboratory that utilized Richmond Field Station was the Sea Water Conversion Laboratory (SWCL). In 1952, congress had created and funded the Office of Saline Water in order to encourage desalination studies as a solution to water shortages.[11] In response, UC Berkeley Mechanical Engineering professor Everett D. Howe formed the SWCL at the Richmond Field Station in 1958.[12]

Building 154 was constructed circa 1958, for SWCL research, and the program continued to expand under Howe's direction for the next decade. SWCL eventually encompassed most of the buildings on the north side of Lark Drive, including Buildings 151, 155, 158, 177, and 180.[13] Howe became the coordinator for Saline Water Conversion Projects throughout the UC system and authored several books on desalination before his retirement in 1968.[14] Although Howe has been referred to as a pioneer in the solar distillation of seawater, research has not

[6] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[7] McGauhey, p. 71.

[8] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

[9] University of California, Berkeley, 2008, p. 13.

[10] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[11] Heather Cooley, Peter H. Gleick, and Gary Wolff, "Desalination, With a Grain of Salt: A California Perspective," Pacific Institute, Oakland, California: 2006, p.11.

[12] University of California (System) Academic Senate, "1991, University of California: In Memoriam," 1991, Internet website: http://texts.cdlib.org/view?docId=hb4t1nb2bd&doc.view=frames&chunk.id=div00031&toc.depth=1&toc.id=.

[13] University of California, Berkeley, Files "Building 151", "Building 154", "Building 158", "Building 177", and "Building 180," located in vertical files in Room 148, Richmond Field Station.

[14] University of California (System) Academic Senate, "1991, University of California: In Memoriam," 1991, Internet website: http://texts.cdlib.org/view?docId=hb4t1nb2bd&doc.view=frames&chunk.id=div00031&toc.depth=1&toc.id=.

B10. Significance (continued)

revealed a significant lasting impact on desalination science resulting from his work.[15] Howe's primary contributions appear to have been administering and promoting desalination research. Breakthroughs such as reverse osmosis were developed by scientists at the University of California Los Angeles (UCLA) and the University of Florida. UCLA researchers also designed the pilot desalination plant in Coalinga, California, that went online in 1965, while Howe's role in that effort seems to have been limited to coordination.[16]

Professor Alan D.K. Laird became SWCL Director when Howe retired, a position he held until the laboratory was closed in 1987.[17] By 1978, SWCL encompassed twelve separate research projects. During this era, the cluster of buildings devoted to SWCL had grown to include Building 150 on the south side of Lark Drive, as well as the six buildings on the north side of the street. In 1978, Laird proposed a major capital improvement project involving 10,000 square feet of new construction.[18] In 1982, the Office of Saline Water was closed when the Reagan administration made broad cuts to funding for scientific research.[19] Professor Laird's proposed capital improvements were never constructed. Alan D.K. Laird does not seem to have been responsible for groundbreaking contributions to desalination science.

Building 154

Building 154 was constructed circa 1958 as a Seawater Conversion Laboratory, which was operated by Professor Everett D. Howe (Photograph 3). In 1965, a 1,600 square-foot addition was constructed on the north end of the building.[20] Initially labeled Building 158A, by 1970, it was being referred to as Building 154.[21] Space station research, sewage system evaluation, robotics evaluation, and insect research also took place in the building.[22] Building 154 is currently used for research.

Evaluation

Building 154 does not meet the criteria for listing in the NRHP or CRHR under Criterion A/1 because it lacks historical significance. The historical record does not indicate that Building 154 was important within local, state, or national events or trends. While academic research is important to anyone directly involved in that field, in order to be eligible for the NRHP or CRHR, the historical record must show that the research or studies conducted had a significant impact on historical events and trends. The SWCL and Building 151 are not significant in this regard.

[15] Soteris A. Kalogirou, *Solar Engineering: Processes and Systems*, Academic Press, Burlington, MA: 2009, p. 31.

[16] Yorem Cohen and Julius Glater, "A Tribute to Sidney Loeb, the Pioneer of Reverse Osmosis Desalination Research," Water Technology Research Center, Chemical and Biomolecular Engineering Research, University of California, Los Angeles, December, 2009, p. 13.

[17] University of California (System) Academic Senate, "1996, University of California: In Memoriam," 1996, Internet website: http://texts.cdlib.org/view?docId=hb0z09n6nn&doc.view=frames&chunk.id=div00041&toc.depth=1&toc.id=.

[18] University of California, Berkeley, Files "Building 180," located in vertical files in Room 148, Richmond Field Station.

[19] Heather Cooley, Peter H. Gleick, and Gary Wolff, "Desalination, With a Grain of Salt: A California Perspective," Pacific Institute, Oakland, California: 2006, p.12.

[20] University of California, Berkeley, File "Building 154," located in vertical files in Room 148, Richmond Field Station.

[21] Sanborn Maps, 1966, 1970.

[22] University of California, Berkeley, 2008, p. 196.

B10. Significance (continued)

Although the structure was used for university research by Professor Howe and others throughout its lifetime, none of the available evidence suggests that the building has association with persons important to the development of the desalination field. Academic research is important to those working directly in that specific field; however, none of the persons associated with Building 154 had a significant impact on local, state, or national history. Therefore, the building lacks the strength of association necessary to be considered historically significant in relation to any particular persons (Criterion B/2).

Building 154 lacks any identifiable architectural stylistic design and is a simple prefabricated building. It does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3).

In rare instances, buildings themselves can serve as sources of important information; however, this building is not a principal source of important information in this regard (Criterion D/4).

Building 154 does not meet the significance criteria for listing in the NRHP or CRHR.

Photographs (continued):

Photograph 2: Rear of building 154, April 30, 2013, camera facing southeast

Photographs (continued):

Photograph 3, Building 154 at center between Buildings 158 and 151, circa 1965, camera facing northwest

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 155

P1. Other Identifier: Richmond Field Station Building 155

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)

***b. USGS 7.5′ Quad** Richmond ___ **Date** 2013 **T** 1N **; R** 4W**;** ___ **¼ of Sec** 20 **;** Mt. Diablo **B.M.**

c. Address _____ City _____ Zip _____

d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558463 mE/ 4196555 mN

e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)

Building 155 is in the southern portion of the Richmond Field Station. It is on the north side of Lark Drive between Buildings 151 and 177. The vernacular building does not strongly express a particular architecture style. It has 1,896 square feet and one story, with an irregular "U" plan. It was constructed in 1953 by combining three building dating from the 1920s.

The building consists of two side gabled wings joined by a wing that runs perpendicular to the street, forming a "U" shape. The roof is sheathed in replacement composition shingles, its walls clad in horizontal wood siding. Fenestration throughout the building consists of fixed, square, wood frame windows. (See Continuation Sheet)

***P3b. Resource Attributes:** (List attributes and codes) P39: Other

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1, Camera facing north, April 30, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
1953/Richmond Field Station Building Files

***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804

***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** April 30, 2013

***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station, prepared by Tetra Tech, Inc., 2013.*

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

***NRHP Status Code** 6Z

***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 155

B1. Historic Name: "Building 64", "Building 67", and "Building 92"

B2. Common Name: Building 155

B3. Original Use: Manufacturing B4. Present Use: Research, offices

***B5. Architectural Style:** Vernacular

***B6. Construction History:** (Construction date, alteration, and date of alterations) Three original buildings constructed circa 1920; moved, connected, and remodeled into one building 1953; replacement windows were likely installed in the 1950s; concrete foundation added 1977.

***B7. Moved?** ☐ **No** ☒**Yes** ☐ **Unknown** **Date:** 1953 **Original Location:** Richmond Field Station

***B8. Related Features:** _____

B9. Architect: Unknown b. Builder: Unknown

***B10. Significance: Theme** N/A **Area** N/A

Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A

(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 155 at the Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). The building was evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code and does not appear to meet the significance criteria in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet)

B11. Additional Resource Attributes: (List attributes and codes)

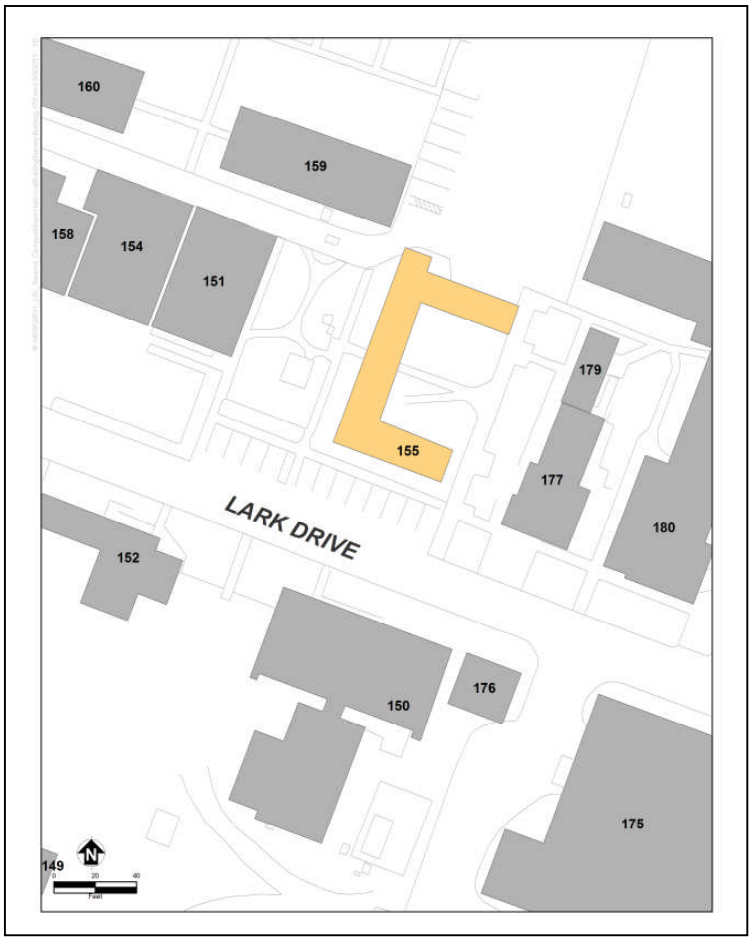
***B12. References:**
(See Footnotes)

B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** April 2013

(This space reserved for official comments.)



P3a. Description (continued)

The windows are not original and were likely replaced during the 1950s. A paneled wood door reached by a set of wooden stairs is centered in the gable end of the southwest wing, which is the closest to Lark Drive. The southwest elevation of the northeast wing features a similar entrance. A third entrance, centered in the connecting wing and faces southeast, is fitted with a modern door and accessed by a concrete ramp.

Construction of Building 155 was pieced together from former California Cap Company buildings, "Building 64", "Building 67", and "Building 92". The California Cap Company constructed these three buildings circa 1920.[1] The buildings were originally used for waterproofing and assembling by the California Cap Company.[2] In 1953, the University of California (UC) appears to have turned "Building 67" perpendicular to its original position to form a connecting wing in a single "U" shaped building. In addition to joining the three buildings, UC replaced original siding and original windows on all three buildings. At first, the southwest wing adjacent to Lark Drive was labeled Building 155, and the northeast (rear) wing was labeled Building 157. At some point, all three wings became known as Building 155.[3] In 1977, a concrete foundation was installed under the building.[4]

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages came upon the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[5] Though subsequent Spanish expeditions passed through the region, the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s, the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000-acre Rancho San Pablo to the Castros in 1823.[6] Americans began farming in Contra Costa County in the late 1830s, and by 1882, two-thirds of the cultivated land in the county was devoted to wheat production.[7]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[8] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo, as well as from the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years, the frogs' legs raised by Richard Stege for the San Francisco

[1] University of California, Berkeley, File "Building 155," located in vertical files in Room 148, Richmond Field Station.

[2] University of California, Berkeley, 2008, p. 200 – 204.

[3] Sanborn Map, 1966.

[4] Scott Shackleton, University of California, Berkeley, Personal communication with Julia Mates, Tetra Tech 2013.

[5] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[6] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[7] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[8] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

B10. Significance (continued)

restaurant market.[9] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade, marrying Quilfelt and gaining title to her ranch. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Company, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[10] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[11] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867, he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive.

During the 1870s, chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch.

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[12] As early as 1870, European explosive companies were experimenting with nitrated guncotton. By 1875, it was being manufactured in England under the name "Tonite."[13] In 1877, Oliver was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock needed an explosive to complete the tunnel that would remain stable at the high temperatures underground, and Oliver was able to solve the problem by substituting Tonite for more volatile compounds.[14]

The California Cap Company

In 1877, William Letts Oliver established the Tonite Powder Company on a portion of the former Stege Ranch.[15] Oliver eventually invented a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter then founded the California Cap Company. It was located

[9] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.
[10] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.
[11] Hulanski p. 288.
[12] Pacific Mining News, p. 222.
[13] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.
[14] Pacific Mining News, p. 222.
[15] Oliver, p. 1.

B10. Significance (continued)

adjacent to the Tonite Powder Company on a 160-acre parcel carved out of the southern portion of Stege Ranch.[16] The California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[17] The California Cap Company was located on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888, he formed the American Lucol Company adjacent to the California Cap Company property.[18] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station. Lucol manufactured a linseed oil substitute.[19] The factory was dismantled and relocated to New Jersey circa 1900.[20] In 1903, the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field Station property.[21] Later known as the U.S. Briquette Company, the plant appears to have operated at this location until at least 1917.[22] The U.S. Briquette Company buildings were demolished during the 1960s.

Eventually, the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[23] By 1916, there were at least a dozen buildings on the site. By 1922, the California Cap Company was substantially expanded and the plant grew to include 150 buildings and a horse-drawn tram line.[24]

During the late nineteenth and early twentieth century, the California Cap Company was one of the most important local employers.[25] As the twentieth century progressed more heavy industry came to Contra Costa County, and by 1940, the county was second only to Los Angeles in overall industrial production.[26] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II, California Cap Company was able to stay open by producing delayed action incendiary bombs that were used against Japan.[27] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed.

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[16] Pacific Mining News, p. 222.

[17] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.

[18] Oliver, p. 1.

[19] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913*, Dewey Publishing Company: 1913, p. 327.

[20] Oliver, p. 1.

[21] Oliver, p. 2.

[22] Hulaniski, p. 354.

[23] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.

[24] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

[25] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

[26] Purcell, p. 649.

[27] Oliver, p. 1.

B10. Significance (continued)

University Research/Richmond Field Station

After World War II, the UC Berkeley Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O'Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. UC Berkeley purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[28]

At first, the Department of Engineering utilized the buildings left behind by the California Cap Company. The department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[29] The current Buildings 102, 110, 118, 128, 150, 152, 155, 175, 177, 176, and 180 all date to the California Cap Company era and were repurposed for the Richmond Field Station. UC Berkeley also constructed new buildings as funds became available, and by the mid-1950s, five new buildings had been completed at the Richmond Field Station.[30] By the 1970s, the Department of Engineering had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

The Richmond Field Station has been the location of research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. The focus of SERL was primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[31] Other early research projects at the field station included heat transfer and cyclic stress research.[32]

Another laboratory that utilized the Richmond Field Station was the Sea Water Conversion Laboratory (SWCL). In 1952, Congress had created and funded the Office of Saline Water in order to encourage desalination studies as a solution to water shortages.[33] In response, UC Berkeley Mechanical Engineering professor Everett D. Howe formed the SWCL at the Richmond Field Station in 1958.[34]

Building 154 was constructed circa 1957 for SWCL research, and the program continued to expand under Howe's direction for the next decade. SWCL eventually encompassed most of the buildings on the north side of Lark

[28] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[29] McGauhey, p. 71.

[30] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

[31] University of California, Berkeley, 2008, p. 13.

[32] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[33] Heather Cooley, Peter H. Gleick, and Gary Wolff, "Desalination, With a Grain of Salt: A California Perspective," Pacific Institute, Oakland, California: 2006, p.11.

[34] University of California (System) Academic Senate, "1991, University of California: In Memoriam," 1991, Internet website: http://texts.cdlib.org/view?docId=hb4t1nb2bd&doc.view=frames&chunk.id=div00031&toc.depth=1&toc.id=.

B10. Significance (continued)

Drive, including Buildings 151, 155, 158, 177, and 180.[35] Howe became the coordinator for Saline Water Conversion Projects throughout the UC system and authored several books on desalination before his retirement in 1968.[36] Although Howe has been referred to as a pioneer in the solar distillation of seawater, research has not revealed a significant lasting impact on desalination science resulting from his work.[37]

Howe's primary contributions appear to have been administering and promoting desalination research. Breakthroughs such as reverse osmosis were developed by scientists at the University of California Los Angeles (UCLA) and the University of Florida. UCLA researchers also designed the pilot desalination plant in Coalinga, California, that went online in 1965, while Howe's role in that effort seems to have been limited to coordination.[38]

Professor Alan D.K. Laird became SWCL Director when Howe retired, a position he held until the laboratory was closed in 1987.[39] By 1978, SWCL encompassed twelve separate research projects. During this era, the cluster of buildings devoted to SWCL had grown to include Building 150 on the south side of Lark Drive as well as the six buildings on the north side of the street. In 1978, Laird proposed a major capital improvement project involving 10,000 square feet of new construction.[40] In 1982, the Office of Saline Water was closed when the Reagan administration made broad cuts to funding for scientific research.[41] Professor Laird's proposed capital improvements were never constructed. Alan D.K. Laird does not seem to have been responsible for groundbreaking contributions to desalination science.

Building 155

Activities in the building in the early years included Low Pressure Research and Sea Water Conversion program administration. The Catalytic Liquefaction of Biomass Project, also known as the Biocrude project, moved into Building 155 in the late 1970s.[42] Building 155 was later used as a solar research facility.[43] It is currently used for research and houses non-profit offices.

[35] University of California, Berkeley, Files "Building 151", "Building 154", "Building 158", "Building 177", and "Building 180," located in vertical files in Room 148, Richmond Field Station.

[36] University of California (System) Academic Senate, "1991, University of California: In Memoriam," 1991, Internet website: http://texts.cdlib.org/view?docId=hb4t1nb2bd&doc.view=frames&chunk.id=div00031&toc.depth=1&toc.id=.

[37] Soteris A. Kalogirou, *Solar Engineering: Processes and Systems*, Academic Press, Burlington, MA: 2009, p. 31.

[38] Yorem Cohen and Julius Glater, "A Tribute to Sidney Loeb, the Pioneer of Reverse Osmosis Desalination Research," Water Technology Research Center, Chemical and Biomolecular Engineering Research, University of California, Los Angeles, December, 2009, p. 13.

[39] University of California (System) Academic Senate, "1996, University of California: In Memoriam," 1996, Internet website: http://texts.cdlib.org/view?docId=hb0z09n6nn&doc.view=frames&chunk.id=div00041&toc.depth=1&toc.id=.

[40] University of California, Berkeley, Files "Building 180," located in vertical files in Room 148, Richmond Field Station.

[41] Heather Cooley, Peter H. Gleick, and Gary Wolff, "Desalination, With a Grain of Salt: A California Perspective," Pacific Institute, Oakland, California: 2006, p.12.

[42] University of California, Berkeley, File "Building 155," located in vertical files in Room 148, Richmond Field Station.

[43] University of California, Berkeley, 2008, p. 196.

B10. Significance (continued)

Evaluation

No association was found between Building 155 and events significant to national, state, or local history. Although the California Cap Company was the first blasting cap manufacturer in the United States, there is no indication that the activities in Building 155 were central to the development of the plant or its technical processes. Academic research took place in the building after UC Berkeley took over the property, and while academic research is important to anyone directly involved in the field, the historical record must show that the research or studies had a significant impact on events and trends for a building to be eligible for the NRHP or CRHR. The historical record does not indicate such significance, and Building 155 is not eligible for inclusion in the NRHP or CRHR under Criterion A/1.

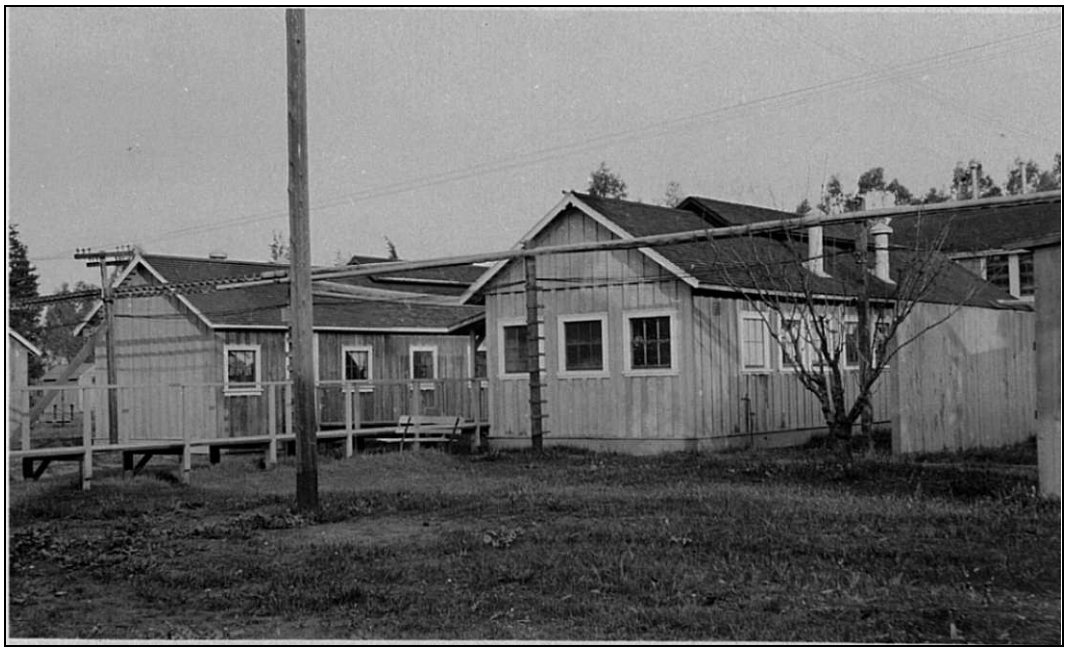
Although the Olivers were significant in the history of the explosives industry, no particular association was found between the Oliver family and Building 155. Although the structure was used for university research by Professor Howe and others throughout its lifetime, none of the available historical evidence suggests that the building has association with persons important to the development of the desalination field. Academic research is important to those working directly in that specific field; however, none of the persons associated with Building 155 had a significant impact on local, state, or national history. The building lacks the strength of association necessary to be considered historically significant in relation to any particular persons (Criterion B/2).

The building does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values. Building 155 is a vernacular building of a type that was commonly constructed in the early twentieth century. It has been heavily altered over the years since UC Berkeley took possession in 1950, so the building is not eligible for the NRHP or CRHR for its architecture (Criterion C/3).

In rare instances, buildings themselves can serve as sources of important information; however, this building is not a principal source of important information (Criterion D/4).

Building 155 does not meet the significance criteria for listing in the NRHP or CRHR.

Photographs (continued):



Photograph 2, California Cap Company "Building 64" and "Building 67," 1921, camera facing northeast

Photographs (continued):

Photograph 3, Buildings 155 and 157, 1953, camera facing west

Photograph 4, Buildings 155 and 157, circa 1953, camera facing northwest

Photographs (continued):

Photograph 5, gable end, southwest wing, April 20, 2013, camera facing west

Photograph 6, Building 155, April 30, 2013, northeast wing, camera facing southwest

Photographs (continued):

Photograph 7, Building 155, connecting wing, April 30, 2013, camera facing west

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 158

P1. Other Identifier: Richmond Field Station Building 158

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 2013 **T** 1N **; R** 4W**;** ___ **¼ of Sec** 20 **;** Mt. Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558442 mE/ 4196541 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate) Assessor Parcel Number

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 158 is in the southern portion of the Richmond Field Station. It is on the north side of Lark Drive, with its primary façade facing southwest. The 3,343 square-foot building is a rectangular, prefabricated building topped with a front gabled roof. It features shallow eaves with exposed rafters and exposed steel purlins. The walls and roof are corrugated metal. Fenestration consists of multi-light metal sashes and replacement sliding sashes. An overhead-mounted, sliding, metal door is centered in its southwest elevation. An entrance fitted with a single metal industrial door with a glass insert is located adjacent to the large door to the east. This entrance is sheltered by a metal awning and accessed at grade.

***P3b. Resource Attributes:** (List attributes and codes) P39: Other

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1, camera facing northeast, April 30, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Circa 1957
***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804
***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** April 30, 2013
***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station, prepared by Tetra Tech, Inc., 2013.*

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

***NRHP Status Code** 6Z

***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 158

B1. Historic Name: _____

B2. Common Name: Building 158

B3. Original Use: Research B4. Present Use: Research

***B5. Architectural Style:** Vernacular

***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed 1957; replacement windows no date

***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____

***B8. Related Features:** _____

B9. Architect: Unknown b. Builder: Unknown

***B10. Significance: Theme** N/A **Area** N/A

Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A

(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 158 at the Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet)

B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:**

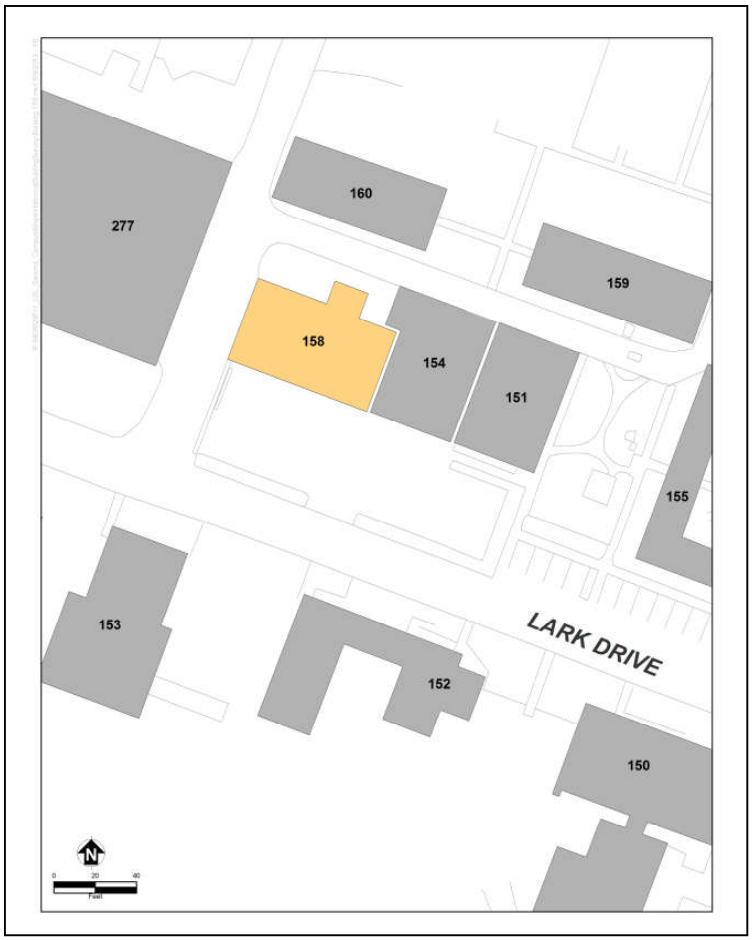
(See Footnotes)

B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** April 2013

(This space reserved for official comments.)



B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages came upon the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[1] Though subsequent Spanish expeditions passed through the region, the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s, the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000-acre Rancho San Pablo to the Castros in 1823.[2] Americans began farming in Contra Costa County in the late 1830s, and by 1882, two-thirds of the cultivated land in the county was devoted to wheat production.[3]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[4] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade, marrying Quilfelt and gaining title to her ranch. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century, several industries, including the California Cap Company, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[5] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County. Stege was eventually absorbed into Richmond as the latter grew.

William Letts Oliver established the Tonite Powder Company and California Cap Company on land purchased from the Stege Ranch in 1877. The California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. The company was operated by Oliver's sons after his death and managed to survive through the end of World War II. By 1949, however, the plant was closed and for sale.

University Research/Richmond Field Station

After World War II, the University of California (UC) Berkeley Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O'Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited for use on a crowded campus. They also wanted a location that was not too remote. UC Berkeley

[1] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[2] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[3] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[4] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[5] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354: Hulanski p. 288.

B10. Significance (continued)

purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[6]

At first, the Department of Engineering utilized the buildings left behind by the California Cap Company. The Department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[7] The current buildings numbered 102, 110, 118, 128, 150, 152, 155, 175, 177, 176, and 180 all date to the California Cap Company era, and were repurposed for the Richmond Field Station. UC Berkeley constructed new buildings as funds became available, and by the mid-1950s, five new buildings had been completed at the Richmond Field Station.[8] By the 1970s, the Department of Engineering had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

The Richmond Field Station has been the location of research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. SERL focused primarily on sewage treatment technology and also researched pollution control and disposal of solid and liquid waste.[9] Other early projects at the field station included heat transfer and cyclic stress research.[10]

Another laboratory that utilized Richmond Field Station was the Sea Water Conversion Laboratory (SWCL). In 1952, congress had created and funded the Office of Saline Water in order to encourage desalination studies as a solution to water shortages.[11] In response, UC Berkeley Mechanical Engineering professor Everett D. Howe formed the SWCL at the Richmond Field Station in 1958.[12]

Building 154 was constructed circa 1957, for SWCL research, and the program continued to expand under Howe's direction for the next decade. SWCL eventually encompassed most of the buildings on the north side of Lark Drive, including Buildings 151, 155, 158, 177, and 180.[13] Howe became the coordinator for Saline Water Conversion Projects throughout the UC system and authored several books on desalination before his retirement in 1968.[14] Although Howe has been referred to as a pioneer in the solar distillation of seawater, research has not

[6] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[7] McGauhey, p. 71.

[8] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

[9] University of California, Berkeley, 2008, p. 13.

[10] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[11] Heather Cooley, Peter H. Gleick, and Gary Wolff, "Desalination, With a Grain of Salt: A California Perspective," Pacifc Institue, Oakland, California: 2006, p.11.

[12] University of California (System) Academic Senate, "1991, University of California: In Memoriam," 1991, Internet website: http://texts.cdlib.org/view?docId=hb4t1nb2bd&doc.view=frames&chunk.id=div00031&toc.depth=1&toc.id=.

[13] University of California, Berkeley, Files "Building 151", "Building 154", "Building 158", "Building 177", and "Building 180," located in vertical files in Room 148, Richmond Field Station.

[14] University of California (System) Academic Senate, "1991, University of California: In Memoriam," 1991, Internet website: http://texts.cdlib.org/view?docId=hb4t1nb2bd&doc.view=frames&chunk.id=div00031&toc.depth=1&toc.id=.

B10. Significance (continued)

revealed a significant lasting impact on desalination science resulting from his work.[15] Howe's primary contributions appear to have been administering and promoting desalination research. Breakthroughs such as reverse osmosis were developed by scientists at the University of California Los Angeles (UCLA) and the University of Florida. UCLA researchers also designed the pilot desalination plant in Coalinga, California, that went online in 1965, while Howe's role in that effort seems to have been limited to coordination.[16]

Professor Alan D.K. Laird became SWCL Director when Howe retired, a position he held until the laboratory was closed in 1987.[17] By 1978, SWCL encompassed twelve separate research projects. During this era, the cluster of buildings devoted to SWCL had grown to include Building 150 on the south side of Lark Drive, as well as the six buildings on the north side of the street. In 1978, Laird proposed a major capital improvement project involving 10,000 square feet of new construction.[18] In 1982, the Office of Saline Water was closed when the Reagan administration made broad cuts to funding for scientific research.[19] Professor Laird's proposed capital improvements were never constructed.

Building 158

Building 158 was constructed circa 1957 for use as a research facility. It appears to have been the first building constructed for use by Professor Everett D. Howe's Seawater Conversion Laboratory.[20] The building is currently used for research.

Evaluation

Building 158 does not meet the criteria for listing in the NRHP or CRHR under Criterion A/1 because it lacks historical significance. The historical record does not indicate that Building 158 was important within local, state, or national events or trends. While academic research is important to anyone directly involved in the field, the historical record must show that the research or studies conducted had a significant impact on historical events and trends in order to be eligible for the NRHP or CRHR. Building 158 is not significant in this regard (Criterion A/1).

Although the structure was used for university research by Professor Howe and others throughout its lifetime, none of the available evidence suggests that the building has association with persons important to the development of the desalination field. Academic research is important to those working directly in that specific field; however, none of the persons associated with Building 158 have had a significant impact on local, state, or

[15] Soteris A. Kalogirou, *Solar Engineering: Processes and Systems*, Academic Press, Burlington, MA: 2009, p. 31.

[16] Yorem Cohen and Julius Glater, "A Tribute to Sidney Loeb, the Pioneer of Reverse Osmosis Desalination Research," Water Technology Research Center, Chemical and Biomolecular Engineering Research,University of California, Los Angeles, December, 2009, p. 13.

[17] University of California (System) Academic Senate, "1996, University of California: In Memoriam," 1996, Internet website: http://texts.cdlib.org/view?docId=hb0z09n6nn&doc.view=frames&chunk.id=div00041&toc.depth=1&toc.id=.

[18] University of California, Berkeley, Files "Building 180," located in vertical files in Room 148, Richmond Field Station.

[19] Heather Cooley, Peter H. Gleick, and Gary Wolff, "Desalination, With a Grain of Salt: A California Perspective," Pacifc Institue, Oakland, California: 2006, p.12.

[20] University of California, Berkeley, File "Building 158", located in vertical files in Room 148, Richmond Field Station.

B10. Significance (continued)

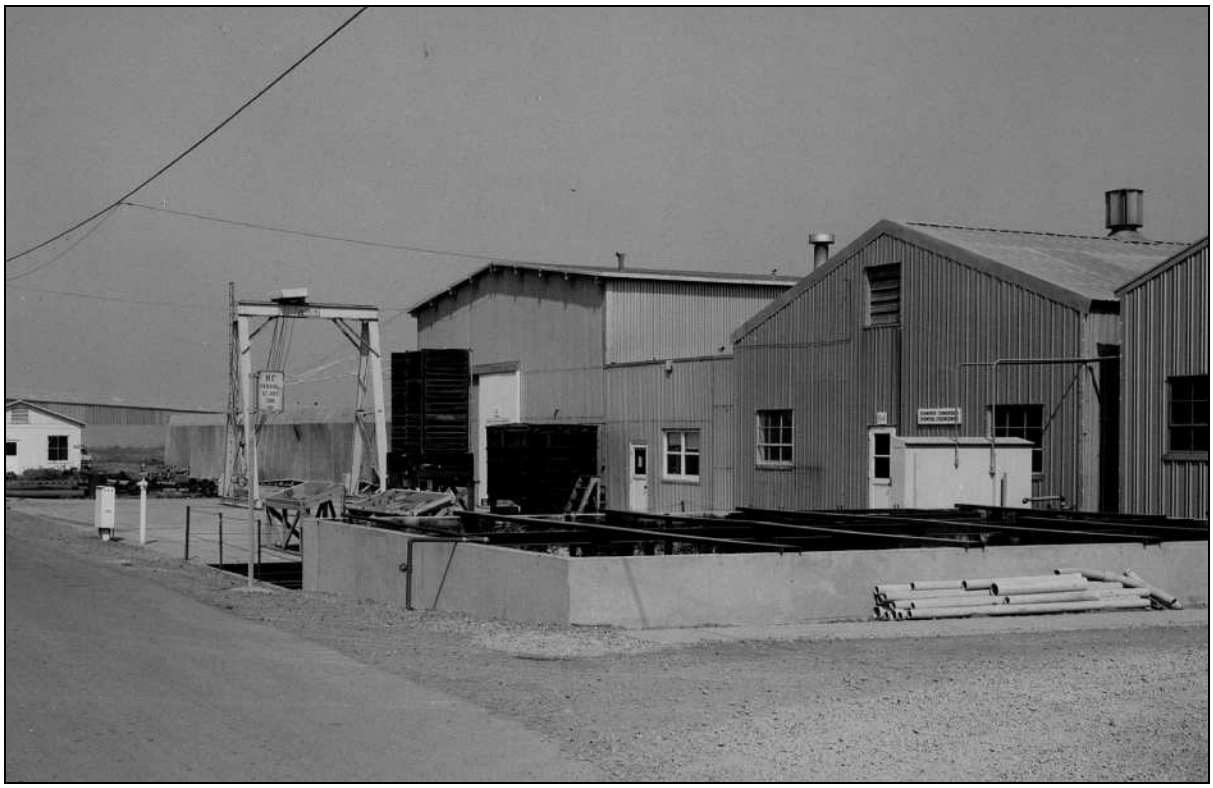
national history. Therefore, the building lacks the strength of association necessary to be considered historically significant in relation to any particular persons (Criterion B/2).

Building 158 lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3).

In rare instances, buildings themselves can serve as sources of important information; however, this building is not a principal source of important information in this regard (Criterion D/4).

Building 158 does not meet the significance criteria for listing in the NRHP or CRHR.

Photographs (continued):



Photograph 2, Building 158 at left with Buildings 154 and 151 to the right, circa 1965, camera facing northwest

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 177

P1. Other Identifier: Richmond Field Station Building 177

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 2013 **T** 1N **; R** 4W**;** ___ **¼ of Sec** 20 **;** Mt. Diablo **B.M.**
c. Address _____ City _____ Zip _____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558528 mE/ 4196527 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 177 is in the southern portion of the Richmond Field Station. It is on the north side of Lark Drive, with its primary façade facing southwest. The vernacular building does not strongly express any particular architectural style. It is a 2,969 square-foot, two-story building with a modified rectangular plan. It is topped by a front gabled roof; its walls are clad in horizontal wood siding. A decorative octagonal vent is centered in the front gable. Fenestration consists of replacement vinyl sashes. The building's main façade is centered in the southwest elevation and features a full width, hipped roof porch. (See Continuation Sheet.)

***P3b. Resource Attributes:** (List attributes and codes) P39: Other

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1, camera facing north, January 4, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Circa 1920

***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804

***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** April 30, 2013

***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station, prepared by Tetra Tech, Inc., 2013.*

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

B1. Historic Name: "Building 72", "Building 131"

B2. Common Name: Building 177

B3. Original Use: Maintenance Shop/Rest Rooms B4. Present Use: Offices

***B5. Architectural Style:** Vernacular

***B6. Construction History:** (Construction date, alteration, and date of alterations) Two original buildings constructed circa 1920; renovated and renumbered 1953; buildings joined, porch remodeled, windows replaced circa 1990s

***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____

***B8. Related Features:** _____

B9. Architect: Unknown b. Builder: Unknown

***B10. Significance: Theme** N/A **Area** N/A

Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A

(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 177 at the Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet)

B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:**

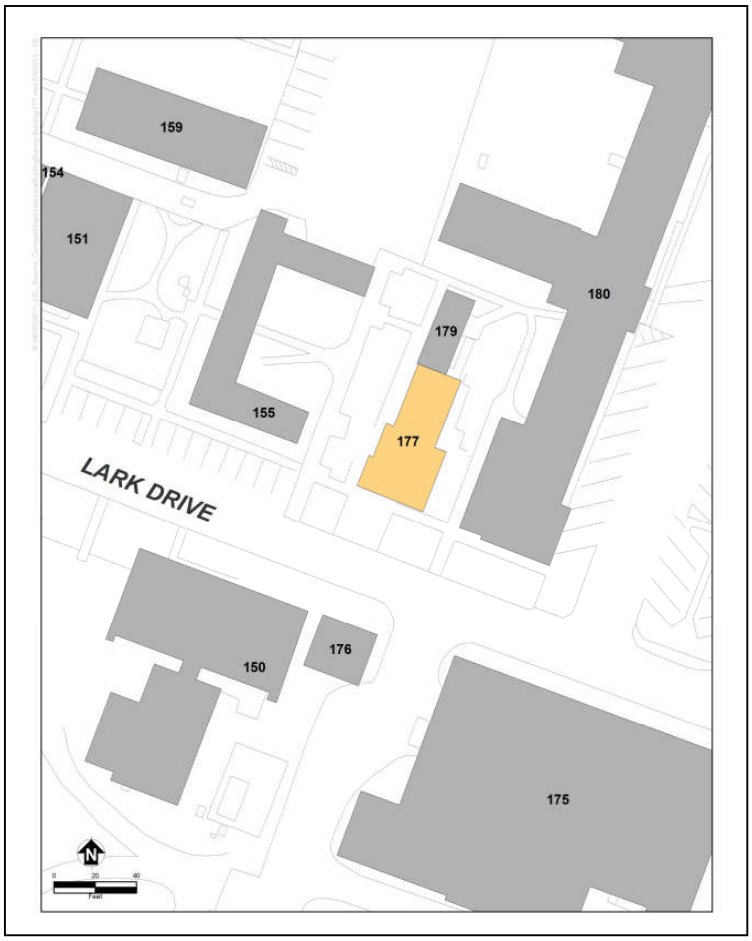
(See Footnotes)

B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** April 2013

(This space reserved for official comments.)



P3a. Description (continued)

The two-story main wing of Building 177 is connected to a small, single-story building at the rear, the former Building 179 (Photograph 2). The single story gable at the rear (northeast) of the building features decorative stickwork at the eaves (Photograph 3). An exterior industrial-style staircase leads to the rear portion of the main wing's second floor (Photograph 4).

Originally constructed circa 1920, Building 177 was known as "Building 72" during the California Cap Company era. "Building 72" consisted of the two story main wing of what is today Building 177, and is depicted on Sanborn Maps as a "Rest Room." A separate one story building to the rear, "Building 131," was also labeled as "Women's Rest Room" and a "Water Closet" on historic maps.

By the time the University of California (UC) took over the property in 1950, Building 177 had small additions added onto its facade and had become somewhat dilapidated (Photographs 5 and 6). The University renovated the building in 1953, removing some of the additions and changing the shed roofed entry porch to a small gable roof (Photograph 7). By 1966, Building 177 was being utilized as a maintenance shop. California Cap Company's "Building 131" at the rear was renumbered Building 179 and continued to be used as a restroom until it was joined to Building 177. Although Building 179 is still shown on maps of the Richmond Field Station, the rear portion of the building is currently labeled Building 177.

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages came upon the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[1] Though subsequent Spanish expeditions passed through the region, the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s, the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000-acre Rancho San Pablo to the Castros in 1823.[2] Americans began farming in Contra Costa County in the late 1830s, and by 1882, two-thirds of the cultivated land in the county was devoted to wheat production.[3]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[4] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo, as well as from the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years, the frogs' legs raised by Richard Stege for the San Francisco

[1] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[2] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[3] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[4] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

B10. Significance (continued)

restaurant market.[5] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade, marrying Quilfelt and gaining title to her ranch. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Company, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[6] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[7] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867, he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive.

During the 1870s, chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch.

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[8] As early as 1870, European explosive companies were experimenting with nitrated guncotton. By 1875, it was being manufactured in England under the name "Tonite."[9] In 1877, Oliver was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock needed an explosive to complete the tunnel that would remain stable at the high temperatures underground, and Oliver was able to solve the problem by substituting Tonite for more volatile compounds.[10]

The California Cap Company

In 1877, William Letts Oliver established the Tonite Powder Company on a portion of the former Stege Ranch.[11] Oliver eventually invented a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter then founded the California Cap Company. It was located

[5] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.
[6] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.
[7] Hulanski p. 288.
[8] Pacific Mining News, p. 222.
[9] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.
[10] Pacific Mining News, p. 222.
[11] Oliver, p. 1.

B10. Significance (continued)

adjacent to the Tonite Powder Company on a 160-acre parcel carved out of the southern portion of Stege Ranch.[12] The California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[13] The California Cap Company was located on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888, he formed the American Lucol Company adjacent to the California Cap Company property.[14] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station. Lucol manufactured a linseed oil substitute.[15] The factory was dismantled and relocated to New Jersey circa 1900.[16] In 1903, the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field Station property.[17] Later known as the U.S. Briquette Company, the plant appears to have operated at this location until at least 1917.[18] The U.S. Briquette Company buildings were demolished during the 1960s.

Eventually, the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[19] By 1916, there were at least a dozen buildings on the site. By 1922, the California Cap Company was substantially expanded and the plant grew to include 150 buildings and a horse-drawn tram line.[20]

During the late nineteenth and early twentieth century, the California Cap Company was one of the most important local employers.[21] As the twentieth century progressed more heavy industry came to Contra Costa County, and by 1940, the county was second only to Los Angeles in overall industrial production.[22] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II, California Cap Company was able to stay open by producing delayed action incendiary bombs that were used against Japan.[23] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed.

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[12] Pacific Mining News, p. 222.

[13] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.

[14] Oliver, p. 1.

[15] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913*, Dewey Publishing Company: 1913, p. 327.

[16] Oliver, p. 1.

[17] Oliver, p. 2.

[18] Hulaniski, p. 354.

[19] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.

[20] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.

[21] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

[22] Purcell, p. 649.

[23] Oliver, p. 1.

B10. Significance (continued)

University Research/Richmond Field Station

After World War II, the UC Berkeley Engineering Department needed an off-campus location in order to perform experiments that required more space than a laboratory. Department Chair Morrough P. O'Brien and others in the department were performing experiments with sewage, sea water, and other materials unsuited to use on a crowded campus. They also wanted a location that was not too remote. UC Berkeley purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[24]

At first, the Department of Engineering utilized the buildings left behind by the California Cap Company. The department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[25] The current Buildings 102, 110, 118, 128, 150, 152, 155, 175, 177, 176, and 180 all date to the California Cap Company era and were repurposed for the Richmond Field Station. UC Berkeley also constructed new buildings as funds became available, and by the mid-1950s, five new buildings had been completed at the Richmond Field Station.[26] By the 1970s, the Department of Engineering had conducted many experiments at the Richmond Field Station that could not have been performed on the main campus.

The Richmond Field Station has been the location of research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to undertake research at the site. The focus of SERL was primarily on sewage treatment technology, and also researched pollution control and disposal of solid and liquid waste.[27] Other early research projects at the field station included heat transfer and cyclic stress research.[28]

Another laboratory that utilized the Richmond Field Station was the Sea Water Conversion Laboratory (SWCL). In 1952, Congress had created and funded the Office of Saline Water in order to encourage desalination studies as a solution to water shortages.[29] In response, UC Berkeley Mechanical Engineering professor Everett D. Howe formed the SWCL at the Richmond Field Station in 1958.[30]

Building 154 was constructed circa 1957 for SWCL research, and the program continued to expand under Howe's direction for the next decade. SWCL eventually encompassed most of the buildings on the north side of Lark

[24] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

[25] McGauhey, p. 71.

[26] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

[27] University of California, Berkeley, 2008, p. 13.

[28] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[29] Heather Cooley, Peter H. Gleick, and Gary Wolff, "Desalination, With a Grain of Salt: A California Perspective," Pacific Institute, Oakland, California: 2006, p.11.

[30] University of California (System) Academic Senate, "1991, University of California: In Memoriam," 1991, Internet website: http://texts.cdlib.org/view?docId=hb4t1nb2bd&doc.view=frames&chunk.id=div00031&toc.depth=1&toc.id=.

B10. Significance (continued)

Drive, including Buildings 151, 155, 158, 177, and 180.[31] Howe became the coordinator for Saline Water Conversion Projects throughout the UC system and authored several books on desalination before his retirement in 1968.[32] Although Howe has been referred to as a pioneer in the solar distillation of seawater, research has not revealed a significant lasting impact on desalination science resulting from his work.[33]

Howe's primary contributions appear to have been administering and promoting desalination research. Breakthroughs such as reverse osmosis were developed by scientists at the University of California Los Angeles (UCLA) and the University of Florida. UCLA researchers also designed the pilot desalination plant in Coalinga, California, that went online in 1965, while Howe's role in that effort seems to have been limited to coordination.[34]

Professor Alan D.K. Laird became SWCL Director when Howe retired, a position he held until the laboratory was closed in 1987.[35] By 1978, SWCL encompassed twelve separate research projects. During this era, the cluster of buildings devoted to SWCL had grown to include Building 150 on the south side of Lark Drive as well as the six buildings on the north side of the street. In 1978, Laird proposed a major capital improvement project involving 10,000 square feet of new construction.[36] In 1982, the Office of Saline Water was closed when the Reagan administration made broad cuts to funding for scientific research.[37] Professor Laird's proposed capital improvements were never constructed. Alan D.K. Laird does not seem to have been responsible for groundbreaking contributions to desalination science.

Building 177

Like the other buildings on the north side of Lark Drive, Building 177 was utilized by the SWCL. By 1978, the building had been abandoned, and its demolition was proposed. Eventually, however, the Richmond Field Station used the building for offices. The full width porch was added and the original windows replaced circa the 1990s.

Evaluation

No association was found between Building 177 and events significant to national, state, or local history (Criterion A/1). Although the California Cap Company was the first blasting cap manufacturer in the United States, there is no indication that the activities that took place in Building 177 were central to the development of the plant or its technical processes. Academic research took place in the building after UC Berkeley took over the

[31] University of California, Berkeley, Files "Building 151", "Building 154", "Building 158", "Building 177", and "Building 180," located in vertical files in Room 148, Richmond Field Station.

[32] University of California (System) Academic Senate, "1991, University of California: In Memoriam," 1991, Internet website: http://texts.cdlib.org/view?docId=hb4t1nb2bd&doc.view=frames&chunk.id=div00031&toc.depth=1&toc.id=.

[33] Soteris A. Kalogirou, *Solar Engineering: Processes and Systems*, Academic Press, Burlington, MA: 2009, p. 31.

[34] Yorem Cohen and Julius Glater, "A Tribute to Sidney Loeb, the Pioneer of Reverse Osmosis Desalination Research," Water Technology Research Center, Chemical and Biomolecular Engineering Research, University of California, Los Angeles, December, 2009, p. 13.

[35] University of California (System) Academic Senate, "1996, University of California: In Memoriam," 1996, Internet website: http://texts.cdlib.org/view?docId=hb0z09n6nn&doc.view=frames&chunk.id=div00041&toc.depth=1&toc.id=.

[36] University of California, Berkeley, Files "Building 180," located in vertical files in Room 148, Richmond Field Station.

[37] Heather Cooley, Peter H. Gleick, and Gary Wolff, "Desalination, With a Grain of Salt: A California Perspective," Pacific Institute, Oakland, California: 2006, p.12.

B10. Significance (continued)

property, and while academic research is important to anyone directly involved in the field, the historical record must show that the research or studies conducted had a significant impact on historical events and trends in order to merit eligibility for listing in the NRHP or CRHR. The historical record does not indicate that Building 177 is eligible in this regard under Criterion A/1.

Although the Olivers were significant in the history of the explosives industry, no particular association was found between the Oliver family and the building. Although Building 177 was used for university research by Professor Howe and others throughout its lifetime, none of the available evidence suggests that the building has association with persons important to the development of the desalination field. Academic research is important to those working directly in that specific field; however, none of the persons associated with Building 177 had a significant impact on local, state, or national history. Therefore, the building lacks the strength of association necessary to be considered historically significant in relation to any particular persons (Criterion B/2).

The building does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values. Building 177 is a vernacular building of a type that was commonly constructed in the early twentieth century. In addition, it has been heavily altered over the years since UC Berkeley took possession in 1950, and the building is not eligible for listing in the NRHP or CRHR for its architecture (Criterion C/3).

In rare instances, buildings themselves can serve as sources of important information; however, this building is not a principal source of important information in this regard (Criterion D/4).

Building 177 does not meet the significance criteria for listing in the NRHP or CRHR.

Photographs (continued):

Photograph 2, rear of Building 177, April 30, 2013, camera facing southeast

Photographs (continued):

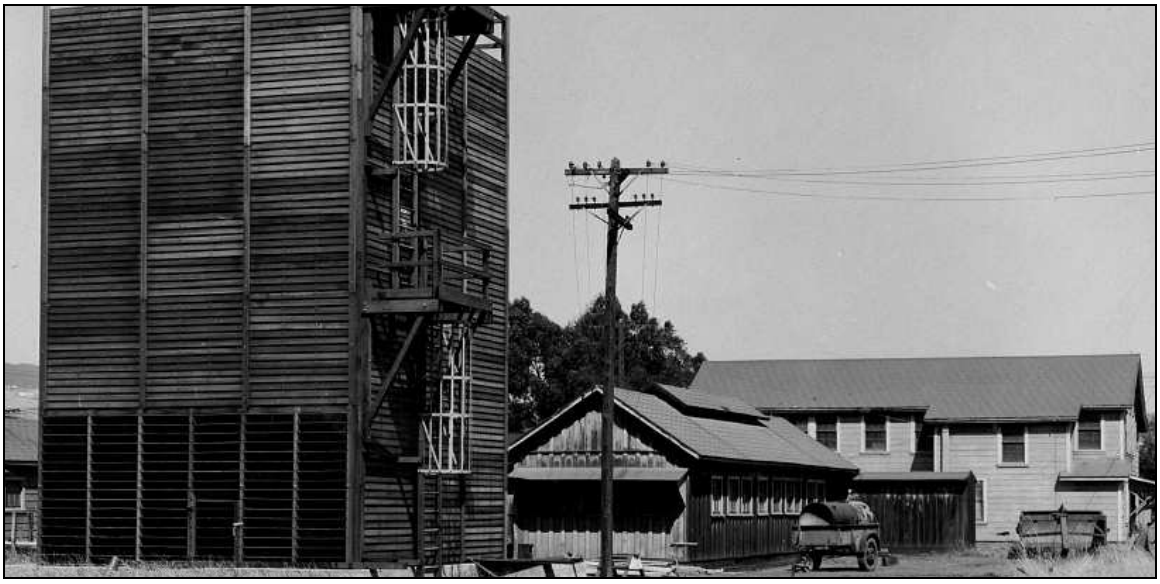
Photograph 3, rear of single-story portion of Building 177 showing decorative stickwork, April 30, 2013, camera facing south

Photographs (continued):

Photograph 4, rear of two-story portion of Building 177 showing exterior stairs, January 4, 2013, camera facing southwest

Photographs (continued):

Photograph 5, Building 177 (background), 1952, camera facing east



Photograph 6, Building 177 (Cooling Tower and "Building 64" in foreground), 1952, camera facing east

Photographs (continued):

Photograph 7, Building 177 with former Building 179 at left of frame, 1953, camera facing east

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 180

P1. Other Identifier: Richmond Field Station Building 180

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 2013 **T** 1N **; R** 4W**;** ___ **¼ of Sec** 20 **;** Mt. Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558555 mE/ 4196547 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)

Building 180 is in the southern portion of the Richmond Field Station. It is on the north side of Lark Drive, and its primary façade faces southwest. The vernacular building does not strongly express any particular architectural style. It is 11,008 square feet, single-story, and has an irregular plan. It is topped with a cross gabled roof. The primary fenestration consists of aluminum replacement sliding and awning sashes. The main entrance is centered in the southeast elevation. Its aluminum framed glass door is sheltered by a flat roofed entry porch and accessed via concrete steps. (See Continuation sheet)

***P3b. Resource Attributes:** (List attributes and codes) 39: Other

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1, camera facing northeast, April 30, 2013
***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Circa 1920/Sanborn maps
***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804
***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612
***P9. Date Recorded:** April 30, 2013
***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station, prepared by Tetra Tech, Inc., 2013.*

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

***NRHP Status Code** 6Z

***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 180

B1. Historic Name: "Building 44", "Building 170", "Building 171", "Building 172", "Building 185"

B2. Common Name: Building 180

B3. Original Use: Manufacturing B4. Present Use: Offices

***B5. Architectural Style:** Vernacular

***B6. Construction History:** (Construction date, alteration, and date of alterations) Five original buildings constructed circa 1920; joined circa 1940; renumbered 1953; windows replaced circa 1980s

***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____

***B8. Related Features:** _____

B9. Architect: Unknown b. Builder: Unknown

***B10. Significance: Theme** N/A **Area** N/A

Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A

(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 180 at the Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). Furthermore, the building has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code and does not appear to meet the significance criteria as outlined in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet)

B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:**

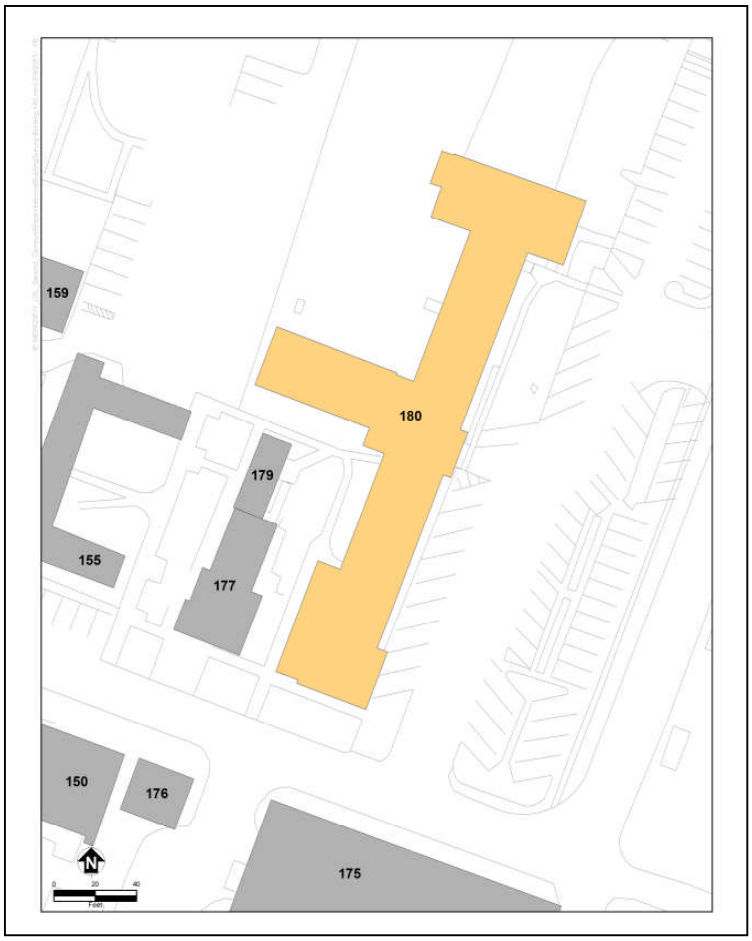
(See Footnotes)

B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** April 2013

(This space reserved for official comments.)



P3a. Description (continued)

Building 180 was constructed piecemeal, combining several buildings, over a period of decades from about the 1920s through the 1930s. This is why the building has multiple types of wall cladding, including two sizes of brick, horizontal wood siding, and vertical groove plywood (Photographs 1-5). A small two-story wing at the northeast corner of the building contains multi-light wood sash windows that have been painted over (Photograph 4).

During the California Cap Company era, the five connected buildings that comprise what is now Building 180 were devoted to manufacturing. "Building 44," which became the south half of Building 180's main wing, was devoted to plugging, soldering, and concaving (Photograph 5) when originally used by the California Cap Company. Wire cutting was performed in "Building 185," which became the small two-story wing at the north end of the building (Photograph 4). The north half of the building's main wing was "Building 170," where plugging was conducted for the company (Photograph 3). "Building 171," currently the west wing of Building 180, was a match head manufacturing area (Photograph 1). "Building 172" is at the center of Building 180's main wing and was originally an office (Photograph 2). Concrete blast walls on either side of the office protected the space from the explosives handled in Buildings 44 and 170.[1]

After the University of California (UC) took over and renumbered the five buildings, the space on which Building 180 now stands was used for photography work and offices. Most of the building's windows were replaced with aluminum sashes sometime during the 1980s (Photographs 1, 2, and 3). In 1982, restrooms and a conference room were installed in Building 180 (Photograph 5). The new restroom facility served the Sea Water Conversion complex which, prior to 1982, did not have plumbed indoor toilets.[2] It is currently used as offices.

B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages came upon the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[3] Though subsequent Spanish expeditions passed through the region, the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s, the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000-acre Rancho San Pablo to the Castros in 1823.[4] Americans began farming in Contra Costa County in the late 1830s, and by 1882, two-thirds of the cultivated land in the county was devoted to wheat production.[5]

[1] Sanborn Maps, 1949.

[2] University of California, Berkeley, File "Building 180," located in vertical files in Room 148, Richmond Field Station.

[3] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[4] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[5] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

B10. Significance (continued)

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[6] Adjacent to San Francisco Bay in what would eventually become the southern portion of the City of Richmond, a wharf and produce warehouse were constructed on the ranch in the 1860s to ship agricultural produce to the San Francisco markets from Rancho San Pablo, as well as from the Quilfelt ranch. The warehouse and wharf were used to transport cattle, grain, fruit, and in later years, the frogs' legs raised by Richard Stege for the San Francisco restaurant market.[7] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade, marrying Quilfelt and gaining title to her ranch. Stege began selling off portions of his ranch to raise money while continuing his frog-raising and other ventures. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century several industries, including the California Cap Company, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[8] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County.[9] Stege was eventually absorbed into Richmond as the latter grew.

The Explosives Industry in Contra Costa County

Swedish chemist Alfred Nobel laid the foundation for the high-explosives industry with his innovations beginning in 1860s, inventing first a detonator and then a blasting cap. In 1867, he invented dynamite, which was safer, cheaper, and more powerful than nitroglycerine, which had been the most commonly used explosive.

During the 1870s, chemical and explosives manufacturers began opening in the vicinity of what would eventually become Richmond. The Tonite Powder Company, Western Mineral Company, and California Cap Company were established at 1877 on the Stege ranch.

William Letts Oliver

William Letts Oliver was born in Chile to English parents in 1844. He initially gained familiarity with an explosive called guncotton while manufacturing collodion for his photography hobby.[10] As early as 1870, European explosive companies were experimenting with nitrated guncotton. By 1875, it was being manufactured in England under the name "Tonite."[11] In 1877, Oliver was mining in the western United States. Engineers working on the Sutro Tunnel in the Comstock needed an explosive to complete the tunnel that would remain stable at the high temperatures underground, and Oliver was able to solve the problem by substituting Tonite for more volatile compounds.[12]

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[6] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[7] Roland Oliver, "Recollections of Early Industries in Stege", August 7, 1959, p. 1.

[8] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354.

[9] Hulanski p. 288.

[10] Pacific Mining News, p. 222.

[11] G.A. Price Cuxson, ed., "Society of Engineers: Transactions for 1889", E. & F. N. Spon, London: 1890, p. 95.

[12] Pacific Mining News, p. 222.

B10. Significance (continued)

The California Cap Company

In 1877, William Letts Oliver established the Tonite Powder Company on a portion of the former Stege Ranch.[13] Oliver eventually invented a blasting cap that was safer to use and had better detonating qualities than imported detonators. Oliver and his partner Freeborn Fletter then founded the California Cap Company. It was located adjacent to the Tonite Powder Company on a 160-acre parcel carved out of the southern portion of Stege Ranch.[14] The California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. Richard Stege, meanwhile, continued to reside on the ranch, and contracted with Tonite Powder and California Cap to transport their products to the railroad.[15] The California Cap Company was located on the parcel that is currently the Richmond Field Station. The Tonite Powder Company appears to have been located to the east on the parcel that became the Stauffer Chemical Company and later the Zeneca site, although its exact location is unclear.

William Letts Oliver continued to innovate throughout his long career in the chemical and explosives industries. In 1888, he formed the American Lucol Company adjacent to the California Cap Company property.[16] The Lucol plant was at what is currently the southeastern corner of the Richmond Field Station. Lucol manufactured a linseed oil substitute.[17] The factory was dismantled and relocated to New Jersey circa 1900.[18] In 1903, the Hotaling Briquette Works opened on Lucol's site at the southeast corner of the current Richmond Field Station property.[19] Later known as the U.S. Briquette Company, the plant appears to have operated at this location until at least 1917.[20] The U.S. Briquette Company buildings were demolished during the 1960s.

Eventually, the Tonite factory appears to have been incorporated into the California Cap Company. The Olivers also formed an entity named Pacific Cartridge Company circa 1910. The Pacific Cartridge Company operated from the California Cap plant during World War I.[21] By 1916, there were at least a dozen buildings on the site. By 1922, the California Cap Company was substantially expanded and the plant grew to include 150 buildings and a horse-drawn tram line.[22]

During the late nineteenth and early twentieth century, the California Cap Company was one of the most important local employers.[23] As the twentieth century progressed more heavy industry came to Contra Costa

[13] Oliver, p. 1.
[14] Pacific Mining News, p. 222.
[15] Nilda Rego, "Enterprising Stege lost all and died without a penny", Time Out, March 27, 1994, p. 2, column 4.
[16] Oliver, p. 1.
[17] Max Wilhelm Von Bernewitz, *Cyanide Practice, 1910 – 1913,* Dewey Publishing Company: 1913, p. 327.
[18] Oliver, p. 1.
[19] Oliver, p. 2.
[20] Hulaniski, p. 354.
[21] R.L. Polk & Company, *Richmond and Contra Costa County Directory, 1914 – 1915*, Oakland, California: 1915.
[22] University of California, Berkeley, *Current Conditions Report,* Prepared by Tetra Tech EM Inc., November 21, 2008, p. 11.
[23] Marguerite Clausen, "On the Waterfront: An Oral History of Richmond, California", Regional Oral History Office, University of California, Berkeley, 1990, p. 21.

B10. Significance (continued)

County, and by 1940, the county was second only to Los Angeles in overall industrial production.[24] The nineteenth-century California Cap Company was dwarfed by the scale of some of the newer enterprises, and its physical plant and technology were aging. During World War II, California Cap Company was able to stay open by producing delayed action incendiary bombs that were used against Japan.[25] The California Cap Company could not survive the transition to a peacetime economy, however, and by 1949 the plant was closed.

University Research/Richmond Field Station

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[25] Oliver, p. 1.

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[27] McGauhey, p. 71.

[28] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

[29] University of California, Berkeley, 2008, p. 13.

[30] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

B10. Significance (continued)

a solution to water shortages.[31] In response, UC Berkeley Mechanical Engineering professor Everett D. Howe formed the SWCL at the Richmond Field Station in 1958.[32]

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[32] University of California (System) Academic Senate, "1991, University of California: In Memoriam," 1991, Internet website: http://texts.cdlib.org/view?docId=hb4t1nb2bd&doc.view=frames&chunk.id=div00031&toc.depth=1&toc.id=.

[33] University of California, Berkeley, Files "Building 151", "Building 154", "Building 158", "Building 177", and "Building 180," located in vertical files in Room 148, Richmond Field Station.

[34] University of California (System) Academic Senate, "1991, University of California: In Memoriam," 1991, Internet website: http://texts.cdlib.org/view?docId=hb4t1nb2bd&doc.view=frames&chunk.id=div00031&toc.depth=1&toc.id=.

[35] Soteris A. Kalogirou, *Solar Engineering: Processes and Systems*, Academic Press, Burlington, MA: 2009, p. 31.

[36] Yorem Cohen and Julius Glater, "A Tribute to Sidney Loeb, the Pioneer of Reverse Osmosis Desalination Research," Water Technology Research Center, Chemical and Biomolecular Engineering Research, University of California, Los Angeles, December, 2009, p. 13.

[37] University of California (System) Academic Senate, "1996, University of California: In Memoriam," 1996, Internet website: http://texts.cdlib.org/view?docId=hb0z09n6nn&doc.view=frames&chunk.id=div00041&toc.depth=1&toc.id=.

[38] University of California, Berkeley, Files "Building 180," located in vertical files in Room 148, Richmond Field Station.

[39] Heather Cooley, Peter H. Gleick, and Gary Wolff, "Desalination, With a Grain of Salt: A California Perspective," Pacific Institute, Oakland, California: 2006, p.12.

B10. Significance (continued)

Evaluation

No association was found between Building 180 and events significant to national, state, or local history (Criterion A/1). Although the California Cap Company was the first blasting cap manufacturer in the United States, there is no indication that the activities that took place in Building 180 were central to the development of the plant or its technical processes. Academic research took place in the building after UC Berkeley took over the property, and while academic research is important to anyone directly involved in the field, the historical record must show that the research or studies conducted had a significant impact on events and trends in order to merit listing in the NRHP or CRHR. The historical record does not indicate such significance, so the building is not eligible for inclusion in the NRHP or CRHR for historical significance (Criterion A/1).

Although the Olivers were significant in the history of the explosives industry, no particular association was found between the Oliver family and the building. The building was used for university research by Professor Howe and others throughout its lifetime; however, none of the available historical evidence suggests that the building has association with persons important to local, state, or national history. Academic research is important to those working directly in that specific field; however, none of the persons associated with Building 180 have the strength of association necessary to be considered eligible under Criterion B/2.

The building does not embody the distinctive characteristics of a type, period, region, or method of construction, or represent the work of an important creative individual or possess high artistic values. Building 180 is a combination of five buildings that were joined to make one building complex and has alteration dates from 1930 through 1950. The building is not eligible for the NRHP or CRHR for its architecture (Criterion C/3).

In rare instances, buildings themselves can serve as sources of important information; however, this building is not a principal source of important information in this regard (Criterion D/4).

Building 180 does not meet the significance criteria for listing in the NRHP or CRHR.

Photographs (continued):

Photograph 2, Building 180, primary entrance in main wing, April 30, 2013, camera facing west

Photograph 3, Building 180, rear of main wing, April 30, 2013, camera facing east

Photographs (continued):

Photograph 4, Building 180, northeast wing,
April 30, 2013, camera facing south

Photograph 5, Building 180, south end of main wing,
April 30, 2013, camera facing west

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

Page 1 **of** 1 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 198

P1. Other Identifier: Richmond Field Station Building 198

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)

***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** ____; __ ¼ **of Sec** ___; Diablo **B.M.**

c. Address _____ City _____ Zip_____

d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558629 mE/ 4196501 mN

e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)

Building 198 is in the southern portion of the Richmond Field Station across Lark Drive from Building 197. It is a 1,800 square-foot, rectangular plan, prefabricated building, topped with a very shallow pitched, gable roof with vents in the gables. Its walls and roof are corrugated steel and the building lacks fenestration. A large metal roll-up door is centered in its northwest elevation, while its southwest elevation features a metal industrial entrance door at grade.

***P3b. Resource Attributes:** (List attributes and codes) HP39: Other

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1, camera facing northeast, April 30, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
1981

***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804

***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** April 30, 2013

***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station, prepared by Tetra Tech, Inc., 2013.*

***Attachments:** NONE ☐ Location Map ☐ Sketch Map ☐ Continuation Sheet ☐ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

Page 1 **of** 1 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 201

P1. Other Identifier: Richmond Field Station Building 201

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)

***b. USGS 7.5′ Quad** Richmond **Date** 1984 **T**___; **R** _____; ¼ **of Sec** ___; Diablo **B.M.**

c. Address _____ City _____ Zip_____

d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558629 mE/ 4196501 mN

e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)

Building 201 is in the southwestern portion of the Richmond Field Station, along Avocet Way, on a 3.5-acre parcel. It is a single-story structure and houses the U.S. Environmental Protection Agency's Region IX laboratory and office building. It is a 46,000 square-foot tilt-up building that is ornamented through with reveals and indentations in the tilt-up panels, with sculpting. Covered trellises surround the building's walkways, and the main entrance features a modern glass enclosure. It was constructed in 1992.

***P3b. Resource Attributes:** (List attributes and codes) HP14: Government Building

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1, camera facing northwest, April 30, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
1992/Richmond Field Station Building Records

***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804

***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** April 30, 2013

***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station, prepared by Tetra Tech, Inc., 2013.*

***Attachments:** NONE ☐ Location Map ☐ Sketch Map ☐ Continuation Sheet ☐ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code _____ Reviewer _____ Date _____

 ***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 277

P1. Other Identifier: Richmond Field Station Building 277

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Contra Costa
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad** Richmond **Date** 2013 **T** 1N **; R** 4W**;** ___ **¼ of Sec** 20 **;** Mt. Diablo **B.M.**
c. Address _____ City _____ Zip_____
d. UTM: (give more than one for large and/or linear resources) Zone 10 ; 558397 mE/ 4196579 mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate) Assessor Parcel Number

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building 277 is in the southern portion of the Richmond Field Station. It is on the north side of Lark Drive, with its primary façade facing northwest. It is 21,426 square feet and was constructed circa 1966. The single-story building is a rectangular plan, prefabricated building topped with a front gabled roof. The walls and roof are corrugated metal. Fenestration consists of metal sash windows that appear to have been repurposed from a vehicle. Its primary entrance is in the northwest elevation, which faces Avocet Way. A metal industrial entry door is set inside a large sliding door. Building 277 was constructed as a model basin building for salinity intrusion study. It has been used throughout its life for storage.

***P3b. Resource Attributes:** (List attributes and codes) HP39: Other

***P4. Resources Present:** ☒ Building ☐ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession #) Photograph 1, camera facing east, April 30, 2013.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
1966/Richmond Field Station Building Files

***P7. Owner and Address:**
U.C. Berkeley
1301 South 46th Street
Richmond, California 94804

***P8. Recorded by:** (Name, affiliation, address)
Kara Brunzell & Julia Mates
Tetra Tech
1999 Harrison Street, Ste 500
Oakland, CA 94612

***P9. Date Recorded:** April 30, 2013

***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") *Historic Properties Survey Report for Portions of the Richmond Field Station, prepared by Tetra Tech, Inc., 2013.*

***Attachments:** NONE ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) _____

BUILDING, STRUCTURE, AND OBJECT RECORD

***NRHP Status Code** 6Z

***Resource Name or #** (Assigned by recorder) Richmond Field Station Building 277

B1. Historic Name: _____

B2. Common Name: Building 277

B3. Original Use: Storage B4. Present Use: Storage

***B5. Architectural Style:** Vernacular

***B6. Construction History:** (Construction date, alteration, and date of alterations) Constructed in 1966

***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** _____ **Original Location:** _____

***B8. Related Features:** _____

B9. Architect: Unknown b. Builder: Unknown

***B10. Significance: Theme** N/A **Area** N/A

Period of Significance N/A **Property Type** N/A **Applicable Criteria** N/A

(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building 277 at the Richmond Field Station does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP). The building was evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code, and does not appear to meet the significance criteria in these guidelines. Therefore, the building is not eligible for listing in the California Register of Historical Resources (CRHR). (See Continuation Sheet)

B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:**

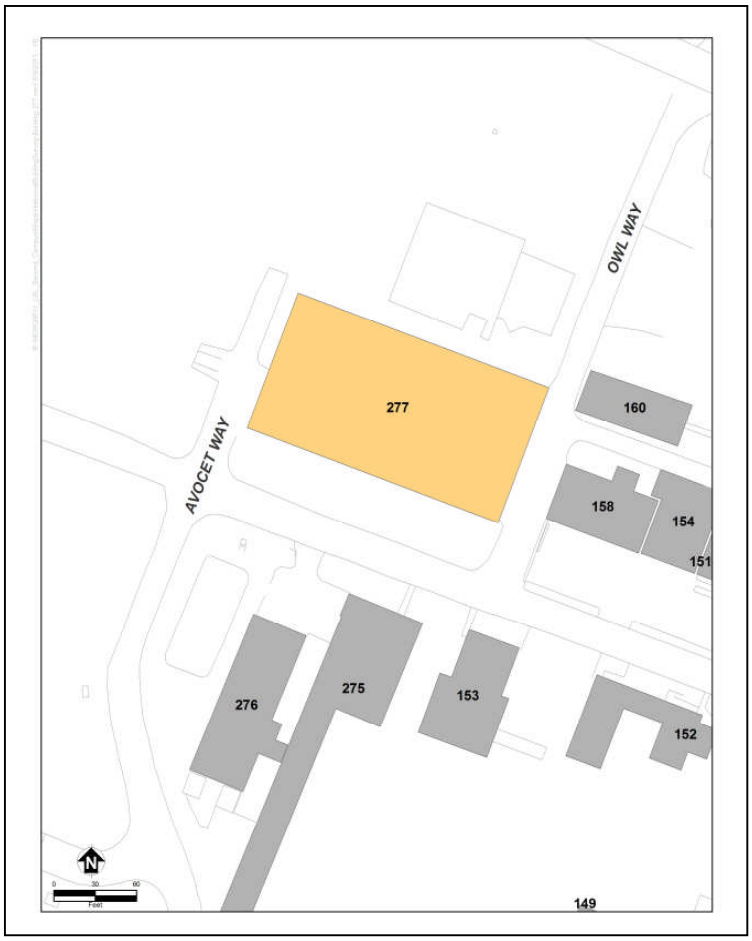
(See Footnotes)

B13. Remarks:

***B14. Evaluator:** Kara Brunzell

***Date of Evaluation:** April 2013

(This space reserved for official comments.)



B10. Significance (continued)

Historic Context

Europeans arrived in what would become Contra Costa County in 1772, when a Spanish expedition led by Pedro Fages discovered the San Pablo Bay and the confluence of the Sacramento and San Joaquin rivers.[1] Though subsequent Spanish expeditions passed through the region, the Spanish do not appear to have settled in the area during the mission period. In the 1820s and 1830s, the Mexican government began granting large tracts of land in the area to its citizens, including Ranchos San Pablo, San Ramon, and Pinole. The first permanent non-native settlers were Francisco Castro and his wife Maria Gabriela Berryessa. The Mexican government granted the 18,000-acre Rancho San Pablo to the Castros in 1823.[2] Americans began farming in Contra Costa County in the late 1830s, and by 1882, two-thirds of the cultivated land in the county was devoted to wheat production.[3]

Minna C. C. Quilfelt (or Quilfeldt) purchased 600 acres of Rancho San Pablo in 1852 and 1853.[4] German native Richard Stege settled on Rancho San Pablo in the late 1860s after stints in the gold fields and the Siberian fur trade, marrying Quilfelt and gaining title to her ranch. A town named Stege formed on Richard Stege's holdings, and by the late nineteenth century, several industries, including the California Cap Company, the United States Briquette Company, the Stauffer Chemical Works and the Stege Lumber Manufacturing Company, were operating from portions of the Stege Ranch.[5] Richmond incorporated in 1905, and by 1917 was already the largest city in Contra Costa County. Stege was eventually absorbed into Richmond as the latter grew.

William Letts Oliver established the Tonite Powder Company and California Cap Company on land purchased from the Stege Ranch in 1877. The California Cap Company, which went on to operate on the site for nearly seven decades, was the first manufacturer of blasting caps in the United States. The company was operated by Oliver's sons after his death and managed to survive through the end of World War II. By 1949, the plant was closed and for sale.

University Research/Richmond Field Station

After World War II, the University of California (UC) Berkeley Engineering Department needed an off-campus location to do experiments requiring more space than a laboratory. Department Chair Morrough P. O'Brien and others in the department were experimenting with sewage, sea water, and other materials unsuited for use on a crowded campus, and they wanted a location that was not too remote. UC Berkeley purchased the California Cap Company from the Oliver family for the use of the Engineering Department in 1950.[6]

---

[1] Mildred B. Hoover, Hero E. Rensch, Ethel G. Rensch, Douglas E. Kyle, *Historic Spots in California, Fourth Edition*, Stanford University Press, Stanford, California: 1958, p. 129.

[2] Donald Bastin, *Images of America: Richmond*, Arcadia Publishing, Charleston SC: 2003, p. 9.

[3] J.P. Munro-Fraser, *History of Contra Costa County, California*, W.A. Slocum & Co., San Francisco: 1882, p. 55 – 57.

[4] Evan Griffins, "Early History of Richmond", December 1938, El Cerrito Historical Society, website: http://www.elcerritowire.com/history/pages/EarlyRichmond.htm, accessed January 2013.

[5] Frederick J. Hulaniski, *The History of Contra Costa County, California*. Elms Publishing Company, Berkeley, California: 1917, p. 354: Hulaniski p. 288.

[6] P.H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research and Consultation, 1950-1975 – An Interview Conducted by Malca Call", Regional Oral History Office, University of California, Berkeley, 1974, p. 70.

B10. Significance (continued)

At first, the Department of Engineering used the buildings left behind by the California Cap Company. The department established a machine shop, computer shop, receiving facility, mail service, and other facilities in addition to laboratories in the old detonator company buildings.[7] The current buildings numbered 102, 110, 118, 128, 150, 152, 155, 175, 177, 176, and 180 all date to the California Cap Company era, and were repurposed for the Richmond Field Station. UC Berkeley constructed new buildings as funds became available, and by the mid-1950s, five new buildings had been completed at the Richmond Field Station.[8] By the 1970s, the Department of Engineering had conducted many experiments at the Richmond Field Station that could not have been done on the main campus.

The Richmond Field Station has been the location of research overseen by numerous UC Berkeley departments over the years. The Sanitary Engineering Research Laboratory (SERL) was one of the first departments to do research at the site. SERL focused primarily on sewage treatment technology and also researched pollution control and disposal of solid and liquid waste.[9] Other early projects at the field station included heat transfer and cyclic stress research.[10]

Another laboratory that used Richmond Field Station was the Sea Water Conversion Laboratory (SWCL). In 1952, Congress created and funded the Office of Saline Water to encourage desalination studies as a solution to water shortages.[11] In response, UC Berkeley Mechanical Engineering professor Everett D. Howe formed the SWCL at the Richmond Field Station in 1958.[12] Professor Alan D.K. Laird became SWCL Director when Howe retired, a position he held until the laboratory was closed in 1987.[13]

Building 277

Building 277 was constructed in 1966. The building has been used for rock storage since its construction.

Evaluation

Building 277 does not meet the criteria for listing in the NRHP or CRHR because it lacks historical significance. The structure has primarily been used for storage throughout its lifetime and lacks the strength of association necessary to be considered historically significant in relation to any particular events or persons (Criteria A/1 and B/2).

[7] McGauhey, p. 71.

[8] University of California, Berkeley, Department of Engineering, "Guide for Engineering Field Station Inspection", undated, p. 3.

[9] University of California, Berkeley, 2008, p. 13.

[10] University of California, Berkeley, Department of Engineering, "Richmond Field Station Open House", May 28, 1952, p. 3 – 4.

[11] Heather Cooley, Peter H. Gleick, and Gary Wolff, "Desalination, With a Grain of Salt: A California Perspective," Pacific Institute, Oakland, California: 2006, p.11.

[12] University of California (System) Academic Senate, "1991, University of California: In Memoriam," 1991, Internet website: http://texts.cdlib.org/view?docId=hb4t1nb2bd&doc.view=frames&chunk.id=div00031&toc.depth=1&toc.id=.

[13] University of California (System) Academic Senate, "1996, University of California: In Memoriam," 1996, Internet website: http://texts.cdlib.org/view?docId=hb0z09n6nn&doc.view=frames&chunk.id=div00041&toc.depth=1&toc.id=.

B10. Significance (continued)

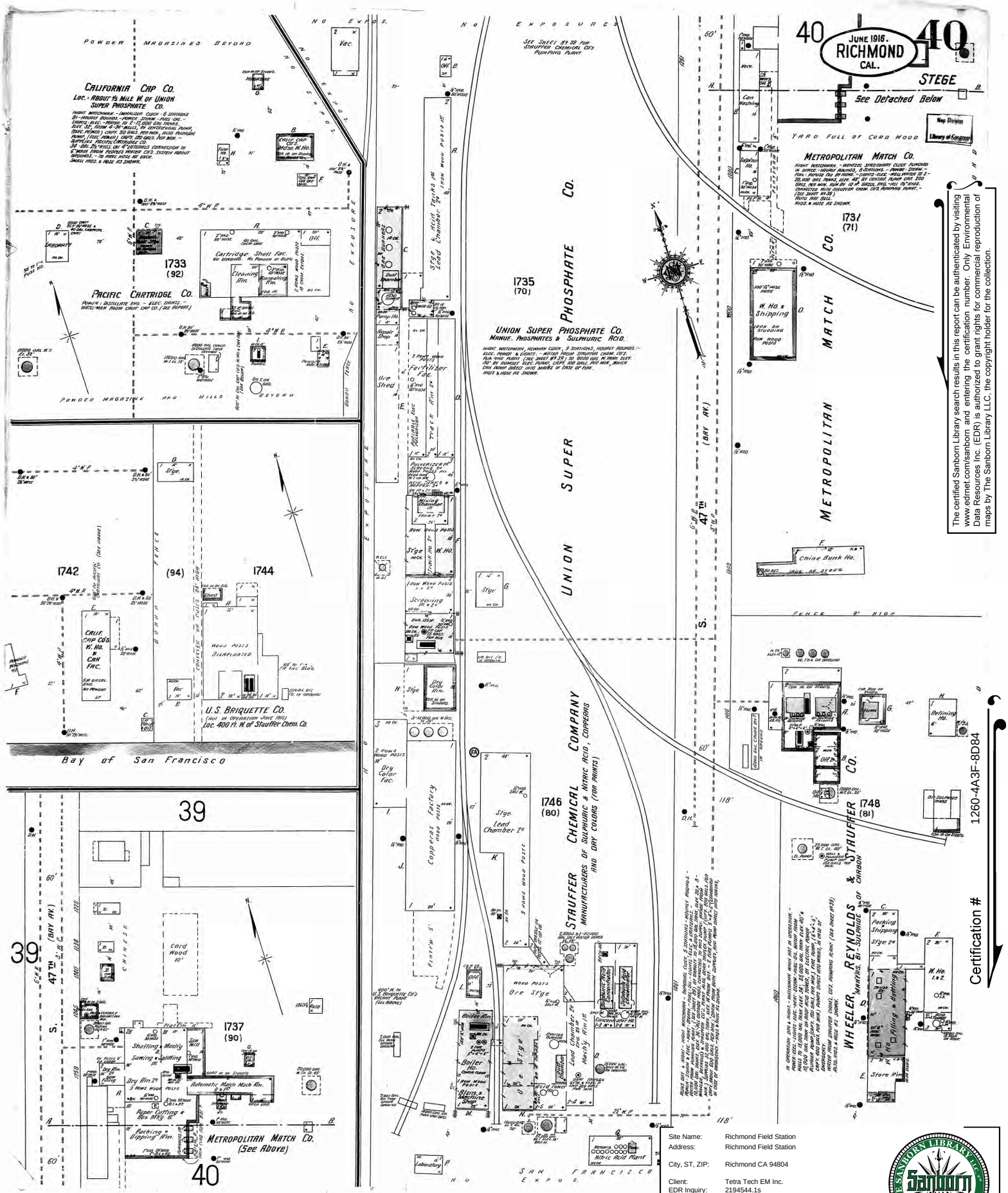
The utilitarian building lacks any identifiable architectural stylistic design and does not embody distinctive architectural or engineering qualities of type, period, or method of construction (Criterion C/3).

In rare instances, buildings themselves can serve as sources of important information, but this building is not a principal source of important information (Criterion D/4).

Building 277 does not meet the significance criteria for listing in the NRHP or CRHR.

APPENDIX B

HISTORIC SANBORN MAPS



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Address:	Richmond Field Station
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EDR Inquiry:	2194544.1s
Order Date:	4/11/2008 12:01:56 PM
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Copyright: 1916

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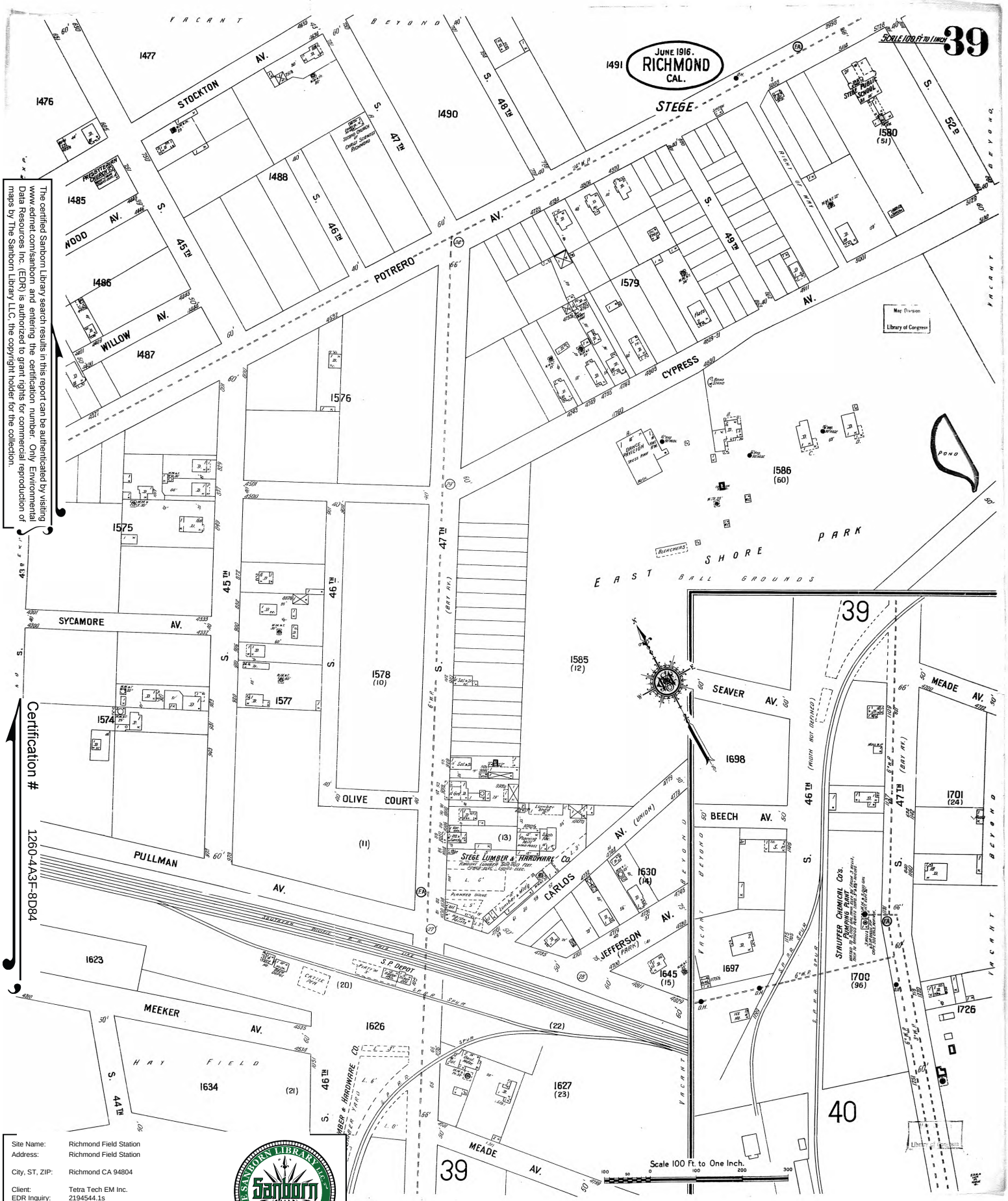

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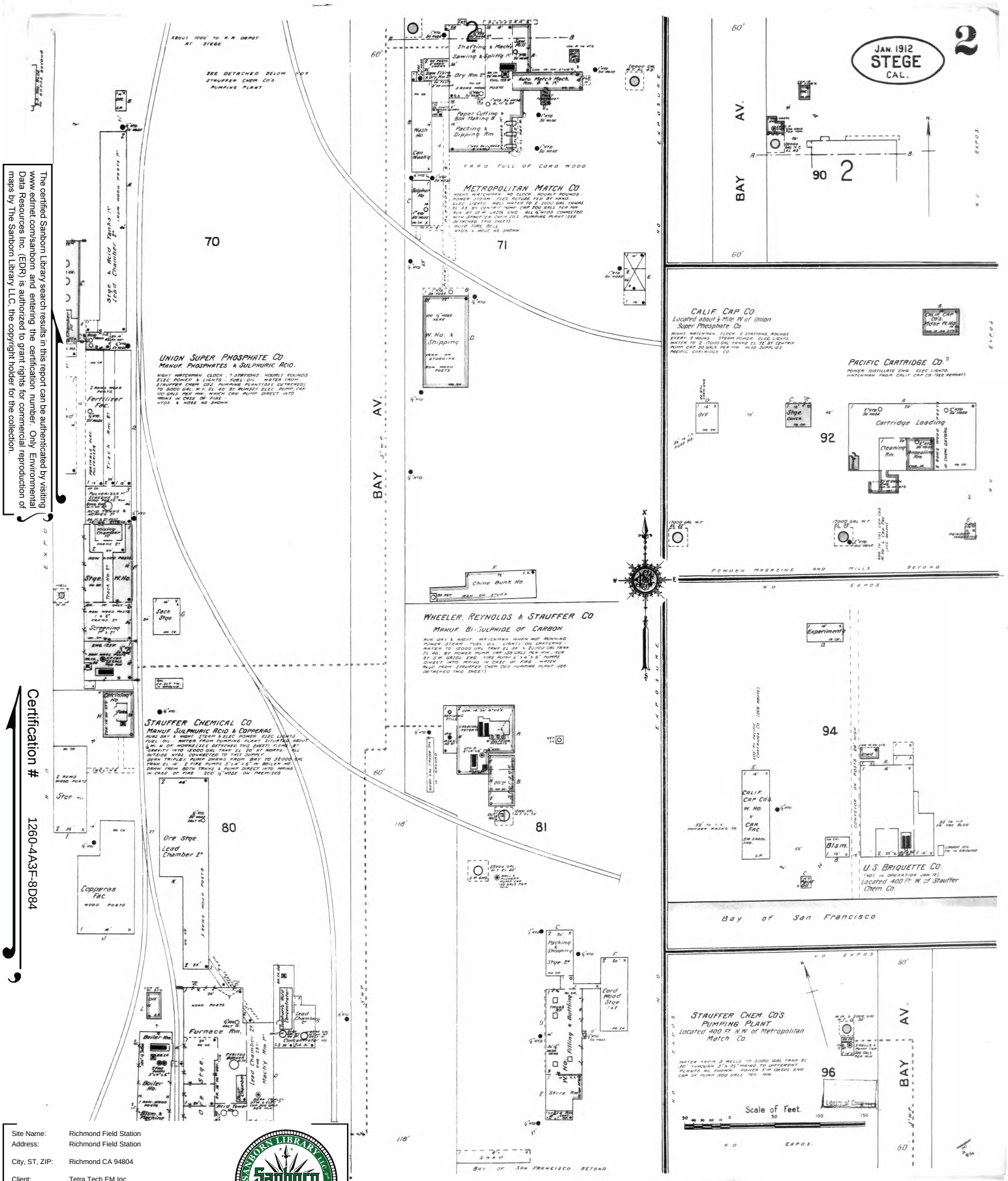
Certification # 1260-4A3F-8D84

Copyright: 1916

Scale 100 Ft. to One Inch.



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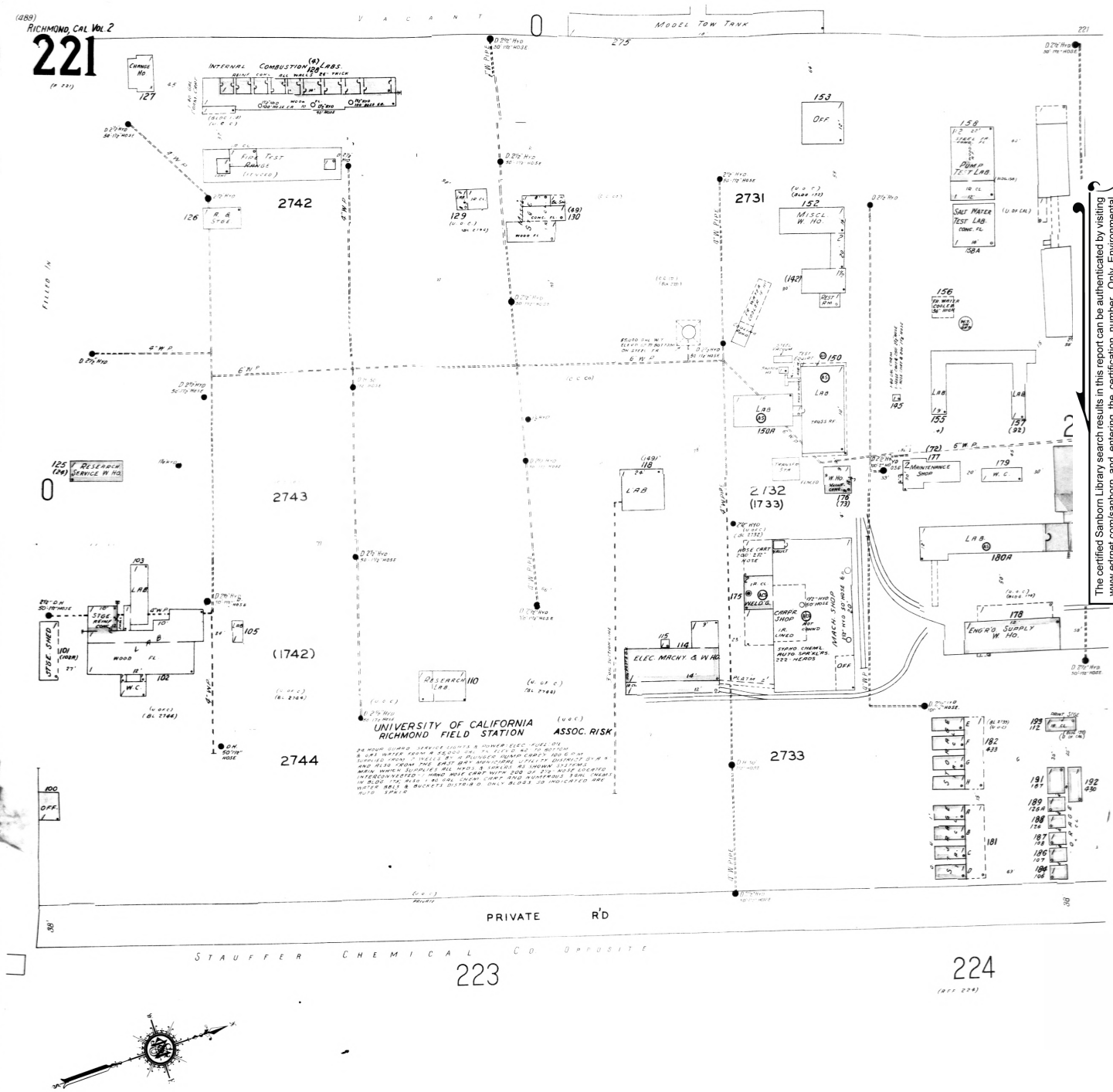

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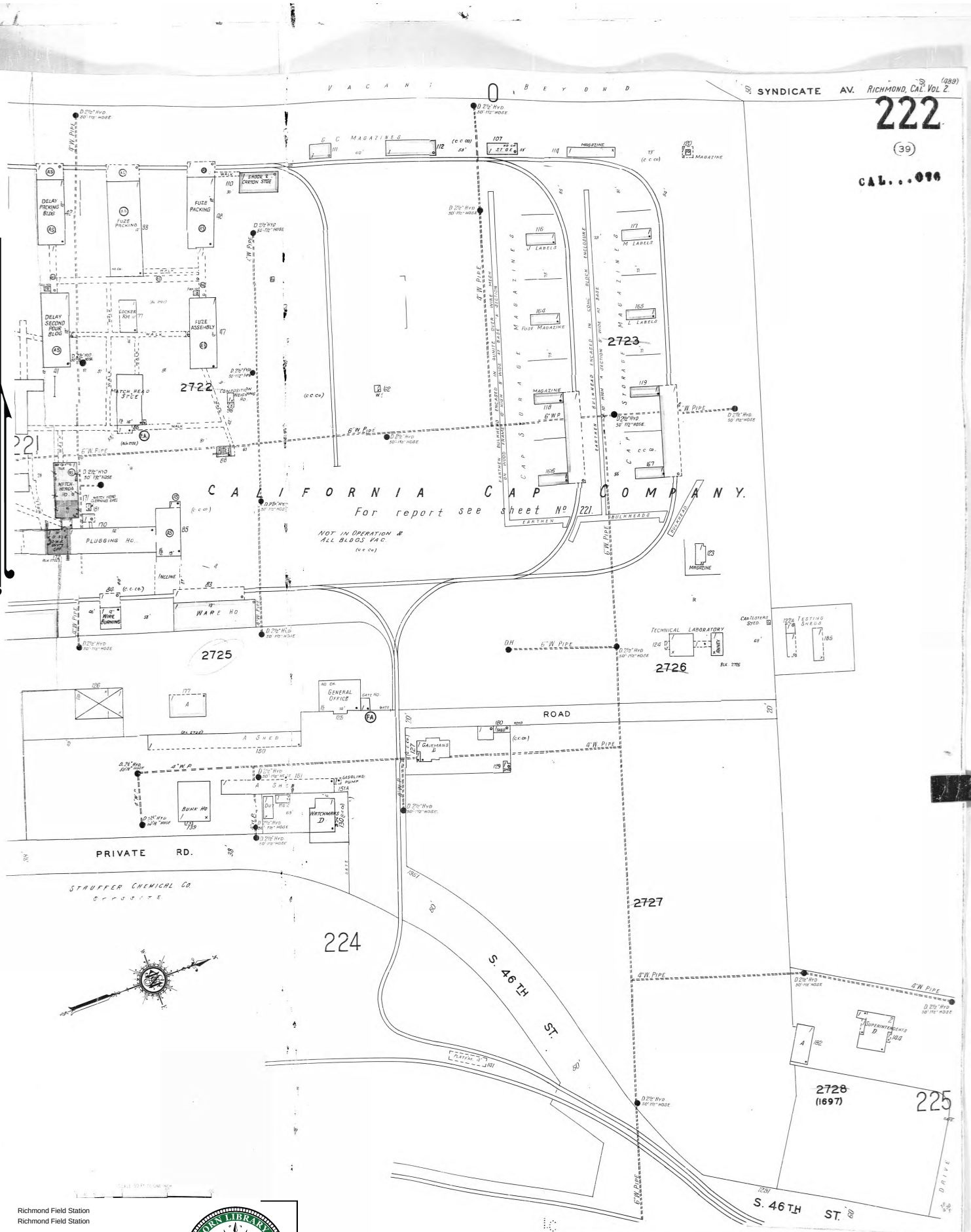

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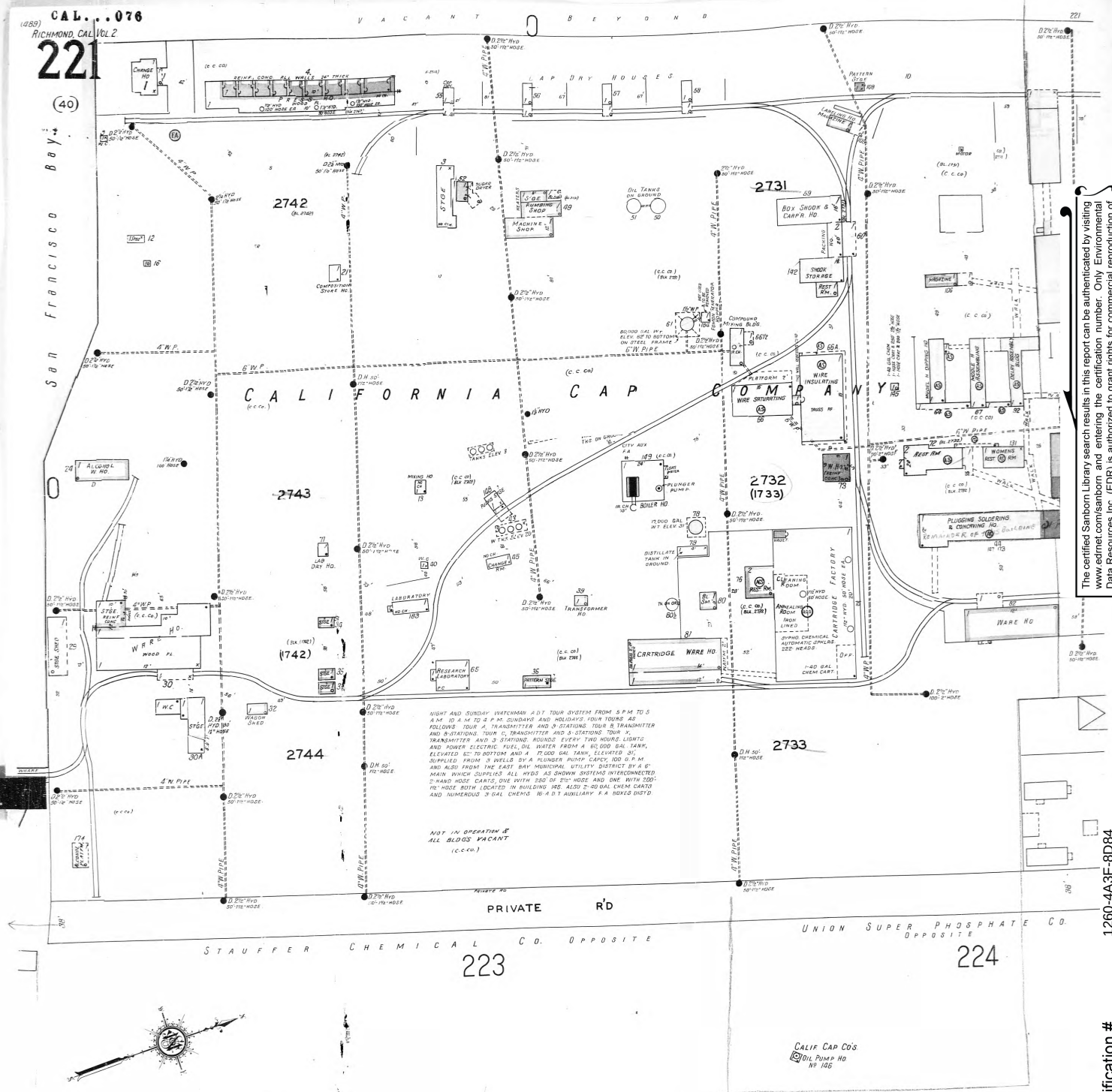

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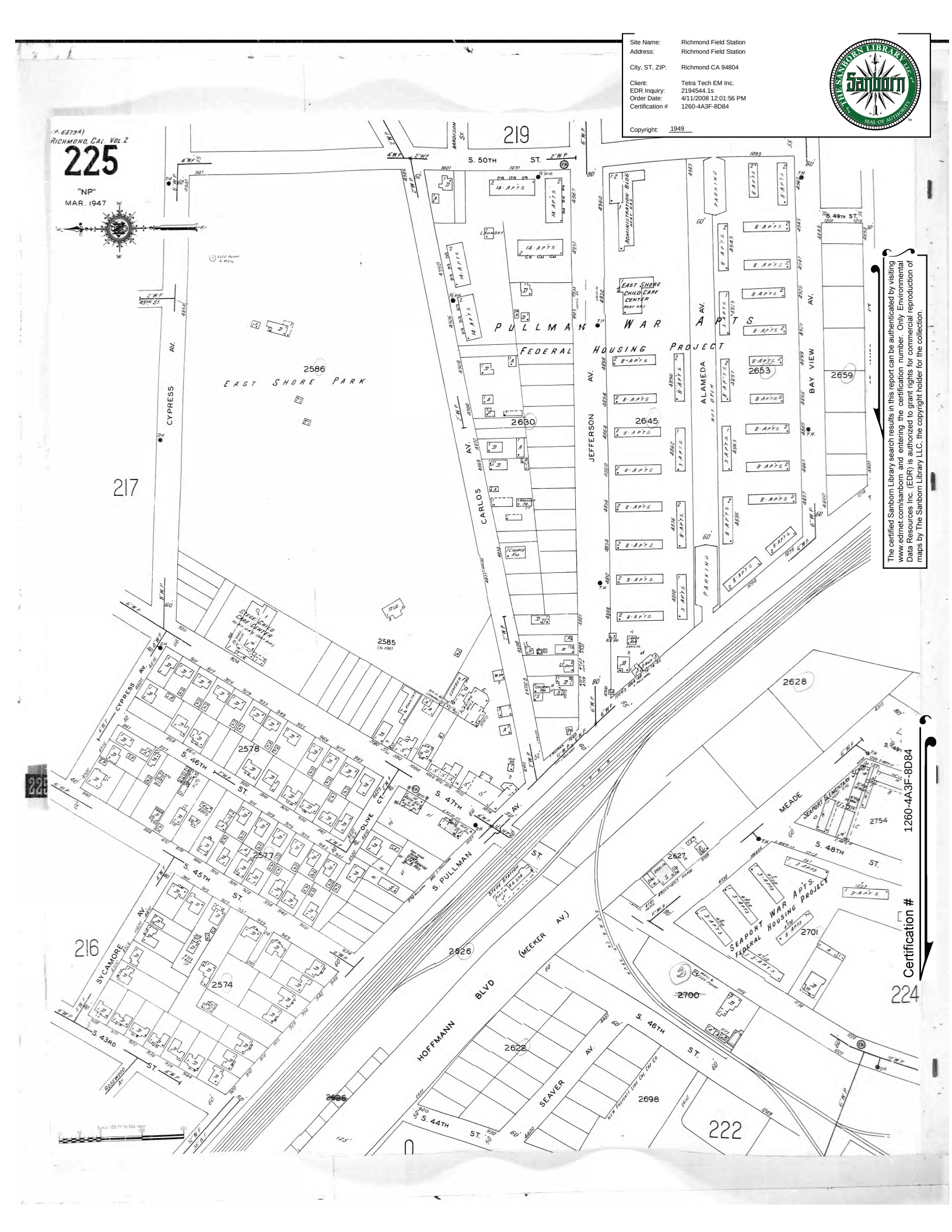

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Richmond Field Station
Richmond, CA 94804

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April 11, 2008

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4/11/08

Site Name:
Richmond Field Station
Richmond Field Station
Richmond, CA 94804

Client Name:
Tetra Tech EM Inc.
135 Main Street
San Francisco, CA 94105

EDR Inquiry # 2194544.1s

Contact: Carolyn Ferlic

EDR® Environmental Data Resources Inc

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Cross Street:
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Certification # 1260-4A3F-8D84

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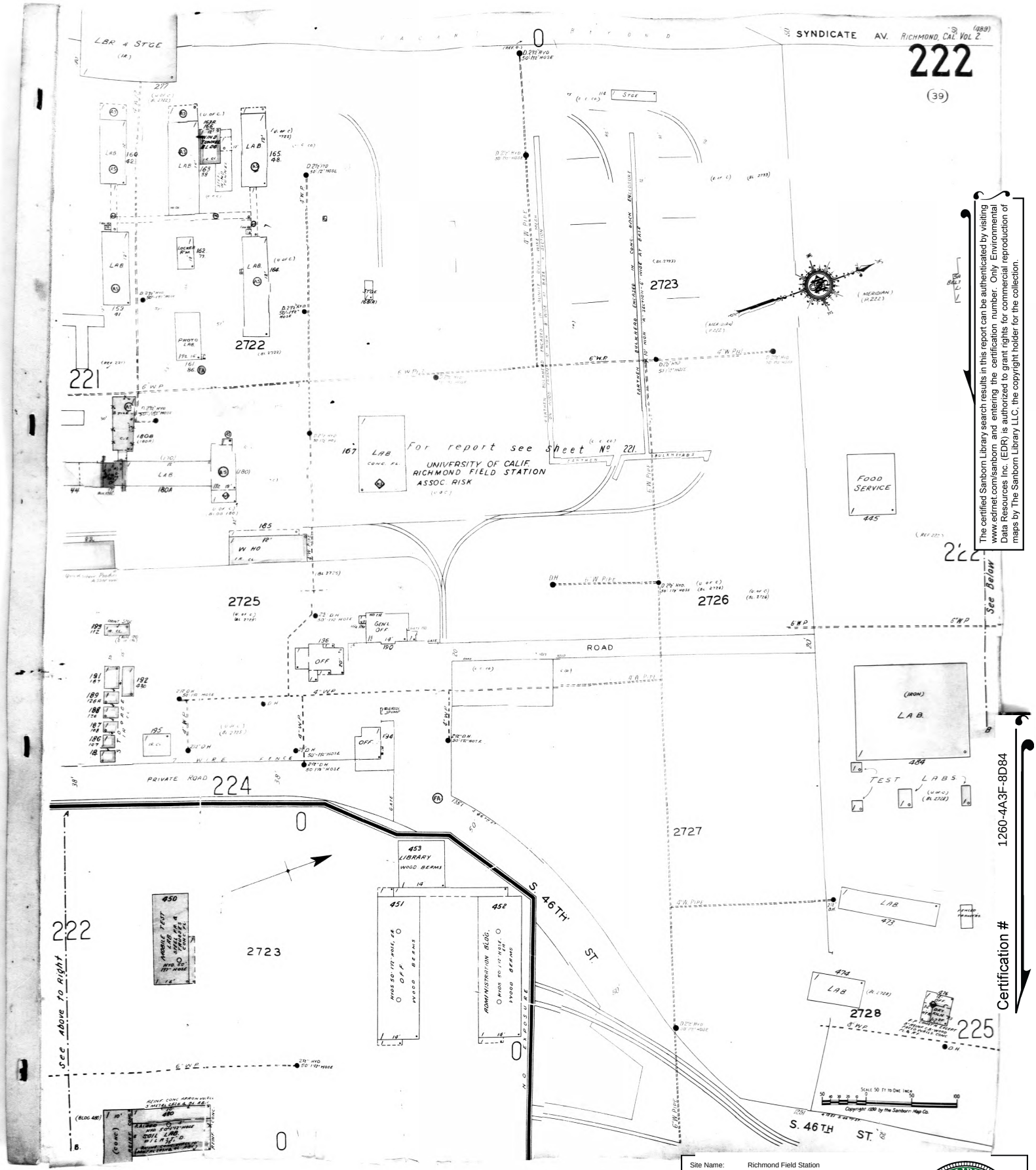

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225
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219
ELLS (S. 50TH ST.)
FLEMING AV.
CYPRESS AV.
49TH ST
EAST SHORE PARK
2586
2630
2645
HARTNETT AV.
2653
217
2585
SAMUEL GOMPERS PUBLIC SCHOOL
2578
S. 48TH ST.
2577
S. 47TH ST.
(S. PULLMAN AV.)
S. 45TH ST.
216
SYCAMORE AV.
CARLSON BLVD
2574
S. 43RD ST.
ROSEMOND AV.
2526
(MEEKER AV.)
HOFFMANN BLVD
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MEADE
S. 48TH ST.
ASSOC. RISK
STAUFFER CHEMICAL CO.
RICHMOND RESEARCH CENTER
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SEAVER
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ENGINEERING FIELD STATION
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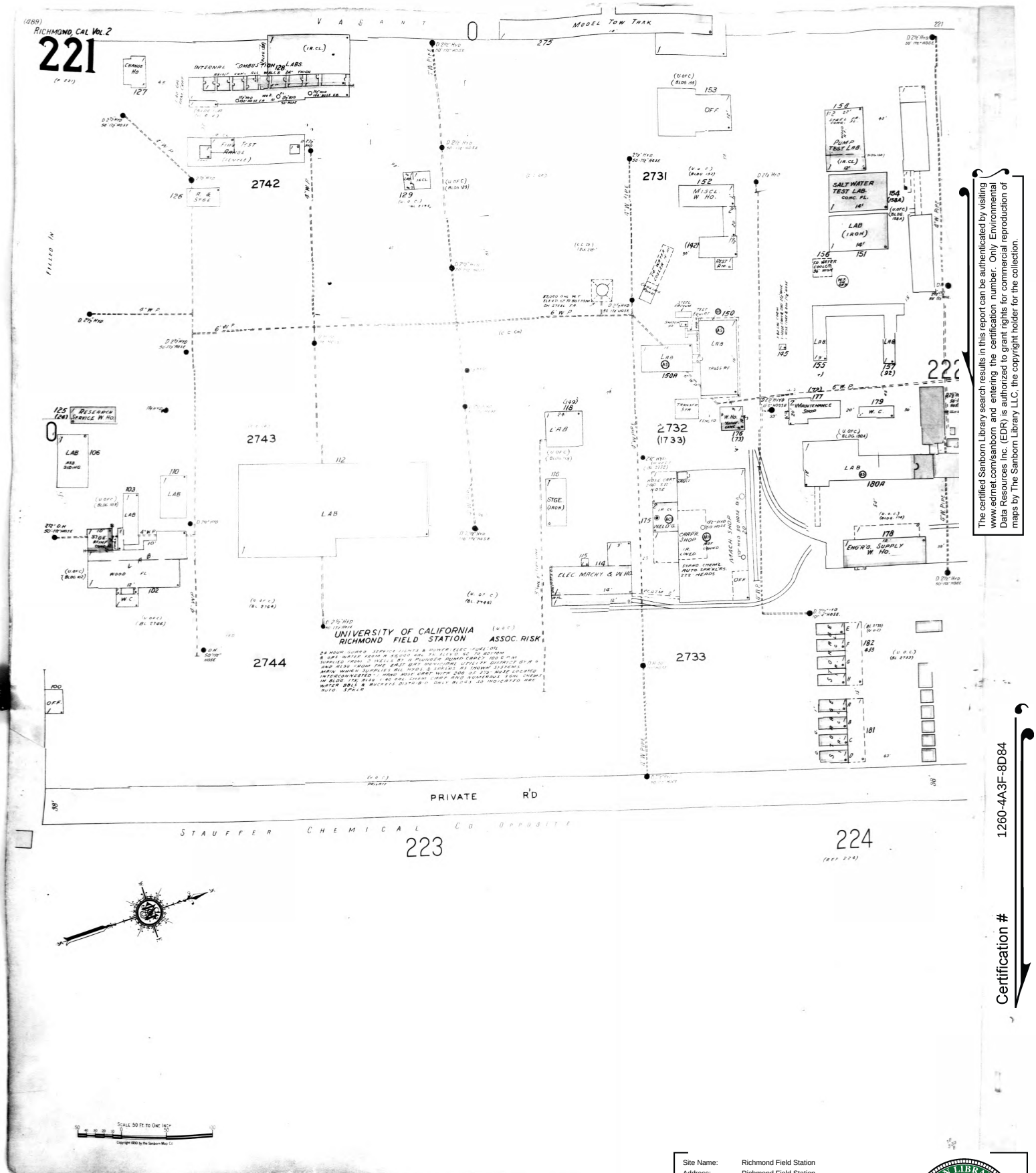

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JEFFERSON AV.
ALAMEDA AV.
BAY VIEW AV.
CARLOS AV.
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2585
SAMUEL GOMPERS PUBLIC SCHOOL
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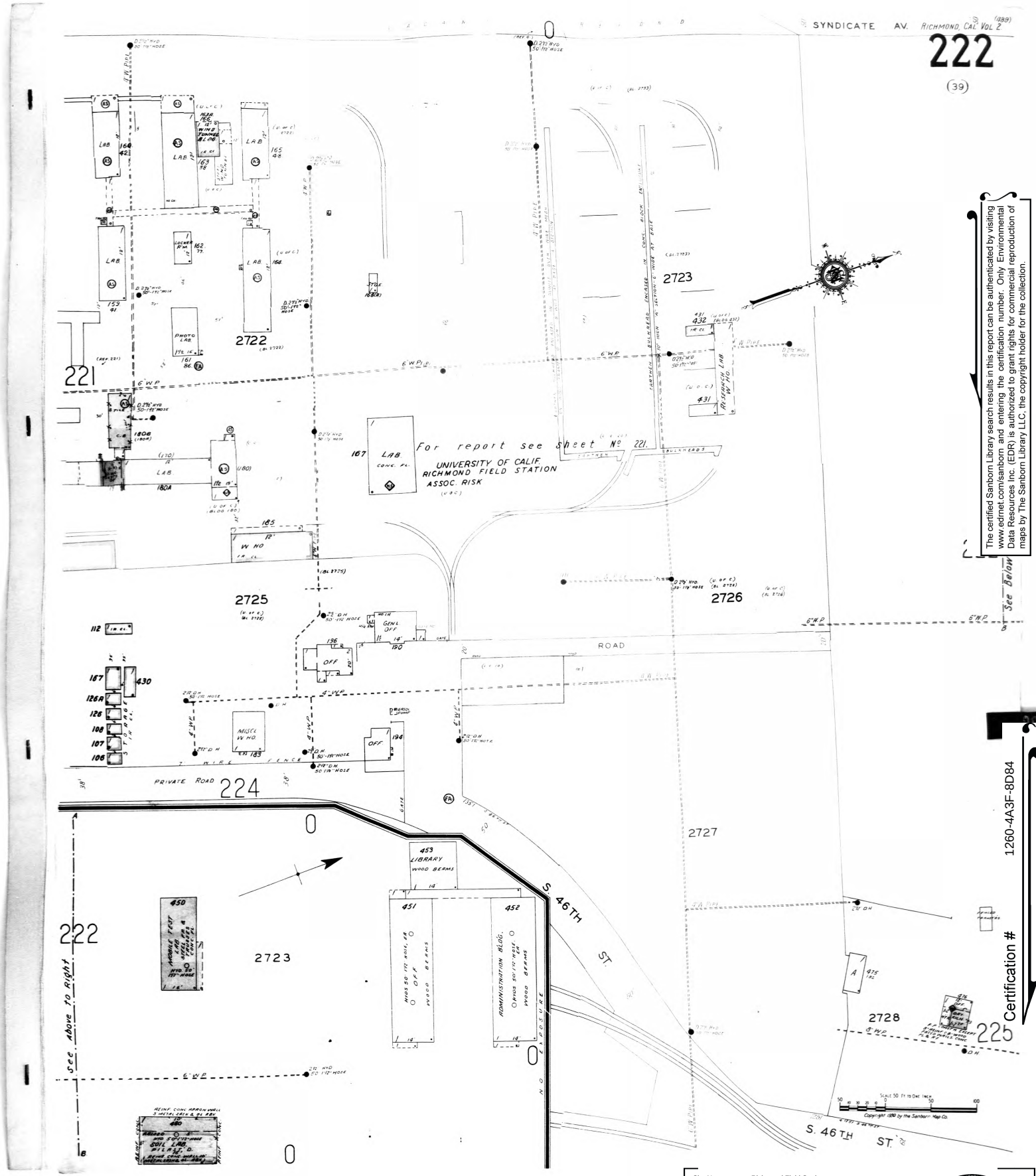

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Appendix E

Noise

BASELINE SOUND STUDY

FOR THE
UNIVERSITY OF CALIFORNIA AND LAWRENCE BERKELEY NATIONAL LABORATORY
RICHMOND BAY CAMPUS PROJECT

RICHMOND, CALIFORNIA

July 2013

PREPARED FOR:
Lawrence Berkeley National Laboratory
One Cyclotron Road
Berkeley, CA 94720

PREPARED BY:
Tetra Tech, Inc.

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A NIST Laboratory Calibration Sheets

LIST OF ACRONYMS

Acronym or Abbreviation	Full Phrase
ANSI	American National Standards Institute
Caltrans	California Department of Transportation
CCR	California Code of Regulations
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CNEL	Community Noise Equivalent Level
dB	decibels
dBA	A-weighted decibels
DOE	United States Department of Energy
gps	global positioning system
gsf	gross square foot
Hall	Lawrence Berkeley Hall of Science
HVAC	heating, ventilation, and air conditioning
Hz	Hertz
in	inches
in/sec	inches per second
INCE	Institute of Noise Control Engineers
kHz	kilohertz
LBNL	Lawrence Berkeley National Laboratory
L_{10}	intrusive noise level
L_{50}	median sound level
L_{90}	residual sound levlel
L_{eq}	equivalent Sound Level
L_{max}	maximum sound level
Ln	Statistical noise levels (i.e., L_{10}, L_{50}, L_{90})
MP	Monitoring Position
NAD	North American Datum
NIST	National Institute of Standards and Technology
OSHA	Occupational Safety and Health
RBC	Richmond Bay Campus
sec	seconds
UC	University of California
µPa	microPascal
UTM	Universal Transverse Mercator

Section 1 Introduction

1.1 PROJECT OVERVIEW AND PURPOSE

The University of California (UC) is proposing to establish new major research facilities at UC properties in Richmond, California. The new campus consolidates the biosciences programs of the Lawrence Berkeley National Laboratory (LBNL) and will also provide for development of additional facilities to be used by both LBNL and UC Berkeley. The campus is referred to as the Richmond Bay Campus (RBC), or the "Project" herein.

Background sound levels were monitored at several sensitive receptors such as nearby residences. Sound pressure levels reported are routinely used in the assessment of compliance with regulatory limits and in the determination of potential adverse impacts when used in conjunction with modeling results. Baseline sound measurements were collected to document the existing conditions for use in determining the expected net increase as a result of RBC construction and operation. Resultant data would be used for comparative purposes, for impact analysis under the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA), and for other applicable federal, state, and local ordinances or regulations. This baseline sound report describes the RBC study area, applicable regulations, measurement methodologies, and results.

1.2 RBC STUDY AREA

The RBC project site is in the city of Richmond, California, on approximately 133 acres owned by the UC. The area is located just off Interstate 580 (I-580) and situated between the San Francisco Bay, the Richmond Annex and the Point Isabel neighborhood. The RBC site is surrounded by institutional, residential and neighborhood commercial land uses.

1.3 SOUND SURVEY DESCRIPTION

Baseline measurements were completed during daytime and nighttime periods on January 24th through the 25th to document the existing acoustic environment. Monitoring was conducted at sensitive land uses such as residences, public use areas, and a National Historical Park property (Rosie the Riveter WWII Home Front). Short-term sound level measurements were completed during daytime (i.e. 10:00 a.m. to 4:00 p.m.) and nighttime (10:00 p.m. to 4:00 a.m.) periods. To avoid high vehicular traffic time periods short-term monitoring was completed outside of peak hour traffic periods. Measurements were completed during meteorological conditions conducive to the collection of measurement data (i.e., no rain or high wind). In accordance with CEQA requirements, noise monitoring at one unattended long-term (24-hour) location on the RBC project site was included to determine diurnal variation. These sound survey locations are shown on Figure 1-1.

Figure 1-1 Proposed Project area for RBC

Section 2 Regulatory Context

The regulatory environment for the Project includes federal, state and local noise control regulations and/or guidance. LBNL, as part of a federal agency (i.e., the Department of Energy or DOE), is subject to state and/or local regulation only if there has been a waiver of federal sovereign immunity through federal law, consistent with the U.S. Constitution's supremacy clause. Federal agencies, by way of the Federal Land Policy Management Act (FLPMA), 43 USC §1701 et seq. which provides a limited waiver of federal sovereign immunity, are required to comply with state or local provisions for environmental protection for portions of the federal agency's activities that would be located on federal lands. The authors understanding is that the properties on which RBC would be constructed are owned by the UC and therefore not federal lands per say, but if these are federal lands compliance with state and/or local regulations may be required. Regardless, LBNL is committed to planning its projects to be consistent with state and local laws or regulations.

2.1 FEDERAL REGULATIONS

Federal laws, regulation and guidance establish the national framework for noise regulations. If NEPA documentation is required, LBNL, part of the U.S. Department of Energy, implements NEPA via 10 Code of Federal Regulations (CFR) Part 1021. Noise considerations are typically addressed in NEPA documentation, which incorporate U.S. Environmental Protection Agency (EPA), state and other local regulations into the analysis.

2.1.1 Occupational Safety and Health Administration, Occupational Noise Exposure; Hearing Conservation Amendment (29 CFR 1910.95)

This standard establishes mandates to protect employees from excessive noise exposure and requires a Hearing Conservation Program when employee noise exposures equal or exceed an 8-hour time-weighted average sound level (TWA) of 85 A-weighted decibels (dBA).

2.1.2 Noise Control Act of 1972, as amended (42 USC 4901 et seq.)

The Noise Control Act of 1972, as amended, requires that all Federal agencies "to the fullest extent within their authority" implement programs within their jurisdictions that promote an environment free from noise that jeopardizes health and welfare. Federal, state and local agencies enforce the requirements and standards of the Noise Control Act to regulate noise from facilities, such as those at the RBC.

2.1.3 U.S. Environmental Protection Agency in "Information of Levels on Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety." (EPA 550/9-74-004)

Published in 1974, this document identifies safe levels of environmental noise exposure and is intended to "provide State and Local governments as well as the Federal Government and the private sector with an informational point of departure for the purpose of decision making." While the EPA has no regulation governing environmental noise, the agency has conducted several extensive studies to identify the effects of sound level on public health and welfare. For outdoor residential areas, the recommended EPA guideline is a day-night average noise level (L_{dn}) of 55 dBA and an indoor L_{dn} limit of 45 dBA. These levels are identified as desirable to protect against speech interference and sleep disturbance for residential, educational, and healthcare areas. Noise-level criteria to protect against hearing damage in are identified as 24-hour L_{eq} values of 70 dBA (both outdoors and indoors), with the value of 70 dBA Leq measured at the human ear, whereas

community/environmental noise is not measured at the ear. This publication remains the authoritative study based on a large sampling of community reaction to noise. The EPA sound level guidelines do not provide an absolute measure of noise impact, but rather a consensus on potential activity interference, human health and welfare effects, and annoyance. Because these protective levels were derived without concern for technical or economic feasibility, and contain a margin of safety to ensure their protective value, they should not be viewed as standards, criteria, regulations, or goals. Rather, they should be viewed as levels below which there is no reason to suspect that the general population will be at risk from any of the identified effects of noise. The following quote from the EPA guidance provides clarification on the use of the cause and effect noise levels:

> *"Perhaps the most fundamental misuse of the Levels Document is treatment of the identified levels as regulatory goals. They are not regulatory goals; they are levels defined by a negotiated scientific consensus. These levels were developed without concern for economic and technological feasibility, are intentionally conservative to protect the most sensitive portion of the American population, and include an additional margin of safety. In short, the levels in Table VIII are neither more nor less than what Congress required."*

The EPA guideline limits are summarized in Table 2-1.

Table 2-1 Summary of EPA Cause and Effect Noise Levels

Location	Level	Effect
All public accessible areas with prolonged exposure	70 dBA $L_{eq(24)}$	Safety
Outdoor at residential structure and other noise sensitive receptors where a large amount of time is spent	55 dBA L_{dn}	Protection against annoyance and activity interference
Outdoor areas where limited amounts of time are spent, e.g., park areas, school yards, golf courses, etc.	55 dBA $L_{eq(24)}$	
Indoor residential	45 dBA L_{dn}	
Indoor non-residential	55 dBA $L_{eq(24)}$	

U.S. Environmental Protection Agency. 1974

$L_{eq(24)}$ – Equivalent sound level for a given 24-hour period.

2.2 STATE REGULATIONS

The California Environmental Quality Act (CEQA) requires that significant environmental impacts be identified and that such impacts be eliminated or mitigated to the extent feasible. The CEQA guidelines (AEP 2012) set forth characteristics that signal a potentially significant impact. Under CEQA the proposed Project would be considered to have significant noise impacts if it results in the following:

- Exposure of persons to or generation of noise levels in excess of standards established in the local general plan (see Section 2.3) or noise ordinance, or applicable standards of other agencies?
- A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?
- A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?
- For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?
- For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?

For the proposed Project, the following criteria were determined to be inapplicable or to result in no impact:

- Exposure of on-site workers to noise levels that exceed occupational safety standards (90 dBA as a time-weighted 8-hour average or peak noise levels above 115 dBA).
- Exposure of residents to airport or private airstrip-related noise levels above a CNEL of 65 dBA.

Occupational noise exposure is governed by federal and state regulations. The California Division of Occupational Safety and Health (Cal/OSHA) administers industrial safety regulations in California. Cal/OSHA regulations establish a time-weighted noise exposure limit of 90 dBA averaged over 8 hours (California Code of Regulations, Title 8, Article 105). Noise source controls, administrative procedures, or worker hearing protection must be provided if worker noise exposure would exceed the 90 dBA limit. These limits are not expected to be a concern for the Project as LBNL complies with the exposure limits outlined in the American Conference of Industrial Hygienists (ACGIH) recommended Threshold Limit Values, 85 dBA with a 3 dB doubling, which is more stringent than the Cal/OSHA regulations (i.e., Cal/OSHA and OSHA are 90 dBA with a 5 dB doubling).

According to the California Energy Commission (CEC), increases in noise less than 5 dBA above background at a sensitive receptor are clearly not significant, and increases in noise greater than 10 dBA above background at a sensitive receptor are clearly significant (CEC 2002). Increases in background noise between 5 and 10 dBA may be significant, depending on the circumstances. It would be reasonable to assume that similar thresholds may be applied to the Project.

The State of California provides regulation by adopted laws and guidance regarding noise emissions through the jurisdiction of state commissions requiring local jurisdictions (California Government Code Section 65302[f]) to prepare general plans, which include Noise Elements. The purpose of the noise element is to identify goals, policies, and implementation measures that can be used to guide future land use development with regard to noise. The State of California identifies the following land uses as noise sensitive: residential areas, schools, convalescent and acute care hospitals, parks and recreational areas, and churches. The recommended noise guideline for exterior living areas (yards and patios) for new residential land uses is a 55 dBA CNEL, and must not exceed 65 dBA CNEL. In addition, for multi-family residential projects, the California Noise Insulation Standard (California Administrative Code, Title 25, Chapter 1, Subchapter 1, Article 4) requires that the indoor noise levels in multi-family residential developments do not exceed a CNEL of 45 dBA to be consistent with State of California standards.

2.3 LOCAL REGULATIONS

The City of Richmond regulates noise via its *"Code of Ordinances, Chapter 9.52 - Community Noise Ordinance"*. Maximum exterior noise levels by zoning district are listed in Table 2-2. Richmond's noise ordinance also provides noise limits applicable to stationary construction equipment.

Table 2-2 Maximum Noise Levels by Zoning District

Zoning District	Maximum Noise Level in dBA (levels not to be exceeded more than 30 minutes in any hour)		Maximum Noise Level in dBA (level not to be exceeded more than 5 minutes in any hour)
	Measured at Property Line or District Boundary	Measured at Any Boundary of a Residential Zone	Between 10 PM and 7 AM***, Measured at Any Boundary of a Residential Zone
Single-Family Residential	60	N/A	N/A
Multifamily Residential	65	N/A	N/A
Commercial	70	60	50 or ambient noise level
Lt. Industrial and Office Flex*	70	60	50 or ambient noise level
Heavy and Marine Industrial	75	65	50 or ambient noise level
Public Facilities and Community Use	65	60	50 or ambient noise level
Open Space and Recreation Districts	65	60	50 or ambient noise level

* For M-1 and M-2 the measurement will be at property line

** For M-3 and M-4 the measurement will be at the boundary of the district

*** Restricted hours may be modified through condition of an approved conditional use permit. Section subsections of Chapter 9.52 also provide for additional restricted hours and the most restrictive hours shall be controlling.

N/A Not applicable

Source: City of Richmond, May 17, 2011

Section 3 Field Methods and Results

This section includes a description of the sound terminology, survey methodologies, a description of areas surveyed, and measurement equipment used. Sound measurements were completed by a full member of the Institute of Noise Control Engineers (INCE) or under their direct supervision. The location of monitoring positions were determined by using a global positioning system (GPS) unit, and photographs were taken from the measurement points in the directions of receptors of interest and the Project site.

3.1 MONITORING LOCATIONS

Ten monitoring locations were identified for baseline sound. Figure 1-1 presents a map of these monitoring locations. Table 3-1 lists the corresponding map identifier to Figure 1-1, the Universal Transverse Mercator (UTM) coordinates, existing land uses, and a description of each location surveyed.

Table Error! No text of specified style in document.**-1 Monitoring Locations**

Map ID	Noise Sensitive Use	UTM Zone 10N X-Coordinate	UTM Zone 10N Y-Coordinate	Description
MP-1	Residential	558230	4196146	Residential Neighborhood at Point Isabel Shoreline
MP-2	Residential	558133	4196302	Eastern Residences at Bayside Court
MP-3	Residential	557948	4196398	Residences at Bayside Court
MP-4	Residential	557626	4196433	Trade Winds Sailing School
MP-5	Civic/Public	557415	4196518	Rosie the Riveter WWII Home Front
MP-6	Residential	557591	4196799	The Anchorage at Marina Bay
MP-7	Residential	557951	4197377	Neighborhood at 30th St. & Hoffman Blvd
MP-8	Residential	558899	4197114	Neighborhood at 43rd St. & Carlson Blvd
MP-9	Civic/Public	559098	4196917	Booker T. Anderson Jr. Park
LT-1	RBC	557415	4196518	Richmond Bay Campus

3.2 TERMINOLOGY AND METRICS

Airborne sound is described as the rapid fluctuation or oscillation of air pressure above and below atmospheric pressure, creating a sound wave. Sound is characterized by properties of the sound waves, which are frequency, wavelength, period, amplitude, and velocity. Sound energy travels in the form of a wave, a rapid fluctuation or oscillation of air pressure above and below atmospheric pressure. Sound levels are presented on a logarithmic scale to account for the large range of acoustic pressures that the human ear is exposed to and is expressed in decibel units or dB. A dB is defined as the ratio between a measured value and a reference value usually corresponding to the lower threshold of human hearing defined as 20 micropascals (μPa). Since the human ear does not perceive every frequency with equal loudness, spectrally varying sounds are often adjusted with a weighting filter. The A-weighted filter is applied to compensate for the frequency response of the human auditory system and sound exposure in acoustic assessments is designated in dBA. Unweighted sound levels are referred to as linear. Linear dBss are used to determine a sound's tonality and to engineer solutions to reduce or control noise as techniques are different for low and high frequency noise.

Several metrics describing the ambient conditions were measured including the time-averaged equivalent sound pressure levels, or the L_{eq}, as well as several statistical parameters including the L_{10}, L_{50}, and L_{90} which

can be used to distinguish long-term baseline sound levels from transitory events. The unit of frequency is hertz (Hz), which corresponds to the rate in cycles per second that sound pressure waves are generated., Typically, a sound frequency analysis examines 11 octave (or 33 1/3 octave) bands ranging from 16 Hz (low) to 16,000 Hz (high). This range encompasses the entire human audible frequency range. Because the human ear does not perceive every frequency with equal loudness, spectrally varying sounds are often adjusted with a weighting filter. The A-weighted filter is applied to compensate for the frequency response of the human auditory system.

Sound levels can be measured and presented in various formats. The sound metrics that were employed in the survey have the following definitions:

- **L_{eq}:** Conventionally expressed in dBA, the L_{eq} is the energy-averaged, A-weighted sound level for the complete time period. It is defined as the steady, continuous sound level over a specified time, which has the same acoustic energy as the actual varying sound levels over the specified period.
- **L_{max}:** The maximum A-weighted sound level as determined during a specified measurement period. It can also be described as the maximum instantaneous sound pressure level generated by a piece of equipment.
- **L_n:** This descriptor identifies the sound level that is exceeded "n" percent of the time over a measurement period (e.g., L_{90} = sound level exceeded 90 percent of the time). The sound level exceeded for a small percent of the time, L_{10}, closely corresponds to short-term, higher-level, intrusive noises (such as vehicle pass-by noise near a roadway). The sound level exceeded for a large percent of the time, L_{90}, closely corresponds to continuous, lower-level background noise (such as continuous noise from a distant industrial facility). L_{50} is the level exceeded 50 percent of the time and is typically referred to the median sound level over a given period.
- **CNEL:** This descriptor is another average A-weighted L_{eq} sound level measured over a 24-hour period; however, this noise scale is adjusted to account for some individuals' increased sensitivity to noise levels during the evening and nighttime hours. A CNEL noise measurement is obtained after adding 5 dB to sound levels occurring during evening hours (7:00 p.m. to 10:00 p.m.) and 10 dB to sound levels occurring during nighttime hours (10:00 p.m. to 7:00 a.m.).

An inherent property of the logarithmic decibel scale is that the sound pressure levels of two separate sources are not directly additive. For example, if a sound of 50 dBA is added to another sound of 50 dBA, the result is a 3-decibel increase (or 53 dBA), not an arithmetic doubling to 100 dBA. With respect to how the human ear perceives changes in sound pressure level relative to changes in "loudness," scientific research demonstrates that the following general relationships hold between sound level and human perception for two sound levels with the same or very similar frequency characteristics:

- **1 dBA** is the practical limit of accuracy for sound measurement systems and corresponds to an approximate 10 percent variation in the sound pressure level. A 1 dBA increase or decrease is a non-perceptible change in sound.
- **3 dBA** increase or decrease is a doubling (or halving) of acoustic energy and it corresponds to the threshold of change in loudness perceptible in a laboratory environment. The average person is generally not able to distinguish a 3 dBA difference in environmental sound outdoors.
- **5 dBA** increase or decrease is described as a perceptible change in sound level and is a readily discernible change in an outdoor environment.
- **10 dBA** increase or decrease is a tenfold increase or decrease in acoustic energy but is perceived as a doubling or halving in loudness (i.e., the average person will judge a 10 dBA change in sound level to be twice or half as loud).

3.3 SURVEY METHODS

Sound measurements were completed with Larson Davis 831 sound level meter equipped with a PCB model 377B02 ½-inch precision condenser microphone. This instrument has an operating range of 5 dB to 140 dB, and an overall frequency range of 8 to 20,000 Hz and meets or exceeds all requirements set forth in the American National Standards Institute (ANSI) standards for Type 1 sound level meters for quality and accuracy (precision). All sound analyzers were programmed to measure full-octave and 1/3-octave band frequency (Hz) levels to document and further describe the quality and character of the existing ambient soundscape. Data was collected for 1/1 and 1/3 octave band data spanning 6.3 Hz to 20 kilohertz. Short-term baseline sound monitoring data were measured and logged at 1-minute intervals for a minimum total duration of 30 minutes. The 24-hour sound monitoring station continuously monitored and logged data in one-hour intervals, consisting of ten-minute time histories.

The microphone and windscreen were tripod-mounted at an approximate height of 1.2 to 1.7 meters (4 to 5.6 feet) above grade. The 24-hour sound monitoring station was self-supporting and weather-proof and was deployed near the Project area centroid. All sound level analyzer microphones were protected from wind-induced self-noise effects by windscreen made of specially prepared open-pored polyurethane. Each sound analyzer was programmed to measure and log broadband A-weighted sound pressure levels, including a number of statistical parameters such as the L_{eq} L_{max}, and statistical L_n sound levels.

Table 3-2 provides an inventory of the measurement equipment that was used. All instrumentation components, including microphones, accelerometer(s), preamplifiers and field calibrators, had current laboratory certified calibrations traceable to the National Institute of Standards Technology (NIST). The NIST laboratory calibration certifications for the measurement instrumentation used on the Project are included in Appendix A.

Table Error! No text of specified style in document.**-2 Measurement Equipment**

Description	Manufacturer	Type
Signal Analyzer	Larson Davis	824/831
Preamplifier	Larson Davis	PRM902
Signal Conditioner	PCB	480E09
Weather Transmitter	Vaisala	WXT520
Microphone	PCB	377B02
Windscreen	ACO Pacific	7-inch
Calibrator	Larson Davis	CAL200

3.4 SURVEY RESULTS, MONITORING POSITION DESCRIPTIONS AND FIELD OBSERVATIONS

Noise measurements were completed to establish baseline conditions. The goal was to identify the regularly occurring baseline sound at monitoring positions near the RBC project site so that a comparison can be made to assess the potential for adverse impacts as a result of the Project. The following survey results and measurement data are intended to support the technical analysis required as part of the permitting process for the Project. Upon completion of the baseline sound survey, the results were tabulated into relevant time periods. The monitoring completed includes the collection and reporting of the following data:

- Sound pressure level data present during daytime and nighttime test periods.
- For each time period, the following sound measurement descriptors were compiled:
    - Spectral octave-band analysis (31.5, 63, 125, 250, 500, 1K, 2K, 4K, and 8K Hz);
    - One hour statistical values including L_{eq}, L_{10}, L_{50}, and L_{90}, in dBA;

- A narrative description of sounds audible during testing as well as a discussion of any anomalous or regularly occurring sound events identified over the course of the monitoring program; and
- Existing land uses in the vicinity of the measurement location.

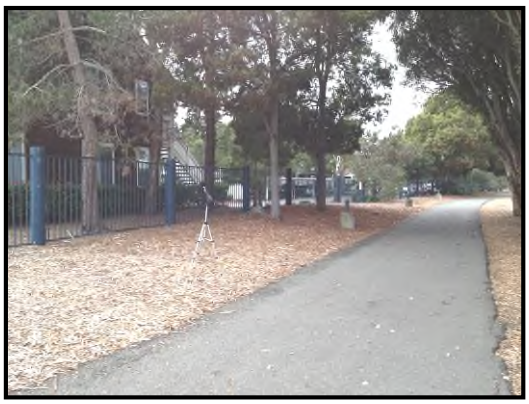
The degree of audibility of a new or modified sound source is dependent in a large part upon the relative level of the ambient noise. A wide range of noise settings occurs in and around the Project area. Variations in acoustic environment are due in part to surrounding land uses, population density, and proximity to transportation corridors. I-580 is generally audible throughout the Project site and throughout all hours of the day. The following subsection provides further details for this data analysis at each of the monitoring locations. A description of the monitoring locations with photographs, acoustic engineer's field observations and pertinent results of the sound survey are summarized in the following charts, tables and graphs. Amplitudes were found to be largely dependent on proximity of the receptor to major roadways and railway lines.

MP-1 – Meeker Slough

Monitoring position (MP) 1 is representative of multi-family residences (i.e., apartments, duplexes, etc.) along the Point Isabel shoreline neighborhood located to the south of the Project. Daytime and nighttime sound monitoring was conducted. Sound monitoring results are included in Table 3-3 and Table 3-4. Field observations included sounds from local roadway traffic, distant highway traffic, multiple aircraft flyovers, distant railroad operations (locomotives, train horns, etc.), pedestrians, bicyclists, birds and frogs.

MP-2 – Multi-Family Residences

MP-2 is representative of multi-family residences located along Bayside Court, southwest of the Project near 32nd street. Daytime and nighttime sound monitoring was conducted, and results are included in Table 3-3 and Table 3-4. Field observations included sounds from distant highway traffic, railroad operations, distant HVAC (heating, ventilation, and air conditioning) unit or units, pedestrians, bicyclists, birds, and sounds from vehicles in the nearby parking lot.



MP-3 – Multi-Family Residences

MP-3 is representative of multi-family residences located along Bayside Court, southwest of the Project but closer to Marina Bay Parkway than MP-2. Daytime and nighttime sound monitoring was conducted, and results are included in Table 3-3 and Table 3-4. Field observations included sounds from local roadway traffic, distant highway traffic, distant railroad operations, distant HVAC unit or units, walkers, bicyclists, birds, and sounds from vehicles in the nearby parking lot.

MP-4 – Trade Winds Sailing School

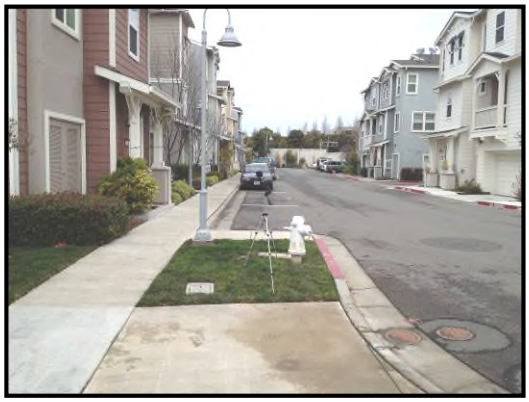
MP-4 is representative of multi-family residences located along Spinnaker Way west of the Project and adjacent to the Trade Winds Sailing School. Daytime and nighttime sound monitoring was conducted, and the results are included in Table 3-3 and Table 3-4. Field observations included sounds from local roadway traffic, distant highway traffic, aircraft overflights, and distant railroad operations.

MP-5 – Rosie the Riveter National Historic Park

MP-5 is representative of the Rosie the Riveter National Historic Park located approximately 1,500 feet west of the Project. The park is only open during the daytime, so only daytime sound monitoring was conducted. Field observations included sounds of roadway traffic, railroad operations including train horns, birds, bicyclists and pedestrians.

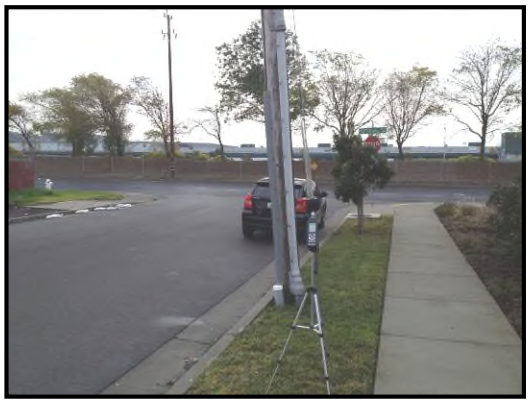
MP-6 – Anchorage Housing

MP-6 represents the Anchorage Residential area near the Marina Bay Highway. Daytime and nighttime sound monitoring was conducted, and sound monitoring results are included in Table 3-3 and Table 3-4. Field observations included sounds from highway traffic, local roadway traffic, aircraft and railroad operations



MP-7 – 30th & Hoffman

MP-7 represents a mix of single-family and multi-family residences located near the intersection of 30th Street and Hoffman Boulevard north of the Project. Only daytime monitoring was conducted at the MP-7 location due to safety concerns with equipment and staff in the area. Nevertheless, nighttime observations were made near MP-7, and sounds from the nearby I-580 dominate the acoustic environment. Daytime observations were similar to nighttime observations with the sounds from highway traffic dominating the acoustic environment mixed in with periodic sounds of local roadway traffic and railroad operations.



MP-8 – Carlson & 43rd

MP-8 represents a single-family residential neighborhood at Carlson Boulevard and 43rd Street northeast of the Project. Daytime monitoring was conducted at MP-8, and the results are included in Table 3-3 and Table 3-4. Only daytime monitoring was conducted due to safety concerns with equipment and staff in the area. Daytime observations included sounds from railroad traffic, traffic noise from I-580, local roadway traffic, periodic aircraft over flights and pedestrians. During the daytime measurement three freight trains accessing the Port of Richmond and one Caltrain passed by the MP. Observations of railroad traffic noted that rail operations reduced after the morning time period; therefore, sound levels associated with low volumes of freight rail traffic at the MP would be similar to those monitored in the afternoon at MP-9.

MP-9 – Booker T. Anderson Jr. Park

MP-9 represents Booker T. Anderson Jr. Park and multi-family residences located northeast of the Project. Daytime sound monitoring was conducted at the MP, and the results are included in Table 3-3 and Table 3-4. The park is closed to the public at night, so only daytime monitoring was conducted. Daytime observations of sound sources included I-580, local roadway traffic including transit buses with a stop near the par, periodic aircraft over flights, and pedestrians.

LT-1 Richmond Bay Campus

LT-1 represents the long term sound station set up in the middle of the Project area at the existing Richmond Field Station. The monitoring equipment was located at a central location to obtain the sound level at a location close to the acoustic centroid of the proposed campus. The acoustic centroid could be considered representative of the average sound level at the RBC project site, meaning that sound levels on the north side of the RBC site near the existing railroad tracks and I-580 are influenced by sounds from the railroad and highway more than locations south of the RBC site near the waterfront. Results of the 24-hour monitoring effort are included in Table 3-3, Table 3-4 and Table 3-5. Figure 3-1 is a chart of the time history for the monitoring period.

Table 3-3 Sound Monitoring Results (L_{eq}, L_{10}, L_{50}, L_{90} and CNEL)

Monitoring Location				Date	Time	Time Period	Sound Level Metrics (dBA)				
Map ID	Land Use	UTM Coordinates (NAD83 Zone 10 m)					L_{eq}	L_{10}	L_{50}	L_{90}	CNEL*
		Easting	Northing								
MP-1	Residential	558243	4566835	1/24/2013	12:57:20 PM	Day	53	54	51	50	58
				1/24/2013	11:25:40 PM	Night	51	53	47	46	
MP-2	Residential	558163	4567111	1/24/2013	1:34:33 PM	Day	53	53	52	51	58
				1/24/2013	10:50:59 PM	Night	51	52	49	48	
MP-3	Residential	557952	4567207	1/24/2013	1:00:59 PM	Day	53	55	51	50	56
				1/24/2013	10:15:22 PM	Night	48	50	46	45	
MP-4	Residential	557633	4567210	1/24/2013	1:41:20 PM	Day	57	61	53	50	59
				1/24/2013	10:48:48 PM	Night	50	53	48	44	
MP-5	Civic/Public	557429	4567387	1/24/2013	11:30:52 AM	Day	50	52	48	46	NA
MP-6	Residential	557591	4567695	1/24/2013	11:26:19 AM	Day	54	58	52	49	61
				1/24/2013	10:15:09 PM	Night	54	58	47	44	
MP-7	Residential	557955	4568452	1/24/2013	9:02:51 AM	Day	62	64	62	60	NA
MP-8	Residential	558866	4568091	1/24/2013	9:34:08 PM	Day	70	71	60	56	NA
MP-9	Civic/Public	559090	4567811	1/24/2013	2:28:15 PM	Day	66	67	65	63	NA
LT-1	Commercial	558561	4567503	1/24/2012 to 1/25/2012		Day	54	54	50	48	57
						Night	51	51	47	45	

*CNEL calculated for only those measurement locations with both day and nighttime monitoring results.

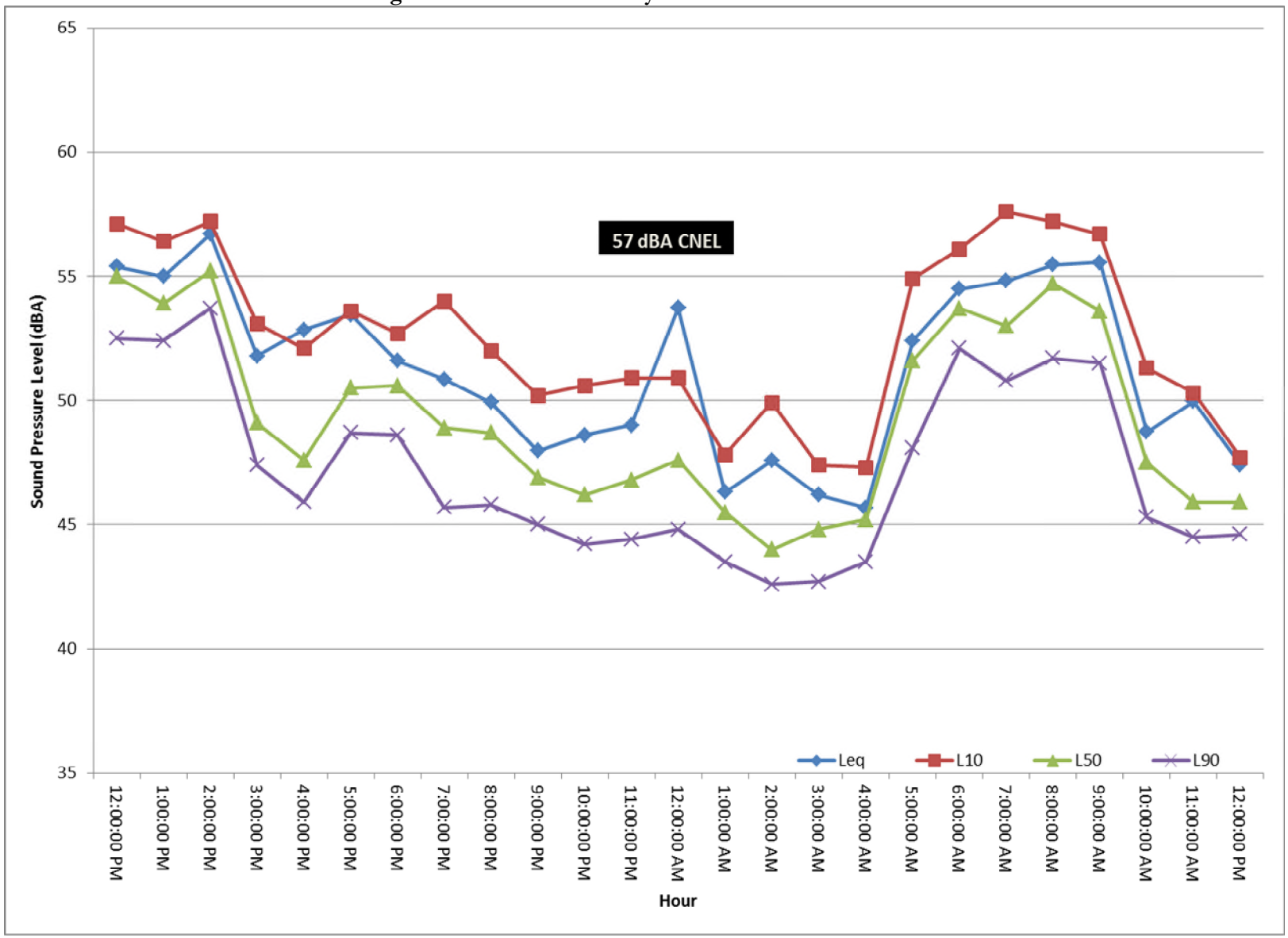
Table 3-4 Sound Monitoring Results (1/1 Octave Band Center Frequencies)

Monitoring Location			Time Period	Octave Band Sound Pressure Levels (dB)											
Map ID	UTM Coordinates (NAD83 Zone 10 m)			8 Hz	16 Hz	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	16 kHz
	Easting	Northing													
MP-1	558243	4566835	Day	61	60	60	60	56	52	51	49	40	30	24	14
			Night	52	58	60	60	55	49	49	47	37	28	24	16
MP-2	558163	4567111	Day	59	60	61	60	52	50	50	50	44	35	29	14
			Night	53	59	61	60	55	52	49	46	38	25	16	10
MP-3	557952	4567207	Day	65	62	59	59	55	52	50	48	42	36	30	25
			Night	51	55	58	57	53	49	47	44	36	26	16	11
MP-4	557633	4567210	Day	59	58	61	63	60	53	52	54	49	41	33	21
			Night	52	56	57	57	56	51	47	45	39	29	19	10
MP-5	557429	4567387	Day	61	58	58	61	56	49	47	46	39	31	23	15
MP-6	557591	4567695	Day	58	59	60	60	58	53	51	51	45	36	26	14
			Night	50	53	57	59	57	52	49	51	46	38	30	22
MP-7	557955	4568452	Day	62	69	70	72	67	59	57	59	54	47	37	27
MP-8	558866	4568091	Day	65	74	73	74	72	66	63	61	59	55	48	38
MP-9	559090	4567811	Day	63	67	69	72	70	62	60	63	57	49	43	39
LT-1	558561	4567503	Day	58	61	61	61	57	51	51	50	39	26	17	9
			Night	54	59	59	60	55	47	49	47	36	21	11	8

Table 3-5 Long-Term (24-Hour) Sound Monitoring Results (dBA)

Date	Time	L_{eq}	L_{10}	L_{50}	L_{90}
1/24/2013	12:00 PM	55	57	55	53
	1:00 PM	55	56	54	52
	2:00 PM	57	57	55	54
	3:00 PM	52	53	49	47
	4:00 PM	53	52	48	46
	5:00 PM	53	54	51	49
	6:00 PM	52	53	51	49
	7:00 PM	51	54	49	46
	8:00 PM	50	52	49	46
	9:00 PM	48	50	47	45
	10:00 PM	49	51	46	44
	11:00 PM	49	51	47	44
1/25/2013	12:00 AM	54	51	48	45
	1:00 AM	46	48	46	44
	2:00 AM	48	50	44	43
	3:00 AM	46	47	45	43
	4:00 AM	46	47	45	44
	5:00 AM	52	55	52	48
	6:00 AM	54	56	54	52
	7:00 AM	55	58	53	51
	8:00 AM	55	57	55	52
	9:00 AM	56	57	54	52
	10:00 AM	49	51	48	45
	11:00 AM	50	50	46	45
	12:00 PM	47	48	46	45
Day Average		54	54	50	48
Night Average		51	51	47	45
CNEL		57			

Figure 3-1 Time History for 24-Hour Measurement



Section 4 References

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American National Standards Institute ANSI/ASA Standard S1.4-2006: American National Standard Specification for Sound Level Meters.

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APPENDIX A

MEASUREMENT EQUIPMENT & NIST LABORATORY CALIBRATION CERTIFICATIONS

Certificate of Calibration and Conformance

This document certifies that the instrument referenced below meets published specifications per Procedure PRD-P263; ANSI S1.4-1983 (R 2006) Type 1; S1.4A-1985; S1.43-1997 Type 1; S1.11-2004 Octave Band Class 0; S1.25-1991; IEC 61672-2002 Class 1; 60651-2001 Type 1; 60804-2000 Type 1; 61260-2001 Class 0; 61252-2002.

Manufacturer:	Larson Davis	Temperature:	75.2	°F
Model Number:	831		25	°C
Serial Number:	1009	Rel. Humidity:	33	%
Customer:		Pressure:	987	mbars
Description:	Sound Level Meter			hPa

Note: As Found / As Left: In Tolerance

Upon receipt for testing, this instrument was found to be:

Within the Stated tolerance of the manufacturer's specification

Calibration Date: 10-Oct-12 Calibration Due:

Calibration Standards Used:

Manufacturer	Model	Serial Number	Cal Due	Traceability No.
Larson Davis	LDSigGen/2239	0760/0109	4/16/2013	2012-157887

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at The Modal Shop and/or Larson Davis Corporate Headquarters. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. Calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of The Modal Shop.

Technician: THR Signature:

The Modal Shop, Inc.
3149 East Kemper Road
Cincinnati, OH 45241
Phone: (513) 351-9919
(800) 860-4867
www.modalshop.com

Certificate of Calibration and Conformance

This document certifies that the instrument referenced below meets published specifications per Procedure PRD-P263; ANSI S1.4-1983 (R 2006) Type 1; S1.4A-1985; S1.43-1997 Type 1; S1.11-2004 Octave Band Class 0; S1.25-1991; IEC 61672-2002 Class 1; 60651-2001 Type 1; 60804-2000 Type 1; 61260-2001 Class 0; 61252-2002.

Manufacturer:	Larson Davis	Temperature:	75.2	°F
Model Number:	831		25	°C
Serial Number:	2546	Rel. Humidity:	33	%
Customer:		Pressure:	987	mbars
Description:	Sound Level Meter			hPa

Note: As Found / As Left: In Tolerance

Upon receipt for testing, this instrument was found to be:

Within the Stated tolerance of the manufacturer's specification

Calibration Date: 9-Oct-12 Calibration Due:

Calibration Standards Used:

Manufacturer	Model	Serial Number	Cal Due	Traceability No.
Larson Davis	LDSigGen/2239	0760/0109	4/16/2013	2012-157887

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at The Modal Shop and/or Larson Davis Corporate Headquarters. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

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Technician: THR Signature:

The Modal Shop, Inc.
3149 East Kemper Road
Cincinnati, OH 45241
Phone: (513) 351-9919
(800) 860-4867
www.modalshop.com

PCB PIEZOTRONICS
A PCB GROUP COMPANY

Certificate of Calibration and Conformance

Certificate Number 2012-163960

Instrument Model 831, Serial Number 0002985, was calibrated on 19SEP2012. The instrument meets factory specifications per Procedure D0001.8310, ANSI S1.4-1983 (R 2006) Type 1; S1.4A-1985 ; S1.43-1997 Type 1; S1.11-2004 Octave Band Class 0; S1.25-1991; IEC 61672-2002 Class 1; 60651-2001 Type 1; 60804-2000 Type 1; 61260-2001 Class 0; 61252-2002.

New Instrument
Date Calibrated: 19SEP2012
Calibration due:

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Stanford Research Systems	DS360	61889	12 Months	27JAN2013	61889-012712

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Temperature: 24 ° Centigrade

Relative Humidity: 28 %

Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

Tested with PRM831-023767

Signed: Ron Harris

Technician: Ron Harris

Provo Engineering and Manufacturing Center, 1681 West 820 North, Provo, Utah 84601
Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
ISO 9001-2008 Certified

Appendix F

Transportation and Traffic

Transportation Impact Analysis

RICHMOND BAY CAMPUS LONG RANGE DEVELOPMENT PLAN

Prepared for:

Tetra Tech
LBNL

November 2013

FEHR & PEERS

WC12-2953

Richmond Bay Campus
Long Range Development Plan
Transportation Impact Analysis

Prepared for:
Tetra Tech
LBNL

November 2013

WC12-2953

FEHR PEERS

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0.0 EXECUTIVE SUMMARY

This report evaluates the impacts of the proposed Richmond Bay Campus (RBC) Long Range Development Plan (LRDP) Project on the transportation network. The analysis identifies impacts and mitigation measures of the Phase 1 Project (consisting of about 1,000 employees) and Campus Buildout (consisting of about 10,000 employees) on traffic operations at intersections and freeway segments in the vicinity of the Project site, as well as on the pedestrian, bicycle, and transit networks. This analysis also assesses the impacts of the Phase 1 Project at Alameda Point and the existing Lawrence Berkeley National Laboratory (LBNL) site and an Additional Employment Alternative (consisting of the 1,000 Phase 1 employees plus an additional 700 employees) at the three sites.

A brief description of each site followed by the impacts and mitigation for each site is provided below.

0.1 RICHMOND BAY CAMPUS

The RBC site is located in the South Shoreline area of Richmond. Phase 1 of the project would provide about 600,000 square feet of space and accommodate up to 1,000 employees. It would also provide about 600 parking spaces in surface parking lots.

At buildout, RBC would provide 5.4 million square feet of space and accommodate up to 10,000 employees. The buildout plan would also consist of a new internal street network providing automobile, bicycle, and pedestrian connections to adjacent streets and trails, emphasizing non-motorized travel within the RBC site. At buildout, RBC is estimated to provide about 6,000 parking spaces mostly in parking structures. The LRDP would also implement a robust Transportation Demand Management (TDM) program, including frequent shuttle service to BART and UC Berkeley/LBNL, to reduce the automobile trips generated by the RBC.

It is estimated that the Phase 1 project would generate about 2,080 daily, 210 AM peak hour, and 200 PM peak hour automobile trips. The buildout project is estimated to generate about 20,230 daily trips, 2,050 AM peak hour, and 1,940 PM peak hour automobile trips.

The Phase 1 project at the RBC site would not result in significant traffic impacts on traffic operations at intersections or freeway segments.

The Additional Employment Alternative would consist of an additional 200,000 square feet of space and accommodate an additional 700 employees at the RBC site. It is estimated that the Additional

Employment Alternative would generate about 3,500 daily, 360 AM peak hour, and 340 PM peak hour automobile trips. The Additional Employment Alternative at the RBC site would not result in significant traffic impacts on traffic operations at intersections or freeway segments.

The Buildout Project at the RBC site would result in the following impacts:

IMPACT 2-1: EXISTING PLUS PROJECT BUILDOUT CONDITIONS INTERSECTION OPERATIONS

The buildout of the RBC would cause significant impacts at the following seven intersections under Existing Plus Buildout conditions:

A. The Project would cause a significant impact at the signalized **Meeker Avenue/23rd Street/Marina Bay Parkway** (Intersection 4) because it would increase v/c ratio by more than 0.01 during the PM peak hour at an intersection operating at LOS F regardless of the Project.

B. The Project would cause a significant impact at the signalized **Regatta Boulevard/ Marina Bay Parkway** (Intersection 5) because it would deteriorate intersection operations from LOS C to LOS F during the AM peak hour and from LOS D to LOS E during the PM peak hour.

C. The Project would cause a significant impact at the signalized **I-580 Eastbound Ramps/ Regatta Boulevard/Meade Street** (Intersection 7) because it would deteriorate intersection operations from LOS A to LOS F during the AM peak hour.

D. The Project would cause a significant impact at the side-street stop-controlled **Meade Street/Seaver Avenue** (Intersection 9) because it would deteriorate operations for the side-street stop-controlled approach from LOS A to LOS F during both AM and PM peak hours and the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

E. The Project would cause a significant impact at the all-way stop-controlled **Seaport Avenue/I-580 Eastbound Ramps/South 51st Street/Bayview Avenue** (Intersection 10) because it would deteriorate intersection operations from LOS D to LOS F during the AM peak hour and from LOS C to LOS E during the PM peak hour. In addition, the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

F. The Project would cause a significant impact at the signalized **I-580 Westbound Ramps/ Bayview Avenue** (Intersection 11) because it would deteriorate intersection operations from LOS A to LOS F during both AM and PM peak hours.

G. The Project would cause a significant impact at the signalized **Carlson Boulevard/I-80 Westbound Ramps** (Intersection 13) because it would deteriorate intersection operations from LOS B to LOS E during the AM peak hour.

Mitigation Measure 2-1: Implement the following:

A. **Meeker Avenue/23rd Street/Marina Bay Parkway** (Intersection 4): Implement the following which requires coordination with City of Richmond:

- Convert the eastbound approach to provide one left-turn lane and one through-right lane
- Convert signal operations for the eastbound and westbound approaches from split phasing to protected left-turn phasing.
- Optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would improve to LOS C during both AM and PM peak hours after implementation of these improvements. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

B. **Regatta Boulevard/Marina Bay Parkway** (Intersection 5): Implement the following which requires coordination with City of Richmond:

- Optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would improve to LOS D during the AM peak hour after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

C. **I-580 Eastbound Ramps/Regatta Boulevard/Meade Street** (Intersection 7): Implement the following which requires coordination with City of Richmond and Caltrans:

- Optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would improve to LOS D during the AM peak hour after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

D. **Meade Street/Seaver Avenue** (Intersection 9): Implement the following which requires coordination with City of Richmond:

- Install an actuated signal at the intersection with protected/permitted phasing for the westbound left-turn movement.
- Convert the northbound approach to provide one left-turn lane and one right-turn lane.

The intersection would improve to LOS C during the AM peak hour and LOS B during the PM peak hour after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

E. **Seaport Avenue/I-580 Eastbound Ramps/Bayview Avenue** (Intersection 10): Implement the following which requires coordination with City of Richmond and Caltrans:

- Install an actuated signal at the intersection with protected phasing for the northbound and southbound left-turn movements.

- Convert the southbound approach to provide two left-turn lanes and one shared right-turn/through lane.

The intersection would improve to LOS C during both AM and PM peak hours after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

F. **I-580 Westbound Ramps/Bayview Avenue** (Intersection 11): Implement the following which requires coordination with City of Richmond and Caltrans:

- Optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would improve to LOS C during the AM peak hour and LOS B during the PM peak hour after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

G. **Carlson Boulevard/I-80 Westbound Ramps** (Intersection 13): Implement the following which requires coordination with City of Richmond and Caltrans:

- Optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would improve to LOS D during the AM peak hour after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

IMPACT 2-2: CUMULATIVE (2035) PLUS PROJECT BUILDOUT CONDITIONS INTERSECTION OPERATIONS

The buildout of the RBC would cause significant impacts at the following six intersections under Cumulative (2035) Plus Buildout conditions:

A. The Project would cause a significant impact at the signalized **Meeker Avenue/23rd Street/Marina Bay Parkway** (Intersection 4) because it would increase v/c ratio by more than 0.01 during the PM peak hour at an intersection operating at LOS F regardless of the Project.

B. The Project would cause a significant impact at the side-street stop-controlled **I-580 Westbound Ramps/Juliga Woods Street** (Intersection 6) because it would deteriorate operations for the side-street stop-controlled approach from LOS C to LOS F during the PM peak hour and the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

C. The Project would cause a significant impact at the side-street stop-controlled **Meade Street/Regatta Boulevard** (Intersection 8) because it would deteriorate operations for the side-street stop-controlled approach from LOS B to LOS F during both AM and PM peak hours and the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

D. The Project would cause a significant impact at the side-street stop-controlled **Meade Street/Seaver Avenue** (Intersection 9) because it would deteriorate operations for the side-street stop-controlled approach from LOS B to LOS F during both AM and PM peak hours and the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

E. The Project would cause a significant impact at the all-way stop-controlled **Seaport Avenue/I-580 Eastbound Ramps/South 51st Street/Bayview Avenue** (Intersection 10) because it would deteriorate intersection operations from LOS D during the AM peak hour and LOS E during the PM peak hour to LOS F during both AM and PM peak hours. In addition, the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

F. The Project would cause a significant impact at the signalized **Carlson Boulevard/I-80 Westbound Ramps** (Intersection 13) because it would deteriorate intersection operations from LOS D to LOS F during the AM peak hour and LOS E to LOS F during the PM peak hour.

Mitigation Measure 2-2: Implement the following:

A. **Meeker Avenue/23rd Street/Marina Bay Parkway** (Intersection 4): Implement the following which requires coordination with City of Richmond (Same as Mitigation Measure 2-1A):

- Convert the eastbound approach to provide one left-turn lane and one through-right lane
- Convert signal operations for the eastbound and westbound approaches from split phasing to protected left-turn phasing. Optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would improve to LOS C during the AM peak hour and LOS D during the PM peak hour after implementation of these improvements. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

B. **I-580 Westbound Ramps/Juliga Woods Street** (Intersection 6): Implement the following which requires coordination with City of Richmond and Caltrans:

- Install an actuated signal at the intersection.

The intersection would improve to LOS A during both AM and PM peak hours after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

C. **Meade Street/Regatta Boulevard** (Intersection 8): Implement the following which requires coordination with City of Richmond:

- Install an actuated signal at the intersection. The new signal shall be connected and coordinated with the existing controls at the at-grade railroad crossing on Meade Street and the existing signal at the I-580 Eastbound Ramps/Regatta

Boulevard/Meade Street (Intersection 7) just west of the intersection to minimize potential queues spilling onto the railroad tracks.

The intersection would improve to LOS B during both AM and PM peak hours after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

D. **Meade Street/Seaver Avenue** (Intersection 9): Implement the following which requires coordination with City of Richmond (Same as Mitigation Measure 2-1D):

- Install an actuated signal at the intersection with protected/permitted phasing for the westbound left-turn movement.
- Convert the northbound approach to provide one left-turn lane and one right-turn lane.

The intersection would improve to LOS D during the AM peak hour and LOS B during the PM peak hour after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

E. **Seaport Avenue/I-580 Eastbound Ramps/Bayview Avenue** (Intersection 10): Implement the following which requires coordination with City of Richmond and Caltrans (Same as Mitigation Measure 2-1E):

- Install an actuated signal at the intersection with protected phasing for the northbound and southbound left-turn movements.
- Convert the southbound approach to provide two left-turn lanes and one shared right-turn/through lane.

The intersection would improve to LOS C during both AM and PM peak hours after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

F. **Carlson Boulevard/I-80 Westbound Ramps** (Intersection 13): Implement the following which requires coordination with City of Richmond and Caltrans:

- Convert the southbound approach to provide one left-turn lane and one right-turn lane.

The intersection would improve to LOS C during both AM and PM peak hours after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

IMPACT 2-3: CUMULATIVE (2035) PLUS PROJECT BUILDOUT CONDITIONS FREEWAY OPERATIONS

The buildout of the RBC would cause a significant impact under Cumulative (2035) Plus Buildout conditions on **I-580 between Central Avenue and I-80** in westbound direction during the AM peak hour and in the eastbound direction during the PM peak hour because the Project would cause the westbound segment to deteriorate from LOS E to LOS F during the AM peak hour and it increase the PM peak hour

volume on the eastbound freeway segment by more than five percent on a freeway segment that would operate at LOS F regardless of the Project.

Mitigation Measure 2-3: This impact can be mitigated by increasing the freeway capacity through adding one more travel lane in each direction of I-580 in this section. No freeway capacity projects are currently planned by Caltrans for this section of I-580. In addition, the feasibility of implementing this mitigation measure is not known at this time. Therefore, this impact is conservatively considered to be *significant and unavoidable*.

IMPACT 2-4: TRANSIT DEMAND

The Project would generate demand for bus transit service that may not be adequately served by the proposed RBC shuttles serving UC Berkeley, LBNL, and El Cerrito Plaza BART station. Although this is not considered a significant impact, the following improvement is recommended.

Environmental Protection Measure 2-4: The University of California shall implement the following:

- Regularly monitor the use of the proposed shuttle services and if necessary, adjust service frequency, stop location, and routes to better serve the RBC population.
- Coordinate with AC Transit and the City of Richmond to modify and/or extend current bus routes to serve demand generated by the RBC, as employment grows at the campus.

IMPACT 2-5: CONSTRUCTION TRAFFIC IMPACTS

The Project construction would temporarily and intermittently impact traffic operations due to truck movements and construction worker commute trips. This is a *significant* impact.

Mitigation Measure 2-5: Prepare a Construction Traffic Management Plan (CTMP) for each construction project at the RBC site to reduce the impacts of construction on traffic and parking. The University of California shall work with City of Richmond in preparing the CTMP which may consist of the following:

- Proposed truck routes
- Hours of construction and limits on number of truck trips during peak commute periods (7:00 to 9:00 AM and 4:00 to 6:00 PM) if traffic conditions demonstrate the need reduce construction traffic to avoid causing significant delays.
- Parking management plan for construction workers.
- Identification of alternative routes for temporary closure of streets and/or paths during construction in order to provide safe access and circulation for automobiles, bicycles, pedestrians, and emergency access vehicles.

Implementation of this mitigation measure will reduce the impact to a *less than significant* level.

0.2 ALAMEDA POINT ALTERNATIVE

The Alameda Point site is located in northwest part of City of Alameda. Phase 1 of the project would provide about 600,000 square feet of space and accommodate up to 1,000 employees at the site. It is estimated that the Phase 1 project at the Alameda Point site would generate about 2,080 daily, 210 AM peak hour, and 200 PM peak hour automobile trips.

The Phase 1 project at the Alameda Point site would result in the following impacts:

IMPACT 3-1: NEAR-TERM (2018) PLUS PROJECT CONDITIONS INTERSECTION OPERATIONS

The proposed Project at Alameda Point would cause a significant impact at the following intersection under Near-Term (2018) Plus Project conditions:

A. The Project would cause a significant impact at the signalized **Harrison Street/7th Street** (Intersection 12) because it would increase the overall intersection v/c ratio by 0.01 or more and increase critical movement v/c ratio by 0.02 or more during both AM and PM peak hours at an intersection in downtown Oakland operating at LOS F regardless of the Project.

Mitigation Measure 3-1: Implement the following:

A. **Harrison Street/7th Street** (Intersection 12): Implement the following which requires coordination with City of Oakland:

- Increase traffic signal cycle length to 75 seconds and optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would continue to operate at LOS F during both AM and PM peak hours after the implementation of this mitigation measure. However, this mitigation measure would reduce the overall intersection v/c ratio and the critical movement v/c ratio to the same level or less than under Near-Term (2018) No Project conditions. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

IMPACT 3-2: CUMULATIVE (2035) PLUS PROJECT CONDITIONS INTERSECTION OPERATIONS

The proposed Project at Alameda Point would cause a significant impact at the following intersections under Cumulative (2035) Plus Project conditions:

A. The Project would cause a significant impact at the signalized **Harrison Street/7th Street** (Intersection 12) because it would increase the overall intersection v/c ratio by .0.01 or more and increase critical movement v/c ratio by 0.02 or more during the PM peak hour at an intersection in downtown Oakland operating at LOS F regardless of the Project.

B. The Project would cause a significant impact at the signalized **Jackson Street/7th Street** (Intersection 13) because it would increase the overall intersection v/c ratio by .0.01 or more and increase critical movement v/c ratio by 0.02 or more during the PM peak hour at an intersection in downtown Oakland operating at LOS F regardless of the Project.

Mitigation Measure 3-2: Implement the following:

A. **Harrison Street/7th Street** (Intersection 12): Implement the following which requires coordination with City of Oakland (Same as Mitigation Measure 3-1A):

- Increase traffic signal cycle length to 80 seconds and optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would continue to operate at LOS F during the PM peak hour. However, this mitigation measure would reduce the overall intersection v/c ratio and the critical movement v/c ratio to the same level or less than under Cumulative (2035) No Project conditions. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

B. **Jackson Street/7th Street** (Intersection 13): Implement the following which requires coordination with City of Oakland:

- Increase traffic signal cycle length to 80 seconds and optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would continue to operate at LOS F during the PM peak hour. However, this mitigation measure would reduce the overall intersection v/c ratio and the critical movement v/c ratio to the same level or less than under Cumulative (2035) No Project conditions. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

The Additional Employment Alternative would consist of an additional 200,000 square feet of space and accommodate an additional 700 employees at the Alameda Point site. It is estimated that the Additional Employment Alternative would generate about 3,500 daily, 360 AM peak hour, and 340 PM peak hour automobile trips. The Additional Employment Alternative at the Alameda Point site would result in the following significant traffic impact, which is the same as the Project Impact 3-1.

IMPACT 3-3: NEAR-TERM (2018) PLUS ADDITIONAL EMPLOYMENT ALTERNATIVE CONDITIONS INTERSECTION OPERATIONS

The Additional Employment Alternative at Alameda Point would cause a significant impact at the following intersection under Near-Term (2018) Plus Additional Employment Alternative conditions:

A. The Additional Employment Alternative would cause a significant impact at the signalized **Harrison Street/7th Street** (Intersection 12) because it would increase the overall intersection v/c ratio by 0.01 or more and increase critical movement v/c ratio by 0.02 or more during both AM and PM peak hours at an intersection in downtown Oakland operating at LOS F regardless of the Alternative.

Mitigation Measure 3-3: Implement the following:

A. **Harrison Street/7th Street** (Intersection 12): Implement the following which requires coordination with City of Oakland (same as Mitigation Measure 3-1A):

- Increase traffic signal cycle length to 75 seconds and optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would continue to operate at LOS F during both AM and PM peak hours after the implementation of this mitigation measure. However, this mitigation measure would reduce the overall intersection v/c ratio and the critical movement v/c ratio to the same level or less than under Near-Term (2018) No Project conditions. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

0.3 LBNL SITE ALTERNATIVE

The LBNL site is located in the hills of Berkeley and Oakland just east of the UC Berkeley campus. Phase 1 of the project would provide about 600,000 square feet of space and accommodate up to 1,000 employees within the existing LBNL campus. It is estimated that the Phase 1 project at the existing LBNL site would generate about 1,590 daily, 160 AM peak hour, and 150 PM peak hour automobile trips.

The Phase 1 project at the existing LBNL site would result in the following impacts:

IMPACT 4-1: NEAR-TERM (2018) PLUS PROJECT CONDITIONS INTERSECTION OPERATIONS

The proposed Project at LBNL site would cause a significant impact at the following intersection under Near-Term (2035) Plus Project conditions:

A. The Project would cause a significant impact at the all-way stop-controlled **Stadium Rim Way/Gayley Road** (Intersection 4) because the Project would contribute to LOS F

operations for a critical movement during the PM peak hour and the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

Mitigation Measure 4-1: Implement the following:

A. **Stadium Rim Way/Gayley Road** (Intersection 4): Implement the following which requires coordination with City of Berkeley and UC Berkeley:

- Install a traffic signal at the intersection.

The intersection would improve to LOS C or better during both AM and PM peak hours after implementation of this improvement. If found to be feasible and implemented, this mitigation measure would reduce the impact to less than significant.

IMPACT 4-2: CUMULATIVE (2035) PLUS PROJECT CONDITIONS INTERSECTION OPERATIONS

The proposed Project at LBNL site would cause a significant impact at the following intersections under Cumulative (2035) Plus Project conditions:

A. The Project would cause a significant impact at the all-way stop-controlled **Stadium Rim Way/Gayley Road** (Intersection 4) because the Project would contribute to LOS F operations during both AM and PM peak hours and the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

B. The Project would cause a significant impact at the all-way stop-controlled **Durant Avenue/Piedmont Avenue** (Intersection 9) because the Project would contribute to LOS F operations during both AM and PM peak hours and the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

Mitigation Measure 4-2: Implement the following:

A. **Stadium Rim Way/Gayley Road** (Intersection 4): Implement the following which requires coordination with City of Berkeley and UC Berkeley (Same as Mitigation Measure 4-1A):

- Install a traffic signal at the intersection.

The intersection would improve to LOS C or better during both AM and PM peak hours after implementation of this improvement. If found to be feasible and implemented, this mitigation measure would reduce the impact to less than significant.

B. **Durant Avenue/Piedmont Avenue** (Intersection 9): Implement the following which requires coordination with City of Berkeley:

- Install a traffic signal at the intersection.

The intersection would improve to LOS B or better during both AM and PM peak hours after implementation of this improvement. If found to be feasible and implemented, this mitigation measure would reduce the impact to less than significant.

The Additional Employment Alternative would consist of an additional 200,000 square feet of space and accommodate an additional 700 employees at the existing LBNL site. It is estimated that the Additional Employment Alternative would generate about 2,700 daily, 270 AM peak hour, and 260 PM peak hour automobile trips. The Additional Employment Alternative at the existing LBNL site would result in the following significant traffic impact, which is the same as the Project Impact 4-1:

IMPACT 4-3: NEAR-TERM (2018) PLUS ADDITIONAL EMPLOYMENT ALTERNATIVE CONDITIONS INTERSECTION OPERATIONS

The Additional Employment Alternative at LBNL site would cause a significant impact at the following intersection under Near-Term (2035) Plus Additional Employment Alternative conditions:

A. The Additional Employment Alternative would cause a significant impact at the all-way stop-controlled **Stadium Rim Way/Gayley Road** (Intersection 4) because it would contribute to LOS F operations for a critical movement during the PM peak hour and the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

Mitigation Measure 4-3: Implement the following:

A. **Stadium Rim Way/Gayley Road** (Intersection 4): Implement the following which requires coordination with City of Berkeley and UC Berkeley (Same as Mitigation Measure 4-1A):

- Install a traffic signal at the intersection.

The intersection would improve to LOS C or better during both AM and PM peak hours after implementation of this improvement. If found to be feasible and implemented, this mitigation measure would reduce the impact to less than significant.

1.0 INTRODUCTION

This report presents an analysis of the impacts of the proposed Richmond Bay Campus (RBC) Long Range Development Plan (LRDP) Project on the transportation network. The University of California (University) is preparing the LRDP to guide campus development across a projected 40-year planning horizon. This analysis assesses impacts of the Phase 1 Project (consisting of about 1,000 employees) and Campus Buildout (consisting of about 10,000 employees) on traffic operations at intersections and freeway segments in the vicinity of the Project site, as well as on the pedestrian, bicycle, and transit networks. This analysis also assesses the impacts of implementing the Phase 1 Project at Alameda Point and at the Lawrence Berkeley National Laboratory (LBNL) site, and an Additional Employment Alternative (consisting of the 1,000 Phase 1 employees plus an additional 700 employees) at the three sites. Details on the proposed Project and the alternatives are provided in Chapters 2, 3, and 4. **Figure 1-1** shows the location of the RBC, Alameda Point, and LBNL sites.

1.1 REPORT ORGANIZATION

This report is divided into the following four chapters:

- ***Chapter 1 – Introduction*** describes the analysis methods used for the transportation impact assessment for all three project alternatives (RBC, Alameda Point, and LBNL Sites). This chapter also includes the significance criteria for each alternative. The criteria vary to reflect the standards and practices for each jurisdiction

- ***Chapter 2 – Richmond Bay Campus Project*** describes the existing conditions in the vicinity of the RBC site and assesses the impacts of the Phase 1 Project and Project Buildout at this site.

- ***Chapter 3 – Alameda Point Alternative*** describes the existing conditions in the vicinity of the Alameda Point site and assesses the impacts of the Phase 1 development at this site.

- ***Chapter 4 – LBNL Site Alternative*** describes the existing conditions in the vicinity of the existing LBNL site and assesses the impacts of the Phase 1 development at this site.

- ***Chapter 5 – References*** lists reference material used in preparing this report.

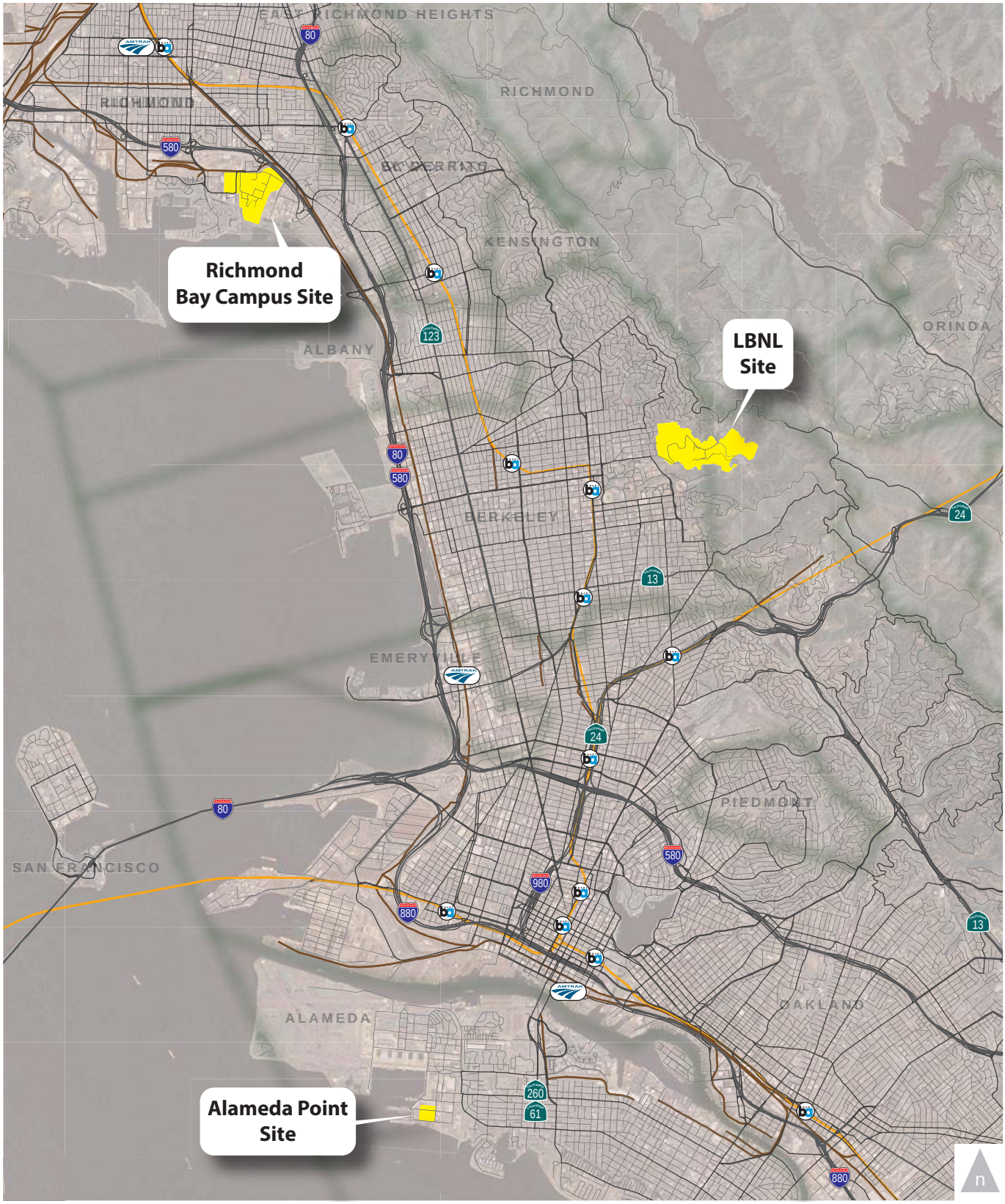

Figure 1-1.

Site Locations

WC12-2953_1-1_SiteLocs

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1.2 INTERSECTION OPERATION ANALYSIS METHOD

Intersection operations are described using the term "Level of Service" (LOS). LOS is a qualitative description of traffic operations from the vehicle driver perspective and consists of the delay experienced by the driver at the intersection. It ranges from LOS A, with no congestion and little delay, to LOS F, with excessive congestion and delays. Different methods are used to assess signalized and unsignalized (stop-controlled) intersections.

1.2.1 SIGNALIZED INTERSECTIONS

Signalized intersection operations are evaluated using methods provided in the 2000 Highway Capacity Manual (HCM). This method uses intersection characteristics to estimate average control delay and then assign an LOS. Control delay is defined as the delay associated with deceleration, stopping, moving up in the queue, and acceleration experienced by drivers at an intersection. **Table 1-1** provides descriptions of various LOS and the corresponding ranges of delays for signalized intersections.

1.2.2 UNSIGNALIZED INTERSECTIONS

Unsignalized intersection (four-way stop-controlled, side-street stop-controlled, and roundabouts) LOS are also analyzed using the 2000 HCM. Delay is calculated for movements that are controlled by a stop sign or that must yield the right-of-way. This method defines operations by average control delay per vehicle (measured in seconds) for each stop-controlled movement. This incorporates delay associated with deceleration, acceleration stopping, and moving up in the queue. For side-street stop-controlled intersections, the movement or approach with the highest delay is reported. **Table 1-1** summarizes the LOS ranges for unsignalized intersections. They are lower than the delay ranges for signalized intersections because drivers will generally tolerate more delay at signals.

1.2.3 ANALYSIS TOOLS

The Synchro Software was used to estimate delay and LOS for all signalized and most of the unsignalized study intersections. Synchro uses the equations provided in 2000 HCM to calculate control delay. These equations use intersection characteristics, such as vehicle and pedestrian volumes, lane geometry, and signal phasings, as inputs in estimating control delay.

TABLE 1-1
INTERSECTION LEVEL OF SERVICE DEFINITIONS

Unsignalized Intersections		Level of Service Grade	Signalized Intersections	
Description	**Average Total Vehicle Delay (Seconds)**		**Average Control Vehicle Delay (Seconds)**	**Description**
No delay for stop-controlled approaches.	≤10.0	A	≤10.0	Free Flow or Insignificant Delays: Operations with very low delay, when signal progression is extremely favorable and most vehicles arrive during the green light phase. Most vehicles do not stop at all.
Operations with minor delay.	>10.0 and ≤15.0	B	>10.0 and ≤20.0	Stable Operation or Minimal Delays: Generally occurs with good signal progression and/or short cycle lengths. More vehicles stop than with LOS A, causing higher levels of average delay. An occasional approach phase is fully utilized.
Operations with moderate delays.	>15.0 and ≤25.0	C	>20.0 and ≤35.0	Stable Operation or Acceptable Delays: Higher delays resulting from fair signal progression and/or longer cycle lengths. Drivers begin having to wait through more than one red light. Most drivers feel somewhat restricted.
Operations with increasingly unacceptable delays.	>25.0 and ≤35.0	D	>35.0 and ≤55.0	Approaching Unstable or Tolerable Delays: Influence of congestion becomes more noticeable. Longer delays result from unfavorable signal progression, long cycle lengths, or high volume to capacity ratios. Many vehicles stop. Drivers may have to wait through more than one red light. Queues may develop, but dissipate rapidly, without excessive delays.
Operations with high delays, and long queues.	>35.0 and ≤50.0	E	>55.0 and ≤80.0	Unstable Operation or Significant Delays: Considered to be the limit of acceptable delay. High delays indicate poor signal progression, long cycle lengths and high volume to capacity ratios. Individual cycle failures are frequent occurrences. Vehicles may wait through several signal cycles. Long queues form upstream from intersection.
Operations with extreme congestion, and with very high delays and long queues unacceptable to most drivers.	>50.0	F	>80.0	Forced Flow or Excessive Delays: Occurs with oversaturation when flows exceed the intersection capacity. Represents jammed conditions. Many cycle failures. Queues may block upstream intersections.

Source: Highway Capacity Manual, Transportation Research Board, 2000.

Delay at some unsignalized intersections (Bancroft Way/Piedmont Avenue and Durant Avenue/Piedmont Avenue intersections in Berkeley) was calculated using SimTraffic because of the unique conditions at these intersections. The heavy pedestrian crossing volumes and the close distance of the intersections to each other cannot be accurately measured by Synchro. SimTraffic is used for modeling and simulating traffic operations based on the behavior of individual drivers in a network. The software accounts for the physical features of the transportation system, traffic flow conditions, and driver behavior characteristics to estimate travel delays and other performance measures that describe traffic operations.

Microsimulation programs, such as SimTraffic, incorporate the element of randomness inherent in traffic flow. Therefore, in order to average out the random fluctuations and obtain a statistically more significant result, a microsimulation model should be run a number of times and the average of the runs should be reported. For this study, the SimTraffic files were each run ten times.

1.3 FREEWAY OPERATIONS ANALYSIS METHOD

1.3.1 FREEWAY MAINLINE SECTIONS

The LOS for a freeway section is based on measures of density (passenger cars/ lane/ mile). Freeway LOS is a qualitative description of traffic flow based on speed, travel time, delay, and freedom to maneuver. There are six levels, ranging from LOS A (i.e., the best operating conditions) to LOS F (i.e., the worst). LOS E represents "at-capacity" operation. When volumes exceed capacity, stop-and-go conditions result and operations are designated as LOS F. **Table 1-2** presents a summary of the relationship between LOS and density for freeway mainline sections.

1.3.2 FREEWAY WEAVE SECTION

The freeway weave sections were analyzed using the Leisch methodology as described in *Highway Design Manual* (California Department of Transportation, 2009). A weave section is defined as a length of freeway where vehicles are crossing paths, changing lanes, or merging/weaving with through traffic as they enter or exit the freeway. This methodology assigns the LOS for the weave section based on volumes, traffic service flow, and capacity using nomographs.

TABLE 1-2
FREEWAY SEGMENT LEVEL OF SERVICE CRITERIA

Level of Service	Freeway Maximum Density (Passenger cars / mile / lane)
A	11
B	18
C	26
D	35
E	45
F	> 45

Notes:
Freeway mainline LOS based on a 65 miles per hour free-flow speed.
Source: Transportation Research Board, 2000.

1.4 SIGNIFICANCE CRITERIA

This section describes the thresholds of significance used to determine if a project would cause a significant impact.

1.4.1 GENERAL

The following thresholds of significance are based on the CEQA Guidelines Appendix G Checklist:

A. Would the Project conflict with an applicable plan, ordinance or policy establishing measures of effectiveness for the performance of the circulation system, taking into account all modes of transportation including mass transit and non-motorized travel and relevant components of the circulation system, including but not limited to intersections, streets, highways and freeways, pedestrian and bicycle paths, and mass transit?

B. Would the Project conflict with an applicable congestion management program, including but not limited to level of service standards and travel demand measures, or other standards established by the county congestion management agency for designated roads and highways?

C. Would the Project result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that result in substantial safety risks;

D. Would the Project substantially increase traffic hazards due to a design feature (e.g. sharp curves or dangerous intersections) or incompatible uses (e.g. farm equipment)?

E. Would the project result in inadequate emergency access?

F. Would the Project conflict with adopted policies, plans, or programs regarding public transit, bicycle or pedestrian facilities, or otherwise decrease the performance or safety of such facilities?

The local jurisdictions and congestion management programs have established specific thresholds of significance for intersections and freeways which are discussed in the next two subsections and used in this analysis. The local jurisdictions do not have specific thresholds for assessing impacts on other aspects of the transportation network; therefore, the thresholds from the CEQA Guidelines Appendix G Checklist, as listed above, are used to determine significant impacts.

1.4.2 INTERSECTION OPERATIONS

For the purposes of this analysis, the following intersection LOS thresholds of significance are used based on the local jurisdictions' standards and practices.

City of Richmond:

An impact is significant if the Project would cause:

- A signalized intersection to deteriorate from LOS D or better to LOS E or LOS F.
- A signalized intersection where the level of service is LOS E, the project would cause the average control delay to increase by more than five seconds or deteriorate to LOS F.
- A signalized intersection where the level of service is LOS F, the project would cause the overall volume-to-capacity ("V/C") ratio to increase 0.01 or more.
- At an unsignalized intersection the project would cause the intersection to operate at LOS F and after project completion satisfy the Caltrans peak hour traffic volume signal warrant.

City of Alameda:

An impact is significant if the Project would cause:

- An intersection to fall from the minimum acceptable LOS (LOS D) to LOS E or F.
- An intersection is already operating at LOS E or F, the impact is significant if the project causes a three percent increase in peak hour traffic volumes.

City of Oakland:

An impact is significant if:

- At a signalized intersection which is located within the Downtown area, the Project would cause the LOS to degrade to worse than LOS E (i.e., LOS F)

- At a signalized intersection for all areas where the level of service is LOS E, the Project would cause an increase in the average delay for any of the critical movements of six (6) seconds or more or degrade to worse than LOS E (i.e., LOS F)
- At a signalized intersection for all areas where the level of service is LOS F, the Project would cause (a) the overall volume-to-capacity ("V/C") ratio to increase 0.01 or more or (b) the critical movement V/C ratio to increase 0.02 or more

***City of Berkeley**:*

An impact is significant if the Project would cause:

- At a signalized intersection operations degrade from LOS D to LOS E or worse and more than a two-second increase in delay; or
- At a signalized intersection, more than a three-second increase in delay at intersections operating at LOS E without and with the project; or
- At a signalized intersection, operations degrade from LOS E to LOS F and more than a three-second increase in delay; or
- At a signalized intersection operating at LOS F without the project, a change in the volume-to-capacity (v/c) ratio of more than 0.01.
- At an unsignalized intersection, the addition of Project-related traffic causes:
    - the critical approach to operate at LOS F; and
    - the intersection meets peak hour traffic volume signal warrants; and
    - no alternative routes are available.

All Jurisdictions:

A project's contribution to cumulative impacts is considered "considerable" (i.e., significant) when the project exceeds at least one of the thresholds listed above under a future year scenario.

1.4.3 FREEWAY SEGMENTS

The 2011 *Contra Costa Congestion Management Program* is the applicable CMP document for the RBC. Based on the CMP requirements, the following standards are used to determine if the Project impacts on a freeway segment are considered significant:

- I-580: Cause a segment to degrade from LOS E or better to LOS F or increase peak hour volume by five percent or more for a segment already operating at LOS F.
- I-80: Increase peak hour volume by five percent or more for a segment already operating at LOS F.

The 2009 Alameda County Congestion Management Program is the applicable CMP document for the Alameda Point Alternative. Based on the CMP requirements, the following standards are used to determine if the Project impacts on a freeway segment are considered significant:

- All freeway segments in Alameda County: Increase peak hour volume by five percent or more for a segment already operating at LOS F.

2.0 RICHMOND BAY CAMPUS PROJECT

This chapter describes existing transportation conditions for the RBC site and identifies impacts and mitigation measures of developing both the Phase 1 and buildout of the proposed LRDP at RBC site.

2.1 EXISTING CONDITIONS

Existing transportation conditions at the RBC site and vicinity are described below.

2.1.1 EXISTING ROADWAY NETWORK

Figure 2-1 shows the existing RBC site, the surrounding roadway system, and study intersections and freeway segments analyzed as part of this assessment. The regional and local roadways serving the project site are described below.

2.1.1.1 Regional Roadways

Interstate 580 (I-580) is a generally east-west six-lane freeway connecting I-80 and points east to US 101 in Marin County, via the Richmond-San Rafael Bridge. Auxiliary lanes (lanes connecting adjacent on-ramps and off-ramps) provide a fourth travel lane in each direction, in the project vicinity. Access between the RBC site and I-580 is provided via interchanges at Bayview Avenue/51st Street, Regatta Boulevard/Juliga Woods Street, and Marina Bay Parkway/South 23rd Street. I-580 has an average annual daily traffic volume (AADT) of 91,000 vehicles (Caltrans, 2011) between the Regatta Boulevard/Juliga Woods Street and Marina Bay Parkway/South 23rd Street interchanges.

Interstate 80 (I-80) freeway connects the San Francisco Bay Area with the Sacramento region and continues east. Near the RBC site, I-80 is oriented in a north-south direction about one mile east, and provides four lanes of travel in each direction. Access between I-80 and the RBC site is provided via I-580 to and from the south and via the Carlson Boulevard interchange to and from the north. I-80 has an AADT of 171,000 vehicles (Caltrans, 2011) north of I-580.

Figure 2-1.

Richmond Bay Campus Study Locations

WC12-2953_2-1_BayCampusStudy

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Regatta Boulevard is an east-west arterial that connects Marina Way South to Meade Street, forming the primary east-west connection in the South Shoreline area of Richmond. Regatta Boulevard provides two travel lanes in each direction with a median, turn lanes at intersections, and a continuous sidewalk/path along the north and an intermittent sidewalk/path along the south side of the roadway between Marina Way South and Marina Bay Parkway. East of Marina Bay Parkway, the roadway narrows to three lanes with one travel lane in each direction, a center two-way left-turn lane and a continuous sidewalk along the north side and intermittent sidewalk along the south side of the roadway; further east, the roadway narrows further to a two-lane cross section with shoulders on both sides of the roadway, terminating at Meade Street. The recently completed extension of Regatta Boulevard provides a direct connection to Meade Street, allowing for another access/egress route for the South Shoreline area when trains at the at-grade railroad crossing block the Marina Bay Parkway just north of Regatta Boulevard. The posted speed limit on Regatta Boulevard is 25 miles per hour (mph).

Marina Bay Parkway/South 23rd Street is a north-south arterial connecting downtown Richmond to the South Shoreline area. South of I-580, the roadway is called Marina Bay Parkway and north of I-580, the roadway is called South 23rd Street. In the study area the roadway generally provides two travel lanes in each direction, with turn lanes at intersections. The roadway provides sidewalks on both sides of the roadway north of Meeker Avenue and only on the west side of the street south of Meeker Avenue. The posted speed limit is 30 mph. Marina Bay Parkway/South 23rd Street is currently designated as a Class 3 Bicycle Route.

Cutting Boulevard is an east-west arterial roadway connecting San Pablo Avenue and I-580 in the east with South Garrard Boulevard in the west. In the study area, Cutting Boulevard generally provides two travel lanes in each direction, with turn lanes at intersections and sidewalks on both sides of the street. The posted speed limit is 35 mph.

Carlson Boulevard is a generally four-lane northwest-southeast arterial through the study area, connecting 23rd Street to I-80 via an interchange, and terminating at San Pablo Avenue in El Cerrito. The roadway generally provides two travel lanes in each direction with turn lanes at major intersections and sidewalks on both sides of the street south of Bay View Avenue. Carlson Boulevard does not provide a continuous sidewalk on the west side of the street north of Bay View Avenue. The posted speed limit is 35 mph. Carlson Boulevard between Potrero Drive and Cutting Boulevard is currently designated as a Class 3 bicycle route.

2.1.1.2 Local Roadways

Meade Street is a two-lane roadway that runs northwest from the I-580/Bayview Avenue interchange to the I-580/Regatta Boulevard interchange and would continue to provide access to the RBC site during both the Phase 1 and buildout scenarios. Meade Street provides a continuous sidewalk along the north side and intermittent sidewalk along the south side of the roadway. The posted speed limit is 30 mph.

2.1.2 INTERSECTION OPERATIONS ANALYSIS

This study analyzes existing traffic operations during typical weekday AM and PM peak hours at the following 14 intersections in the City of Richmond:

1. Cutting Boulevard/23rd Street
2. I-580 Westbound Ramps/23rd Street
3. I-580 Eastbound Ramps/23rd Street
4. Meeker Avenue/23rd Street/Marina Bay Pkwy
5. Regatta Boulevard/Marina Bay Parkway
6. I-580 Westbound Ramps/Juliga Woods Street
7. I-580 Eastbound Ramps/Regatta Boulevard/ Meade Street
8. Meade Street/Regatta Boulevard
9. Meade Street/Seaver Avenue
10. Seaport Avenue/I-580 Eastbound Ramps/South 51st Street/Bayview Avenue
11. I-580 Westbound Ramps/Bayview Avenue
12. Carlson Boulevard/Bayview Avenue
13. Carlson Boulevard/I-80 Eastbound Ramps
14. Carlson Boulevard/I-80 Westbound Ramps

These intersections were selected for analysis because they are most likely to be affected by the proposed Project. **Figure 2-1** shows the location of the study intersections.

2.1.2.1 Existing Intersection Volumes

The intersection operations analysis presented in this study are based on AM and PM peak period (7:00 to 9:00 AM and 4:00 to 6:00 PM) intersection turning movement, pedestrian, and bicycle volumes collected on December 12 and 13, 2012. These time periods were selected because trips generated by the proposed Project, in combination with background traffic, are expected to represent typical worst traffic conditions. Within the peak periods, the peak hours (i.e., the hour with the highest traffic volumes observed in the study area) are from 7:30 AM to 8:30 AM (AM peak hour) and 5:00 PM to 6:00 PM (PM peak hour).

Because the traffic counts were collected in December when traffic patterns may be atypical due to irregular school schedules, holidays, and more frequent shopping trips[1], "check counts" were collected during the week of January 28, 2013, at three locations (Meeker Avenue/23rd Street/Marina Bay Parkway, Meade Street/Regatta Boulevard, and Carlson Boulevard/Bayview Avenue). These check counts were compared to the December 2012 counts, in terms of total intersection volumes and also critical

[1] Since the RBC site is not located near schools or major shopping destinations, it is not expected to have different traffic patterns in December, which was confirmed with the counts collected in February.

movements. In comparison, some movements were higher in December 2012 while others were higher in January/February 2013. Overall, the January/February 2013 intersections volumes were between 12 percent lower and 15 percent higher than the December 2012 volumes, which is within the typical daily fluctuation expected in traffic volumes. Thus, the December 2012 traffic volumes represent typical conditions in the vicinity of the RBC site.

Although the December 2012 traffic volumes represent typical conditions in the study area, they were adjusted to reflect the higher traffic volumes observed in January/February 2013 in order to present a more conservative analysis, resulting in a slight overestimation of the anticipated traffic impacts. The adjustments included increasing the northbound through movement at Marina Bay Parkway/Meeker Street intersection and corresponding upstream movements, and increasing the truck percentages at all the intersections based on observed higher truck volumes in the January/February 2013 counts.

Figures 2-2A and 2-2B present the existing AM and PM peak hour intersection vehicle turn movement volumes at the study intersections. **Figures 2-3A and 2-3B** present the existing AM and PM peak hour pedestrian and bicycle volumes at the study intersections. **Appendix A** presents the detailed count sheets at the study intersections.

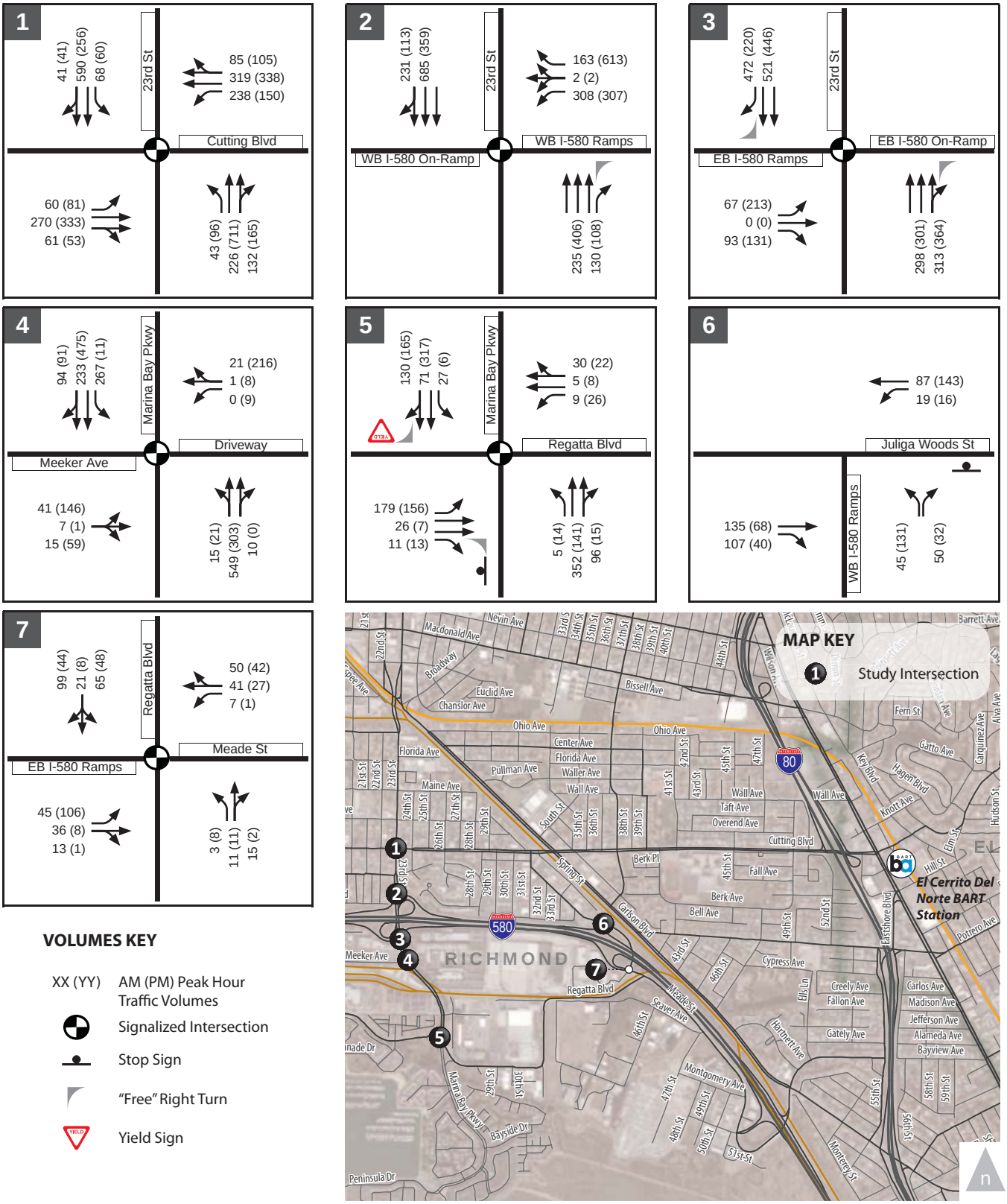
2.1.2.2 Existing Intersection Operations

Table 2-1 summarizes existing weekday peak hour intersection LOS analysis results. **Appendix B** provides the detailed calculation work sheets. As shown in the table, all study intersections during the AM peak hour, and all but one intersection during the PM peak hour operate at LOS D or better. The one sub-standard intersection is Meeker Avenue/23rd Street/Marina Bay Parkway, which operates at LOS F during the PM peak hour.

2.1.3 FREEWAY OPERATIONS

This study analyzes existing traffic operations during typical weekday AM and PM peak hours at the following seven freeway segments:

1. I-580 between Harbor Way and Marina Bay Parkway
2. I-580 between Marina Bay Parkway and Regatta Boulevard
3. I-580 between Regatta Boulevard and Bayview Avenue
4. I-580 between Bayview Avenue and Central Avenue
5. I-580 between Central Avenue and I-80
6. I-80 between Carlson Boulevard and Potrero Avenue
7. I-80 at the Gilman Street Overpass



VOLUMES KEY

XX (YY)	AM (PM) Peak Hour Traffic Volumes
	Signalized Intersection
	Stop Sign
	"Free" Right Turn
YIELD	Yield Sign

Figure 2-2A.

Richmond Bay Campus Existing
Peak Hour Traffic Volumes, Lane Configurations and Traffic Control

WC12-2953_2-2A_ExVol

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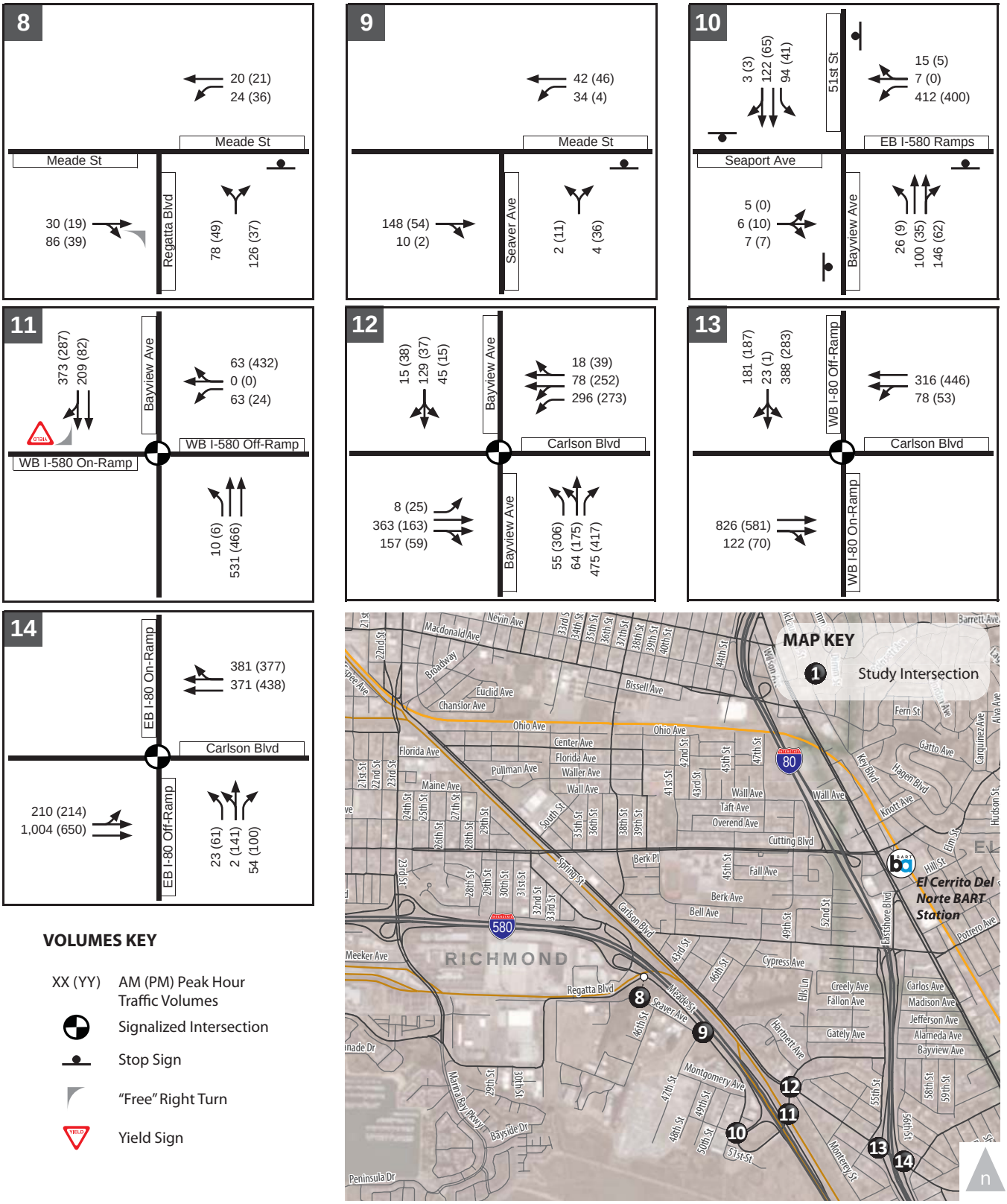

Figure 2-2B.

Richmond Bay Campus Existing
Peak Hour Traffic Volumes, Lane Configurations and Traffic Control

WC12-2953_2-2B_ExVol

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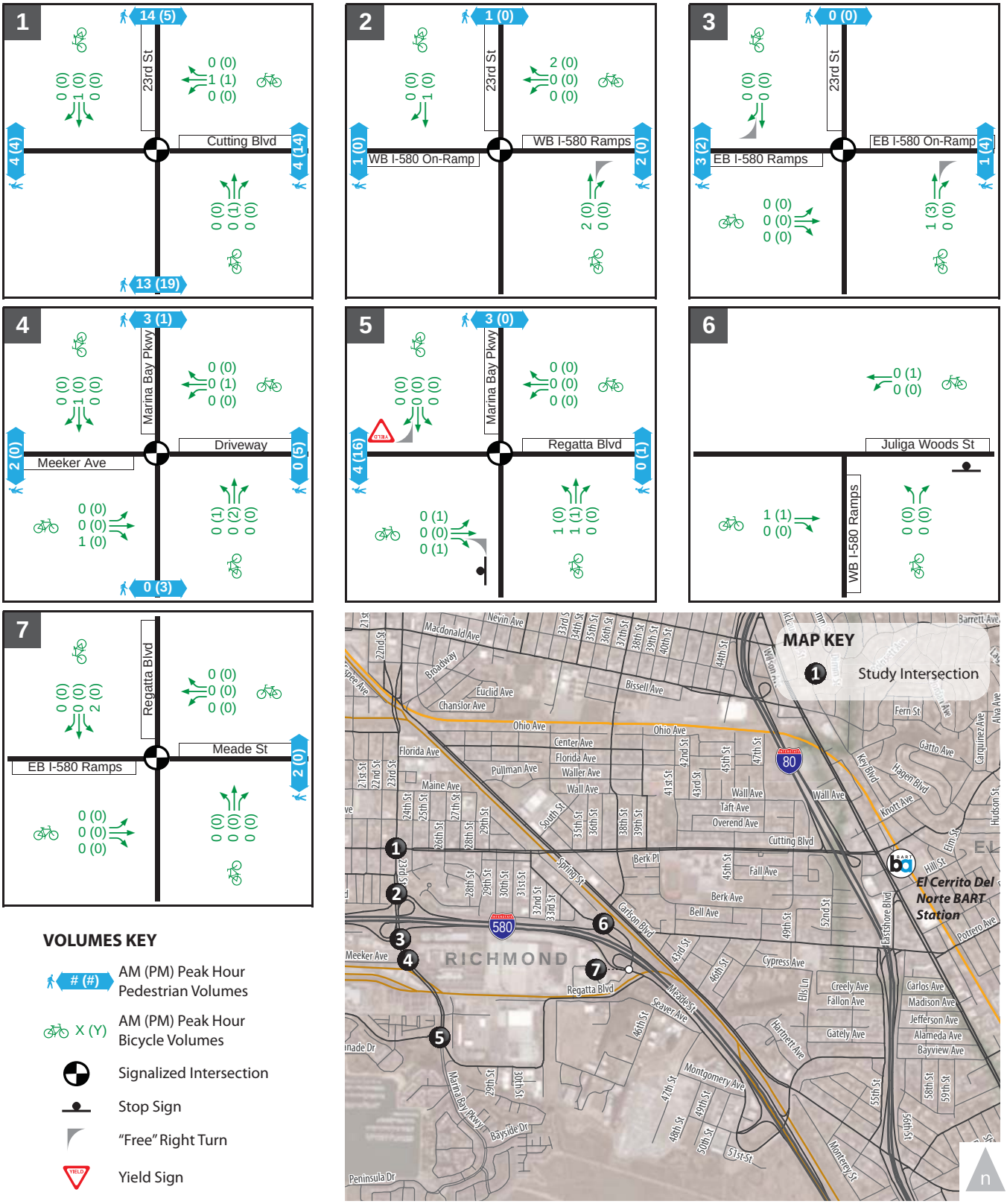

Figure 2-3A.

Richmond Bay Campus Existing Pedestrian and Bicycle Volumes

WC12-2953_2-3A_ExPedBikeVol

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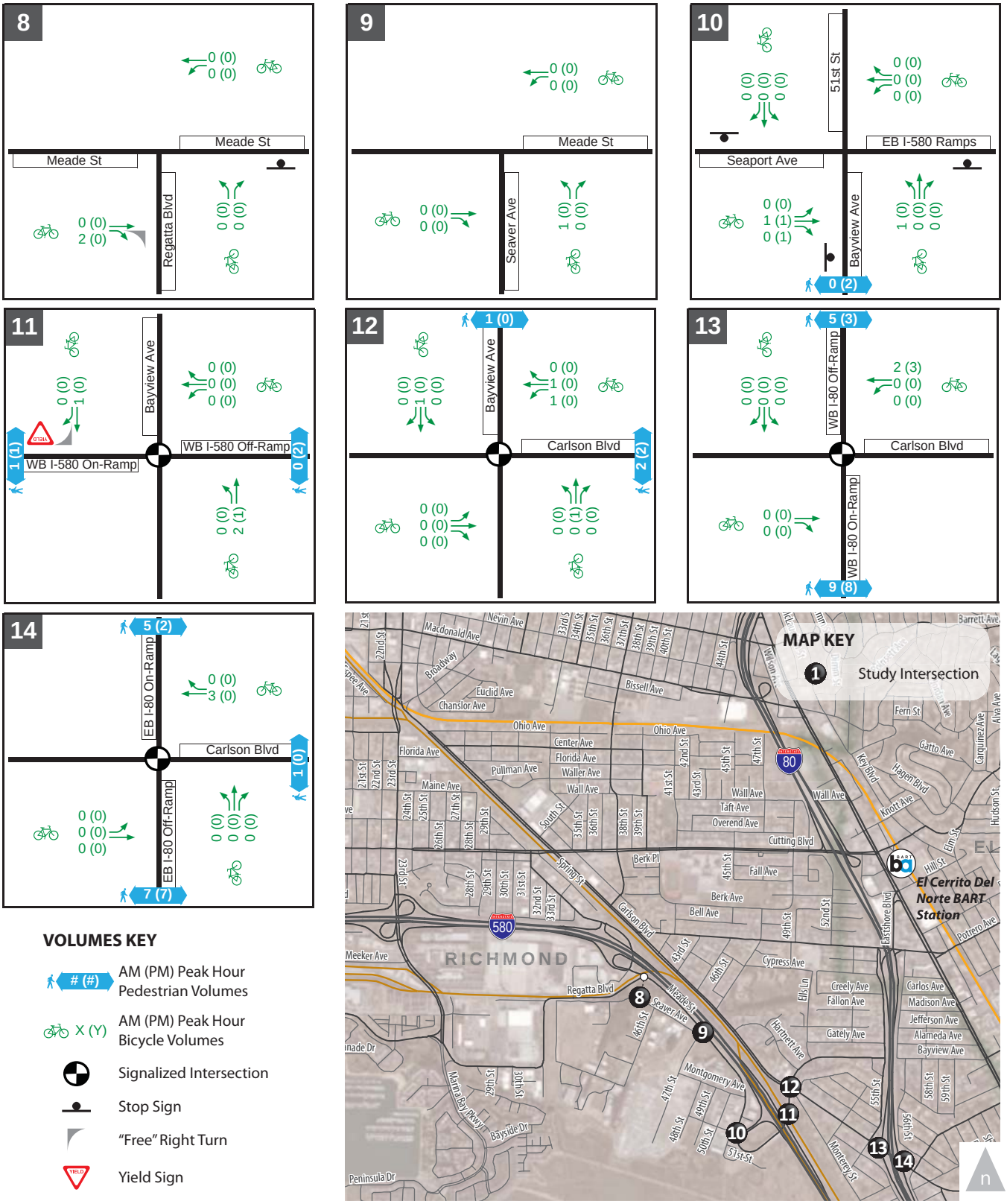

Figure 2-3B.

Richmond Bay Campus Existing Pedestrian and Bicycle Volumes

WC12-2953_2-3B_ExPedBikeVol

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TABLE 2-1
RICHMOND BAY CAMPUS
EXISTING CONDITIONS – STUDY INTERSECTION LOS SUMMARY

Intersection	Control	AM Peak Hour		PM Peak Hour	
		Delay (Seconds)[1]	LOS [1]	Delay (Seconds) [1]	LOS [1]
1. Cutting Boulevard/ 23rd Street	Signal	22.9	C	23.0	C
2. I-580 Westbound Ramps/ 23rd Street	Signal	6.9	A	6.8	A
3. I-580 Eastbound Ramps/ 23rd Street	Signal	3.6	A	6.3	A
4. Meeker Avenue/23rd Street/ Marina Bay Pkwy	Signal	37.1	D	**115.8**	**F**
5. Regatta Boulevard/ Marina Bay Parkway	Signal	30.0	C	43.6	D
6. I-580 Westbound Ramps/ Juliga Woods Street	Side Street Stop	2.5 (10.0)	A (B)	4.4 (10.9)	A (B)
7. I-580 Eastbound Ramps/ Regatta Boulevard/ Meade Street	Signal	9.7	A	9.1	A
8. Meade Street/ Regatta Boulevard	Side Street Stop	6.4 (10.6)	A (B)	5.6 (10.0)	A (B)
9. Meade Street/ Seaver Avenue	Side Street Stop	1.3 (9.7)	A (A)	3.0 (9.0)	A (A)
10. Seaport Avenue/I-580 Eastbound Ramps/South 51st Street/Bayview Avenue	All-way Stop	27.6	D	20.0	C
11. I-580 Westbound Ramps/ Bayview Avenue	Signal	5.4	A	6.7	A
12. Carlson Boulevard/ Bayview Avenue	Signal	27.0	C	21.6	C
13. Carlson Boulevard/ I-80 Westbound Ramps	Signal	19.3	B	20.0	B
14. Carlson Boulevard/ I-80 Eastbound Ramps	Signal	10.7	B	9.8	A

Notes: **Bold** indicates an intersection operating at unacceptable LOS E or LOS F.
1. Signalized and all-way stop-controlled intersection delay and LOS based on average control delay per vehicle, according to the Highway Capacity Manual, Special Report 209, Transportation Research Board, 2000.

Source: Fehr & Peers.

These freeway segments were selected for analysis because they are most likely to be affected by the proposed Project.

2.1.3.1 Existing Freeway Volumes

Existing freeway volumes are primarily derived from two sources of data: (1) October 2012 freeway volumes published by Caltrans through the California Freeway Performance Measurement System (PeMS), and (2) ramp terminal intersection turning movement counts collected in December 2012, and described in Section 2.1.2.1.

2.1.3.2 Existing Freeway Operations

Table 2-2 summarizes existing weekday AM and PM peak hour freeway segment LOS analysis results for both mainline and weave sections. **Appendix C** provides the detailed calculation work sheets. As shown in the table, all freeway segments currently operate at LOS D or better during both AM and PM peak hour.

TABLE 2-2
RICHMOND BAY CAMPUS
EXISTING CONDITIONS – FREEWAY SEGMENT LOS SUMMARY

Freeway Segment	Type[1]	Dir[2]	AM Peak Hour		PM Peak Hour	
			Density[2]	LOS	Density[2]	LOS
1. I-580 between Harbor Way and Marina Bay Pkwy	Weave	EB	N/A	A	N/A	A
	Weave	WB	N/A	A	N/A	A
2. I-580 between Marina Bay Pkwy and Regatta Blvd	Weave	EB	N/A	A	N/A	A
	Weave	WB	N/A	A	N/A	A
3. I-580 between Regatta Blvd and Bayview Ave	Weave	EB	N/A	A	N/A	A
	Weave	WB	N/A	A	N/A	A
4. I-580 between Bayview Ave and Central Ave	Basic	EB	15.4	B	14.0	B
	Basic	WB	14.3	B	16.9	B
5. I-580 between Central Ave and I-80	Basic	EB	23.5	C	28.7	D
	Basic	WB	25.0	C	22.6	C
6. I-80 between Carlson Blvd and Potrero Ave	Basic	EB	21.3	C	27.3	D
	Basic	WB	29.5	D	24.0	C
7. I-80 at Gilman St Overpass	Basic	EB	21.7	C	27.3	D
	Basic	WB	30.9	D	25.6	C

1. Segments with auxiliary lanes are classified as weave segments, and were analyzed based on the Leisch Method. Basic segments are analyzed as basic segments using the 2000 HCM methodologies.
2. EB = Eastbound; WB = Westbound
3. Density is presented in passenger cars per lane per mile (pc/ln/mi).

Source: Fehr & Peers.

2.1.4 EXISTING TRANSIT AND SHUTTLE SERVICES

The RBC site is served indirectly by Bay Area Rapid Transit (BART), Alameda-Contra Costa Transit (AC Transit), Amtrak, and directly by the Richmond Field Station (RFS) shuttle. **Figure 2-4** shows the transit routes in the vicinity of the site. Each transit service is described below.

2.1.4.1 BART

BART provides regional commuter rail transit in Alameda, Contra Costa, San Francisco, and San Mateo counties. Currently, BART trains operate on weekdays from 4:00 AM to midnight, on Saturdays from 6:00 AM to midnight, and on Sundays from 8:00 AM to midnight. The nearest BART stations to the RBC site are the Richmond Station (about two miles northwest of the RBC site and at the end of the Richmond-Fremont line), the El Cerrito del Norte Stations (about two miles northeast of the RBC site), and the El Cerrito Plaza Station (about three miles east of the RBC site). These three stations are served by the Richmond-Fremont and Richmond-Daly City/Millbrae lines. Other destinations in the BART system can be reached by transferring at stations in Oakland. Typically, these three stations are served by a train every seven (peak weekday commute periods) to 20 minutes (Sundays). The average weekday daily ridership for the Richmond, El Cerrito del Norte, and El Cerrito Plaza Stations were about 7,500, 15,800 and 9,000 riders in January 2013, respectively.

2.1.4.2 AC Transit

Local bus service in Richmond is provided by AC Transit. **Figure 2-4** illustrates the existing AC Transit routes in the vicinity of the RBC site. **Table 2-3** describes the service provided on these routes and the nearest stops to the RBC site.

2.1.4.3 Amtrak

The Richmond Transit Station, located adjacent to the Richmond BART station, provides Amtrak service on three routes – the Capital Corridor (15 trains per day in each direction between San Jose and Sacramento); the San Joaquin Intercity (four trains per day in each direction to Bakersfield via Modesto and Fresno) and the California Zephyr (one train per day in each direction between Chicago and Emeryville).

2.1.4.4 Richmond Field Station Shuttle

UC Berkeley currently operates a shuttle connecting the main University campus with El Cerrito Plaza BART Station and the Richmond Field Station (RFS) with other stops on Buchanan Street at Jackson Street, Martin Luther King Jr. Way at Hopkins Street, and Downtown Berkeley BART Station. The shuttle operates approximately hourly between 7:00 AM and 6:00 PM on weekdays. Current LBNL staff can use the LBNL (See Section 4.1.1.4 for details for LBNL shuttles) and RFS shuttles to travel between LBNL and RFS.

Figure 2-4.

Richmond Bay Campus Existing Transit Service

WC12-2953_2-4_ExTransit

FEHR & PEERS

TABLE 2-3
RICHMOND BAY CAMPUS
AC TRANSIT SERVICE SUMMARY

Line	Route	Nearest Stop[1]	Weekday		Weekend	
			Hours	Frequency	Hours	Frequency
Local Routes						
71	Richmond Parkway Transit Center – El Cerrito BART	Carlson Blvd./ Cutting Blvd. (About 1.0 miles)	5:00 AM – 8:00 PM	30 minutes	6:30 AM – 9:30 PM	60 minutes
74	Castro Ranch – Richmond BART – Harbor Way South/Ford Point	Marina Bay Pkwy/Regatta Blvd. (About 1.3 miles)	7:00 AM – 10:00 PM	30-40 minutes	7:00 AM – 8:00 PM	30-40 minutes
76	El Cerrito Del Norte BART – Hilltop Mall	Carlson Blvd./ Cutting Blvd. (About 1.0 miles)	6:00 AM – 7:40 PM	30-40 minutes	6:30 AM – 8:20 PM	30 minutes
376	El Cerrito Del Norte BART – Pinole Vista Center	Carlson Blvd./ Cutting Blvd. (About 1.0 miles)	8:00 PM – 3:45 AM	30 minutes	8:00 PM – 3:45 AM	30 minutes

1. Distance shown is current walking distance between bus stop and south 46th Street at Seaver Avenue.
Source: AC Transit, 2013

2.1.5 EXISTING PEDESTRIAN AND BICYCLE CIRCULATION

2.1.5.1 Pedestrian and Bicycle Facilities

Pedestrian facilities in the study area include sidewalks, crosswalks, and multi-use trails. Most roadways in the study area provide sidewalks on both sides of the street; except Regatta Boulevard east of Marina Bay Parkway, where sidewalks are generally only provided where there are fronting uses; Meade Street, which has sidewalks only on the north side of the street; and Marina Bay Parkway south of Meeker Avenue, which has sidewalks only on the west side of the street. The Richmond Bay Trail is located along the bay shoreline to the south of the RBC site, connecting via Marina Bay Parkway to Regatta Boulevard and continuing west.

Based on the *City of Richmond Bicycle Master Plan* (October 2011), bicycle facilities in the study area can be classified into three types, including:

- ***Bicycle Paths (Class 1)*** – These facilities are located off-street and can serve both bicyclists and pedestrians.

- ***Bicycle Lanes (Class 2)*** – These facilities provide a dedicated area for bicyclists within the paved street width through the use of striping and appropriate signage.

- ***Bicycle Routes (Class 3)*** – These facilities are found along streets that do not provide sufficient width for dedicated bicycle lanes. The street is designated as a bicycle route through the use of signage informing drivers to expect bicyclists.

Figure 2-5 identifies existing and proposed bicycle facilities in the study area. Existing bicycle facilities near the project site include the Class 1 Bay Trail along the bay shoreline, and Class 3 routes on Marina Bay Parkway and on Regatta Boulevard west of Marina Bay Parkway.

As previously shown on Figures 2-3A and 2-3B, study intersections in the vicinity of the RBC site have minimal pedestrian and bicycle activity.

2.1.5.2 Proposed Pedestrian and Bicycle Improvements

The *Richmond Bicycle Master Plan* and *City of Richmond Pedestrian Plan* propose the following bicycle and pedestrian improvements in the study area:

- Class 1 path connecting Regatta Boulevard west of Marina Bay Parkway and Bayview Avenue just south of the I-580 Interchange.

- Class 1 path adjacent to the east-west railroad tracks connecting Meade Street at Seaver Street to Regatta Boulevard.

- Class 1 path along south 46th connecting the Bay Trail and Meade Street.

- Class 2 lanes on Regatta Boulevard between Marina Way and Meade Street.

- Class 2 lanes on South 23rd Street/Marina Bay Parkway including potential improvements at the I-580 Overpass such as widening sidewalks, and realigning the freeway ramps to square the intersection and shorten pedestrian crossings.

- Class 2 lanes on Meade Street/South 51st Street between Regatta Boulevard and Seaport Avenue.

- Class 2 lanes on Bay View Avenue between Seaport Avenue and Carlson Boulevard.

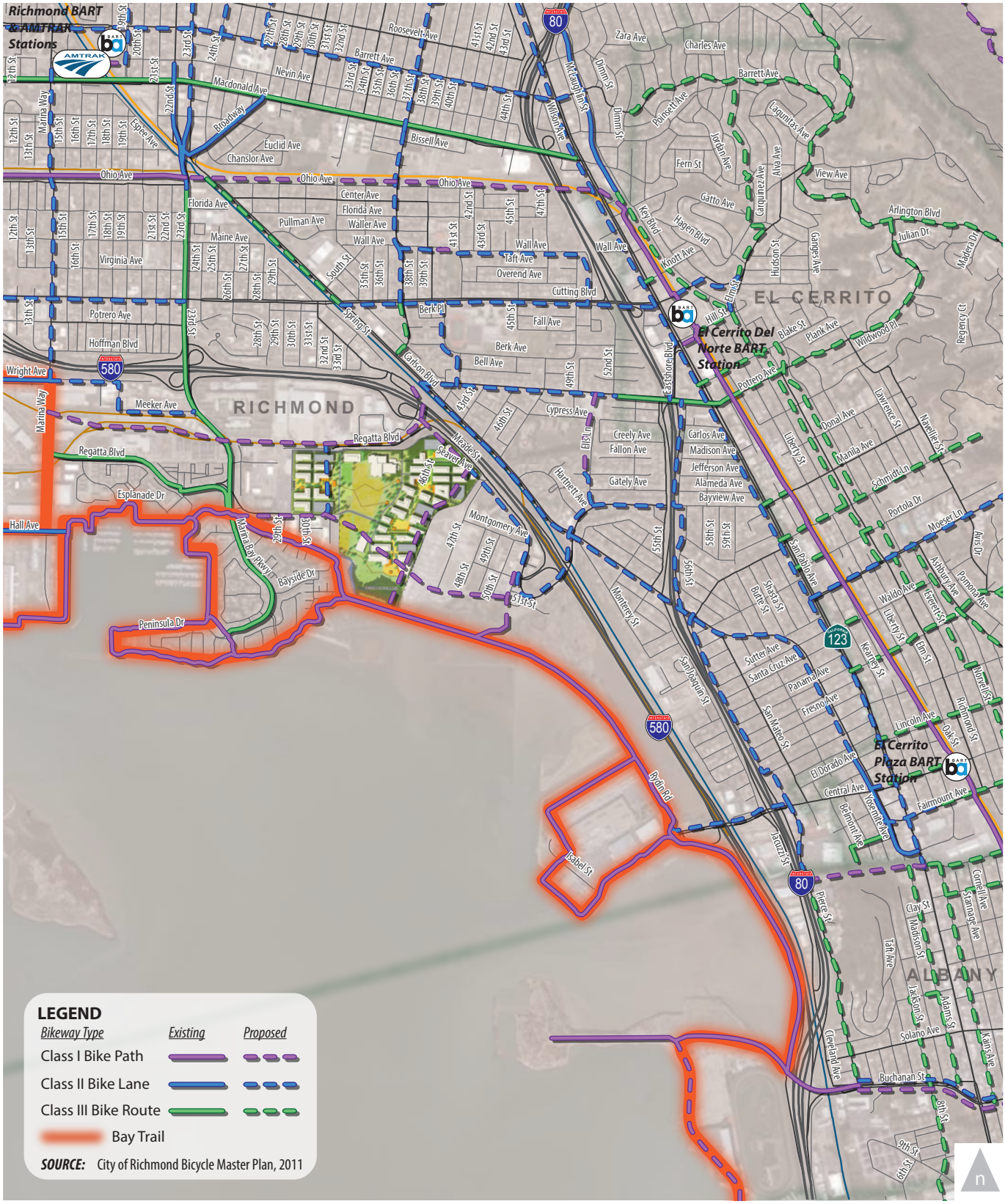

Figure 2-5.

Richmond Bay Campus Existing and Future Bicycle Network

WC12-2953_2-5_ExBikeNet

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- Class 2 lanes on Carlson Boulevard between El Cerrito City Limit and Broadway.

The potential improvements listed above are not fully funded, designed, or approved. It is not known if and when they would be implemented. Therefore, this assessment does not assume them in the analysis of future conditions.

2.1.6 EXISTING AT-GRADE RAILROAD CROSSINGS

There are two at-grade railroad crossings in the study area, on Marina Bay Parkway between Meeker Avenue and Regatta Boulevard, and on Meade Street between Regatta Boulevard and the recently completed Regatta Boulevard extension as shown on Figure 2-1. The at-grade crossings are operated by Richmond Pacific and Union Pacific Railroad Corporations.

Based on data provided by Federal Railroad Administration (FRA), about nine trains use the at-grade crossing on Marina Bay Parkway on a typical day with speeds from about one to ten mph, and about four trains use the at-grade crossing on Meade Street with speeds from five to ten mph. The vehicular approaches at both crossings provide gate controls with bells, pavement markings, and advanced warning signs. The crossing on Marina Bay Parkway also includes a sidewalk on the west side of the roadway and the crossing on Meade Street provides a sidewalk on the north side of the roadway.

Based on six years (2007-2012) of collision data summarized by the FRA, one collision was reported at the at-grade crossing on Marina Bay Parkway in 2007 and no collisions were reports at the crossing on Meade Street. The reported collision involved an automobile that drove around or through the safety gates and struck rail equipment. No injuries were reported.

The Marina Bay Parkway at-grade crossing is currently scheduled to be replaced with a grade-separated crossing. The undercrossing will also include separated pedestrian/bicycle path on both sides of the roadway. This project is fully funded and construction is expected to start in 2013.[2]

[2] Source: City of Richmond, www.ci.richmond.ca.us/index.aspx?NID=951

2.2 REGULATORY CONSIDERATIONS

2.2.1 RICHMOND GENERAL PLAN 2030

The Richmond General Plan 2030 Circulation Element contains the following goals, policies and actions that are relevant to the Project. The General Plan document contains more detailed descriptions of these goals, policies and actions; brief statements are provided below.

Goal CR1 An Expanded Multimodal Circulation System. Make conditions safer and more attractive for all modes of transportation including travel by foot and bicycle, public transit and automobiles. Evaluate streets and potential enhancements based on surrounding land use, street function and desired character and by relying on the place-based approach to circulation planning articulated in the General Plan. Take potential improvement measures ranging from physical design treatment of the street environment to social and programmatic responses appropriate to the particular street context.

Policy CR1.1 Balanced Modes of Travel and Equitable Access. Encourage multiple circulation options in the City and work with transit operators to ensure equitable access for all members of the community.

Policy CR1.2 An Interconnected Street System. Promote an interconnected system of streets that adequately serves current and future travel needs.

Policy CR1.3 Local and Regional Transportation Linkages. Enhance circulation linkages within the City and region.

Policy CR1.4 Expanded and Affordable Public Transit. Coordinate with regional transportation agencies and support enhanced and expanded public transit to improve mobility options for residents and visitors.

Policy CR1.5 Safe and Convenient Walking and Bicycling. Promote walking and bicycling as a safe and convenient mode of transportation.

Policy CR1.6 Comprehensive Network of Multi-Use Trails. Develop a comprehensive network of multi-use trails including to enhance bicycle and pedestrian connectivity throughout the City and the region.

Policy CR1.8 Place-Based Circulation Approach. Promote the place-based planning approach and classification system.

Policy CR1.9 Place-Based Circulation Classification System and Multi-Modal Level of Service Standards. Classify all streets in the City to conform to the Place-Based Circulation Classification System discussed in

the Circulation Element of the General Plan and adopt multi-modal level of service (MMLOS) standards that are consistent with each street type's intended function and character.

Policy CR1.10 Vehicular Level of Service Standards for West County Routes of Regional Significance. Maintain vehicular level of service (LOS) standards for signalized intersections consistent with the Contra Costa Transportation Authority's (CCTA) West County Action Plan for Routes of Regional Significance.

Relevant Actions under Goal CR1: Actions CR1.A, B, C, D, E, J, L, and M.

Goal CR2 Walkable Neighborhoods and Complete Streets. Activate the public right-of-way and improve the experience of moving people between key destinations at the pedestrian level. In order to make walking and bicycling a more attractive options, enhance connectivity between neighborhoods, schools, the workplace, and daily goods and services so that reaching key destinations is safer and more convenient. Contribute to walkability and livability by promoting mixed-use and complete streets, high-quality pedestrian environments, context-based street design, and efficient public transit.

Policy CR2.2 Complete Streets. Promote mixed-use urban streets that balance public transit, walking and bicycling with other modes of travel.

Policy CR2.3 Integrated Bicycle and Pedestrian System. Plan, construct and maintain a safe, comprehensive and integrated bicycle and pedestrian system.

Relevant Actions under Goal CR2: Actions CR2.A, D, E and G.

Goal CR3 A safe and well-maintained Circulation System. In order to create a safe and efficient circulation system, emphasize on-going street maintenance and safety improvements that consider all modes of transportation including walking, bicycling, and public transit. Require new facilities and infrastructure as development occurs in order to meet the needs of all users while enhancing mobility and connectivity.

Policy CR3.1 Safety and Accessibility. Enhance safety and accessibility for pedestrians, bicyclists and transit riders.

Policy CR3.3 Concurrent Infrastructure Development. Require concurrent infrastructure development for new and redevelopment projects that may have a significant impact on the existing circulation system including streets, trails, sidewalks, bicycle paths and public transit.

Relevant Actions Under Goal CR3: Actions CR3.A, B, and C.

Goal CR5 Sustainable and Green Practices. In order to create sustainable and clean circulation options, encourage the use of low-impact alternative fuels and new technologies and implement transportation demand management programs. Encourage measures to treat and retain storm water in the design of pedestrian and parking amenities.

Policy CR5.1 Transportation Demand Management. Promote transportation demand management (TDM) strategies among residents and businesses to reduce reliance on automobiles.

Policy CR5.2 Renewable Energy and Clean Technology. Promote the use of renewable energy, including non-fossil fuels, and clean technology for transportation including public transit and goods movement.

Policy CR5.3 Green Streets. Promote the development of street design elements that incorporate natural storm water drainage and landscaping in new and retrofitted streets.

Relevant Actions Under Goal CR5: Actions CR5.A, B, C, E, and F.

2.2.2 RICHMOND BICYCLE MASTER PLAN

Consistent with the vision presented in the General Plan, the City of Richmond *Bicycle Master Plan* provides detailed action items to complete a bikeway system and supporting facilities in the City of Richmond. The Richmond *Bicycle Master Plan* contains the following four goals and objectives:

Goal 1: Expand the city's bicycle routes and parking facilities into an extensive, well-connected and well-designed network, and improve and maintain these facilities over time.

> **Objective:** Increase the number of bikeway miles by 75 percent, complete all gaps in the Bay Trail and double the number of bicycle parking spaces.

Goal 2: Increase the number of people of all ages and backgrounds who bicycle for transportation, recreation and health.

> **Objective:** Double the number of trips made by bicycle.

Goal 3: Make the streets safer for bicyclists, not only during the day but also at night.

> **Objective:** Reduce the number of bicycle fatalities and injuries by 25 percent (even as the number of bicyclists increases).

Goal 4: Incorporate the needs and concerns of cyclists in all transportation and development projects.

Objective: Adopt, institutionalize and have relevant City departments implement a "Complete Streets" policy and bicycle-friendly design standards and guidelines for streets and developments.

2.2.3 RICHMOND PEDESTRIAN PLAN

Consistent with the vision presented in the General Plan, the City of Richmond *Pedestrian Plan* aims to improve the safety, convenience, and appeal of waking throughout the City of Richmond. The Richmond Pedestrian Plan contains the following goals:

Increased Safety. Streets will be developed and retrofitted to accommodate all types of users. Designs and devices will produce speed moderation, visibility, awareness and communication for motorists and non-motorists alike.

Improved Security. Streets, trails and other public spaces will be designed and improved to create active places that are watched over, maintained and that project a sense of control and community ownership.

Improved Connectivity. A range of strategies and solutions will address physical barriers to walking, such as dead-end streets, railroad right of ways, wide roadways, and wide, complex intersections.

Increased Equity. Walking, the cheapest form of transportation, will be a safe, viable and convenient choice for those who cannot afford, are unable, or choose not to drive a car.

Improved Health. Walking and bicycling, the healthiest forms of transportation, will become desirable alternatives for trips to daily destinations.

Increased Sustainability. Walking and bicycling in the city will reduce the number of vehicle miles Richmond residents and visitors travel, and will reduce associated climate change, air and water quality impacts from vehicle emissions. Opportunities will be identified to convert excess paved rights of way to lower impact spaces with trees and landscaping.

Neighborhood and Downtown Revitalization. Improvements to the streets and pedestrian realm will beautify the public realm and set the stage for new investment in private property that can help fund improvements and attract development that supports walking, bicycling and the use of transit.

2.3 PROJECT TRANSPORTATION CHARACTERISTICS

Phase 1 of the project, expected to be completed by 2018, would include up to six new buildings providing 600,000 total square feet of space. The Phase 1 buildings are expected to accommodate 1,000

new employees at the RBC. Phase 1 of the project would provide about 600 parking spaces in surface parking lots. Access to the site would continue to be provided at the current location on Meade Street at Seaver Avenue.

Campus buildout would include a total of 5.4 million square feet of space accommodating up to 10,000 employees. The buildout plan would also reroute Regatta Boulevard to the west and provide multiple access points on Meade Street, Regatta Boulevard, and South 46th Street. At buildout, the RBC is estimated to provide about 6,000 parking spaces mostly in parking structures.

Based on information provided in the Preliminary Project Description, various aspects of site and circulation are described in more detail below.

2.3.1 VEHICLE ACCESS AND CIRCULATION

Regional access to and from the RBC would continue to be provided through the existing interchanges on I-580. In the near-term, direct access to and from the RBC site would continue to be provided through the existing entry on Meade Street at Seaver Street. As the RBC is developed, additional entries on Meade Street to the north, Regatta Boulevard to the west, and South 46th Street to the east would also be provided. Currently, the LRDP envisions up to seven access points from Regatta Boulevard and Meade Street at buildout. These access points would either provide direct access to parking facilities for employees and visitors or provide service access for buildings throughout the campus.

The RBC site would also provide new internal roadways to provide direct access to each facility. Internal streets in the RBC would be generally designed to accommodate multiple travel modes with priority for pedestrians and bicycles with the intent that the majority of internal trips would be walk or bike trips. Internal streets accommodating automobiles would be designed for vehicles with low traveling speeds. The proposed RBC street network is further described below:

- Regatta Boulevard - As part of RBC buildout, Regatta Boulevard would be rerouted to the north and west to continue to provide east-west access through the South Shoreline area of Richmond, and internally connect eastern and western portions of the site and reduce automobile traffic within the RBC.

- Lark Drive – Lark Drive would form the main east-west roadway through the RBC and would connect Regatta Boulevard in the west to South 46th Street in the east. Although it would traverse the RBC site and provides through access, it would be designed to reduce automobile speeds and discourage through traffic. Lark Drive is expected to provide one automobile lane and a bicycle lane in each

direction, with sidewalks on both sides of the street, and parking and/or automobile drop-off area at select locations.

- Peripheral Streets – Streets, such as 46th Street, connecting to Regatta Boulevard and Meade Street, would provide access to parking structures and other facilities throughout the RBC. These streets would provide bicycle lanes and sidewalks and may accommodate transit vehicles.

- Service Access Streets – These streets would allow service vehicles to access each individual building; however, they would restrict general automobile access. These streets would be designed to encourage pedestrian and bicycle use.

2.3.2 AUTOMOBILE PARKING

It is expected over time that the proposed Project would eliminate about 690 of the existing 760 automobile parking spaces in the RBC site's current surface parking lots. In the short term (including Phase 1), automobile parking would continue to be provided in surface parking lots. It is expected that about 600 parking spaces would be provided as part of Phase 1 development. As the RBC site develops, parking structures would be constructed to provide most of the 6,000 vehicle parking spaces estimated for the buildout of the RBC. The LRDP proposes to locate most of parking spaces in parking structures located on the periphery of the site, in order to provide a pedestrian-friendly vehicle-free central campus. Although parking is expected to be free in the early phases of development, a parking charge may be established as parking structures are developed.

2.3.3 BICYCLE CIRCULATION AND PARKING

The RBC site would accommodate bicycles internal to the site by providing on-site paths and on-street facilities that connect to existing and proposed bicycle network in City of Richmond and beyond, including the Bay Trail, located just south of the site. As previously discussed in section 2.1.5.1 and shown on Figure 2-5, the Richmond Bicycle Plan proposes bicycle facilities through the RBC site; the proposed LRDP is consistent with the Richmond Bicycle Plan by providing various facilities internal to the site that connect to existing and proposed bicycle facilities external to the site.

In addition, the RBC may provide a bike sharing system to allow for internal site circulation and travel to and from other nearby destinations.

RBC proposes to provide bicycle parking at a rate of at least one space per every five daily occupants, which corresponds to about 200 bicycle parking spaces at completion of Phase 1 and 2,000 spaces at

buildout. New buildings would provide indoor secure bicycle parking, and amenities such as showers and lockers, in addition to outdoor bicycle racks.

2.3.4 PEDESTRIAN ACCESS AND CIRCULATION

The RBC would be designed so that walking is the primary travel mode for trips within the campus. All internal roadways would provide sidewalks; paths and walkways would connect buildings to parking structures, other roadways providing access to and from the site, and the Bay Trail. A central pedestrian "main street" corridor would provide pedestrian connection to most buildings in the eastern portion of the campus.

2.3.5 TRANSIT

The following two shuttle lines are proposed for the RBC:

- The LBNL-UC Berkeley-RBC Shuttle would provide a no-transfer 20-minute ride between LBNL and the RBC with a single stop at the main UC Berkeley campus.
- The BART-RBC Shuttle would operate continuously between the El Cerrito Plaza BART Station and the RBC, providing a nonstop nine-minute ride between BART and the RBC. This shuttle can also be used to access AC Transit buses at the El Cerrito Plaza BART Station.

As the RBC develops, these routes may be modified or additional routes may be added to serve other destinations. The RBC would provide shuttle stops throughout the campus to ensure minimal walking distance to and from each building. Shuttle stops would provide amenities such as shelters and benches.

2.3.6 TRANSPORTATION DEMAND MANAGEMENT

In addition to providing shuttle services and a potential bike sharing system, the University would also implement a Transportation Demand Management (TDM) program to encourage RBC employees to use transit, bicycling, walking, and carpooling for traveling to and from the site and reduce the number of automobile trips. Although the specific components of the TDM program are not known at this time, it would be similar to the program currently implemented at the LBNL site in Berkeley, and may include strategies such as subsidized or discounted transit passes, Guaranteed Ride Home, carpool matching, and flexible car share programs.

2.3.7 TRIP GENERATION

Table 2-4 shows the estimated vehicle trip generation for RBC at Phase 1 and buildout. The trip generation estimates are derived from trip generation rates per average daily population observed at the existing LBNL site in Berkeley. The LBNL rates were developed based on vehicle counts at the LBNL gates in 2011 and the corresponding on-site population. For the RBC site, these trip rates were adjusted to reflect the differences between the two sites, most notably differences in transit availability, pedestrian and bicycle facilities, and proximity to residential and non-residential uses. The Contra Costa Transportation Authority (CCTA) and Alameda County Transportation Commission (ACTC) Travel Demand Models were used to estimate these effects, by comparing employment zone trip generation for the LBNL zone with employment trip generation in the RBC zone.

TABLE 2-4
RICHMOND BAY CAMPUS
PROJECT VEHICLE TRIP GENERATION SUMMARY

	Average Daily Population	Daily	AM Peak Hour			PM Peak Hour		
			In	Out	Total	In	Out	Total
Project Phase 1 [1]	1,000	2,079	182	29	211	27	172	199
Project Buildout [2]	10,000	20,226	1,770	283	2,053	259	1,678	1,937

1. Based on following trip generation rates:
Daily = 2.08 trips per Average Daily Population (ADP); AM Peak Hour = 0.21 trips per ADP (86% in, 14% out); PM Peak Hour = 0.20 trips per ADP (13% in, 87% out)
2. Based on following trip generation rates:
Daily = 2.02 trips per ADP; AM Peak Hour = 0.20 trips per ADP (86% in, 14% out); PM Peak Hour = 0.19 trips per ADP (13% in, 87% out)

Source: Fehr & Peers, based on trip generation rate per average daily population at the existing LBNL site in Berkeley adjusted to reflect the different characteristics of the RBC.

The RBC LRDP Project would include a robust TDM program intended to reduce the vehicular trips generated by the Project. Since the specific components of the TDM program are not known and their effectiveness cannot be accurately measured, the trip generation used for this analysis assumes that the TDM program would be similar to the existing LBNL site. In addition, the trip generation estimate conservatively assumes that parking for both employees and site visitors would be free, similar to the existing LBNL site in Berkeley. If parking at RBC is not free, then fewer employees and visitors would drive to and from the site and reduce the project vehicle trip generation.

The buildout trip generation is estimated at a slightly lower rate than Phase 1, based on a projected economy of scale and more amenities provided on-site. It is estimated that the Project Buildout would generate about 20,230 daily automobile trips, 2,050 AM peak hour trips, and 1,940 PM peak hour trips.

2.3.8 TRIP DISTRIBUTION AND ASSIGNMENT

Trip distribution is defined as the directions of approach and departure that vehicles would use to arrive at and depart from the Project site. This assessment estimated the distribution of project trips based on existing travel patterns, location of complementary land uses, and results from the CCTA Travel Demand Model. **Figure 2-6** shows the resulting trip distribution. **Figures 2-7A and 2-7B** show the Project Phase 1 trip assignment at the study intersections, based on the distribution, and **Figures 2-8A and 2-8B** show the Project Buildout trip assignment.

2.3.9 EXISTING PLUS PHASE 1 PROJECT CONDITIONS

Figures 2-9A and 2-9B show the Existing Plus Phase 1 traffic volumes, which consist of traffic volumes under Existing conditions (Figures 2-2A and 2-2B) plus Phase 1 traffic assignment (Figures 2-7A and 2-7B). This analysis assumes no roadway modifications under this scenario.

2.3.9.1 Intersection Operations

Table 2-5 summarizes intersection operations at the study intersections under the Existing Plus Phase 1 Project conditions. **Appendix B** provides the detailed calculation work sheets.

The addition of the Phase 1 Project traffic would not cause any of the intersections that currently operate at an acceptable LOS to degrade to an unacceptable LOS. At the one intersection currently operating below the LOS standard, Meeker Avenue/23rd Street/Marina Bay Parkway, the addition of project generated traffic would not change the overall v/c ratio. This is because the Project would add traffic to the north-south through movements at the intersection, which are not critical movements for purposes of overall intersection control delay calculation. Therefore, the Phase 1 Project would not cause a significant impact at this or other study intersections under Existing Plus Phase 1 Project conditions.

2.3.9.2 Freeway Operations

Table 2-6 shows the freeway segment LOS results for the Existing Plus Phase 1 Project conditions. **Appendix C** provides the detailed calculation work sheets.

Figure 2-6.

Richmond Bay Campus Project Trip Distribution

WC12-2953_2-6_TripDistro

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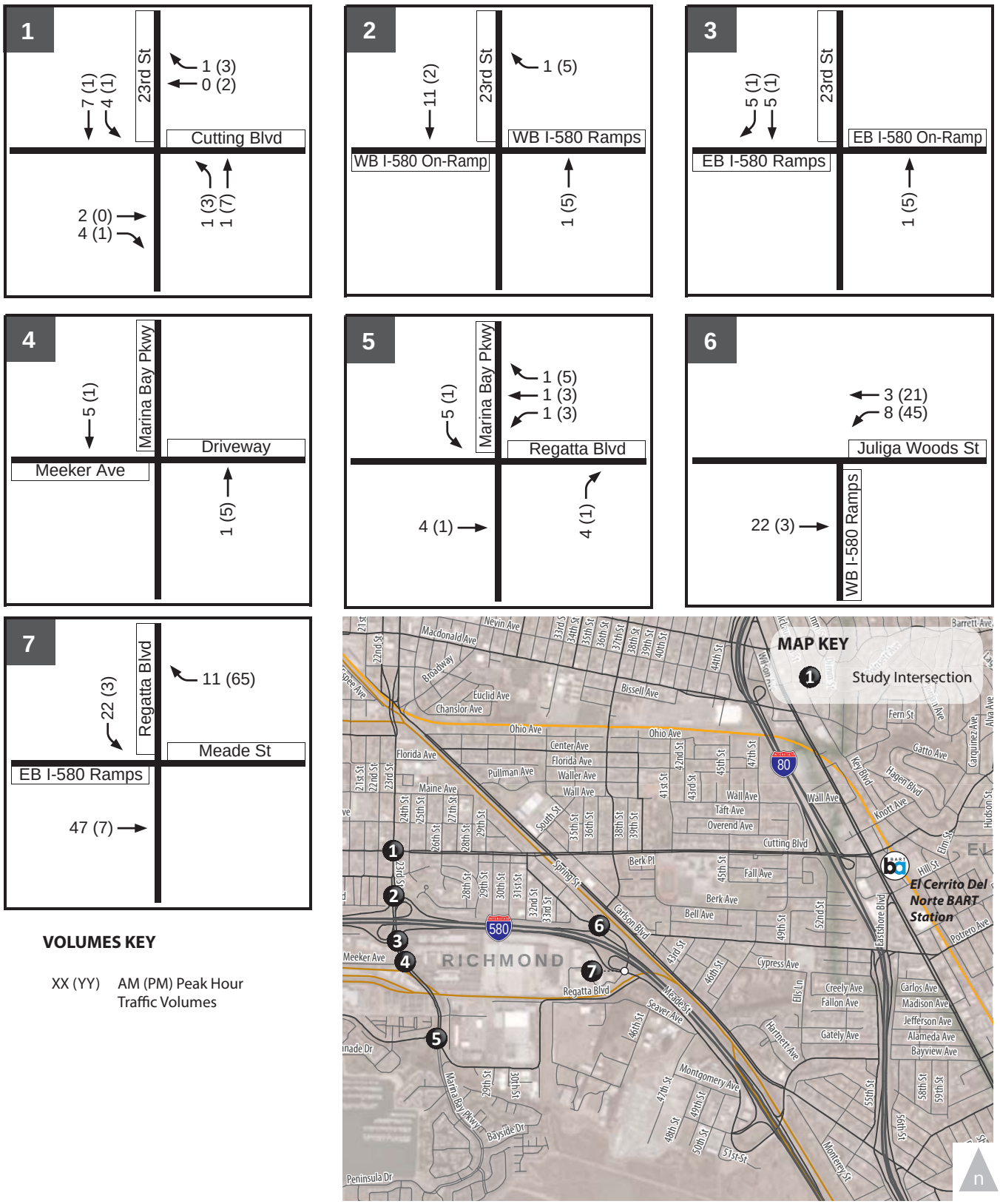


VOLUMES KEY

XX (YY) AM (PM) Peak Hour Traffic Volumes

Figure 2-7A.

Richmond Bay Campus
Project Trip Assignment (Phase 1)

WC12-2953_2-7A_PTAPhase1

FEHR PEERS

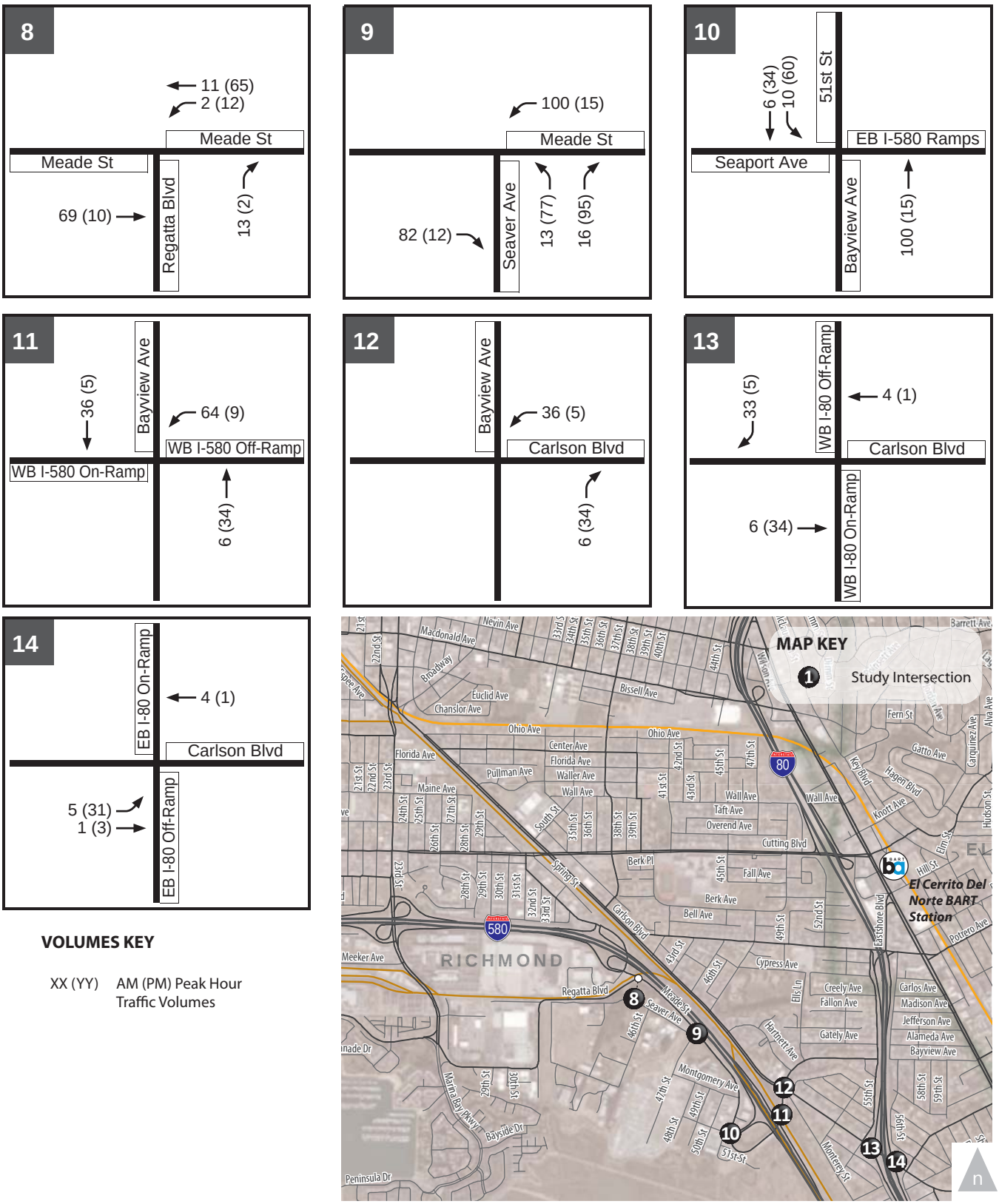
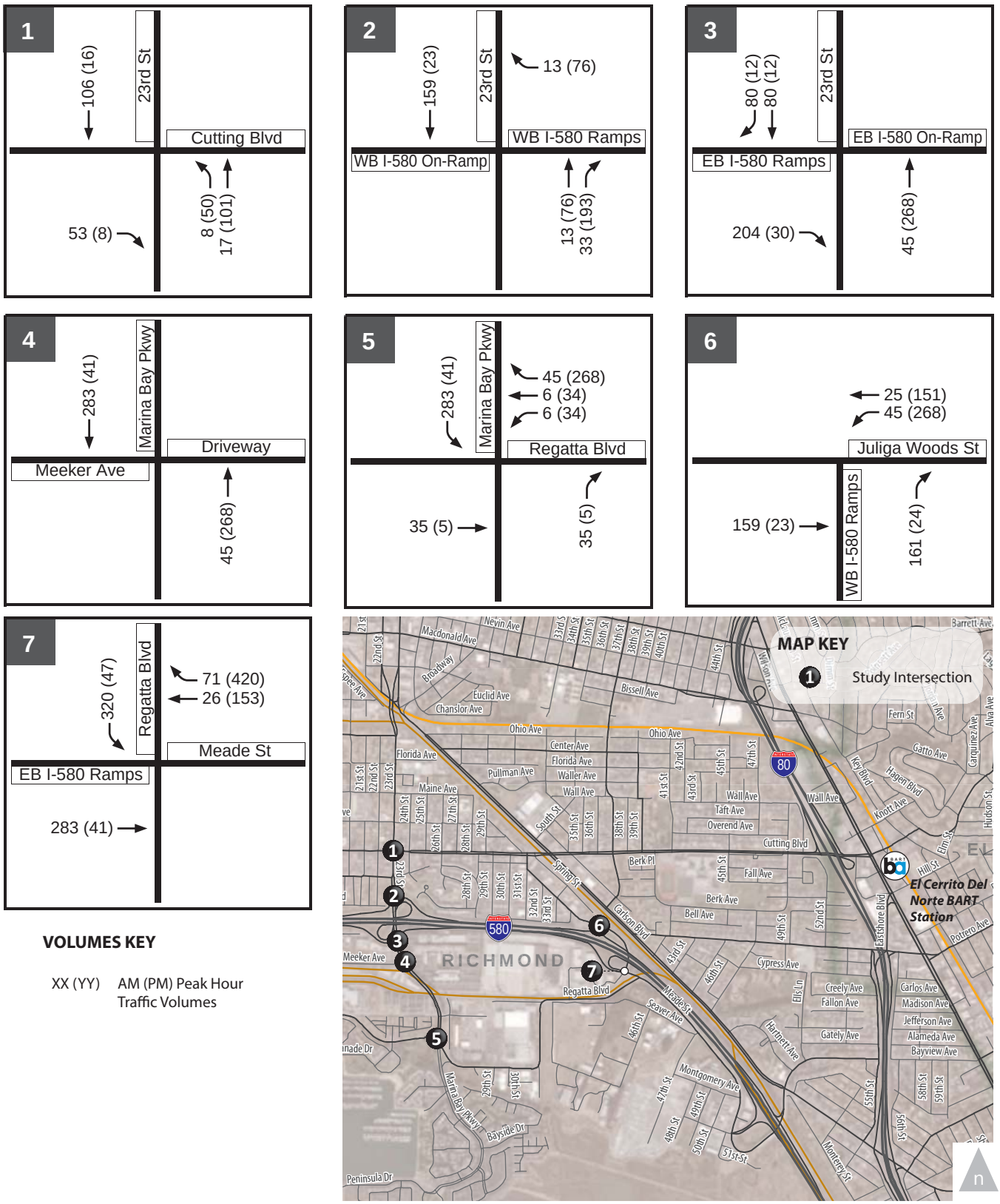


Figure 2-7B.

Richmond Bay Campus
Project Trip Assignment (Phase 1)

WC12-2953_2-7B_PTAPhase1

FEHR PEERS



VOLUMES KEY

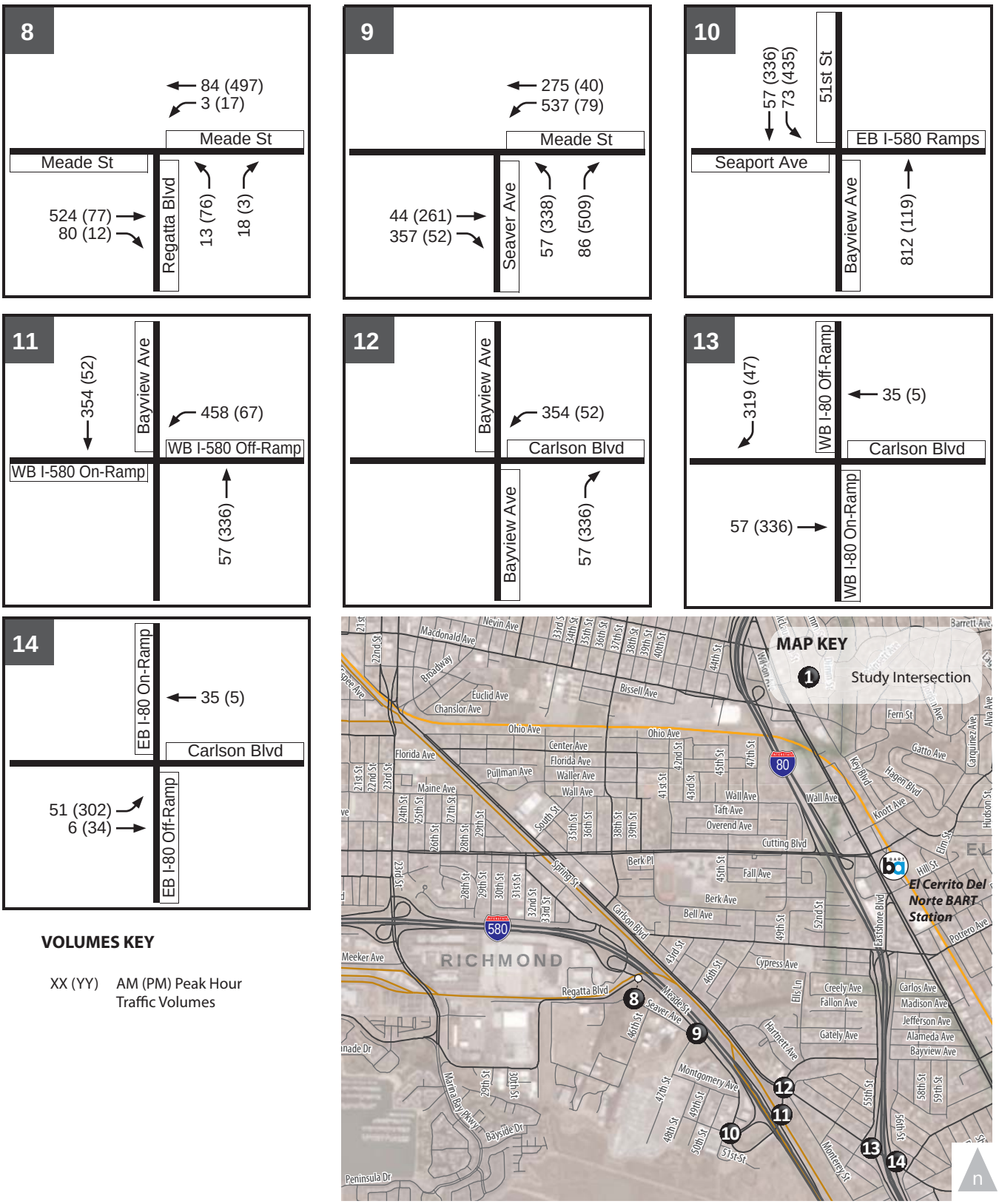
XX (YY) AM (PM) Peak Hour Traffic Volumes

Figure 2-8A.

Richmond Bay Campus
Project Trip Assignment (Buildout)

WC12-2953_2-8A_PTABuildout

FEHR PEERS



VOLUMES KEY

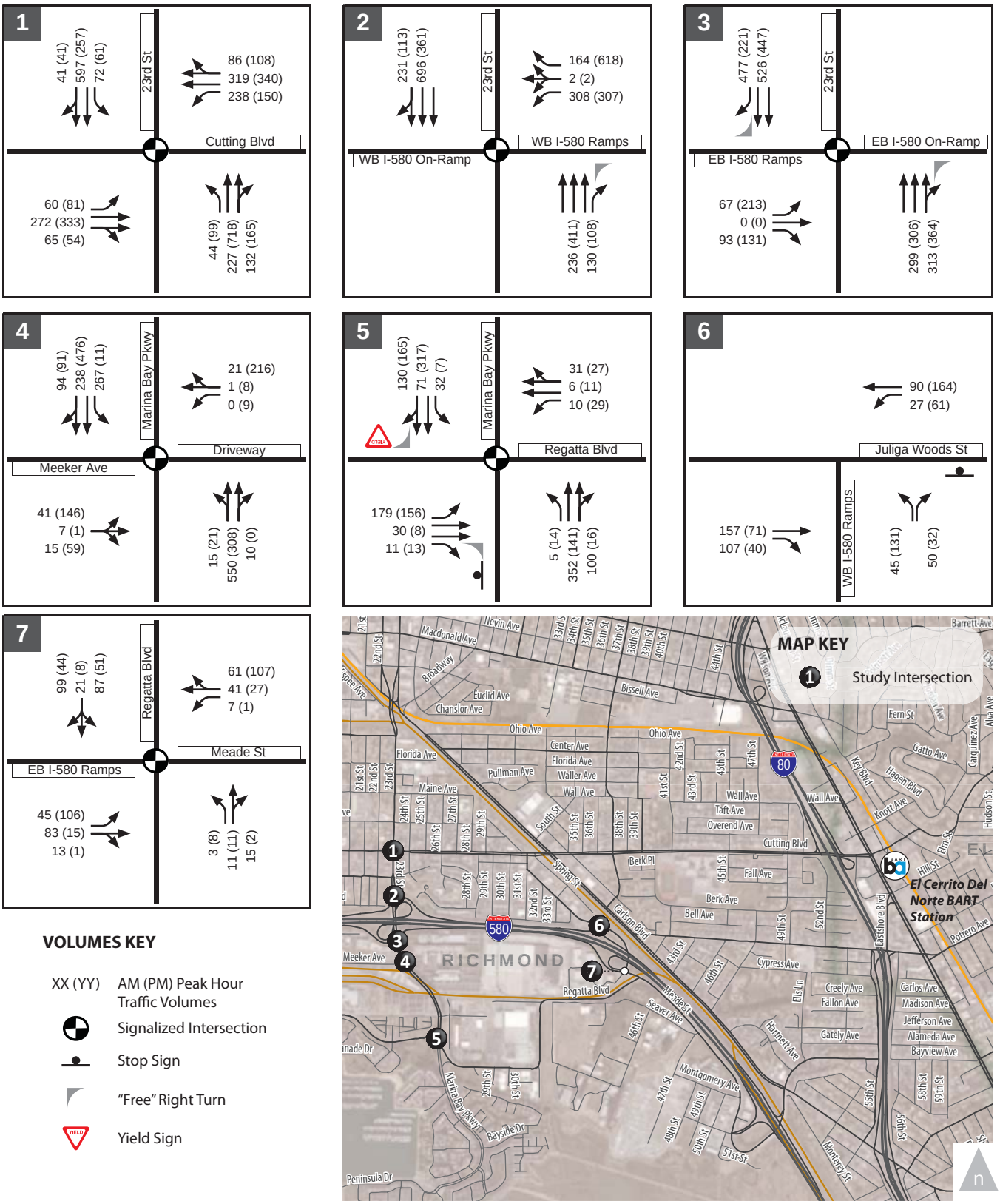
XX (YY) AM (PM) Peak Hour Traffic Volumes

Figure 2-8B.

Richmond Bay Campus
Project Trip Assignment (Buildout)

WC12-2953_2-8B_PTABuildout

FEHR & PEERS



VOLUMES KEY

XX (YY)	AM (PM) Peak Hour Traffic Volumes
	Signalized Intersection
	Stop Sign
	"Free" Right Turn
	Yield Sign

Figure 2-9A.

Richmond Bay Campus
Existing Plus Phase 1 Peak Hour Traffic Volumes

WC12-2953_2-9A_Ex+Ph1Vols

FEHR PEERS

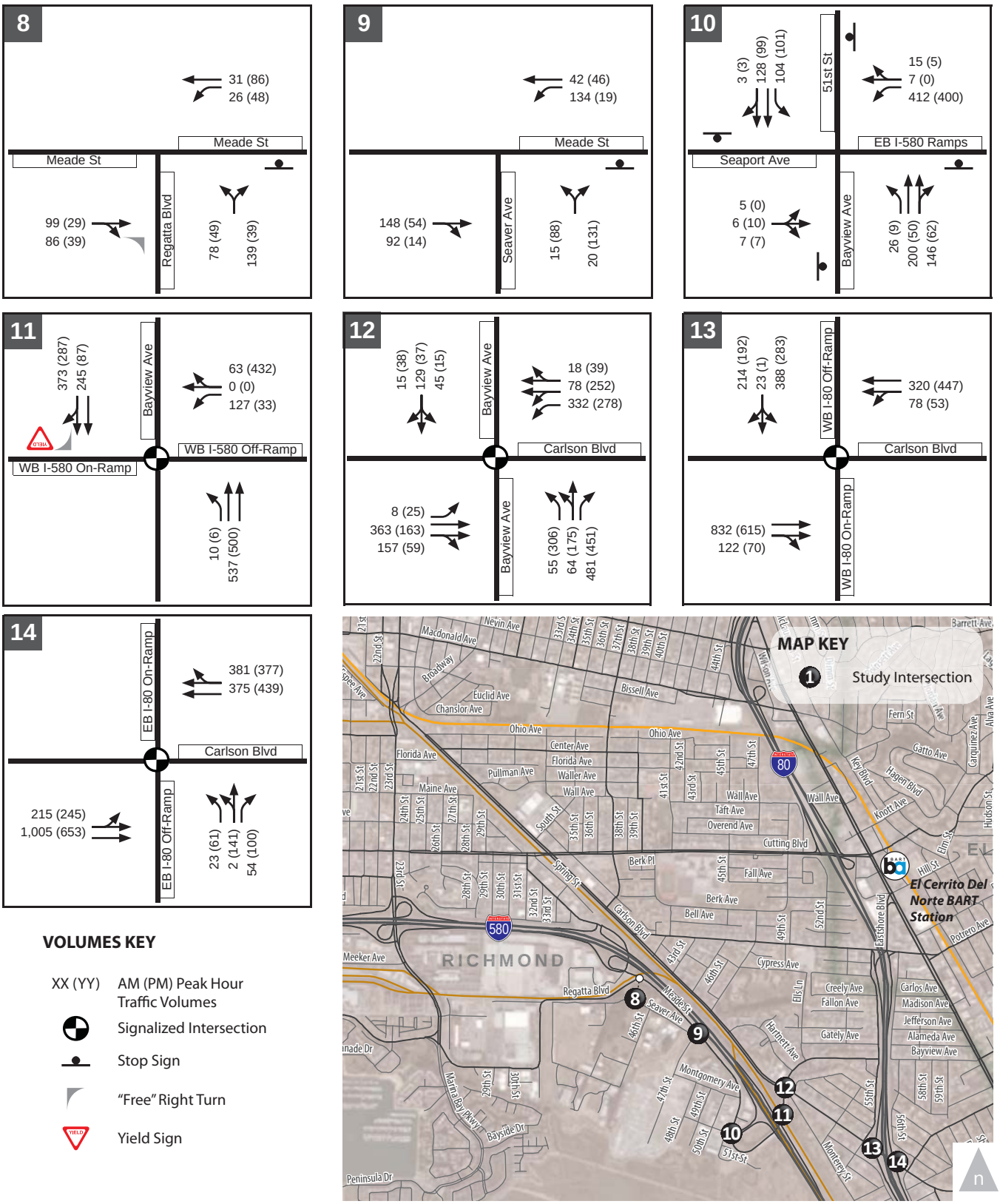


Figure 2-9B.

Richmond Bay Campus
Existing Plus Phase 1 Peak Hour Traffic Volumes

WC12-2953_2-9B_Ex+Ph1Vols

FEHR PEERS

1

TABLE 2-5
RICHMOND BAY CAMPUS
EXISTING PLUS PHASE 1 CONDITIONS – STUDY INTERSECTION LOS SUMMARY

Intersection	Traffic Control	Peak Hour	Existing		Existing Plus Phase 1 Project		Significant Impact?
			Delay[1] (seconds)	LOS[1]	Delay[1] (seconds)	LOS[1]	
1. Cutting Boulevard/ 23rd Street	Signal	AM	22.9	C	23.0	C	No
		PM	23.0	C	23.1	C	No
2. I-580 Westbound Ramps/ 23rd Street	Signal	AM	6.9	A	6.9	A	No
		PM	6.8	A	6.9	A	No
3. I-580 Eastbound Ramps/ 23rd Street	Signal	AM	3.6	A	3.6	A	No
		PM	6.3	A	6.4	A	No
4. Meeker Avenue/23rd Street/ Marina Bay Pkwy	Signal	AM	37.1	D	37.1	D	No
		PM	**115.8 (v/c=0.50)**	**F**	**115.8 (v/c=0.50)**	**F**	No
5. Regatta Boulevard/ Marina Bay Parkway	Signal	AM	30.0	C	39.8	D	No
		PM	43.6	D	51.2	D	No
6. I-580 Westbound Ramps/ Juliga Woods Street	Side Street Stop	AM	2.5 (10.0)	A (B)	2.5 (10.3)	A (B)	No
		PM	4.4 (10.9)	A (B)	5.0 (12.4)	A (B)	No
7. I-580 Eastbound Ramps/ Regatta Blvd/Meade Street	Signal	AM	9.7	A	10.8	B	No
		PM	9.1	A	10.4	B	No
8. Meade Street/ Regatta Boulevard	Side Street Stop	AM	6.4 (10.6)	A (B)	6.4 (12.3)	A (B)	No
		PM	5.6 (10.0)	A (B)	5.6 (10.0)	A (B)	No
9. Meade Street/ Seaver Avenue	Side Street Stop	AM	1.3 (9.7)	A (A)	3.4 (11.9)	A (B)	No
		PM	3.0 (9.0)	A (A)	7.2 (10.8)	A (B)	No
10. Seaport Avenue/I-580 Eastbound Ramps/South 51st Street/Bayview Avenue	All-way Stop	AM	27.6	D	33.3	D	No
		PM	20.0	C	22.9	C	No
11. I-580 Westbound Ramps/ Bayview Avenue	Signal	AM	5.4	A	11.3	B	No
		PM	6.7	A	7.0	A	No
12. Carlson Boulevard/ Bayview Avenue	Signal	AM	27.0	C	27.5	C	No
		PM	21.6	C	21.6	C	No
13. Carlson Boulevard/ I-80 Westbound Ramps	Signal	AM	19.3	B	20.5	C	No
		PM	20.0	B	19.4	B	No
14. Carlson Boulevard/ I-80 Eastbound Ramps	Signal	AM	10.7	B	11.0	B	No
		PM	9.8	A	9.8	A	No

Notes: **Bold** indicates an intersection operating at unacceptable LOS E or LOS F.
1. For signalized and all-way stop-controlled intersections, average intersection delay and LOS based on the 2000 HCM method is shown. For side-street stop-controlled intersections, delays for worst movement and average intersection delay are shown: intersection average (worst movement).

Source: Fehr & Peers.

1

TABLE 2-6
RICHMOND BAY CAMPUS
EXISTING PLUS PHASE 1 CONDITIONS
FREEWAY SEGMENT LOS SUMMARY

Freeway Segment	Type[1]	Dir[2]	Existing No Project				Existing Plus Phase 1 Project				Significant Impact?
			AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour		
			Density[3]	LOS	Density[3]	LOS	Density[3]	LOS	Density[3]	LOS	
1. I-580 between Harbor Way and Marina Bay Pkwy	Weave	EB	N/A	A	N/A	A	N/A	A	N/A	A	No
	Weave	WB	N/A	A	N/A	A	N/A	A	N/A	A	No
2. I-580 between Marina Bay Pkwy and Regatta Blvd	Weave	EB	N/A	A	N/A	A	N/A	A	N/A	A	No
	Weave	WB	N/A	A	N/A	A	N/A	A	N/A	A	No
3. I-580 between Regatta Blvd and Bayview Ave	Weave	EB	N/A	A	N/A	A	N/A	A	N/A	A	No
	Weave	WB	N/A	A	N/A	A	N/A	A	N/A	A	No
4. I-580 between Bayview Ave and Central Ave	Basic	EB	15.4	B	14.0	B	15.4	B	14.4	B	No
	Basic	WB	14.3	B	16.9	B	14.7	B	16.9	B	No
5. I-580 between Central Ave and I-80	Basic	EB	23.5	C	28.7	D	23.6	C	29.3	D	No
	Basic	WB	25.0	C	22.6	C	25.5	C	22.6	C	No
6. I-80 between Carlson Blvd and Potrero Ave	Basic	EB	21.3	C	27.3	D	21.3	C	27.5	D	No
	Basic	WB	29.5	D	24.0	C	29.7	D	24.0	C	No
7. I-80 at Gilman St Overpass	Basic	EB	21.7	C	27.3	D	22.0	C	27.3	D	No
	Basic	WB	30.9	D	25.6	C	31.0	D	25.9	C	No

1. Segments with auxiliary lanes are classified as weave segments, and were analyzed based on the Leisch Method. Basic segments are analyzed as basic segments using the 2000 HCM methodologies.
2. EB = Eastbound; WB = Westbound
3. Density is presented in passenger cars per lane per mile (pc/ln/mi).

Source: Fehr & Peers.

2

3

The addition of the Phase 1 Project traffic would not cause any of the study freeway segments to operate at an unacceptable LOS. Therefore, the Phase 1 Project would not cause a significant impact at the study freeway segments under Existing Plus Phase 1 Project conditions.

2.3.10 EXISTING PLUS PROJECT BUILDOUT CONDITIONS

Figures 2-10A and 2-10B show the Existing Plus Project Buildout traffic volumes, which consist of traffic volumes under Existing conditions (Figures 2-2A and 2-2B) plus Project Buildout traffic assignment (Figures 2-8A and 2-8B). This analysis assumes no roadway modifications under this scenario.

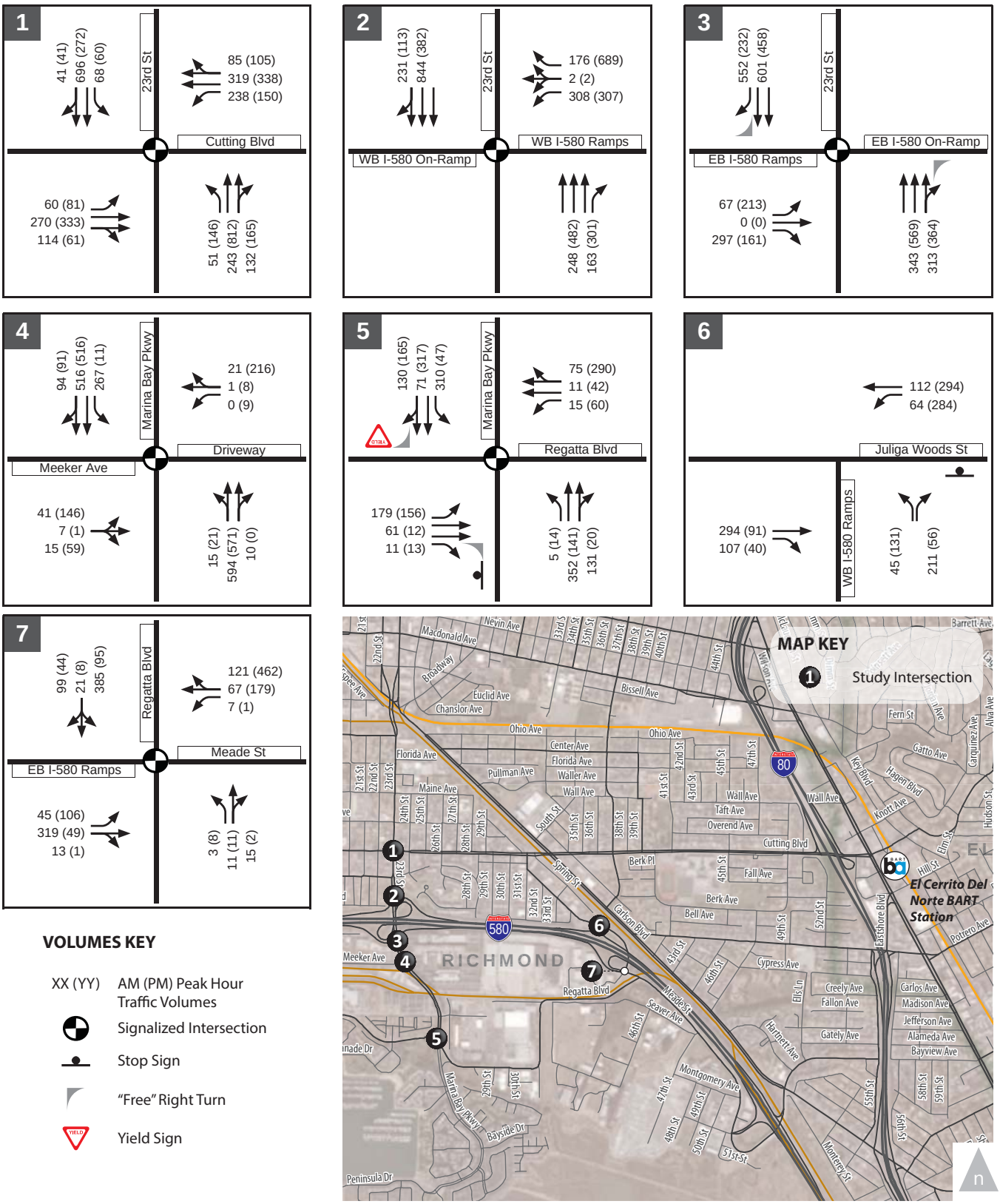
2.3.10.1 Intersection Operations

Table 2-7 summarizes intersection operations at the study intersections under the Existing Plus Project Buildout conditions. **Appendix B** provides the detailed calculation work sheets.

The addition of Project Buildout traffic would cause eight intersections to deteriorate from acceptable (LOS D or better) to unacceptable (LOS E or LOS F) conditions during one or both peak hours and would contribute to one intersection that currently operates at LOS F.

The addition of Project Buildout traffic would cause the side-street stop-controlled approach at the I-580 Westbound Ramps/Juliga Woods Street (Intersection 6) to degrade from LOS B to LOS F during the PM peak hour, and the side-street stop-controlled approach at the Meade Street/Regatta Boulevard (intersection 8) to degrade from LOS C to LOS F during the AM peak hour. However, these are not considered significant impacts because neither intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

The Project would cause a significant impact at seven intersections which are summarized under Impact 2-1 discussion.



VOLUMES KEY

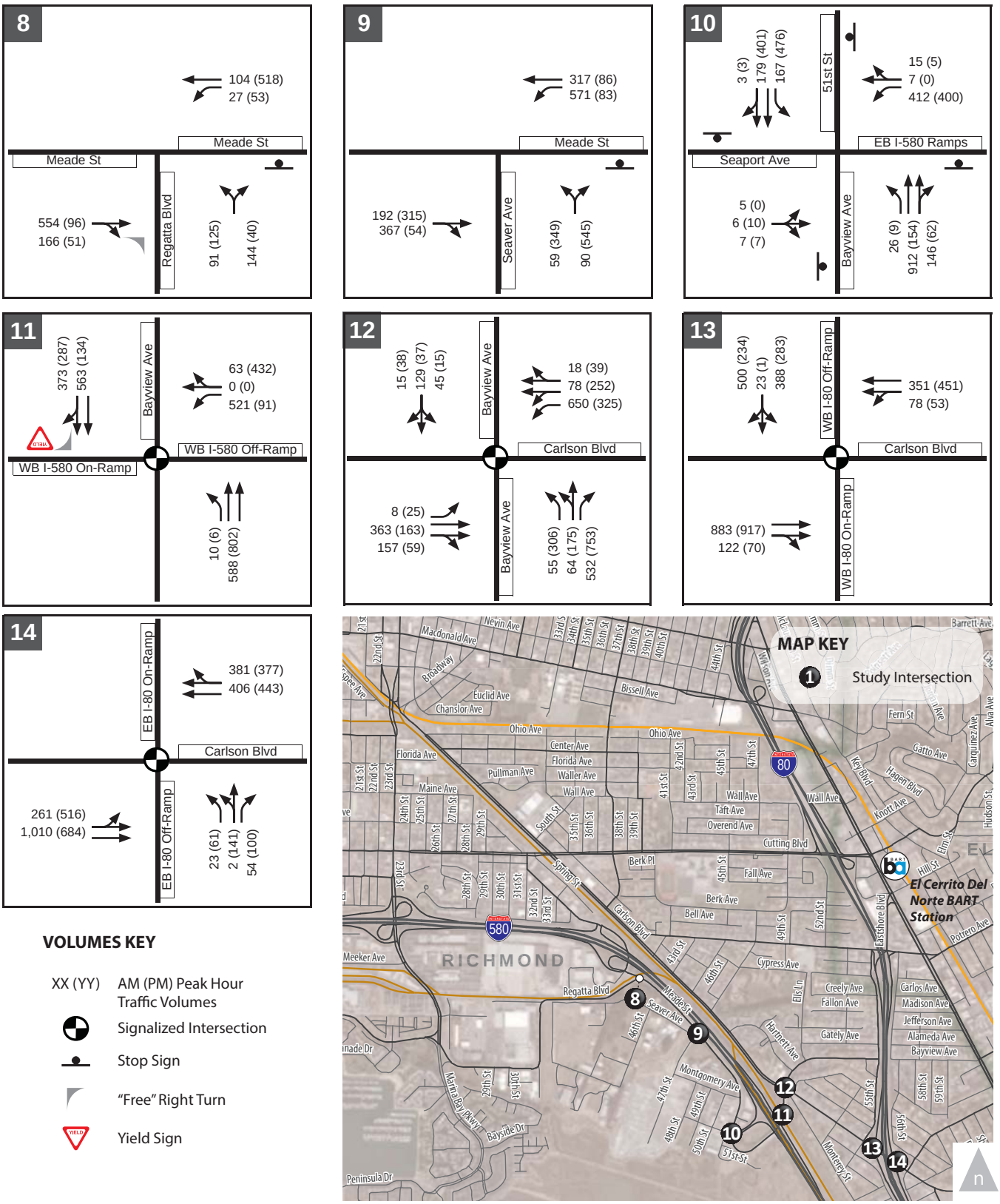
XX (YY)	AM (PM) Peak Hour Traffic Volumes
	Signalized Intersection
	Stop Sign
	"Free" Right Turn
	Yield Sign

Figure 2-10A.

Richmond Bay Campus
Existing Plus Buildout Peak Hour Traffic Volumes

WC12-2953_2-10A_Ex+BuildoutVols

FEHR PEERS



VOLUMES KEY

XX (YY)	AM (PM) Peak Hour Traffic Volumes
	Signalized Intersection
	Stop Sign
	"Free" Right Turn
	Yield Sign

Figure 2-10B.

Richmond Bay Campus
Existing Plus Buildout Peak Hour Traffic Volumes

WC12-2953_2-10B_Ex+BuildoutVols

FEHR & PEERS

1

TABLE 2-7
RICHMOND BAY CAMPUS
EXISTING PLUS BUILDOUT PROJECT CONDITIONS – STUDY INTERSECTION LOS SUMMARY

Intersection	Traffic Control	Peak Hour	Existing		Existing Plus Buildout Project		Significant Impact?
			Delay[1] (seconds)	LOS[1]	Delay[1] (seconds)	LOS[1]	
1. Cutting Boulevard/ 23rd Street	Signal	AM	22.9	C	25.3	C	No
		PM	23.0	C	24.4	C	No
2. I-580 Westbound Ramps/ 23rd Street	Signal	AM	6.9	A	7.1	A	No
		PM	6.8	A	6.8	A	No
3. I-580 Eastbound Ramps/ 23rd Street	Signal	AM	3.6	A	5.6	A	No
		PM	6.3	A	6.7	A	No
4. Meeker Avenue/23rd Street/ Marina Bay Pkwy	Signal	AM	37.1	D	37.1	D	No
		PM	**115.8 (v/c=0.50)**	**F**	**>120 (v/c=0.59)**	**F**	**Yes**
5. Regatta Boulevard/ Marina Bay Parkway	Signal	AM	30.0	C	**>120 (v/c=0.64)**	**F**	**Yes**
		PM	43.6	D	**69.3**	**E**	**Yes**
6. I-580 Westbound Ramps/ Juliga Woods Street	Side Street Stop	AM	2.5 (10.0)	A (A)	4.7 (13.1)	A (B)	No
		PM	4.4 (10.9)	A (B)	12.3 (**46.2**)	B (**E**)	No
7. I-580 Eastbound Ramps/ Regatta Boulevard/ Meade Street	Signal	AM	9.7	A	**>120 (v/c=1.03)**	**F**	**Yes**
		PM	9.1	A	19.5	B	No
8. Meade Street/ Regatta Boulevard	Side Street Stop	AM	6.4 (10.6)	A (B)	18.2 (82.9)	C (**F**)	No
		PM	5.6 (10.0)	A (B)	4.4 (21.4)	A (C)	No
9. Meade Street/ Seaver Avenue	Side Street Stop	AM	1.3 (9.7)	A (A)	**>120 (>120)**	**F (F)**	**Yes**
		PM	3.0 (9.0)	A (A)	**>120 (>120)**	**F (F)**	**Yes**
10. Seaport Avenue/I-580 Eastbound Ramps/South 51st Street/Bayview Avenue	All-way Stop	AM	27.6	D	**60.2**	**F**	**Yes**
		PM	20.0	C	**49.4**	**E**	**Yes**
11. I-580 Westbound Ramps/ Bayview Avenue	Signal	AM	5.4	A	**>120 (v/c=1.02)**	**F**	**Yes**
		PM	6.7	A	**109.1 (v/c=0.52)**	**F**	**Yes**
12. Carlson Boulevard/ Bayview Avenue	Signal	AM	27.0	C	34.7	C	No
		PM	21.6	C	22.5	C	No

TABLE 2-7
RICHMOND BAY CAMPUS
EXISTING PLUS BUILDOUT PROJECT CONDITIONS – STUDY INTERSECTION LOS SUMMARY

Intersection	Traffic Control	Peak Hour	Existing		Existing Plus Buildout Project		Significant Impact?
			Delay[1] (seconds)	LOS[1]	Delay[1] (seconds)	LOS[1]	
13. Carlson Boulevard/ I-80 Westbound Ramps	Signal	AM	19.3	B	**77.7**	**E**	**Yes**
		PM	20.0	B	20.0	B	No
14. Carlson Boulevard/ I-80 Eastbound Ramps	Signal	AM	10.7	B	14.6	B	No
		PM	9.8	A	14.1	B	No

Notes: **Bold** indicates an intersection operating at unacceptable LOS E or LOS F.
1. For signalized and all-way stop-controlled intersections, average intersection delay and LOS based on the 2000 HCM method is shown. For side-street stop-controlled intersections, delays for worst movement and average intersection delay are shown: intersection average (worst movement).

Source: Fehr & Peers.

IMPACT 2-1: EXISTING PLUS PROJECT BUILDOUT CONDITIONS INTERSECTION OPERATIONS

The buildout of the RBC would cause significant impacts at the following seven intersections under Existing Plus Buildout conditions:

A. The Project would cause a significant impact at the signalized **Meeker Avenue/23rd Street/Marina Bay Parkway** (Intersection 4) because it would increase v/c ratio by more than 0.01 during the PM peak hour at an intersection operating at LOS F regardless of the Project.

B. The Project would cause a significant impact at the signalized **Regatta Boulevard/ Marina Bay Parkway** (Intersection 5) because it would deteriorate intersection operations from LOS C to LOS F during the AM peak hour and from LOS D to LOS E during the PM peak hour.

C. The Project would cause a significant impact at the signalized **I-580 Eastbound Ramps/ Regatta Boulevard/Meade Street** (Intersection 7) because it would deteriorate intersection operations from LOS A to LOS F during the AM peak hour.

D. The Project would cause a significant impact at the side-street stop-controlled **Meade Street/Seaver Avenue** (Intersection 9) because it would deteriorate operations for the side-street stop-controlled approach from LOS A to LOS F during both AM and PM peak hours and the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

E. The Project would cause a significant impact at the all-way stop-controlled **Seaport Avenue/I-580 Eastbound Ramps/South 51st Street/Bayview Avenue** (Intersection 10) because it would deteriorate intersection operations from LOS D to LOS F during the AM

peak hour and from LOS C to LOS E during the PM peak hour. In addition, the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

F. The Project would cause a significant impact at the signalized **I-580 Westbound Ramps/ Bayview Avenue** (Intersection 11) because it would deteriorate intersection operations from LOS A to LOS F during both AM and PM peak hours.

G. The Project would cause a significant impact at the signalized **Carlson Boulevard/I-80 Westbound Ramps** (Intersection 13) because it would deteriorate intersection operations from LOS B to LOS E during the AM peak hour.

Mitigation Measure 2-1: Implement the following:

A. **Meeker Avenue/23rd Street/Marina Bay Parkway** (Intersection 4): Implement the following which requires coordination with City of Richmond:

- Convert the eastbound approach to provide one left-turn lane and one through-right lane
- Convert signal operations for the eastbound and westbound approaches from split phasing to protected left-turn phasing.
- Optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would improve to LOS C during both AM and PM peak hours after implementation of these improvements. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

B. **Regatta Boulevard/Marina Bay Parkway** (Intersection 5): Implement the following which requires coordination with City of Richmond:

- Optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would improve to LOS D during the AM peak hour after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

C. **I-580 Eastbound Ramps/Regatta Boulevard/Meade Street** (Intersection 7): Implement the following which requires coordination with City of Richmond and Caltrans:

- Optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would improve to LOS D during the AM peak hour after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

D. **Meade Street/Seaver Avenue** (Intersection 9): Implement the following which requires coordination with City of Richmond:

- Install an actuated signal at the intersection with protected/permitted phasing for the westbound left-turn movement.
- Convert the northbound approach to provide one left-turn lane and one right-turn lane.

The intersection would improve to LOS C during the AM peak hour and LOS B during the PM peak hour after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

E. **Seaport Avenue/I-580 Eastbound Ramps/Bayview Avenue** (Intersection 10): Implement the following which requires coordination with City of Richmond and Caltrans:

- Install an actuated signal at the intersection with protected phasing for the northbound and southbound left-turn movements.
- Convert the southbound approach to provide two left-turn lanes and one shared right-turn/through lane.

The intersection would improve to LOS C during both AM and PM peak hours after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

F. **I-580 Westbound Ramps/Bayview Avenue** (Intersection 11): Implement the following which requires coordination with City of Richmond and Caltrans:

- Optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would improve to LOS C during the AM peak hour and LOS B during the PM peak hour after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

G. **Carlson Boulevard/I-80 Westbound Ramps** (Intersection 13): Implement the following which requires coordination with City of Richmond and Caltrans:

- Optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would improve to LOS D during the AM peak hour after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

2.3.10.2 Freeway Operations

Table 2-8 shows the freeway segment LOS results for the Existing Plus Project Buildout conditions. **Appendix C** provides the detailed calculation work sheets.

TABLE 2-8
RICHMOND BAY CAMPUS
EXISTING PLUS BUILDOUT PROJECT CONDITIONS
FREEWAY SEGMENT LOS SUMMARY

Freeway Segment	Type[1]	Dir[2]	Existing No Project				Existing Plus Buildout Project				Significant Impact?
			AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour		
			Density[3]	LOS	Density[3]	LOS	Density[3]	LOS	Density[3]	LOS	
1. I-580 between Harbor Way and Marina Bay Pkwy	Weave	EB	N/A	A	N/A	A	N/A	A	N/A	A	No
	Weave	WB	N/A	A	N/A	A	N/A	A	N/A	A	No
2. I-580 between Marina Bay Pkwy and Regatta Blvd	Weave	EB	N/A	A	N/A	A	N/A	B	N/A	A	No
	Weave	WB	N/A	A	N/A	A	N/A	A	N/A	B	No
3. I-580 between Regatta Blvd and Bayview Ave	Weave	EB	N/A	A	N/A	A	N/A	A	N/A	A	No
	Weave	WB	N/A	A	N/A	A	N/A	A	N/A	A	No
4. I-580 between Bayview Ave and Central Ave	Basic	EB	15.4	B	14.0	B	16.0	B	17.4	B	No
	Basic	WB	14.3	B	16.9	B	17.9	B	17.4	B	No
5. I-580 between Central Ave and I-80	Basic	EB	23.5	C	28.7	D	24.4	C	37.0	E	No
	Basic	WB	25.0	C	22.6	C	31.7	D	23.4	C	No
6. I-80 between Carlson Blvd and Potrero Ave	Basic	EB	21.3	C	27.3	D	21.6	C	29.4	D	No
	Basic	WB	29.5	D	24.0	C	32.2	D	24.3	C	No
7. I-80 at Gilman St Overpass	Basic	EB	21.7	C	27.3	D	24.4	C	27.7	D	No
	Basic	WB	30.9	D	25.6	C	31.6	D	28.6	D	No

1. Segments with auxiliary lanes are classified as weave segments, and were analyzed based on the Leisch Method. Basic segments are analyzed as basic segments using the 2000 HCM methodologies.
2. EB = Eastbound; WB = Westbound
3. Density is presented in passenger cars per lane per mile (pc/ln/mi).

Source: Fehr & Peers.

The addition of Project Buildout traffic would not cause any study freeway segment to operate at an unacceptable LOS F. Therefore, Project Buildout would not cause a significant impact at the study freeway segments under Existing Plus Project Buildout conditions.

2.4 NEAR-TERM (2018) ANALYSIS

This section summarizes traffic operations under Near-Term (2018) No Project and Near-Term (2018) Plus Phase 1 Project conditions. Project Buildout conditions were not analyzed because no RBC development beyond Phase 1 would occur in 2018.

2.4.1 NEAR-TERM (2018) NO PROJECT CONDITIONS

The Near-Term (2018) No Project traffic volumes were developed by interpolating between the existing volumes (Figure 2-2) and the projected 2035 volumes (Figure 2-13), which were prepared using the CCTA Countywide Travel Demand Model and described in Section 2.5. **Figures 2-11A and 2-11B** show the Near-Term (2018) No Project traffic volumes.

The Near-Term (2018) No Project scenario assumes that signal timing parameters at the signalized study intersections would be optimized to reflect typical signal timing updates due to changing traffic flow over time. No other roadway modifications are assumed in the study area under the Near-Term (2018) No Project scenario.

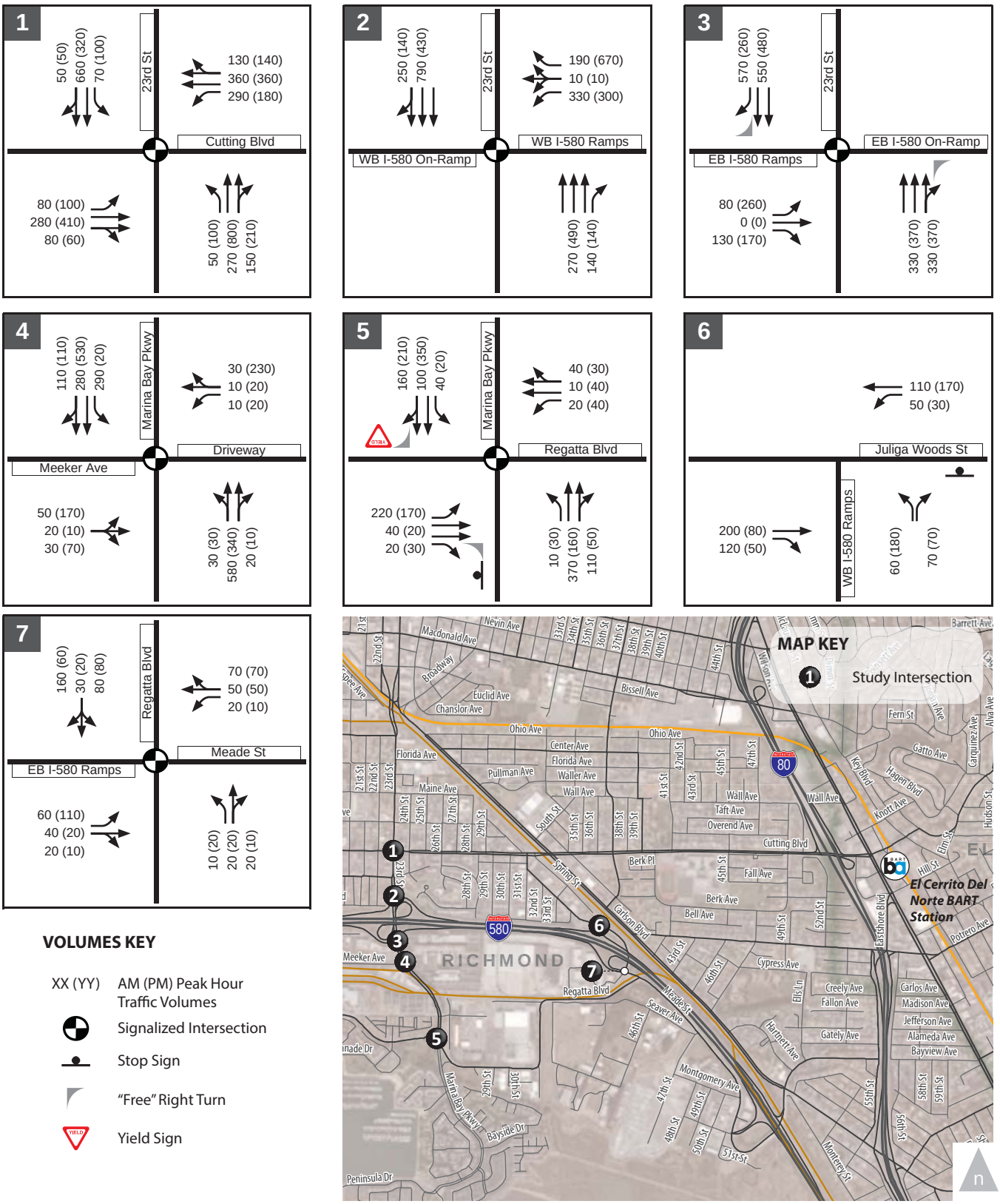
2.4.1.1 Intersection Operations

Table 2-9 summarizes the Near-Term (2018) No Project intersection LOS analysis results. **Appendix B** provides the detailed calculation work sheets.

All study intersections would continue to operate at LOS D or better, except Meeker Avenue/23rd Street/Marina Bay Parkway intersection, which would continue to operate at LOS F with additional delay during the PM peak hour.

2.4.1.2 Freeway Operations

Table 2-10 summarizes the AM and PM peak hour freeway LOS analysis results under Near-Term (2018) No Project conditions. **Appendix C** provides the detailed calculation work sheets. All freeway segments are projected to continue to operate at LOS D or better during both AM and PM peak hours.



VOLUMES KEY

XX (YY)	AM (PM) Peak Hour Traffic Volumes
	Signalized Intersection
	Stop Sign
	"Free" Right Turn
	Yield Sign

Figure 2-11A.

Richmond Bay Campus
Near-Term (2018) No Project Peak Hour Traffic Volumes

WC12-2953_2-11A_NT2018NPVols

FEHR PEERS

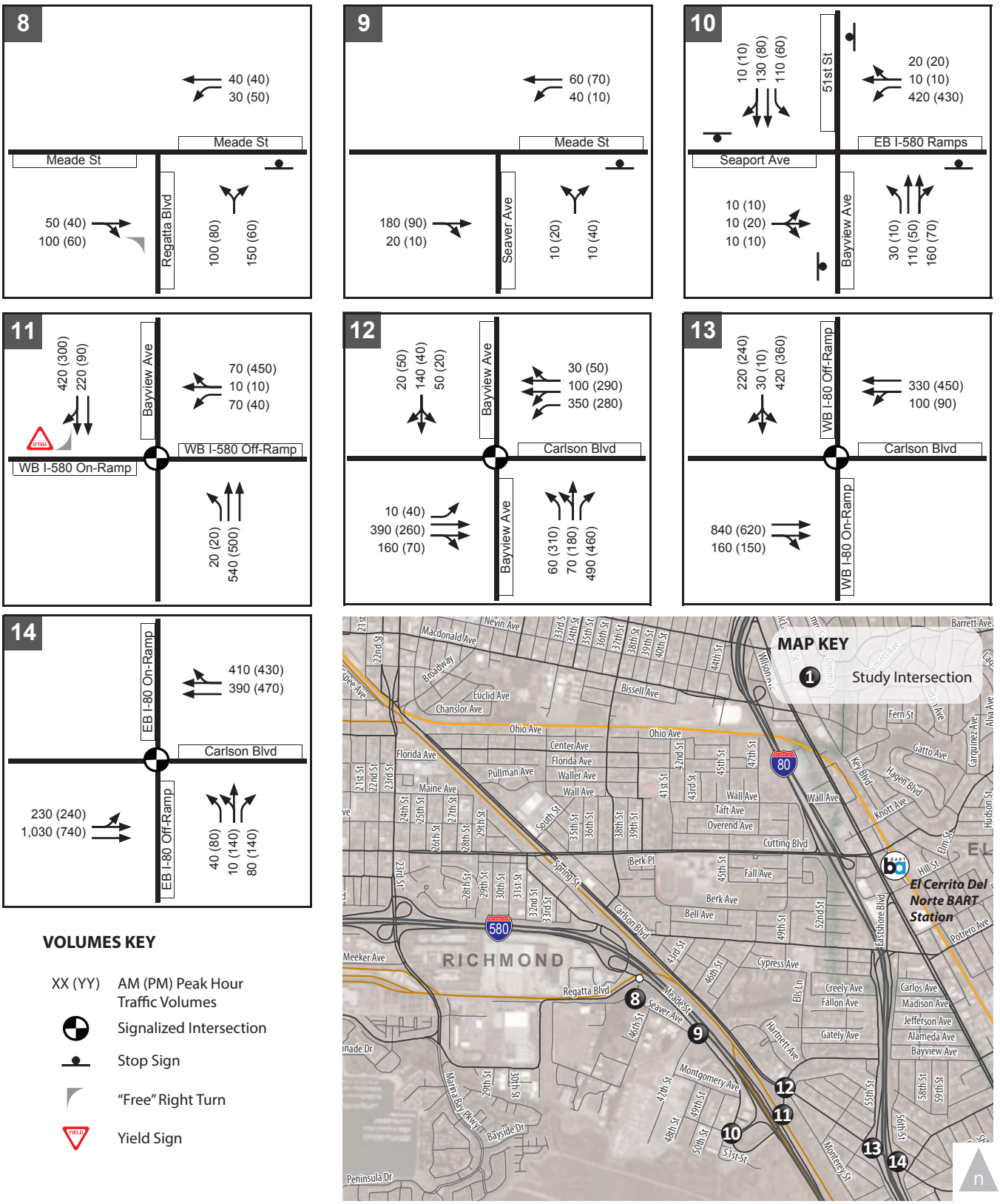


Figure 2-11B.

Richmond Bay Campus
Near-Term (2018) No Project Peak Hour Traffic Volumes

WC12-2953_2-11B_NT2018NPVols

FEHR & PEERS

TABLE 2-9
RICHMOND BAY CAMPUS
NEAR-TERM (2018) CONDITIONS – STUDY INTERSECTION LOS SUMMARY

Intersection	Traffic Control	Peak Hour	Near-Term (2018) No Project		Near-Term (2018) Plus Phase 1 Project		Significant Impact?
			Delay[1] (seconds)	LOS[1]	Delay[1] (seconds)	LOS[1]	
1. Cutting Boulevard/ 23rd Street	Signal	AM	24.4	C	24.9	C	No
		PM	24.5	C	24.6	C	No
2. I-580 Westbound Ramps/ 23rd Street	Signal	AM	7.3	A	7.3	A	No
		PM	7.5	A	7.5	A	No
3. I-580 Eastbound Ramps/ 23rd Street	Signal	AM	4.2	A	4.2	A	No
		PM	6.5	A	6.5	A	No
4. Meeker Avenue/23rd Street/ Marina Bay Pkwy	Signal	AM	40.0	D	40.0	D	No
		PM	**148.5 (v/c=0.54)**	**F**	**148.5 (v/c=0.54)**	**F**	No
5. Regatta Boulevard/ Marina Bay Parkway	Signal	AM	22.0	C	22.0	C	No
		PM	15.1	B	15.5	B	No
6. I-580 Westbound Ramps/ Juliga Woods Street	Side Street Stop	AM	3.1 (11.2)	A (B)	3.1 (11.6)	A (B)	No
		PM	5.5 (12.0)	A (B)	6.3 (14.0)	A (B)	No
7. I-580 Eastbound Ramps/ Regatta Blvd/Meade Street	Signal	AM	11.1	B	12.1	B	No
		PM	11.1	B	11.1	B	No
8. Meade Street/ Regatta Boulevard	Side Street Stop	AM	6.6 (11.5)	A (B)	6.6 (12.9)	A (B)	No
		PM	5.5 (10.4)	A (B)	5.5 (11.1)	A (B)	No
9. Meade Street/ Seaver Avenue	Side Street Stop	AM	1.6 (10.3)	A (B)	3.3 (12.5)	A (B)	No
		PM	2.7 (9.4)	A (A)	6.3 (11.1)	A (B)	No
10. Seaport Avenue/I-580 Eastbound Ramps/South 51st Street/Bayview Avenue	All-way Stop	AM	27.2	D	32.6	D	No
		PM	20.8	C	23.8	C	No
11. I-580 Westbound Ramps/ Bayview Avenue	Signal	AM	5.6	A	7.0	A	No
		PM	8.6	A	8.9	A	No
12. Carlson Boulevard/ Bayview Avenue	Signal	AM	28.6	C	29.2	C	No
		PM	24.5	C	24.6	C	No
13. Carlson Boulevard/ I-80 Westbound Ramps	Signal	AM	20.4	C	21.9	C	No
		PM	15.9	B	16.0	B	No
14. Carlson Boulevard/ I-80 Eastbound Ramps	Signal	AM	12.9	B	13.3	B	No
		PM	12.2	B	12.2	B	No

Notes: **Bold** indicates an intersection operating at unacceptable LOS E or LOS F.
1. For signalized and all-way stop-controlled intersections, average intersection delay and LOS based on the 2000 HCM method is shown. For side-street stop-controlled intersections, delays for worst movement and average intersection delay are shown: intersection average (worst movement).

Source: Fehr & Peers.

1

TABLE 2-10
RICHMOND BAY CAMPUS
NEAR-TERM (2018) CONDITIONS – FREEWAY SEGMENT LOS SUMMARY

Freeway Segment	Type[1]	Dir[2]	Near-Term (2018) No Project				Near-Term (2018) Plus Phase 1 Project				Significant Impact?
			AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour		
			Density[3]	LOS	Density[3]	LOS	Density[3]	LOS	Density[3]	LOS	
1. I-580 between Harbor Way and Marina Bay Pkwy	Weave	EB	N/A	A	N/A	B	N/A	A	N/A	B	No
	Weave	WB	N/A	A	N/A	A	N/A	A	N/A	A	No
2. I-580 between Marina Bay Pkwy and Regatta Blvd	Weave	EB	N/A	A	N/A	B	N/A	B	N/A	B	No
	Weave	WB	N/A	B	N/A	A	N/A	B	N/A	A	No
3. I-580 between Regatta Blvd and Bayview Ave	Weave	EB	N/A	B	N/A	B	N/A	B	N/A	B	No
	Weave	WB	N/A	B	N/A	A	N/A	B	N/A	A	No
4. I-580 between Bayview Ave and Central Ave	Basic	EB	17.8	B	17.1	B	17.9	B	17.4	B	No
	Basic	WB	17.3	B	18.6	C	17.6	B	18.7	C	No
5. I-580 between Central Ave and I-80	Basic	EB	26.1	D	32.8	D	26.2	D	33.7	D	No
	Basic	WB	29.1	D	24.0	C	29.8	D	24.1	C	No
6. I-80 between Carlson Blvd and Potrero Ave	Basic	EB	22.9	C	28.2	D	22.9	C	28.5	D	No
	Basic	WB	31.4	D	25.3	C	31.7	D	25.4	C	No
7. I-80 at Gilman St Overpass	Basic	EB	23.0	C	28.4	D	23.2	C	28.4	D	No
	Basic	WB	32.1	D	26.3	D	32.2	D	26.6	D	No

1. Segments with auxiliary lanes are classified as weave segments, and were analyzed based on the Leisch Method. Basic segments are analyzed as basic segments using the 2000 HCM methodologies.
2. EB = Eastbound; WB = Westbound
3. Density is presented in passenger cars per lane per mile (pc/ln/mi).

Source: Fehr & Peers.

2

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2.4.2 NEAR-TERM (2018) PLUS PHASE 1 PROJECT CONDITIONS

Figures 2-12A and 2-12B show the Near-Term (2018) Plus Phase 1 Project traffic volumes which consist of traffic volumes under Near-Term (2018) No Project conditions (Figures 2-11A and 2-11B) plus Phase 1 traffic assignment (Figures 2-7A and 2-7B).

2.4.2.1 Intersection Operations

Table 2-9 summarizes intersection operations at the study intersections under the Near-Term (2018) Plus Phase 1 Project conditions. **Appendix B** provides the detailed calculation work sheets.

The addition of the Phase 1 Project traffic would not cause any of the study intersections that currently operate at an acceptable LOS to degrade to an unacceptable LOS under Near-Term (2018) conditions. At the one intersection that would operate below the LOS standard regardless of the Project, Meeker Avenue/23rd Street/Marina Bay Parkway, the addition of project generated traffic would not change the overall v/c ratio. Therefore, the Phase 1 Project would not cause a significant impact at this or other study intersections under Near-Term (2018) Plus Phase 1 Project conditions.

2.4.2.2 Freeway Operations

Table 2-10 shows the freeway segment LOS results for the Near-Term (2018) Plus Phase 1 Project conditions. **Appendix C** provides the detailed calculation work sheets.

The addition of the Phase 1 Project traffic would not cause any of the study freeway segments to operate at an unacceptable LOS. Therefore, the Phase 1 Project would not cause a significant impact at the study freeway segments under Near-Term (2018) Plus Phase 1 Project conditions.

2.5 CUMULATIVE (2035) ANALYSIS

This section summarizes traffic operations under Cumulative (2035) No Project and Cumulative (2035) Plus Project Buildout conditions.

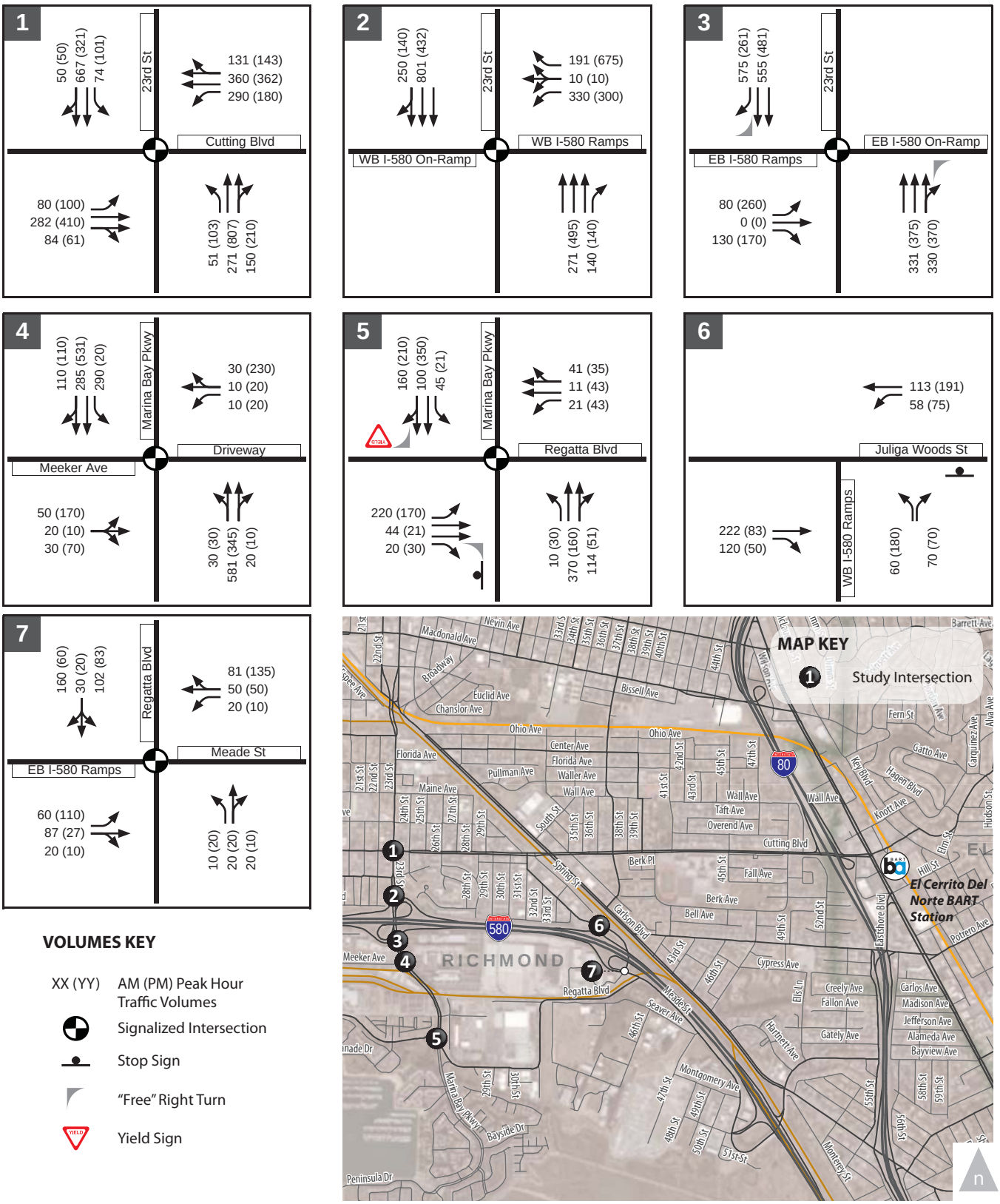
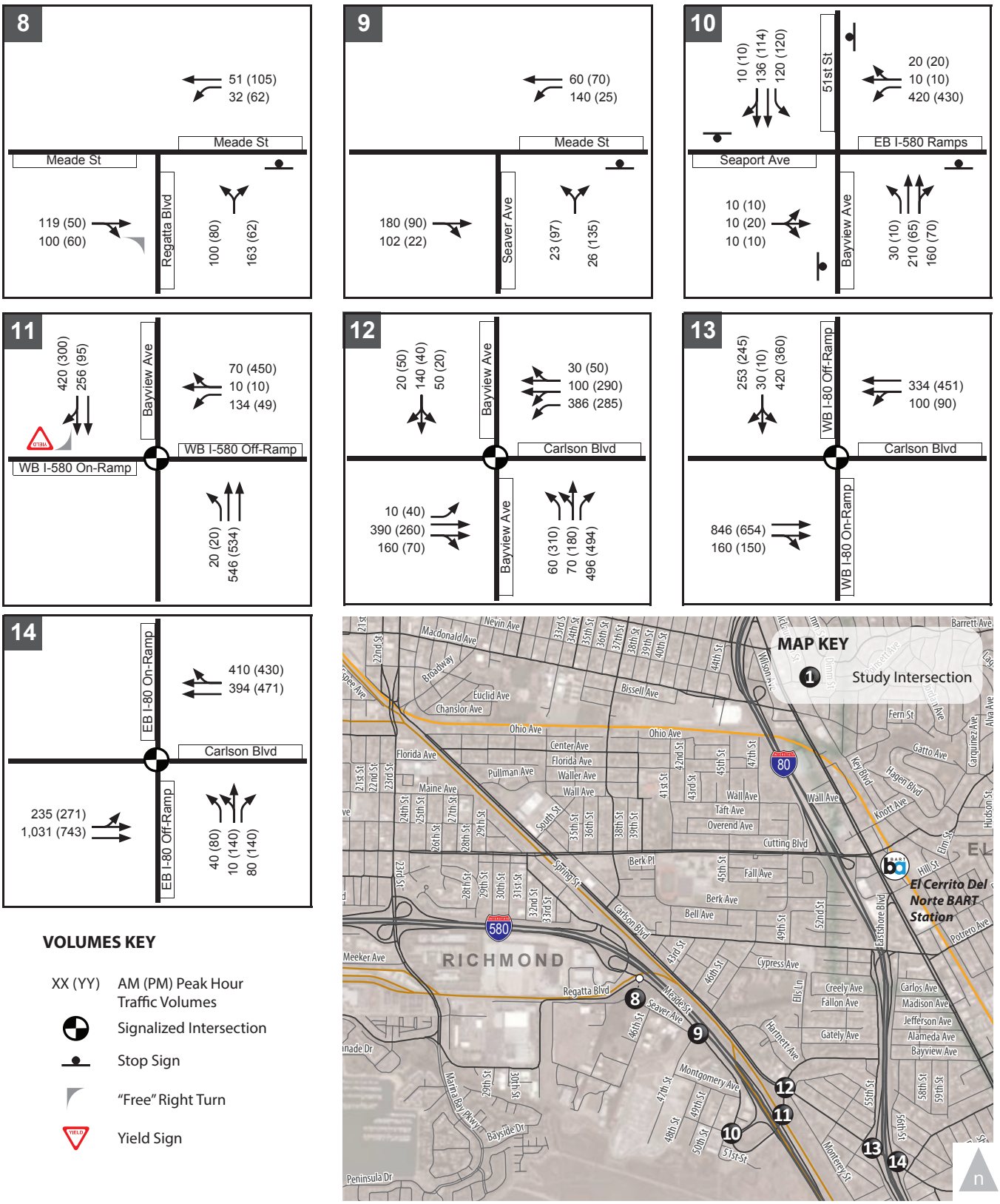


Figure 2-12A.

Richmond Bay Campus
Near-Term (2018) Plus Phase 1 Peak Hour Traffic Volumes

WC12-2953_2-12A_NT2018+Ph1Vols

FEHR PEERS



VOLUMES KEY

XX (YY)	AM (PM) Peak Hour Traffic Volumes
	Signalized Intersection
	Stop Sign
	"Free" Right Turn
	Yield Sign

Figure 2-12B.

Richmond Bay Campus
Near-Term (2018) Plus Phase 1 Peak Hour Traffic Volumes

WC12-2953_2-12B_NT2018+Ph1Vols

FEHR & PEERS

2.5.1 CUMULATIVE (2035) NO PROJECT CONDITIONS

Traffic forecasts to the year 2035 were developed based on the results of the CCTA Countywide Travel Demand Model. The most recent version of the CCTA Model, which reflects assumptions in residential and non-residential land use growth consistent with the Association of Bay Area Governments (ABAG) *Projections 2007,* served as the basis for developing AM and PM peak hour intersection turning movement forecasts for the year 2035. The Model land use database was checked to ensure the land use growth in Richmond is consistent with the recently adopted *General Plan 2030*. Consistent with CCTA's *Technical Procedures* (2006), the forecasting process involved running the 2010 and 2035 models and using the model produced volumes and existing turning movement count data, to estimate year 2035 intersection turn movements using the Furness[3] method. The 2035 model run did not assume any growth at the RBC site. **Figures 2-13A and 2-13B** shows the Cumulative (2035) No Project traffic volumes.

The Cumulative (2035) No Project scenario assumes that signal timing parameters at the signalized study intersections would be optimized to reflect typical signal timing updates due to changing traffic flow over several years. No other roadway modifications are assumed in the study area under the Cumulative (2035) No Project scenario.

2.5.1.1 Intersection Operations

Table 2-11 summarizes the Cumulative (2035) No Project intersection LOS analysis results. **Appendix B** provides the detailed calculation work sheets.

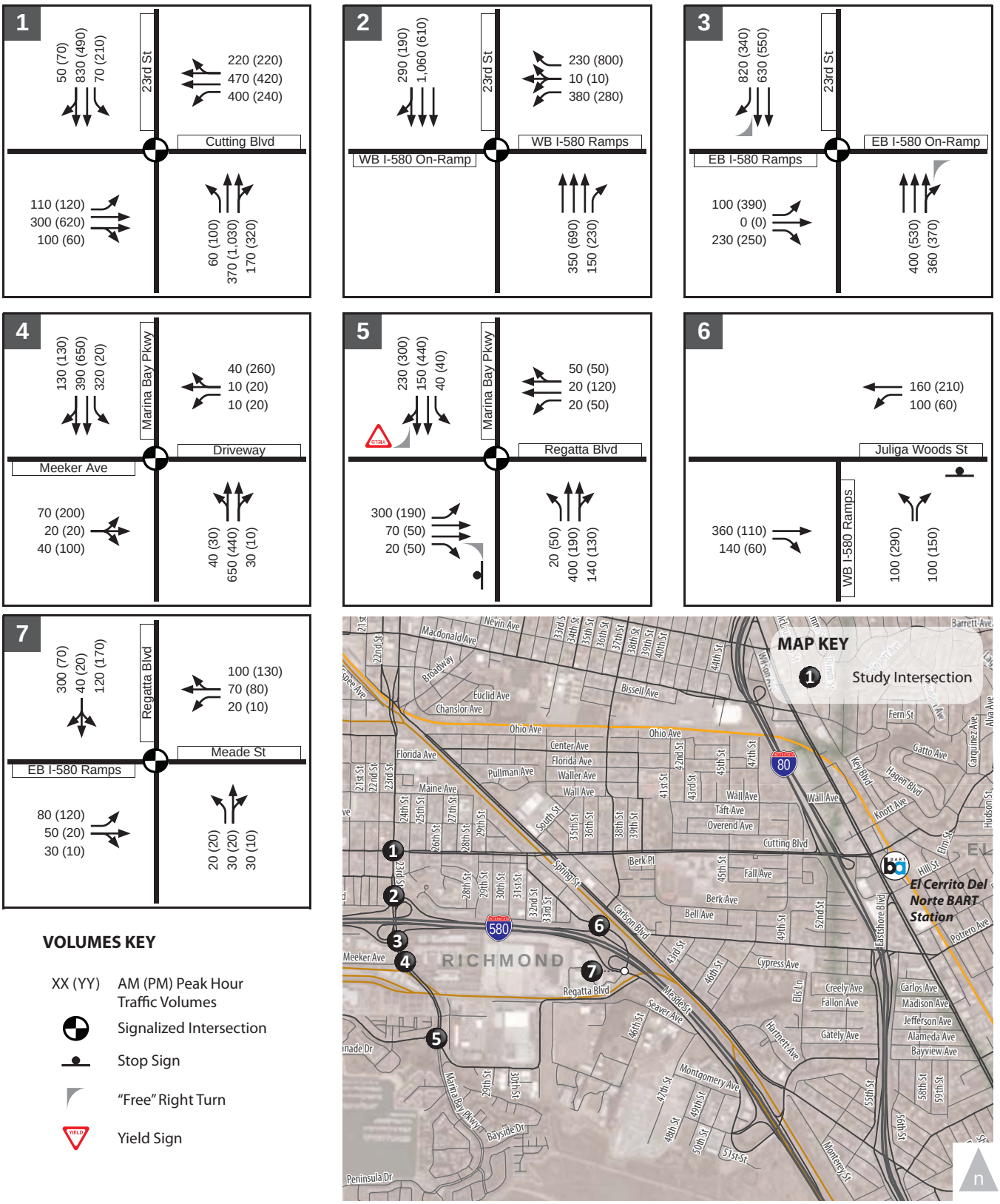
The delay at all study intersections would increase in comparison to Existing and Near-Term (2018) conditions. All study intersections would continue to operate at LOS D or better, except Meeker Avenue/ 23rd Street/Marina Bay Parkway intersection, which would continue to operate at LOS F during the PM peak hour.

2.5.1.2 Freeway Operations

Table 2-12 summarizes the AM and PM peak hour freeway LOS analysis results under Cumulative (2035) No Project conditions. **Appendix C** provides the detailed calculation work sheets.

All freeway segments are projected to continue to operate at LOS E or better during both AM and PM peak hours, except I-580 between Central Avenue and I-80 which would operate at LOS F in the eastbound direction during the PM peak hour.

[3] Furnessing is an iterative process that develops future turning movements by applying the difference between the base model volumes and the existing counts to future model approach and departure volumes.



VOLUMES KEY

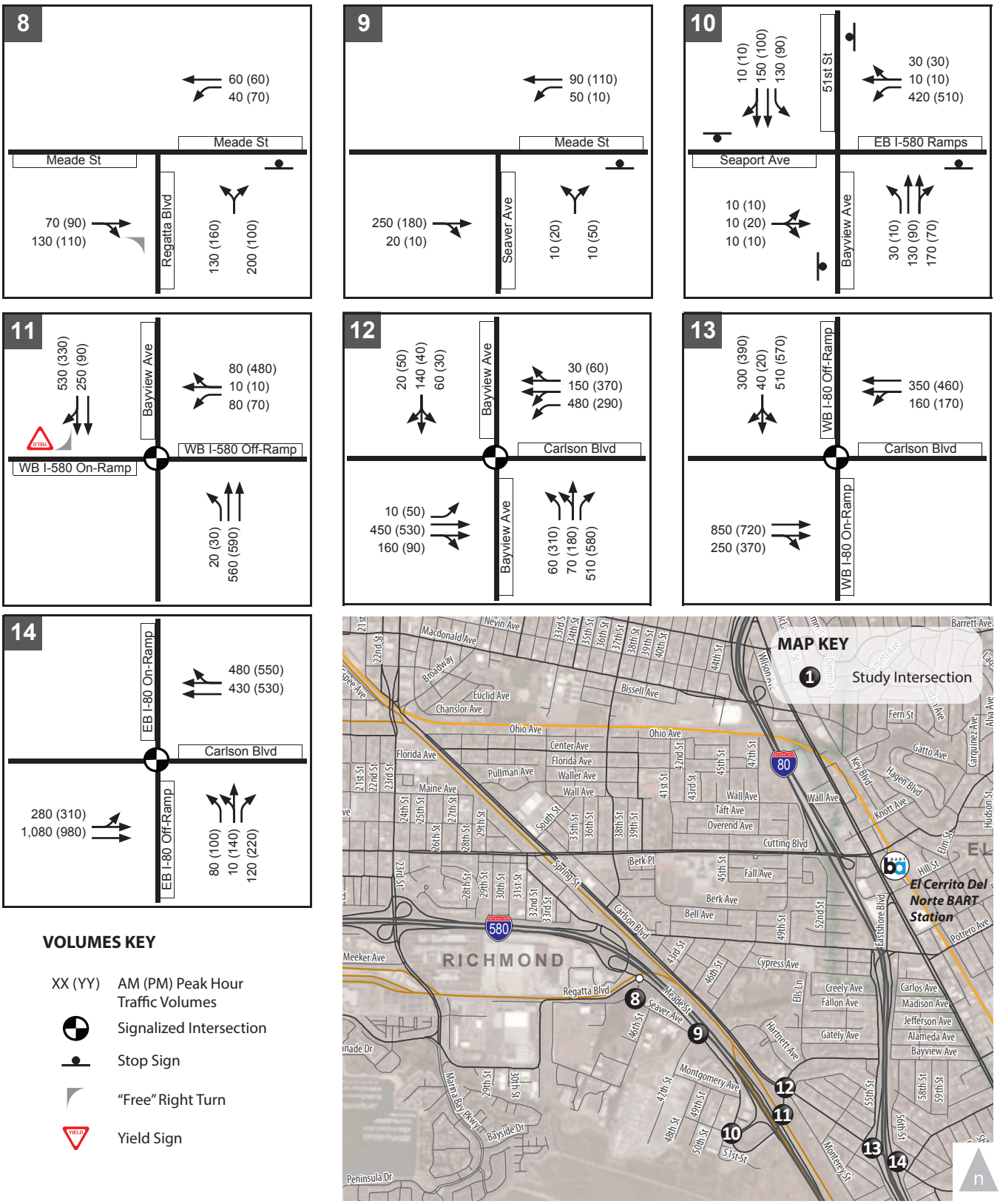
XX (YY)	AM (PM) Peak Hour Traffic Volumes
	Signalized Intersection
	Stop Sign
	"Free" Right Turn
	Yield Sign

Figure 2-13A.

Richmond Bay Campus
Cumulative (2035) No Project Peak Hour Traffic Volumes

WC12-2953_2-13A_Cumu2035NPVols

FEHR PEERS



VOLUMES KEY

XX (YY)	AM (PM) Peak Hour Traffic Volumes
	Signalized Intersection
	Stop Sign
	"Free" Right Turn
	Yield Sign

Figure 2-13B.

Richmond Bay Campus
Cumulative (2035) No Project Peak Hour Traffic Volumes

WC12-2953_2-13B_Cumu2035NPVols

FEHR PEERS

TABLE 2-11
RICHMOND BAY CAMPUS
CUMULATIVE (2035) CONDITIONS – STUDY INTERSECTION LOS SUMMARY

Intersection	Traffic Control	Peak Hour	Cumulative (2035) No Project		Cumulative (2035) Plus Buildout Project		Significant Impact?
			Delay[1] (seconds)	LOS[1]	Delay[1] (seconds)	LOS[1]	
1. Cutting Boulevard/ 23rd Street	Signal	AM	32.8	C	36.6	D	No
		PM	43.3	D	46.1	D	No
2. I-580 Westbound Ramps/ 23rd Street	Signal	AM	8.4	A	8.6	A	No
		PM	9.4	A	9.8	A	No
3. I-580 Eastbound Ramps/ 23rd Street	Signal	AM	4.8	A	7.7	A	No
		PM	7.8	A	8.8	A	No
4. Meeker Avenue/23rd Street/ Marina Bay Pkwy	Signal	AM	**61.4**	**E**	**61.4**	**E**	No
		PM	**>120 (v/c=0.65)**	**F**	**>120 (v/c=0.75)**	**F**	**Yes**
5. Regatta Boulevard/ Marina Bay Parkway	Signal	AM	28.2	C	35.0	C	No
		PM	17.4	B	20.9	C	No
6. I-580 Westbound Ramps/ Juliga Woods Street	Side Street Stop	AM	4.5 (17.0)	A (C)	8.3 (27.1)	A (D)	No
		PM	9.5 (18.0)	A (C)	**>120 (>120)**	**F (F)**	**Yes**
7. I-580 Eastbound Ramps/ Regatta Boulevard/ Meade Street	Signal	AM	17.8	B	54.9	D	No
		PM	13.8	B	41.9	D	No
8. Meade Street/ Regatta Boulevard	Side Street Stop	AM	7.5 (13.5)	A (B)	**46.3 (>120)**	**E (F)**	**Yes**
		PM	7.2 (14.3)	A (B)	47.6 **(>120)**	E **(F)**	**Yes**
9. Meade Street/ Seaver Avenue	Side Street Stop	AM	1.5 (11.2)	A (B)	**>120 (>120)**	**F (F)**	**Yes**
		PM	2.1 (10.2)	A (B)	**>120 (>120)**	**F (F)**	**Yes**
10. Seaport Avenue/I-580 Eastbound Ramps/South 51st Street/Bayview Avenue	All-way Stop	AM	30.9	D	**59.8**	**F**	**Yes**
		PM	**39.3**	**E**	**50.2**	**F**	**Yes**
11. I-580 Westbound Ramps/ Bayview Avenue	Signal	AM	6.6	A	25.7	C	No
		PM	10.7	B	13.6	B	No
12. Carlson Boulevard/ Bayview Avenue	Signal	AM	33.6	C	43.2	D	No
		PM	30.6	C	49.1	D	No
13. Carlson Boulevard/ I-80 Westbound Ramps	Signal	AM	43.6	D	**97.9 (v/c=1.21)**	**F**	**Yes**
		PM	**58.1**	**E**	**79.4**	**E**	**Yes**

TABLE 2-11
RICHMOND BAY CAMPUS
CUMULATIVE (2035) CONDITIONS – STUDY INTERSECTION LOS SUMMARY

Intersection	Traffic Control	Peak Hour	Cumulative (2035) No Project		Cumulative (2035) Plus Buildout Project		Significant Impact?
			Delay[1] (seconds)	LOS[1]	Delay[1] (seconds)	LOS[1]	
14. Carlson Boulevard/ I-80 Eastbound Ramps	Signal	AM	13.3	B	23.7	C	No
		PM	14.6	B	49.0	D	No

Notes: **Bold** indicates an intersection operating at unacceptable LOS E or LOS F.
1. For signalized and all-way stop-controlled intersections, average intersection delay and LOS based on the 2000 HCM method is shown. For side-street stop-controlled intersections, delays for worst movement and average intersection delay are shown: intersection average (worst movement).
Source: Fehr & Peers.

2.5.2 CUMULATIVE (2035) PLUS PROJECT BUILDOUT CONDITIONS

Figures 2-14A and 2-14B shows the Cumulative (2035) Plus Project Buildout volumes, which consist of traffic volumes under Cumulative (2035) No Project conditions (Figures 2-13A and 2-13B) plus Project Buildout traffic assignment (Figures 2-8A and 2-8B). This analysis assumes no roadway modifications under this scenario compared to the Cumulative (2035) No Project conditions.

2.5.2.1 Intersection Operations

Table 2-11 summarizes intersection operations at the study intersections under the Cumulative (2035) Plus Project Buildout conditions. **Appendix B** provides the detailed calculation work sheets.

The addition of Project Buildout traffic would cause six intersections to either deteriorate from acceptable (LOS D or better) to unacceptable (LOS E or LOS F) conditions or contribute to already unacceptable conditions during one or both peak hours.

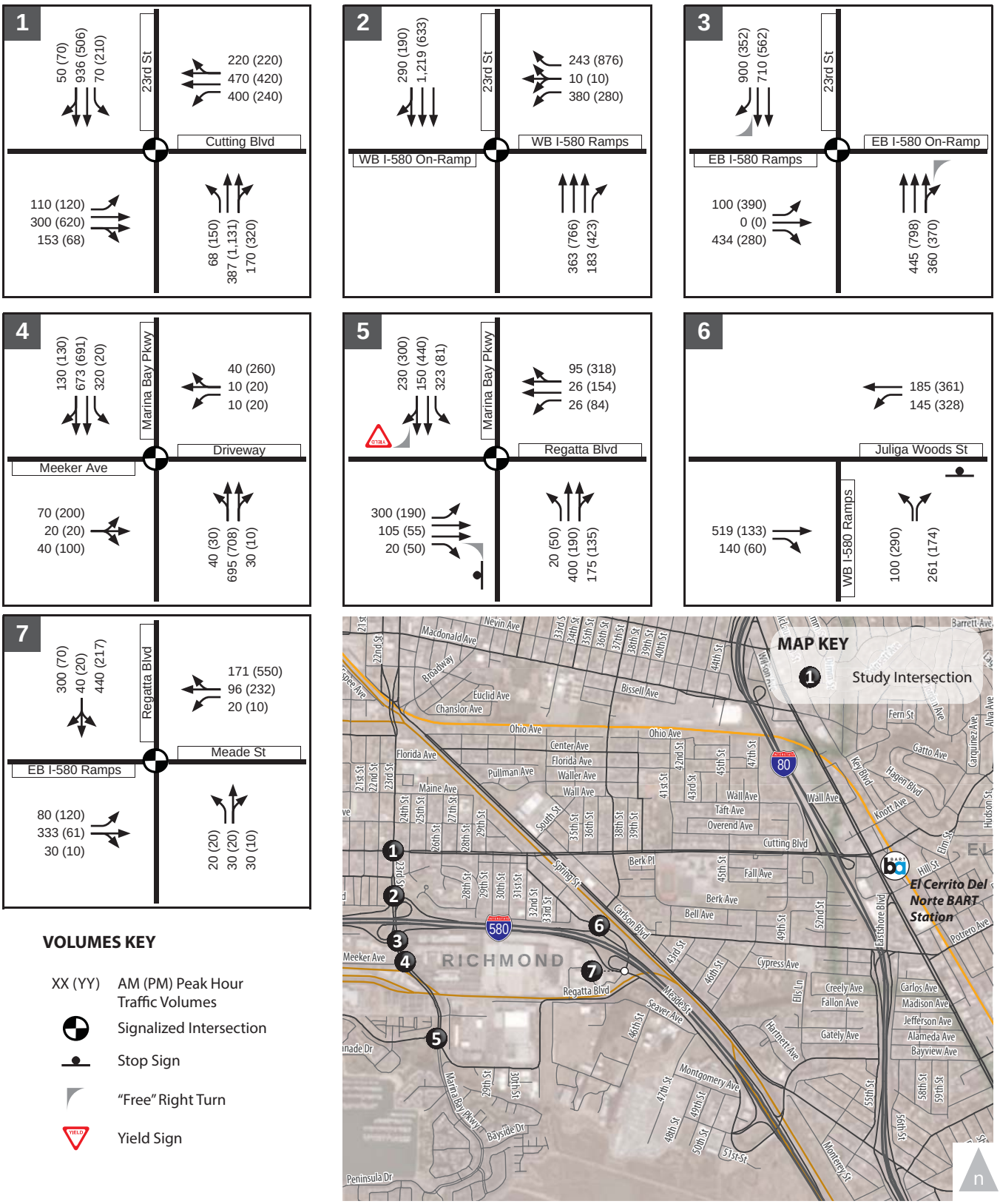
The Project would cause a significant impact at six intersections which are summarized under Impact 2-2 discussion.

TABLE 2-12
RICHMOND BAY CAMPUS
CUMULATIVE (2035) CONDITIONS – FREEWAY SEGMENT LOS SUMMARY

Freeway Segment	Type[1]	Dir[2]	Cumulative (2035) No Project				Cumulative (2035) Plus Project Buildout				Significant Impact?
			AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour		
			Density[3]	LOS	Density[3]	LOS	Density[3]	LOS	Density[3]	LOS	
1. I-580 between Harbor Way and Marina Bay Pkwy	Weave	EB	N/A	A	N/A	C	N/A	B	N/A	C	No
	Weave	WB	N/A	C	N/A	A	N/A	C	N/A	A	No
2. I-580 between Marina Bay Pkwy and Regatta Blvd	Weave	EB	N/A	B	N/A	C	N/A	B	N/A	C	No
	Weave	WB	N/A	C	N/A	B	N/A	C	N/A	C	No
3. I-580 between Regatta Blvd and Bayview Ave	Weave	EB	N/A	C	N/A	C	N/A	C	N/A	C	No
	Weave	WB	N/A	C	N/A	B	N/A	C	N/A	B	No
4. I-580 between Bayview Ave and Central Ave	Basic	EB	24.5	C	25.8	C	25.1	C	29.9	D	No
	Basic	WB	25.9	C	23.5	C	30.3	D	24.0	C	No
5. I-580 between Central Ave and I-80	Basic	EB	36.1	E	--	**F**	37.9	E	--	**F**	Yes
	Basic	WB	40.5	E	26.5	D	--	**F**	27.4	D	Yes
6. I-80 between Carlson Blvd and Potrero Ave	Basic	EB	27.2	D	31.5	D	27.5	D	34.3	D	No
	Basic	WB	37.6	E	28.8	D	42.2	E	29.2	D	No
7. I-80 at Gilman St Overpass	Basic	EB	26.2	D	32.2	D	29.5	D	32.8	D	No
	Basic	WB	35.1	E	28.3	D	36.0	E	31.8	D	No

Bold indicates freeway segment operating at unacceptable LOS.
1. Segments with auxiliary lanes are classified as weave segments, and were analyzed based on the Leisch Method. Basic segments are analyzed as basic segments using the 2000 HCM methodologies.
2. EB = Eastbound; WB = Westbound
3. Density is presented in passenger cars per lane per mile (pc/ln/mi).

Source: Fehr & Peers.



VOLUMES KEY

XX (YY)	AM (PM) Peak Hour Traffic Volumes
	Signalized Intersection
	Stop Sign
	"Free" Right Turn
	Yield Sign

Figure 2-14A.

Richmond Bay Campus
Cumulative (2035) Plus Buildout Peak Hour Traffic Volumes

WC12-2953_2-14A_Cumu2035+BuildoutVols

FEHR PEERS

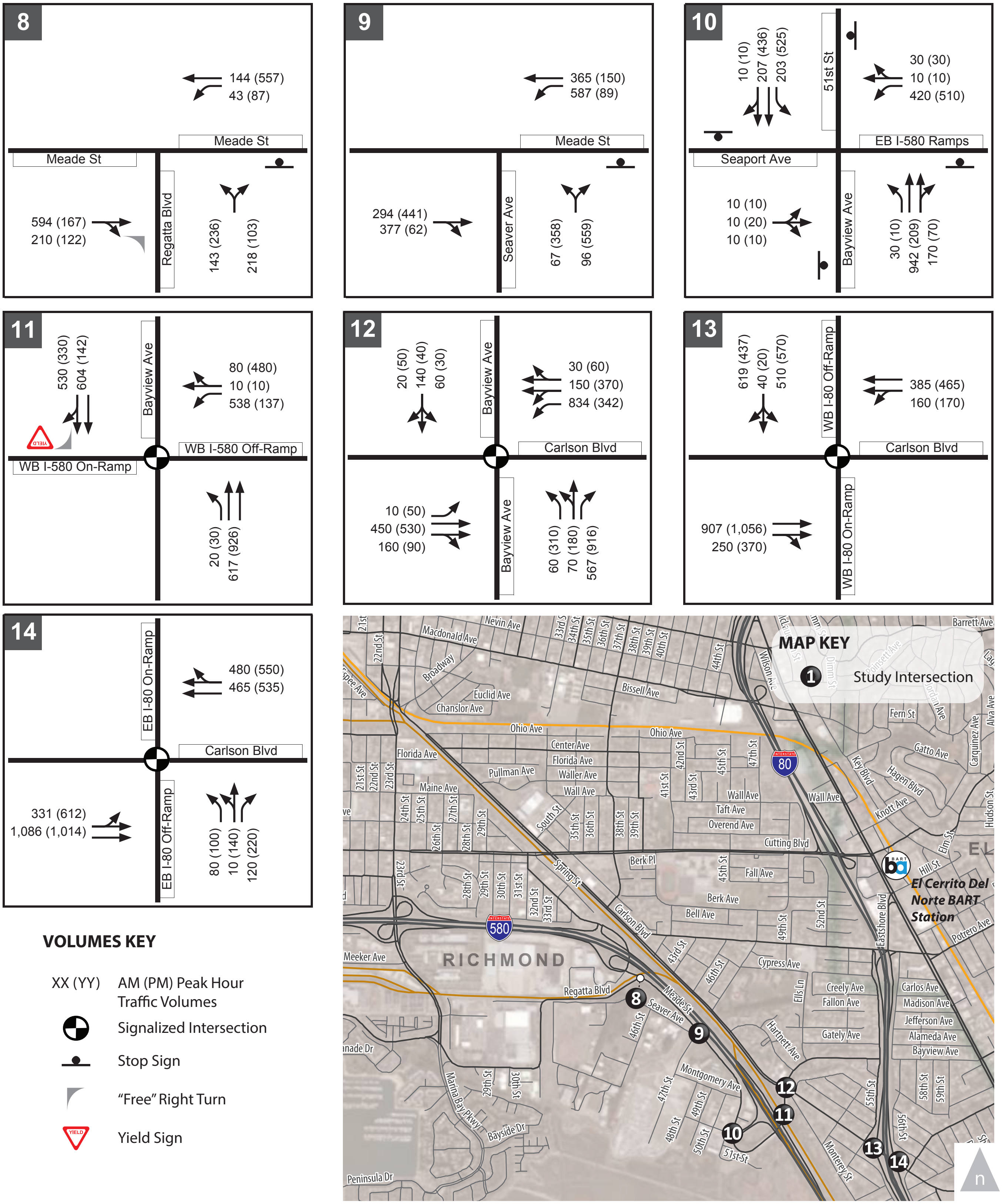


Figure 2-14B.

Richmond Bay Campus
Cumulative (2035) Plus Buildout Peak Hour Traffic Volumes

WC12-2953_2-14B_Cumu2035+BuildoutVols

FEHR & PEERS

IMPACT 2-2: CUMULATIVE (2035) PLUS PROJECT BUILDOUT CONDITIONS INTERSECTION OPERATIONS

The buildout of the RBC would cause significant impacts at the following six intersections under Cumulative (2035) Plus Buildout conditions:

A. The Project would cause a significant impact at the signalized **Meeker Avenue/23rd Street/Marina Bay Parkway** (Intersection 4) because it would increase v/c ratio by more than 0.01 during the PM peak hour at an intersection operating at LOS F regardless of the Project.

B. The Project would cause a significant impact at the side-street stop-controlled **I-580 Westbound Ramps/Juliga Woods Street** (Intersection 6) because it would deteriorate operations for the side-street stop-controlled approach from LOS C to LOS F during the PM peak hour and the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

C. The Project would cause a significant impact at the side-street stop-controlled **Meade Street/Regatta Boulevard** (Intersection 8) because it would deteriorate operations for the side-street stop-controlled approach from LOS B to LOS F during both AM and PM peak hours and the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

D. The Project would cause a significant impact at the side-street stop-controlled **Meade Street/Seaver Avenue** (Intersection 9) because it would deteriorate operations for the side-street stop-controlled approach from LOS B to LOS F during both AM and PM peak hours and the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

E. The Project would cause a significant impact at the all-way stop-controlled **Seaport Avenue/I-580 Eastbound Ramps/South 51st Street/Bayview Avenue** (Intersection 10) because it would deteriorate intersection operations from LOS D during the AM peak hour and LOS E during the PM peak hour to LOS F during both AM and PM peak hours. In addition, the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

F. The Project would cause a significant impact at the signalized **Carlson Boulevard/I-80 Westbound Ramps** (Intersection 13) because it would deteriorate intersection operations from LOS D to LOS F during the AM peak hour and LOS E to LOS F during the PM peak hour.

Mitigation Measure 2-2: Implement the following:

A. **Meeker Avenue/23rd Street/Marina Bay Parkway** (Intersection 4): Implement the following which requires coordination with City of Richmond (Same as Mitigation Measure 2-1A):

- Convert the eastbound approach to provide one left-turn lane and one through-right lane

- Convert signal operations for the eastbound and westbound approaches from split phasing to protected left-turn phasing. Optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would improve to LOS C during the AM peak hour and LOS D during the PM peak hour after implementation of these improvements. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

B. **I-580 Westbound Ramps/Juliga Woods Street** (Intersection 6): Implement the following which requires coordination with City of Richmond and Caltrans:

- Install an actuated signal at the intersection.

The intersection would improve to LOS A during both AM and PM peak hours after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

C. **Meade Street/Regatta Boulevard** (Intersection 8): Implement the following which requires coordination with City of Richmond:

- Install an actuated signal at the intersection. The new signal shall be connected and coordinated with the existing controls at the at-grade railroad crossing on Meade Street and the existing signal at the I-580 Eastbound Ramps/Regatta Boulevard/Meade Street (Intersection 7) just west of the intersection to minimize potential queues spilling onto the railroad tracks.

The intersection would improve to LOS B during both AM and PM peak hours after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

D. **Meade Street/Seaver Avenue** (Intersection 9): Implement the following which requires coordination with City of Richmond (Same as Mitigation Measure 2-1D):

- Install an actuated signal at the intersection with protected/permitted phasing for the westbound left-turn movement.
- Convert the northbound approach to provide one left-turn lane and one right-turn lane.

The intersection would improve to LOS D during the AM peak hour and LOS B during the PM peak hour after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

E. **Seaport Avenue/I-580 Eastbound Ramps/Bayview Avenue** (Intersection 10): Implement the following which requires coordination with City of Richmond and Caltrans (Same as Mitigation Measure 2-1E):

- Install an actuated signal at the intersection with protected phasing for the northbound and southbound left-turn movements.

- Convert the southbound approach to provide two left-turn lanes and one shared right-turn/through lane.

The intersection would improve to LOS C during both AM and PM peak hours after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

F. **Carlson Boulevard/I-80 Westbound Ramps** (Intersection 13): Implement the following which requires coordination with City of Richmond and Caltrans:

- Convert the southbound approach to provide one left-turn lane and one right-turn lane.

The intersection would improve to LOS C during both AM and PM peak hours after implementation of this improvement. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

2.5.2.2 Freeway Operations

Table 2-12 shows the freeway segment LOS results for the Cumulative (2035) Plus Project Buildout conditions. **Appendix C** provides the detailed calculation work sheets. The addition of Project Buildout traffic would cause one study freeway segment to operate at LOS F and contribute to one study freeway segment that would operate at LOS F regardless of the Project.

The Project would cause a significant impact at one freeway segment which is summarized under Impact 2-3 discussion.

IMPACT 2-3: CUMULATIVE (2035) PLUS PROJECT BUILDOUT CONDITIONS FREEWAY OPERATIONS

The buildout of the RBC would cause a significant impact under Cumulative (2035) Plus Buildout conditions on **I-580 between Central Avenue and I-80** in westbound direction during the AM peak hour and in the eastbound direction during the PM peak hour because the Project would cause the westbound segment to deteriorate from LOS E to LOS F during the AM peak hour and it increase the PM peak hour volume on the eastbound freeway segment by more than five percent on a freeway segment that would operate at LOS F regardless of the Project.

Mitigation Measure 2-3: This impact can be mitigated by increasing the freeway capacity through adding one more travel lane in each direction of I-580 in this section. No freeway capacity projects are currently planned by Caltrans for this section of I-580. In addition, the feasibility of implementing this mitigation measure is not known at this time. Therefore, this impact is conservatively considered to be *significant and unavoidable*.

2.6 ADDITIONAL EMPLOYMENT ALTERNATIVE ANALYSIS

This section presents trip generation for the Additional Employment Alternative scenario and summarizes traffic operations under the Near-Term (2018) Plus Additional Employment Alternative conditions. The Additional Employment Alternative would consist of an additional 200,000 square feet of space and accommodate an additional 700 employees at the RBC site.

2.6.1 TRIP GENERATION

Table 2-13 shows the estimated vehicle trip generation for the Additional Employment Alternative at the RBC site. The trip generation estimates is based on the same methodology used to estimate trip generation for the Phase 1 project as documented in section 2.3.7. The 700 additional employees under the Additional Employment Alternative at the RBC site are expected to increase trip generation to about 3,500 daily, 360 AM peak hour, and 340 PM peak hour automobile trips.

TABLE 2-13
RICHMOND BAY CAMPUS
ADDITIONAL EMPLOYMENT ALTERNATIVE VEHICLE TRIP GENERATION SUMMARY

	Average Daily Population	Daily	AM Peak Hour			PM Peak Hour		
			In	Out	Total	In	Out	Total
Project Phase 1 [1]	1,000	2,079	182	29	211	27	172	199
Additional Employees [1]	700	1,455	127	20	147	18	121	139
Additional Employment Alternative Total	1,700	3,534	309	49	358	45	293	338

1. Based on following trip generation rates:
Daily = 2.08 trips per Average Daily Population (ADP); AM Peak Hour = 0.21 trips per ADP (86% in, 14% out); PM Peak Hour = 0.20 trips per ADP (13% in, 87% out)

Source: Fehr & Peers, based on trip generation rate per average daily population at the existing LBNL site in Berkeley adjusted to reflect the different characteristics of the RBC.

2.6.2 NEAR-TERM (2018) PLUS ADDITIONAL EMPLOYMENT ALTERNATIVE CONDITIONS

Figures 2-15A and 2-15B show the traffic volumes under the Near-Term (2018) Plus Additional Employment Alternative conditions, which consists of traffic volumes under Near-Term (2018) No Project conditions plus traffic generated by the 1,000 Phase 1 employees and the 700 additional employees under the Additional Employment Alternative.

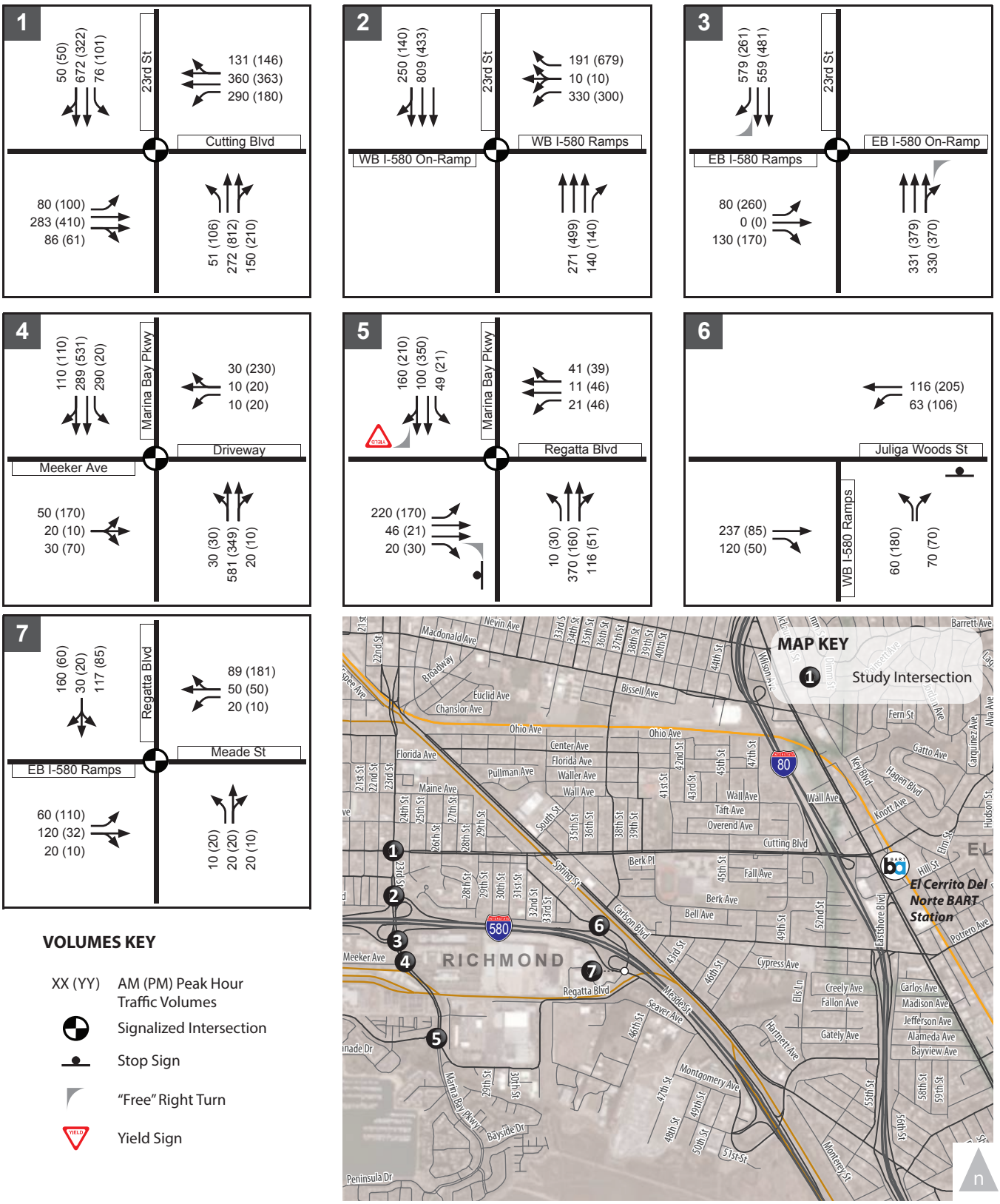


Figure 2-15A.

Richmond Bay Campus Near-Term (2018)
Plus Additional Employment Alternative Peak Hour Traffic Volumes

WC12-2953_2-15A_NT2018+AEAVols

FEHR PEERS

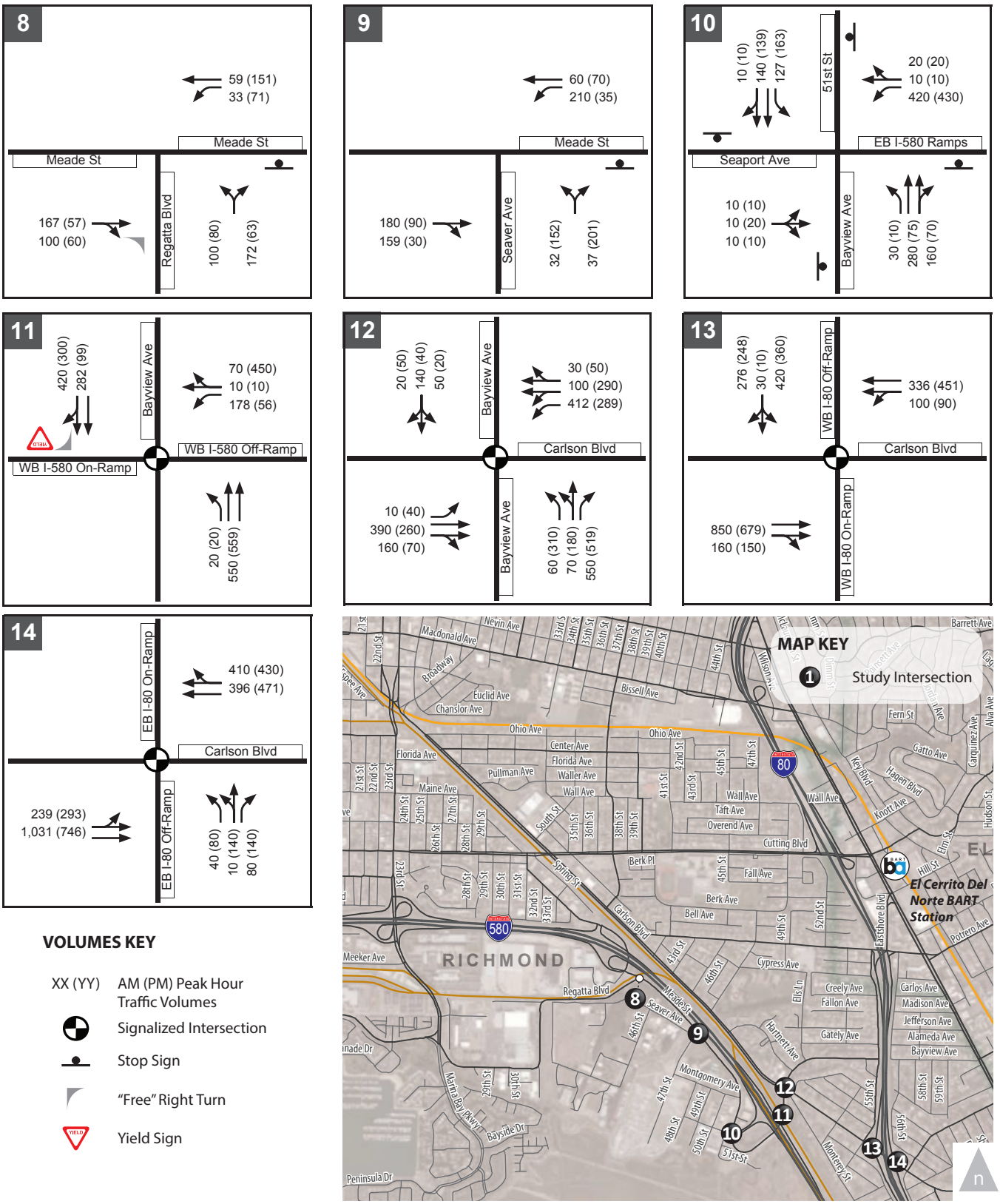


Figure 2-15B.

Richmond Bay Campus Near-Term (2018)
Plus Additional Employment Alternative Peak Hour Traffic Volumes

WC12-2953_2-12B_NT2018+AEAVols

FEHR PEERS

2.6.2.1 Intersection Operations

Table 2-14 summarizes intersection operations at the study intersections under the Near-Term (2018) Plus Additional Employment Alternative conditions. **Appendix B** provides the detailed calculation work sheets.

The traffic generated by the Additional Employment Alternative would not cause any of the study intersections that currently operate at an acceptable LOS to degrade to an unacceptable LOS under Near-Term (2018) conditions. At the one intersection that would operate below the LOS standard regardless of the Alternative, Meeker Avenue/23rd Street/Marina Bay Parkway, the addition of traffic generated by the Additional Employment Alternative would not change the overall v/c ratio. Therefore, the Alternative, combined with the Phase 1 Project would not cause a significant impact at this or other study intersections under Near-Term (2018) Plus Cumulative Alternative conditions.

2.6.2.2 Freeway Operations

Table 2-15 shows the freeway segment LOS results for the Near-Term (2018) Plus Additional Employment Alternative conditions. **Appendix C** provides the detailed calculation work sheets.

The addition of the Alternative traffic would not cause any of the study freeway segments to operate at an unacceptable LOS. Therefore, it would not cause a significant impact at the study freeway segments under Near-Term (2018) Plus Additional Employment Alternative conditions.

2.7 SITE ACCESS AND CIRCULATION IMPACTS

Various aspects of site access and circulation are discussed below.

2.7.1 VEHICULAR ACCESS AND CIRCULATION

Under Phase 1, the RBC site will have vehicle access only at the current location on Meade Street/Seaver Avenue intersection. The Conceptual Layout shows that at buildout, vehicle access to parking lots and structures would be provided at several locations along Regatta Boulevard, Meade Street, and South 46th Street. In addition, cross-campus vehicle circulation will be served via Lark Drive, extending east from Regatta Boulevard, and connecting to a north-south axis roadway that connects to Regatta Boulevard between South 34th Street and Meade Street. Cross-campus access via Lark Drive to South 46th Street may also be provided. These connections would allow campus employees and visitors to travel to/from the site without excessive circulation around the site periphery. The multiple access points from the

TABLE 2-14
RICHMOND BAY CAMPUS
ADDITIONAL EMPLOYMENT ALTERNATIVE (2018) CONDITIONS –
STUDY INTERSECTION LOS SUMMARY

Intersection	Traffic Control	Peak Hour	Near-Term (2018) No Project		Near-Term (2018) Plus Additional Employment Alternative		Significant Impact?
			Delay[1] (seconds)	LOS[1]	Delay[1] (seconds)	LOS[1]	
1. Cutting Boulevard/ 23rd Street	Signal	AM	24.4	C	25.1	C	No
		PM	24.5	C	24.8	C	No
2. I-580 Westbound Ramps/ 23rd Street	Signal	AM	7.3	A	7.3	A	No
		PM	7.5	A	7.5	A	No
3. I-580 Eastbound Ramps/ 23rd Street	Signal	AM	4.2	A	4.2	A	No
		PM	6.5	A	6.5	A	No
4. Meeker Avenue/23rd Street/ Marina Bay Pkwy	Signal	AM	40.0	D	40.0	D	No
		PM	**148.5 (v/c=0.54)**	**F**	**148.5 (v/c=0.54)**	**F**	No
5. Regatta Boulevard/ Marina Bay Parkway	Signal	AM	22.0	C	22.1	C	No
		PM	15.1	B	15.9	B	No
6. I-580 Westbound Ramps/ Juliga Woods Street	Side Street Stop	AM	3.1 (11.2)	A (B)	3.1 (11.9)	A (B)	No
		PM	5.5 (12.0)	A (B)	6.9 (16.0)	A (C)	No
7. I-580 Eastbound Ramps/ Regatta Blvd/Meade Street	Signal	AM	11.1	B	13.2	B	No
		PM	11.1	B	11.2	B	No
8. Meade Street/ Regatta Boulevard	Side Street Stop	AM	6.6 (11.5)	A (B)	6.5 (14.1)	A (B)	No
		PM	5.5 (10.4)	A (B)	4.6 (11.7)	A (B)	No
9. Meade Street/ Seaver Avenue	Side Street Stop	AM	1.6 (10.3)	A (B)	4.3 (15.4)	A (C)	No
		PM	2.7 (9.4)	A (A)	8.5 (13.2)	A (B)	No
10. Seaport Avenue/I-580 Eastbound Ramps/South 51st Street/Bayview Avenue	All-way Stop	AM	27.2	D	34.6	D	No
		PM	20.8	C	26.5	D	No
11. I-580 Westbound Ramps/ Bayview Avenue	Signal	AM	5.6	A	7.6	A	No
		PM	8.6	A	9.2	A	No
12. Carlson Boulevard/ Bayview Avenue	Signal	AM	28.6	C	29.7	C	No
		PM	24.5	C	24.6	C	No
13. Carlson Boulevard/ I-80 Westbound Ramps	Signal	AM	20.4	C	23.3	C	No
		PM	15.9	B	16.1	B	No
14. Carlson Boulevard/ I-80 Eastbound Ramps	Signal	AM	12.9	B	13.6	B	No
		PM	12.2	B	12.8	B	No

Notes: **Bold** indicates an intersection operating at unacceptable LOS E or LOS F.
1. For signalized and all-way stop-controlled intersections, average intersection delay and LOS based on the 2000

TABLE 2-14
RICHMOND BAY CAMPUS
ADDITIONAL EMPLOYMENT ALTERNATIVE (2018) CONDITIONS –
STUDY INTERSECTION LOS SUMMARY

HCM method is shown. For side-street stop-controlled intersections, delays for worst movement and average intersection delay are shown: intersection average (worst movement).
Source: Fehr & Peers.

1

TABLE 2-15
RICHMOND BAY CAMPUS
ADDITIONAL EMPLOYMENT ALTERNATIVE (2018) CONDITIONS –
FREEWAY SEGMENT LOS SUMMARY

Freeway Segment	Type[1]	Dir[2]	Near-Term (2018) No Project				Near-Term (2018) Plus Additional Employment Alternative				Significant Impact?
			AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour		
			Density[3]	LOS	Density[3]	LOS	Density[3]	LOS	Density[3]	LOS	
1. I-580 between Harbor Way and Marina Bay Pkwy	Weave	EB	N/A	A	N/A	B	N/A	A	N/A	B	No
	Weave	WB	N/A	A	N/A	A	N/A	A	N/A	A	No
2. I-580 between Marina Bay Pkwy and Regatta Blvd	Weave	EB	N/A	A	N/A	B	N/A	B	N/A	B	No
	Weave	WB	N/A	B	N/A	A	N/A	B	N/A	B	No
3. I-580 between Regatta Blvd and Bayview Ave	Weave	EB	N/A	B	N/A	B	N/A	B	N/A	B	No
	Weave	WB	N/A	B	N/A	A	N/A	B	N/A	A	No
4. I-580 between Bayview Ave and Central Ave	Basic	EB	17.8	B	17.1	B	17.9	B	17.6	B	No
	Basic	WB	17.3	B	18.6	C	17.9	B	18.7	C	No
5. I-580 between Central Ave and I-80	Basic	EB	26.1	D	32.8	D	26.2	D	34.3	D	No
	Basic	WB	29.1	D	24.0	C	30.4	D	24.2	C	No
6. I-80 between Carlson Blvd and Potrero Ave	Basic	EB	22.9	C	28.2	D	23.0	C	28.6	D	No
	Basic	WB	31.4	D	25.3	C	31.9	D	25.4	C	No
7. I-80 at Gilman St Overpass	Basic	EB	23.0	C	28.4	D	23.4	C	28.5	D	No
	Basic	WB	32.1	D	26.3	D	32.2	D	26.8	D	No

1. Segments with auxiliary lanes are classified as weave segments, and were analyzed based on the Leisch Method. Basic segments are analyzed as basic segments using the 2000 HCM methodologies.
2. EB = Eastbound; WB = Westbound
3. Density is presented in passenger cars per lane per mile (pc/ln/mi).

Source: Fehr & Peers.

campus periphery, combined with the internal circulation roadways, would distribute peak hour traffic volumes and reduce the project traffic volume at any one driveway or intersection.

Regatta Boulevard would be relocated to west and north of its current alignment so that through traffic using Regatta Boulevard would not travel through the RBC site and provide more connectivity between the eastern and western portions of the RBC. Although other internal RBC roadways may allow through traffic to traverse the RBC site, these streets would be designed to minimize automobile speeds to discourage through automobile traffic and prioritize pedestrian and bicycle travel in the RBC.

Traffic generated by the RBC would travel to and from the parking facilities in the RBC. Currently, the exact size, location, and access points of the parking facilities are not known. It is expected that as the size, location, and access points of each future parking facility is established, a more detailed analysis will be conducted to determine the infrastructure (i.e., number of lanes, signal, etc.) needed to serve each parking facility. Therefore, the impacts on vehicular access and circulation are expected to be less than significant.

2.7.2 PEDESTRIAN AND BICYCLE CIRCULATION

The City of Richmond's *Bicycle Master Plan* and *Pedestrian Plan* outline goals and policy objectives to guide and promote the development of bicycle and pedestrian facilities throughout the city and link these facilities, where possible, to other local and regional bicycle and pedestrian networks. Several of these goals and polices are applicable to development of the RBC. Goal 1 of the *Bicycle Master Plan* expands the city's bicycle routes and parking facilities into an extensive, well-connected and well-designed network, and would improve and maintain these facilities over time. Goal 4 incorporates the needs and concerns of cyclists in all transportation and development projects. Similarly, the Increased Connectivity and Increased Sustainability goals of the *Pedestrian Plan* seek to reduce physical barriers to walking and promote walking as a long-term transportation alternative to reduce vehicle miles travelled and climate change and air quality impacts.

The proposed bicycle and pedestrian networks of both plans show pathways through the area encompassing the RBC site connecting to the Bay Trail and to other existing and proposed facilities in the vicinity of the site. The primary pathway outlined in these plans would consist of a bicycle and pedestrian spine through the site connecting Seaver Avenue with the Bay Trail. While minimal detail is provided on the design of internal roadways or paths, the Conceptual Layout for the LRDP shows a pedestrian-friendly workplace, with buildings clustered together connected by tree-lined paths, and internal roadways that minimize walking distance between the two building clusters. Consistent with the goals in the bicycle and pedestrian plans, pathways would provide pedestrian and bicycle connections between the RBC, Meeker

Tidal Slough and the San Francisco Bay Trail. These pathways would also promote walking as an alternative to vehicular transportation within the site, consistent with the Increased Sustainability goal.

2.7.3 TRANSIT DEMAND

As previously described, two shuttle lines, serving UC Berkeley and LBNL campuses and El Cerrito Plaza BART Station, are proposed for the RBC. It is expected that hours of operations and frequency of service will be increased as the RBC expands and the number of employees increases.

As previously described, currently, AC Transit does not serve the RBC directly. However, it is expected that AC Transit would initiate direct service to the RBC as the number of employees and associated transit demand increases. This service may involve modifications of existing routes or a new route.

IMPACT 2-4: TRANSIT DEMAND

The Project would generate demand for bus transit service that may not be adequately served by the proposed RBC shuttles serving UC Berkeley, LBNL, and El Cerrito Plaza BART station. Although this is not considered a significant impact, the following improvement is recommended.

Environmental Protection Measure 2-4: The University of California shall implement the following:

- Regularly monitor the use of the proposed shuttle services and if necessary, adjust service frequency, stop location, and routes to better serve the RBC population.
- Coordinate with AC Transit and the City of Richmond to modify and/or extend current bus routes to serve demand generated by the RBC, as employment grows at the campus.

2.7.4 TRAFFIC HAZARDS

The proposed RBC LRDP would result in increased vehicular traffic and pedestrian and bicycle activity in and around the Project site. The LRDP proposes gateway elements to orient the visitor that they are arriving at the RBC, and vehicular access would be limited primarily to the perimeter of the campus to promote pedestrian and bicycle activity and safety. The exception is Lark Drive, which would provide an important link to adjoining research and industrial districts to the east as they are developed with the LRDP. Lark Drive would also provide public access into the campus, including access to public amenities, including the San Francisco Bay Trail. The LRDP proposes to design this street to discourage cut-through traffic or speeding, and proposes design elements, such as narrow roadway width, stop signs or other traffic controls, street alignment (e.g., curve radii), and special paving to denote pedestrian crossing zones. This design, combined with the design of other internal and access streets, would minimize potential

conflicts between different modes of travel and provide safe and efficient pedestrian, bicycle, and vehicular access and circulation throughout the RBC. Although, detailed design for various buildings, parking facilities, and internal roadways and pathways has not been completed, the final design for each project element will be reviewed to ensure consistency with applicable design standards. In addition, the proposed uses at the RBC are similar to and consistent with the existing uses at the site. Thus, the proposed Project would not cause a significant impact by substantially increasing traffic hazards to motor vehicles, bicycles, or pedestrians due to a design feature or incompatible uses.

2.7.5 RAILROAD CROSSINGS

The existing at-grade railroad crossing on Marina Bay Parkway is expected to be replaced by a grade separated crossing, which will also provide grade separated facilities for bicycles and pedestrians. Construction is scheduled to begin in 2013. Thus, neither the Phase 1 Project, nor the buildout project would cause an impact at this location.

The other at-grade railroad crossing is on Meade Street between the RBC and I-580 Interchange at Regatta Boulevard/Juliga Woods Street. The recently completed Meade Street bypass allows traffic on Regatta Boulevard to access I-580 further east via Meade Street and the Bayview Avenue Interchange without crossing the at-grade railroad tracks. At both Phase 1 and buildout of the RBC, drivers who may typically use the Regatta Boulevard/Juliga Woods Street to travel to and from the site have a choice of using different streets to access the site. Thus, if trains are using the at-grade crossing and blocking through vehicular traffic, drivers can divert to other streets. Mitigation Measure 2-2C would also signalize the recently constructed Meade Street/Regatta Boulevard (Intersection 8) and interconnect the signal operations with the controls at the at-grade railroad crossing and the existing signal at the I-580 Eastbound Ramps/Regatta Boulevard/Meade Street (intersection 7). This improvement would minimize the potential for vehicular queues at either intersection to spill back onto the railroad tracks.

The at-grade railroad crossing on Meade Street provides a center median and directional safety gates that prevent automobiles and bicycles from crossing the tracks when trains are passing. The crossing currently provides a sidewalk on the north side of the roadway which also provides a safety gate to prevent pedestrians from crossing the tracks when trains are passing. The crossing currently provides a sidewalk on the north side of the roadway which provides a safety gate. In addition, considering the infrequent use of the at-grade crossing by trains, and that the at-grade crossing currently provides safety features such as gates and bells, the Project would not cause a significant impact at this at-grade railroad crossing.

2.7.6 CONSISTENCY WITH ADOPTED POLICIES, PLANS OR PROGRAMS SUPPORTING ALTERNATIVE TRANSPORTATION

The proposed RBC LRDP is consistent with adopted policies, plans, and programs that support alternative transportation and would not cause a significant impact by conflicting with adopted policies, plans, or programs supporting public transit, bicycle, or pedestrian through the following:

- The Conceptual Layout locates parking facilities in the parameter of the RBC site and provides paths connecting the various buildings. Thus, walking would be the primary mode of transportation for internal trips within the RBC. This is consistent with the Increased Connectivity, Improved Health, and Increased Sustainability goals of the *Pedestrian Plan*.
- The LRDP would provide connections to Bay Trail and other planned bicycle facilities in City of Richmond, consistent with Goals 1 and 4 of the Bicycle Master Plan.
- The Project would provide adequate bicycle parking and amenities such as showers and lockers. The Project may also provide bike sharing. This is consistent with the objective of doubling the number of bicycle parking spaces per Goal 1 of the *Bicycle Master Plan*.
- The LRDP would not prevent the installation of planned and proposed pedestrian and bicycle facilities in the City of Richmond as previously described in Section 2.1.5, consistent with Goal 1 of the *Bicycle Master Plan* and the Increased Connectivity goal of the *Pedestrian Plan*.
- The Project would include a robust Transportation Demand Management Program (TDM) program that provides incentives that encourage the use of transit, walking, biking, and carpooling. This is consistent with Policy CR5.1 of the Circulation Element of the City of Richmond General Plan 2030.
- The Project would provide on-site amenities, such as food service and temporary housing, that would reduce the need for off-site travel. This would be consistent with the Increased Sustainability goal of the *Pedestrian Plan*.
- The Project would provide frequent shuttle service to BART, UC Berkeley, and LBNL, consistent with Goal 4 of the Bicycle Master Plan and Goal CR3 of the Circulation Element.
- The high number of employees expected at buildout of the RBC would make extending transit service in the project area more viable, consistent with Goal CR3 of the Circulation Element.

Thus, the proposed RBC Project would not cause a significant impact on consistency with adopted policies, plans, and programs that support alternative transportation.

2.7.7 EMERGENCY ACCESS

The nearest fire station to the RBC site is Richmond Fire Department Station 64, which is located at 4801 Bayview Avenue, about one-half mile to the east of the site. It is expected that Richmond Fire Department would continue to provide emergency services at the RBC through Phase 1 of the Project. However, the LRDP anticipates construction of an on-site fire station when sufficient development is provided within the RBC.

The overall RBC site would continue to provide multiple access points and each facility would also be designed to provide multiple access points. Thus, if one site access were blocked, the other access point(s) could be used by emergency vehicles to reach any part of the campus or specific building. In addition, all RBC buildings and internal streets would be designed to accommodate access by fire apparatus and other emergency response vehicles.

Thus, there would be adequate emergency service and access after Phase 1 and at buildout, and the Project would not cause a significant impact on emergency access.

2.7.8 CONSTRUCTION PERIOD IMPACTS

Construction of Phase 1 Project is expected to start in 2014. Construction activity at the RBC site is estimated to continue until 2050 when the proposed LRDP would be completed. During the demolition of existing buildings or construction of new buildings, roadways, and other infrastructure in the RBC site, temporary and intermittent transportation impacts may result from truck movements as well as construction worker vehicle commute trips. The construction-related traffic may temporary reduce capacities of roadways in the vicinity because of the slower movements and larger turning radii of construction trucks compared to passenger vehicles.

Construction worker and truck trips during peak commute periods (7:00 to 9:00 AM and 4:00 to 6:00 PM on weekdays) may result in short-term adverse effects during the construction period.

In addition, temporary closure of streets and paths for construction staging may also affect automobile, pedestrian, and bicycle access and circulation and may cause a significant temporary impact by increasing traffic hazards or impeding emergency access.

IMPACT 2-5: CONSTRUCTION TRAFFIC IMPACTS

The Project construction would temporarily and intermittently impact traffic operations due to truck movements and construction worker commute trips. This is a *significant* impact.

Mitigation Measure 2-5: Prepare a Construction Traffic Management Plan (CTMP) for each construction project at the RBC site to reduce the impacts of construction on traffic and parking. The University of California shall work with City of Richmond in preparing the CTMP which may consist of the following:

- Proposed truck routes
- Hours of construction and limits on number of truck trips during peak commute periods (7:00 to 9:00 AM and 4:00 to 6:00 PM) if traffic conditions demonstrate the need to reduce construction traffic to avoid causing significant delays.

- Parking management plan for construction workers.
- Tools to provide safe access for pedestrians, bicyclists, automobiles, and emergency access vehicles.
- Identification of alternative routes for temporary closure of streets and/or paths during construction.

Implementation of this mitigation measure will reduce the impact to a *less than significant* level.

2.7.9 CHANGES IN AIR TRAFFIC PATTERNS

The nearest airport to the RBC is the Oakland International Airport, which is about 15 miles to the south. The proposed LRDP would increase density and increase building heights at the RBC. However, building heights would not interfere with current flight patterns of Oakland International Airport or other nearby airports. Therefore, the proposed RBC Project would not cause a significant impact on air traffic patterns.

3.0 ALAMEDA POINT ALTERNATIVE

This chapter describes existing transportation conditions for the Alameda Point site and identifies impacts and mitigation measures of Phase 1 development of the proposed LRDP at Alameda Point under Near-Term (2018) and Cumulative (2035) conditions.

3.1 EXISTING CONDITIONS

Existing transportation conditions at Alameda Point and vicinity are described below.

3.1.1 EXISTING ROADWAY NETWORK

Figure 3-1 shows the existing Alameda Point site, the surrounding roadway system, and study intersections and freeway segments analyzed as part of this assessment. The regional and local roadways serving the project site are described below.

3.1.1.1 Regional Roadways

Interstate 880 (I-880) is a north-south eight -lane freeway, between Oakland and San Jose. Near the Alameda Point site, I-880 provides a direct connection to I-980/SR-24. Alameda Point connects to I-880 via an interchange at Broadway and Jackson Street in Oakland, the Webster/Posey Tubes and other streets in Alameda. I-880 has an AADT of 199,000 vehicles south of I-980 (Caltrans, 2011).

Webster/Posey Tubes (SR260) are each two-lane, one-way tunnels under the Oakland Estuary that connect City of Alameda to Oakland. Posey Tube provides access to Oakland from Alameda, whereas Webster Tube provides access from Oakland to Alameda. Alameda Point connects to the Webster/Posey tubes via Atlantic Avenue, Pacific Avenue, Main Street/Central Avenue, and Webster Street or Constitution Way. Each tube provides two travel lanes. Posey Tube also provides a separated pedestrian and bicycle path. The speed limit is 45 mph in the tubes. The Webster and Posey Tubes have an AADT of about 22,300 vehicles (Caltrans, 2011).

Webster Street (SR260) is a north-south major arterial that connects Central Avenue in the south to the Webster/Posey Tubes in the north. Webster Street provides two travel lanes in each direction and on-street parking and sidewalks south of Atlantic Avenue on both sides of the street. The speed limit is 25 mph.

Figure 3-1.

Alameda Point Campus Study Locations

WC12-2953_3-1_AlamedaPtCampusStudy

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Constitution Way is a north-south major arterial in Alameda that provides one of the two connections to the Webster/Posey Tubes. Constitution Way connects to Webster Tube directly and to Posey Tube via Webster Street. Constitution Way provides two travel lanes in each direction, a median, and left turn lanes at most signalized intersections and sidewalks on both sides of the roadway. South of Lincoln Avenue, Constitution Way becomes 8th Street. The speed limit is 25 mph.

Willie Stargell Avenue is an east-west arterial that connects Webster Street and Alameda Point. Between Main and 5th streets, Willie Stargell Avenue provides one travel lane in each direction. East of 5th Street, Willie Stargell Avenue widens to two travel lanes in each direction and a center median. The speed limit is 25 mph. Willie Stargell Avenue provides intermittent sidewalks on both sides of the roadway. It also provides Class 2 bicycle lanes east of 5th Street, and is a designated Class 3 bicycle route west of 5th Street.

Atlantic Avenue (Ralph Appezzato Memorial Parkway) is an east-west arterial that connects Alameda Point in the west to Webster Street, Constitution Way and points east. West of Constitution Way, Atlantic Avenue provides two travel lanes in each direction, intermittent sidewalks, a raised median, and left turn pockets at signalized intersections. East of Constitution Way, Atlantic Avenue narrows to one travel lane with class 2 bike lanes in each direction and sidewalks on both sides of the roadway. The speed limit is 35 mph between Main and Webster streets and is 25 mph east of Webster Street.

Pacific Avenue is an east-west arterial that connects Main Street in the west to Park Street in the east. Near the Project site, Pacific Avenue generally provides two travel lanes in each direction with on-street parking and sidewalks on both sides of the street. The speed limit is 25 mph.

Lincoln Avenue is generally an east-west arterial that connects Central Avenue in the west to High Street in the east. Near the Project site, Lincoln Avenue generally provides two travel lanes in each direction with on-street parking and sidewalks on both sides of the street. The speed limit is 25 mph.

Main Street is a north-south arterial that connects Central Avenue to the Alameda Main Street Ferry Terminal. Main Street provides two travel lanes in each direction and left-turn pockets at signalized intersections with intermittent sidewalks and a parallel Class 1 path. The speed limit is 35 mph. South of Pacific Avenue, Main Street becomes Central Avenue and extends through the City of Alameda.

3.1.1.2 Local Roadways

Ferry Point is a north-south collector to the west of the Alameda Point site, connecting the Project site to Atlantic Avenue and points north. In the vicinity of the Project site, Ferry Point provides one travel lane in each direction with striped shoulders, and minimal pedestrian facilities. The speed limit is 25 mph.

Viking Street is a north-south local street on the east side of the Alameda Point site connecting the Project site to Atlantic Avenue and points north. In the vicinity of the Project site, Viking Street provides one travel lane in each direction with striped shoulders, and minimal pedestrian facilities. The speed limit is 25 mph.

Hornet Avenue is an east-west local street on the south side of the Alameda Point site. In the vicinity of the Project site, Hornet Avenue provides one travel lane in each direction with striped shoulders, and minimal pedestrian facilities. A parallel Class 1 path is provided just south of Hornet Avenue. The speed limit is 25 mph.

3.1.2 INTERSECTION OPERATIONS ANALYSIS

This study analyzes existing traffic operations during typical weekday AM and PM peak hours at the following 13 intersections:

City of Alameda:
1. Willie Stargell Avenue/Webster Street
2. Main Street/Atlantic Avenue
3. Third Street/Atlantic Avenue
4. Webster Street/Atlantic Avenue
5. Constitution Way/Atlantic Street
6. Main Street/Pacific Avenue
7. Webster Street/Lincoln Avenue
8. Constitution Way/Lincoln Avenue
9. 8th Street/Central Avenue

City of Oakland:
10. Broadway/5th Street
11. Webster Street/8th Street
12. Harrison Street/7th Street
13. Jackson Street/7th Street

These intersections were selected for analysis because they are most likely to be affected by the proposed Project. **Figure 3-1** shows the location of the study.

3.1.2.1 Existing Intersection Volumes

For all study intersections, the operations analysis presented in this study is based on AM and PM peak period (7:00 to 9:00 AM and 4:00 to 6:00 PM) intersection turning movement, pedestrian, and bicycle volumes. These time periods were selected because trips generated by the proposed Project, in combination with background traffic, are expected to represent typical worst traffic conditions. Traffic counts were collected in October 2010[4] for intersections in Oakland and on December 12, 2012 for intersections in Alameda. Within the peak periods, the peak hours (i.e., the hour with the highest traffic volumes observed in the study area) are from 7:45 AM to 8:45 AM (AM peak hour) and 5:00 PM to 6:00 PM (PM peak hour).

[4] In general, traffic volume counts that are three years old or newer are considered to be valid. Considering that minimal new development or roadway modifications have occurred in the vicinity of these intersections in the last three years, the counts continue to be valid and present typical current conditions.

Because the traffic counts in Alameda were collected in December when traffic patterns maybe atypical due to irregular school schedules, holidays, and more frequent shopping trips, "check" counts were collected during the week of January 28, 2013 at two study intersections, while local schools and College of Alameda were in regular session. These "check" counts were compared to the December 2012 counts, in terms of total intersection volumes and also critical movements. In comparison, some movements were higher in December 2012 while others were higher in January 2013. The January 2013 intersections volumes were about two to ten percent higher than the December 2012 volumes, which is within the typical daily fluctuation expected in traffic volumes. Thus, the December 2012 traffic volumes represent typical conditions in the Alameda study intersections. Although the December 2012 traffic volumes represent typical conditions in the study area, they were adjusted to reflect the higher traffic volumes observed in January 2013 in order to present a more conservative analysis.

Figures 3-2A and 3-2B present the existing AM and PM peak hour intersection vehicle turn movement volumes at the study intersections. **Figures 3-3A and 3-3B** present the existing AM and PM peak hour pedestrian and bicycle volumes at the study intersections. **Appendix D** presents the detailed count sheets at the study intersections.

3.1.2.2 Existing Intersection Operations

Table 3-1 summarizes existing weekday peak hour intersection LOS analysis results. **Appendix E** provides the detailed calculation work sheets. As shown in the table, all study intersections in Alameda currently operate at LOS D or better during both AM and PM peak hours. All but one study intersection in Oakland currently operate at LOS E or better during both AM and PM peak hours. The one sub-standard intersection in Oakland is the 7th Street/Harrison Street intersection which operates at LOS F during the PM peak hour.

3.1.3 FREEWAY OPERATIONS

This study analyzes existing traffic operations during typical weekday AM and PM peak hours at the following four freeway segments:

1. I-880 west of I-980
2. I-880 between I-980 and Oak Street
3. I-880 south of Oak Street
4. Webster/Posey Tubes

These freeway segments were selected for analysis because they are most likely to be affected by the proposed Project.

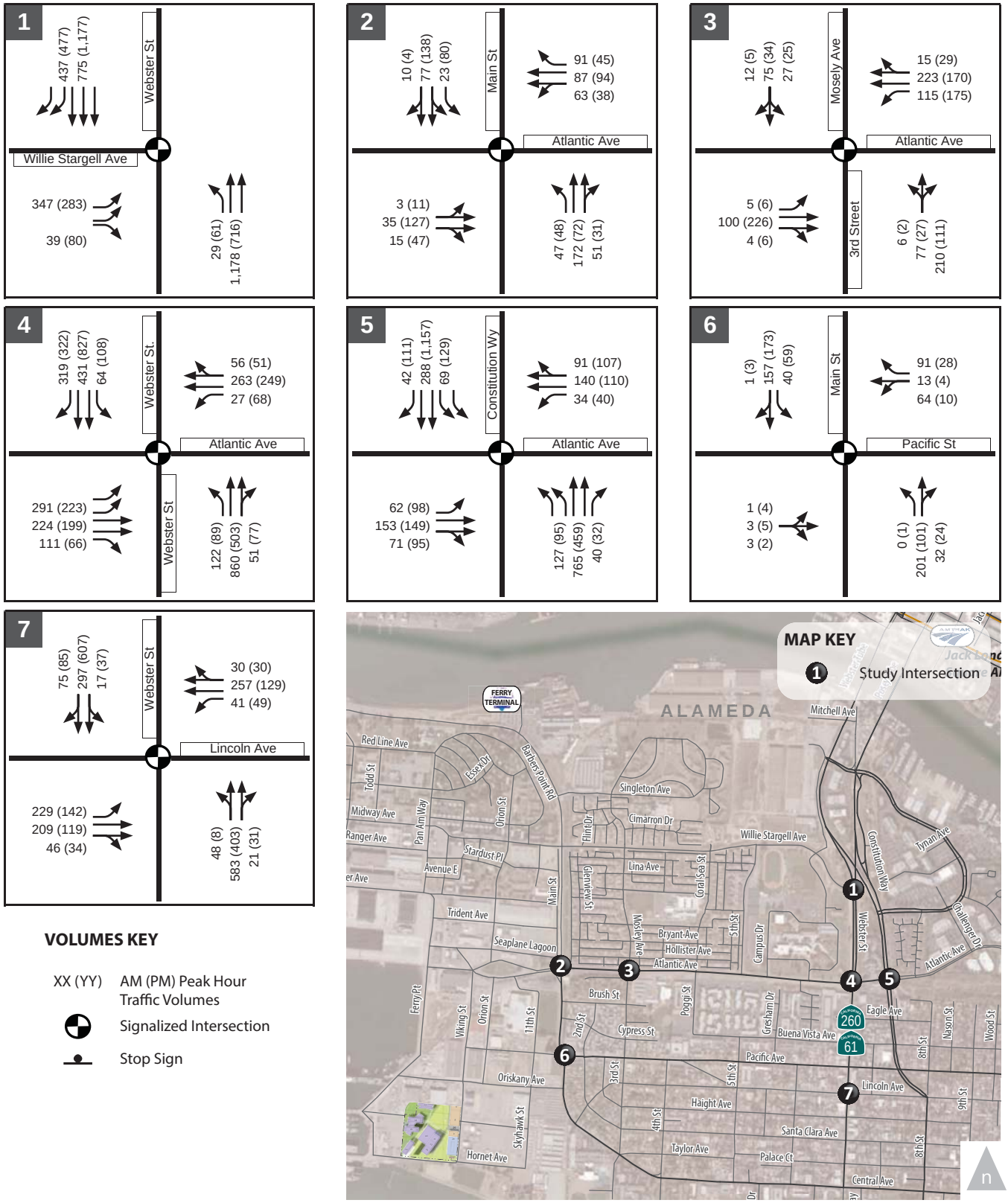

Figure 3-2A.

Alameda Point Campus
Existing Peak Hour Traffic Volumes, Lane Configurations and Traffic Control

WC12-2953_3-2A_ExVol

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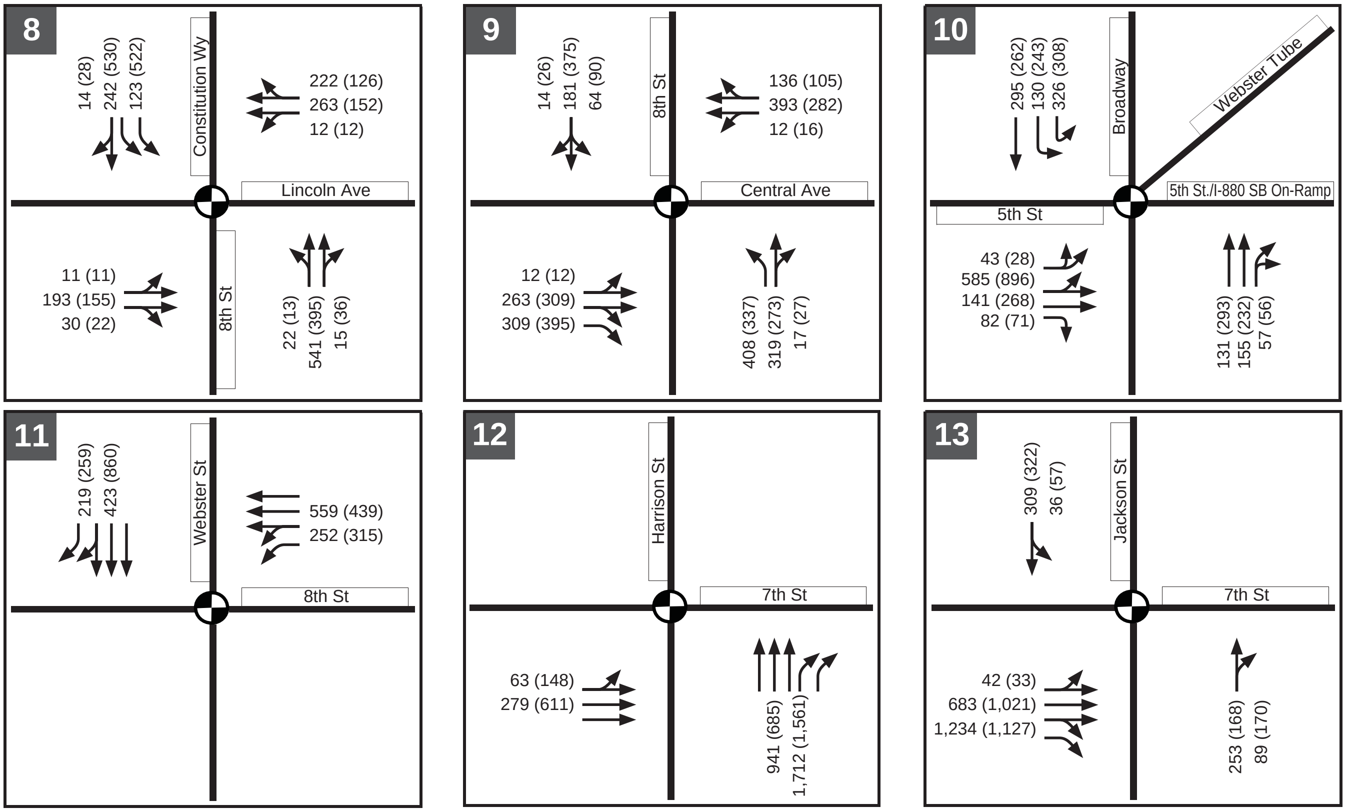
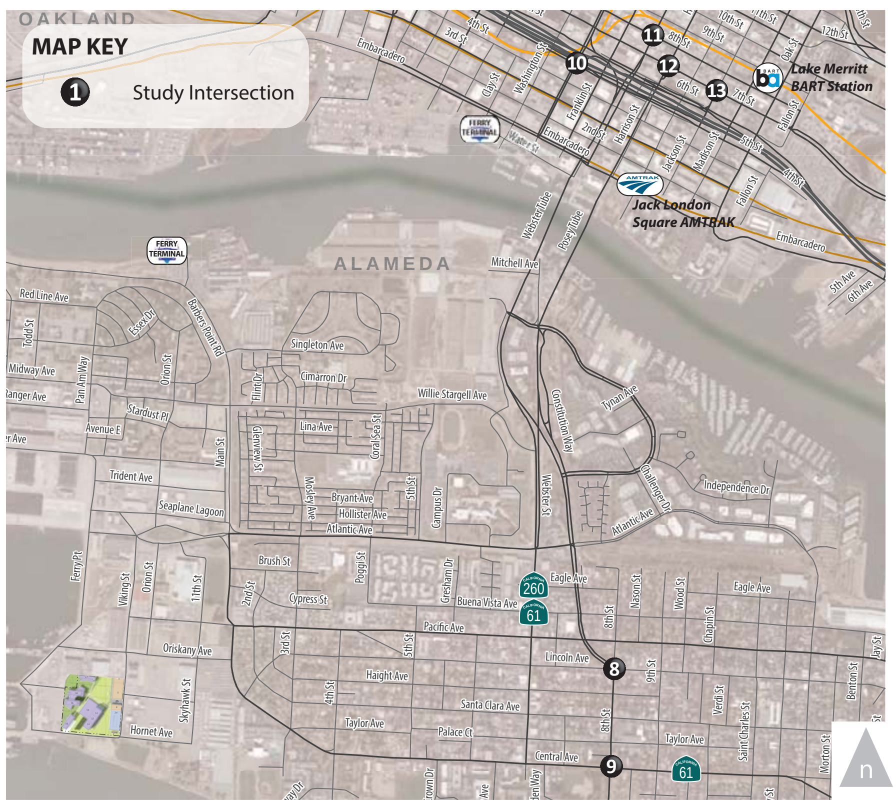




VOLUMES KEY

XX (YY) AM (PM) Peak Hour Traffic Volumes

Signalized Intersection

Stop Sign

Figure 3-2B.

Alameda Point Campus
Existing Peak Hour Traffic Volumes, Lane Configurations and Traffic Control

WC12-2953_3-2B_ExVol

FEHR & PEERS

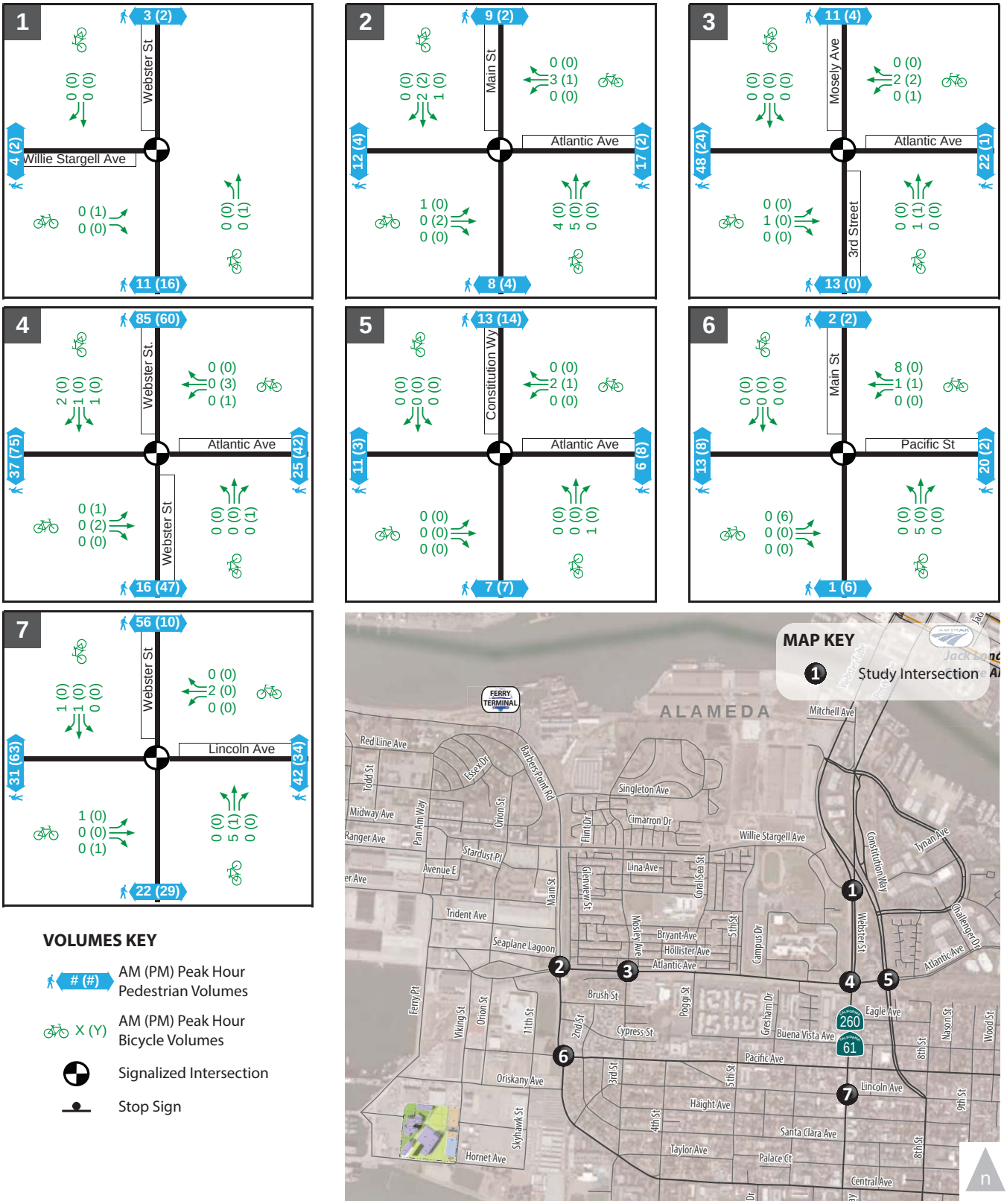
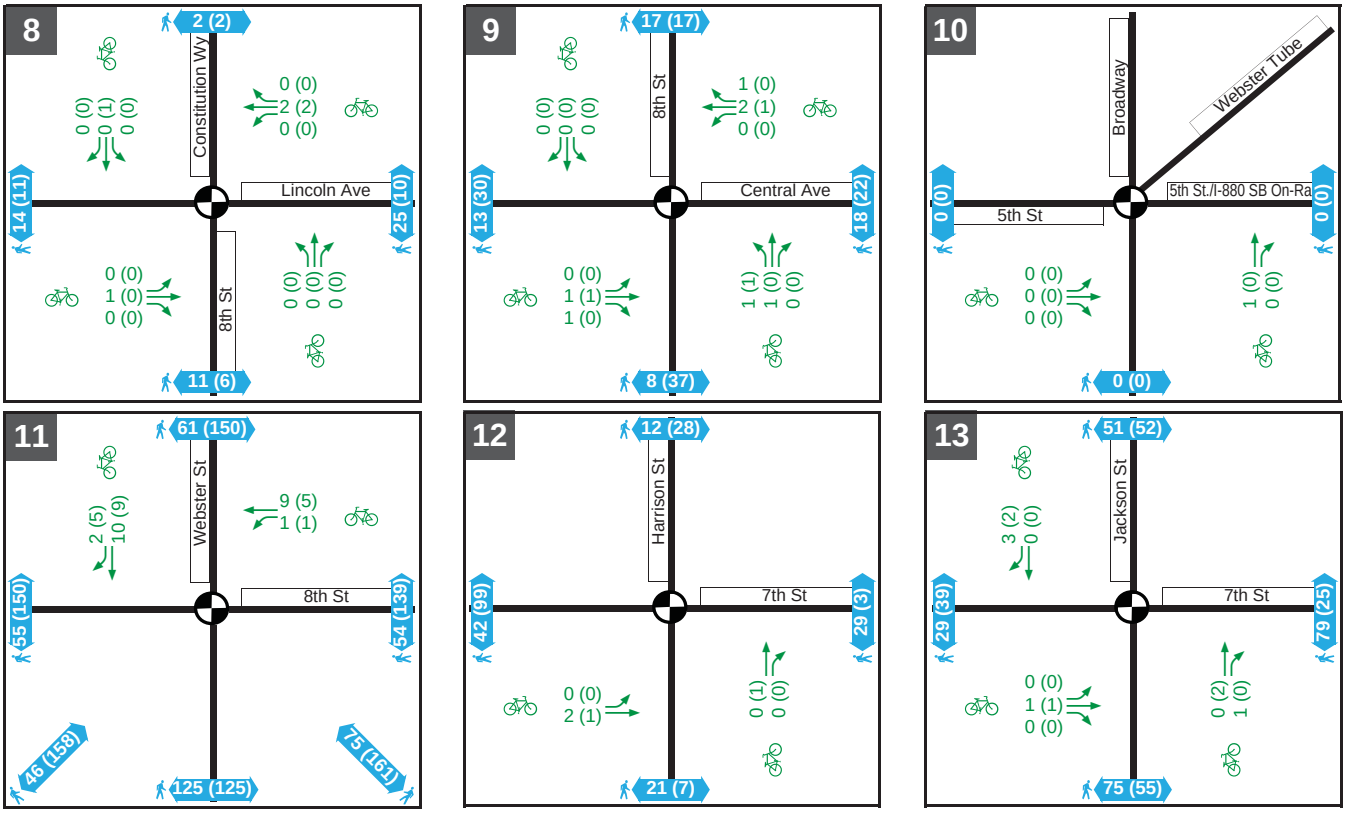


Figure 3-3A.

Alameda Point Campus
Existing Pedestrian and Bicycle Volumes

WC12-2953_3-3A_BikePedVol

FEHR PEERS



VOLUMES KEY

- # (#) — AM (PM) Peak Hour Pedestrian Volumes
- X (Y) — AM (PM) Peak Hour Bicycle Volumes
- Signalized Intersection
- Stop Sign

Figure 3-3B.

Alameda Point Campus
Existing Pedestrian and Bicycle Volumes

WC12-2953_3-3B_BikePedVol

FEHR PEERS

TABLE 3-1
ALAMEDA POINT
EXISTING CONDITIONS – STUDY INTERSECTION LOS SUMMARY

Intersection	Control	AM Peak Hour		PM Peak Hour	
		Delay (Seconds)[1]	LOS [1]	Delay (Seconds) [1]	LOS [1]
City of Alameda:					
1. Webster Street/ Willie Stargell Avenue	Signal	20.7	C	18.9	B
2. Main Street/ Atlantic Avenue	Signal	11.2	B	11.5	B
3. Third Street/ Atlantic Avenue	Signal	19.8	B	43.3	D
4. Webster Street/ Atlantic Avenue	Signal	36.1	D	28.3	C
5. Constitution Way/ Atlantic Street	Signal	20.5	C	23.1	C
6. Main Street/ Pacific Avenue	Signal	22.6	C	13.5	B
7. Webster Street/ Lincoln Avenue	Signal	16.9	B	13.9	B
8. Constitution Way/ Lincoln Avenue	Signal	20.3	C	21.1	C
9. 8th Street/ Central Avenue	Signal	39.3	D	39.9	D
City of Oakland:					
10. Broadway/ 5th Street	Signal	23.5	C	31.9	C
11. Webster Street/ 8th Street	Signal	15.3	B	16.7	B
12. Harrison Street/ 7th Street	Signal	77.4	E	**>120 (v/c=0.73)**	**F**
13. Jackson Street/ 7th Street	Signal	12.0	B	12.2	B

Notes: **Bold** indicates intersection operating at unacceptable LOS E/F in Alameda or unacceptable LOS F in Oakland.
1. Signalized and all-way stop-controlled intersection delay and LOS based on average control delay per vehicle, according to the Highway Capacity Manual, Special Report 209, Transportation Research Board, 2000.

Source: Fehr & Peers.

1
2

3.1.3.1 Existing Freeway Volumes

Existing freeway volumes are primarily derived from two sources of data: (1) October 2012 freeway volumes published by Caltrans through the California Freeway Performance Measurement System (PeMS), and (2) intersection turning movement counts at the tube termini collected in December 2012, and described in Section 3.1.2.1.

3.1.3.2 Existing Freeway Operations

Table 3-2 summarizes existing weekday AM and PM peak hour freeway LOS analysis results. **Appendix F** provides the detailed calculation work sheets. As shown in the table, both directions of I-880 west of I-980 and southbound I-880 between I-980 and Oak Street currently operate at LOS F during both peak hours. The Webster/Posey Tubes operate at LOS C or better during both peak hours.

TABLE 3-2
ALAMEDA POINT
EXISTING CONDITIONS – FREEWAY SEGMENT LOS SUMMARY

Freeway Segment	Type[1]	Dir[2]	AM Peak Hour		PM Peak Hour	
			Density[3]	LOS	Density[3]	LOS
1. I-880, west of I-980	Basic	NB	--	F	--	F
	Basic	SB	--	F	--	F
2. I-880, between I-980 and Oak Street	Basic	NB	34.7	D	36.1	E
	Basic	SB	--	F	--	F
3. I-880, south of Oak Street	Basic	NB	33.1	D	33.0	D
	Basic	SB	32.5	D	36.6	E
4. Webster/Posey Tubes	Basic	NB	22.4	C	19.0	C
	Basic	SB	14.8	B	22.0	C

1. Basic segments are analyzed as basic segments using the 2000 HCM methodologies.
2. NB = Northbound; SB = Southbound
3. Density is presented in passenger cars per lane per mile (pc/ln/mi).

Source: Fehr & Peers.

3.1.4 EXISTING TRANSIT SERVICES

The Alameda Point site is served indirectly by BART, AC Transit, ferries, and Amtrak. **Figure 3-4** shows the transit routes in the vicinity of the site. Each transit service is described below.

Figure 3-4.

Alameda Point Campus Existing Transit Service

WC12-2953_3-4_APCtransit

FEHR PEERS

3.1.4.1 BART

BART provides regional commuter rail transit in Alameda, Contra Costa, San Francisco, and San Mateo counties. Currently, BART trains operate on weekdays from 4:00 AM to midnight, on Saturdays from 6:00 AM to midnight, and on Sundays from 8:00 AM to midnight. The nearest BART station to Alameda Point is the Lake Merritt BART Station (about 2.5 miles northeast of Alameda Point) in Oakland, which is served by the Fremont-Richmond, Fremont-Daily City, and Dublin/Pleasanton-Daly City lines. Typically, the Lake Merritt BART Station is served by a train every five (peak weekday commute periods) to ten minutes (Sundays). The average weekday daily ridership for the Lake Merritt BART Station is about 11,800, riders in January 2013.

3.1.4.2 AC Transit

Local bus service in Alameda is provided by AC Transit. **Figure 3-4** illustrates the existing AC Transit routes in the vicinity of Alameda Point. **Table 3-3** describes the major bus routes serving the Project area. Most bus routes operate along Webster Street, which is about one mile east of the Alameda Point site.

3.1.4.3 Ferry Service

The Alameda Main Street Ferry Terminal is located about one mile north of the Project site. The Water Emergency Transportation Authority (WETA) provides weekday commute ferry service between the Alameda Main Street Ferry Terminal and San Francisco, South San Francisco, and Oakland Jack London Square. The Alameda Ferry Terminal is typically in operation on weekdays from 6:00 AM to 8:45 PM with seasonal service provided on weekends.

3.1.4.4 Amtrak

The Oakland Jack London Square Station, located about 3.5 miles northeast of the Alameda Point site, provides Amtrak service on three routes – the Capital Corridor (15 trains per day in each direction between San Jose and Sacramento); the San Joaquin Intercity (four trains per day in each direction to Bakersfield via Modesto and Fresno) and the Coast Starlight (one train per day in each direction between Seattle and Los Angeles).

TABLE 3-3
ALAMEDA POINT
AC TRANSIT SERVICE SUMMARY

Line	Route	Nearest Stop [1]	Weekday		Weekend	
			Hours	Frequency	Hours	Frequency
Local Routes						
20	Dimond District – Downtown Oakland	Webster St./ Central Ave. (About 1.6 miles)	5:00 AM – 10:00 PM	30 minutes	5:00 AM – 10:00 PM	30 minutes
31	Alameda Point – Macarthur BART	Main St./ Pacific Ave. (About 0.8 miles)	6:00 AM – 10:00 PM	30 minutes	6:00 AM – 10:00 PM	30 minutes
51A	Rockridge BART – Fruitvale BART	Webster St./ Santa Clara Ave. (About 1.6 miles)	5:15 AM – 12:00 AM	10-20 minutes	5:40 AM – 12:00 AM	15-20 minutes
Night Routes						
851	Downtown Berkeley – Fruitvale BART	Webster St./ Santa Clara Ave. (About 1.6 miles)	12:30 AM – 4:30 AM	60 minutes	12:30 AM – 4:30 AM	60 minutes
Transbay Routes						
O	Fruitvale BART – San Francisco	Webster St./ Santa Clara Ave. (About 1.6 miles)	5:20 AM – 9:20 PM	30 – 60 minutes	5:20 AM – 9:20 AM	60 minutes
W	Broadway & Blanding – San Francisco	Webster St./ Santa Clara Ave. (About 1.6 miles)	6:00 AM – 9:00 AM	20 – 30 minutes	N/A	N/A

1. Distance shown is current walking distance between bus stop and Ferry Point at West Hornet Avenue.
Source: AC Transit, 2013.

3.1.5 EXISTING PEDESTRIAN AND BICYCLE CIRCULATION

As the area in the vicinity of Alameda Point site is mostly industrial, few of the streets currently provide sidewalks. Most pedestrian activity occurs in the extended shoulder of the streets and along industrial driveways. Roadways in the study area that do provide pedestrian facilities include: Hornet Avenue on the south side of the street; Ferry Point north of Avenue L; and Atlantic Avenue. Although there are no sidewalks along the remaining roadways, some of the intersections include marked crosswalks. In addition to sidewalks and crosswalks, there is a multi-use trail just south of the Alameda Point site, along Alameda Park.

Based on the *City of Alameda Bicycle Master Plan Update* (November 2010), bicycle facilities in the study area can be classified into three types, including:

- ***Bicycle Paths (Class 1)*** – These facilities are located off-street and can serve both bicyclists and pedestrians.

- ***Bicycle Lanes (Class 2)*** – These facilities provide a dedicated area for bicyclists within the paved street width through the use of striping and appropriate signage.

- ***Bicycle Routes (Class 3)*** – These facilities are found along streets that do not provide sufficient width for dedicated bicycle lanes. The street is then designated as a bicycle route through the use of signage informing drivers to expect bicyclists.

Figure 3-5 identifies existing and proposed bicycle facilities in the study area. Currently, bicyclists are allowed on all roadways in the study area. Existing bicycle facilities near the project site include Class 1 bicycle paths along the shoreline in Alameda Park and adjacent to Main Street and Class 3 bicycle routes on Hancock Street between Central Avenue and the shoreline. The *2010 Alameda Bicycle Master Plan Update* proposes to extend the existing Class 1 paths adjacent to Atlantic Avenue and the shoreline further into Alameda Point. The Bicycle Master Plan Update also identifies Central and Pacific Avenues as future Class 3 bicycle routes.

As previously shown on Figures 3-3A and 3-3B, study intersections nearest to the Alameda Point site have minimal pedestrian and bicycle activity, while study intersections along Webster Street and Constitution Way have moderate pedestrian and bicycle activity, and study intersections in Oakland have high pedestrian activity as they are located in a high-density urban commercial area.

3.2 REGULATORY CONSIDERATIONS

3.2.1 ALAMEDA GENERAL PLAN

The Alameda General Plan Transportation Element contains the following objectives and supporting policies that are relevant to the Project:

Objective 4.1.2: Protect and enhance the service level of the transportation system.

Policy 4.1.2.a Develop multimodal level of service (LOS) standards that development will be required to maintain by encouraging the use of non-automotive modes.

Objective 4.1.6: Increase the efficiency of the existing transportation system by emphasizing Transportation System Management (TSM) strategies and Transportation Demand Management (TDM) techniques.

Figure 3-5.

Alameda Point Campus Existing and Future Bicycle Network

WC12-2953_3-5_APCbike

FEHR & PEERS

Policy 4.1.6.a Identify, develop, and implement travel demand management strategies to reduce demand on the existing transportation system.

1. Establish peak hour trip reduction goals for all new developments as follows:
    - 10 percent peak hour trip reduction for new residential developments
    - 30 percent peak hour trip reduction for new commercial developments

Policy 4.1.6.e Support and maintain an up-to-date Transportation System Management (TSM) and Transportation Demand Management (TDM) plan consistent with state law to provide adequate traffic flow to maintain established LOS.

1. Develop a TDM plan which would include specific requirements for new developments to implement measures to mitigate their traffic impacts based on an applicable nexus.

2. Develop one or more sub-area TDM plans to help address the unique conditions of different areas within Alameda.

Policy 4.1.6.f Require monitoring programs to ensure that TSM and TDM measures mitigate impacts.

1. Develop thresholds of significance for ongoing monitoring and evaluation of TSM/ TDM measures

Objective 4.2.3: Plan, develop and implement a transportation system that protects and enhances air and water quality, protects and enhances views and access to the water, and minimizes noise impacts on residential areas.

Policy 4.2.3.c Identify and pursue opportunities to enhance shoreline access for pedestrians.

Policy 4.2.3.d Support and prioritize trip reduction strategies that maximize air quality benefits and reduce greenhouse gas emissions.

1. Support the use of alternative fuel vehicles for all transportation modes.

2. Encourage shift of trips to alternative transportation modes. This includes short trips, as these will have a disproportionate impact on air quality.

Objective 4.2.4: Develop a Transportation plan based on existing and projected land uses and plans. Encourage land use decisions that facilitate implementation of this transportation system.

Policy 4.2.4.a Encourage development patterns and land uses that promote the use of alternate modes and reduce the rate of growth in region-wide vehicle miles traveled.

Policy 4.2.4.b Integrate planning for Environmentally Friendly Modes, including transit, bicycling and walking, into the City's development review process.

Objective 4.3.1: Develop programs and infrastructure to encourage the use of high occupancy vehicles (HOVs), such as buses, ferries, vans and carpools.

Policy 4.3.1.c Actively encourage increases in public transit, including frequency and geographic coverage.

Policy 4.3.1.d Encourage and support efforts to provide information to use environmentally-friendly transportation modes.

Policy 4.3.1.e Provide amenities or support programs to make using alternative modes a more attractive option.

Policy 4.3.1.f Reduce vehicle trips through telecommuting or other options.

Policy 4.3.1.i Develop parking management strategies for both new development projects and, as appropriate, for existing development.

Objective 4.4.1: Require developers to reserve and construct (if nexus exists) rights of way, transportation corridors and dedicated transportation facilities through the development process and other means.

1. Develop design guidelines for pedestrian access in new development and redevelopment areas, including shopping centers, residential developments, and business parks.
2. In any new development or re-development, safe and convenient pedestrian connections between major origins and destinations, including connections within the development and between the development and adjacent areas, should be a high priority in evaluating the site plan.
3. Develop shoreline access design guidelines.

Objective 4.4.2: Ensure that new development implement approved transportation plans, including the goals, objectives, and policies of the Transportation Element of the General Plan and provides the transportation improvements needed to accommodate that development and cumulative development.

Policy 4.4.2.a Roadways will not be widened to create additional automobile travel lanes to accommodate additional automobile traffic volume with the exception of increasing transit exclusive lanes or non-motorized vehicle lanes.

Policy 4.4.2.b Intersections will not be widened beyond the width of the approaching roadway with the exception of a single exclusive left turn lane when necessary with the exception of increasing transit exclusive lanes or non-motorized vehicle lanes.

Policy 4.4.2.d All EIRs must include analysis of the effects of the project on the city's transit, pedestrian and bicycling environment, including adjacent neighborhoods and the overall City network.

Policy 4.4.2.e EIRs will not propose mitigations that significantly degrade the bicycle and pedestrian environment which are bellwethers for quality of life issues and staff should identify "Levels of Service" or other such measurements to ensure that the pedestrian and bicycling environment will not be significantly degraded as development takes place.

Policy 4.4.2.f Transportation related mitigations for future development should first implement TDM measures with appropriate regular monitoring; transit, bicycle and pedestrian capital projects; and more efficient use of existing infrastructure such as traffic signal re-timing in order to reduce the negative environmental effects of development, rather than attempting to accommodate them. Should appropriate regular monitoring indicate that these mitigations are unable to provide the predicted peak-hour vehicle trip reductions, additional TDM measures, development specific traffic caps, or mitigations through physical improvements of streets and intersections, consistent with policy 4.4.2.a and policy 4.4.2.b, may be implemented.

Policy 4.4.2.g After the implementation of quantifiable/verifiable TDM measures (verified through appropriate regular monitoring), and mitigation measures consistent with 4.4.2.f and identification of how multimodal infrastructure relates to congestion concerns, some congestion may be identified in an EIR process as not possible to mitigate. This unmitigated congestion should be evaluated and disclosed (including intersection delay length of time) during the EIR process, and acknowledged as a by-product of the development and accepted with the on-going funding of TDM measures.

3.3 PROJECT TRANSPORTATION CHARACTERISTICS

Similar to the Phase 1 development at the RBC site (described in Section 2.3), the proposed development at Alameda Point would include up to six new buildings providing 600,000 square feet of space and would accommodate up to 1,000 employees by 2018. The project would develop generally vacant land in the area bound by Ferry Point, Avenue L, Orion Street and West Hornet Avenue. Vehicular access to and from the site would be provided from West Hornet Avenue.

It is expected that the development would provide adequate parking in surface parking lots to meet demand at the site. This analysis also assumes that the development at Alameda Point, similar to the RBC project, would provide regular shuttle service to and from the Lake Merritt BART Station and LBNL/UC Berkeley.

3.3.1 TRIP GENERATION

Table 3-4 shows the estimated vehicle trip generation for the proposed Project at Alameda Point. This assessment uses the same trip generation used for the Phase 1 Project at the RBC site (See Section 2.3.6 for a detailed description) because the Alameda Point and RBC sites have similar characteristics such as transit availability, pedestrian and bicycle facilities, and proximity to residential and non-residential uses.

For example, both sites are more than two miles from BART and Amtrak stations, both sites have less than 5,000 residents and less than 500 retail employees within one mile of their locations.

TABLE 3-4
ALAMEDA POINT
PROJECT VEHICLE TRIP GENERATION SUMMARY

	Average Daily Population	Daily	AM Peak Hour			PM Peak Hour		
			In	Out	Total	In	Out	Total
Alameda Point Alternative [1]	1,000	2,079	182	29	211	27	172	199

1. Based on following trip generation rates:
Daily = 2.08 trips per Average Daily Population (ADP); AM Peak Hour = 0.21 trips per ADP (86% in, 14% out); PM Peak Hour = 0.20 trips per ADP (13% in, 87% out)

Source: Fehr & Peers, based on trip generation rate per average daily population at the existing LBNL site in Berkeley adjusted to reflect the different characteristics of the Alameda Point site.

It is estimated that the proposed development at Alameda Point would generate about 2,080 daily automobile trips, 210 AM peak hour trips, and 200 PM peak hour trips.

3.3.2 TRIP DISTRIBUTION AND ASSIGNMENT

Trip distribution is defined as the directions of approach and departure that vehicles would use to arrive at and depart from the Project site. The assessment of the Alameda Point site estimated the distribution of project trips based on existing travel patterns, location of complementary land uses, and results from the ACTC Travel Demand Model. **Figure 3-6** shows the resulting trip distribution. **Figures 3-7A and 3-7B** show the Project Phase 1 trip assignment at the study intersections, based on the distribution.

3.4 NEAR-TERM (2018) ANALYSIS

This section summarizes traffic operations under Near-Term (2018) No Project and Near-Term (2018) Plus Project conditions.

3.4.1 NEAR-TERM (2018) NO PROJECT CONDITIONS

The Near-Term (2018) No Project traffic volumes were developed by interpolating between the existing volumes (Figure 3-2) and the projected 2035 volumes (Figure 3-10), which were prepared using the ACTC Countywide Travel Demand Model and described in Section 3.5. **Figures 3-8A and 3-8B** show the Near-Term (2018) No Project traffic volumes.

Figure 3-6.

Alameda Point Campus Project Trip Distribution

WC12-2953_3-6_APCtripdistro

FEHR & PEERS

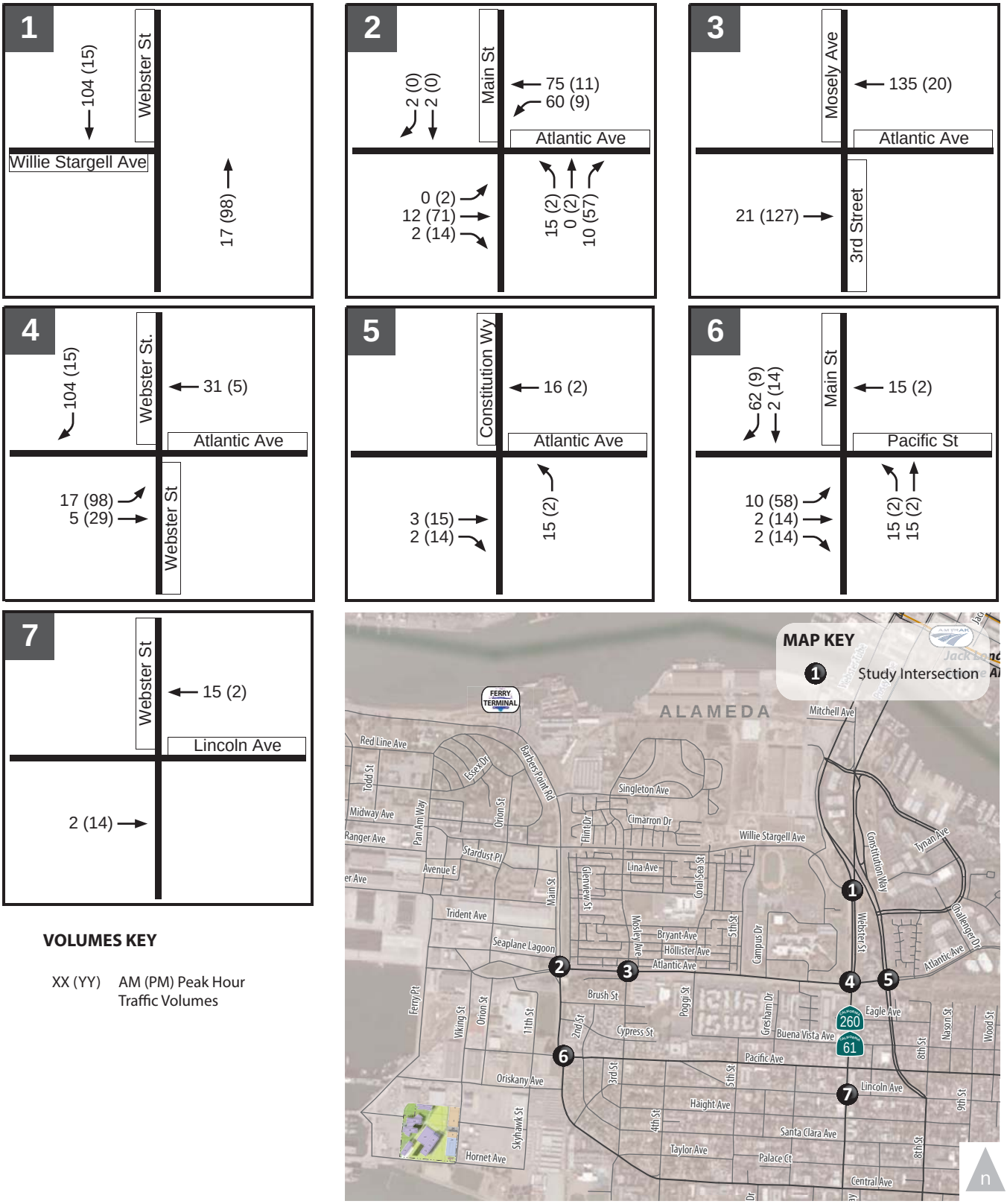


Figure 3-7A.

Alameda Point Campus
Project Trip Assignment (Phase 1)

WC12-2953_3-7A_Ph1PTA

FEHR PEERS

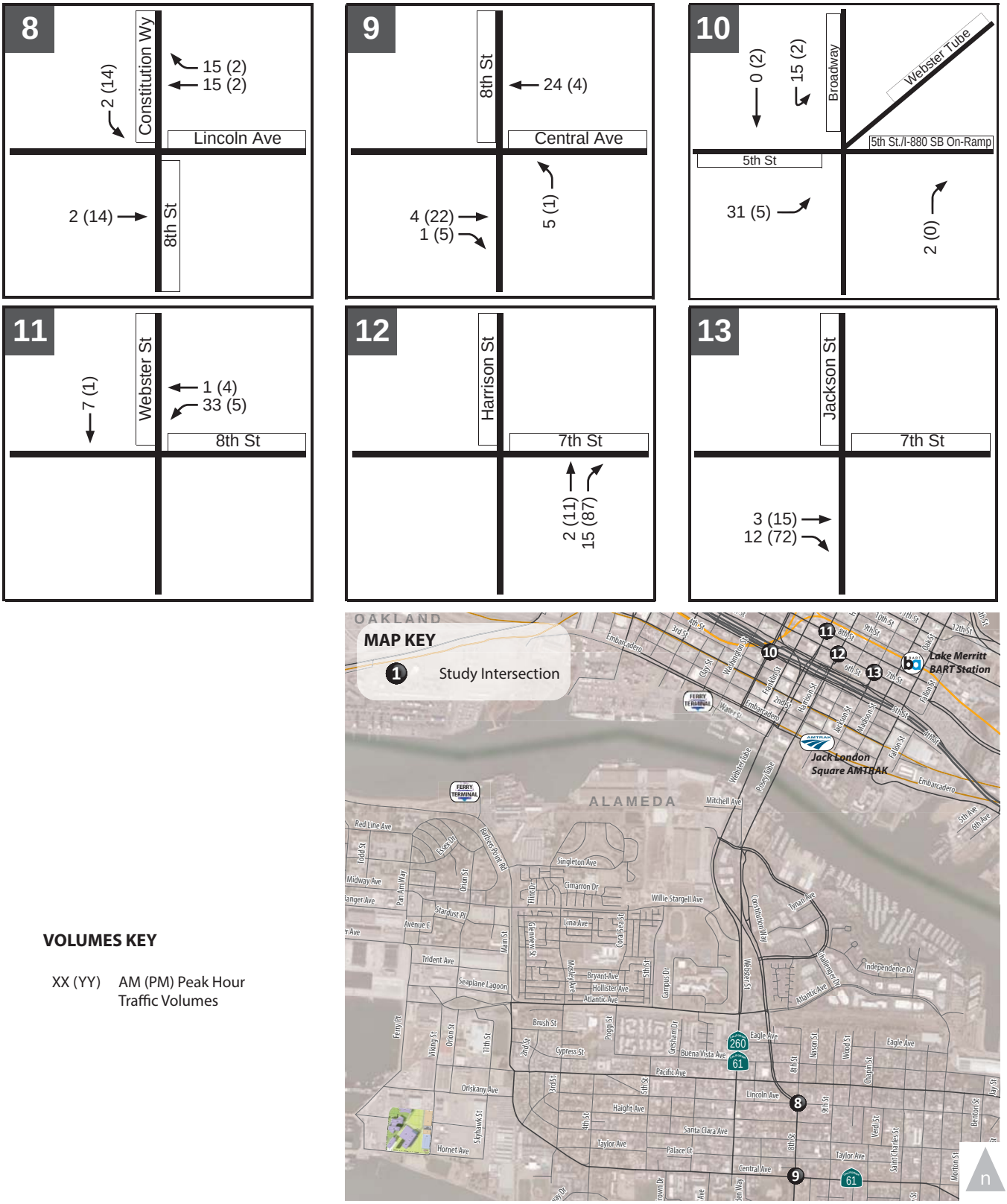
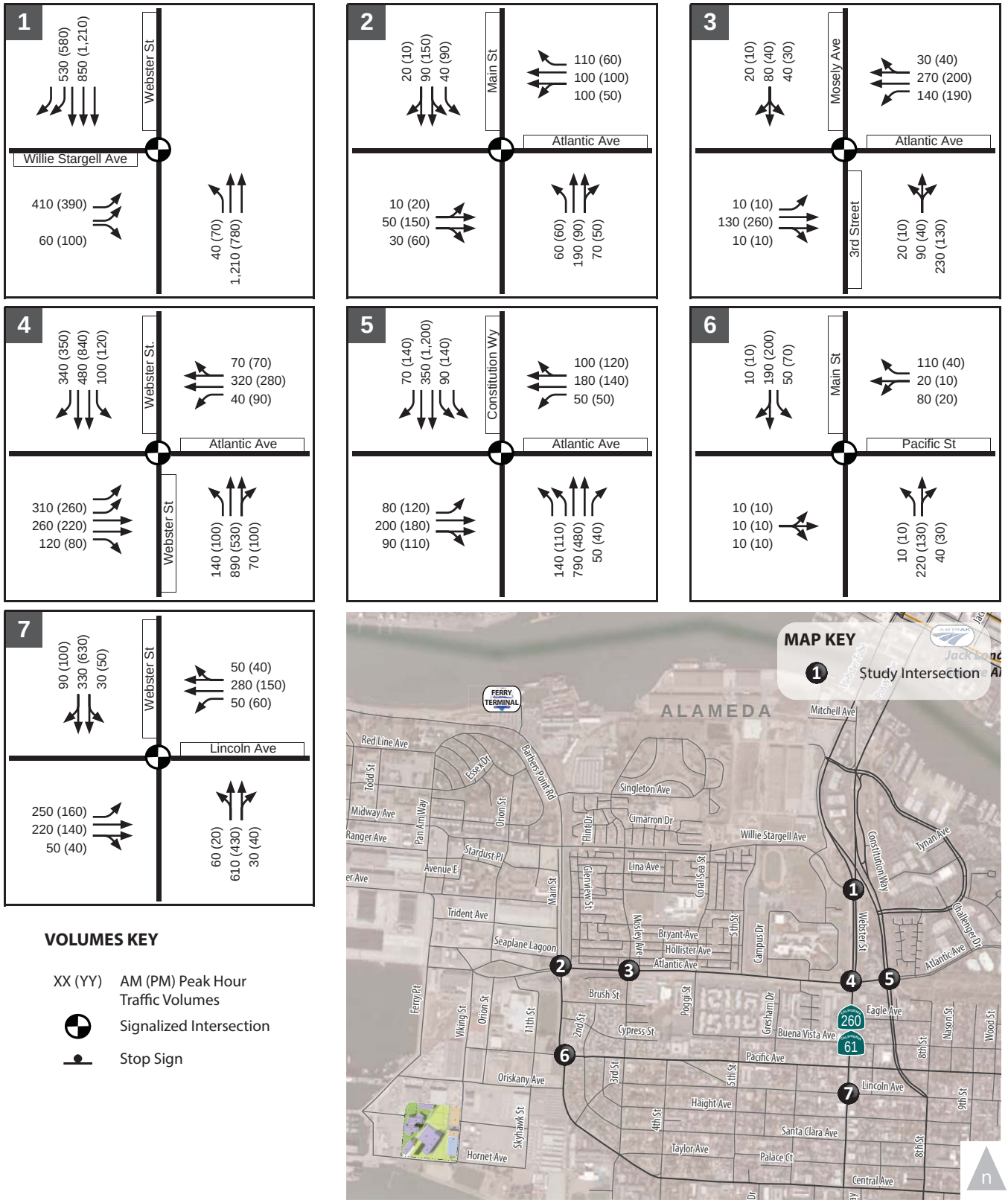


Figure 3-7B.

Alameda Point Campus
Project Trip Assignment (Phase 1)

WC12-2953_3-7B_Ph1PTA

FEHR PEERS



VOLUMES KEY

XX (YY) AM (PM) Peak Hour Traffic Volumes

Signalized Intersection

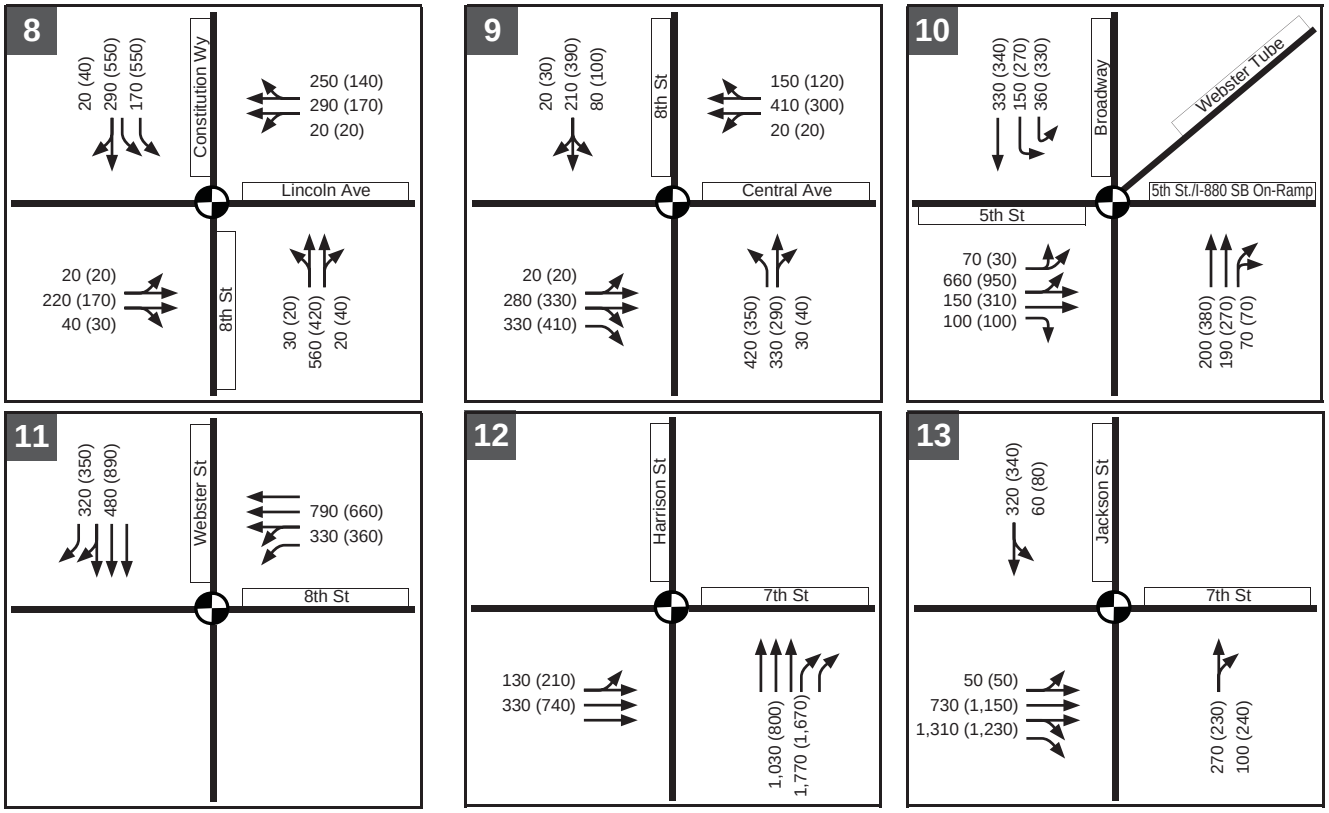
Stop Sign

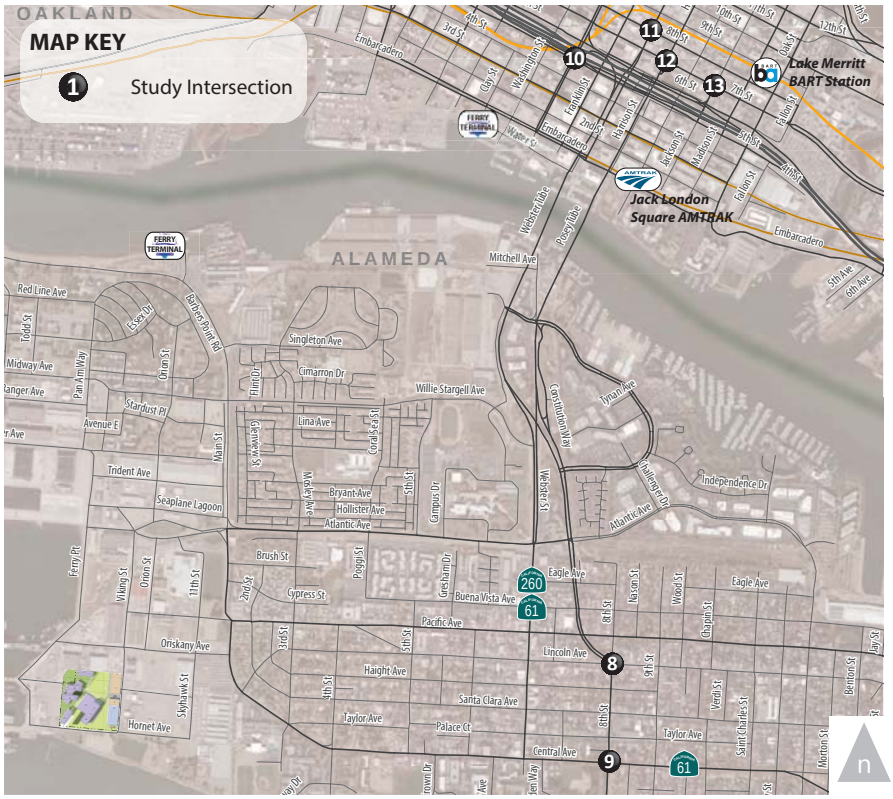
Figure 3-8A.

Alameda Point Campus
Near-Term (2018) No Project Peak Hour Traffic Volumes

WC12-2953_3-8A_NT2018NPvols

FEHR PEERS





VOLUMES KEY

XX (YY)	AM (PM) Peak Hour Traffic Volumes
	Signalized Intersection
	Stop Sign

Figure 3-8B.

Alameda Point Campus
Near-Term (2018) No Project Peak Hour Traffic Volumes

WC12-2953_3-8B_NT2018NPvols

FEHR PEERS

The Near-Term (2018) No Project scenario assumes that signal timing parameters at the signalized study intersections in Alameda would be optimized to reflect typical signal timing updates due to changing traffic flow over time. Consistent with City of Oakland practice, this analysis assumes that signal timing parameters would not change at the study intersections in Oakland. No other roadway modifications are assumed at any of the study intersections under the Near-Term (2018) No Project scenario.

3.4.1.1 Intersection Operations

Table 3-5 summarizes the Near-Term (2018) No Project intersection LOS analysis results. **Appendix E** provides the detailed calculation work sheets.

All study intersections in Alameda would continue to operate at LOS D or better during both AM and PM peak hours under Near-Term (2018) No Project conditions. All but one study intersection in Oakland would continue to operate at LOS E or better during both AM and PM peak hours. The one sub-standard intersection in Oakland is the 7th Street/Harrison Street intersection which would deteriorate from LOS E under Existing conditions to LOS F under Near-Term (2018) No Project conditions during the AM peak hour and would continue to operate at LOS F during the PM peak hour.

3.4.1.2 Freeway Operations

Table 3-6 summarizes the AM and PM peak hour freeway LOS analysis results under Near-Term (2018) No Project conditions. **Appendix F** provides the detailed calculation work sheets. Similar to Existing Conditions, both directions of I-880 west of I-980 and southbound I-880 between I-980 and Oak Street would continue to operate at LOS F during both peak hours; Webster/Posey Tubes would continue to operate at LOS C or better during both peak hours.

3.4.2 NEAR-TERM (2018) PLUS PROJECT CONDITIONS

Figures 3-9A and 3-9B show the Near-Term (2018) Plus Project traffic volumes, which consist of traffic volumes under Near-Term (2018) No Project conditions (Figures 3-8A and 3-8B) plus Project traffic assignment (Figures 3-7A and 3-7B). This analysis assumes no roadway modifications under this scenario.

3.4.2.1 Intersection Operations

Table 3-5 summarizes intersection operations at the study intersections under the Near-Term (2018) Plus Project conditions. **Appendix E** provides the detailed calculation work sheets.

All study intersections in Alameda would continue to operate at LOS D or better during both AM and PM peak hours under the Near-Term (2018) Plus Project conditions. The Project would not cause a significant impact at the study intersections in Alameda.

TABLE 3-5
ALAMEDA POINT
NEAR-TERM (2018) CONDITIONS – STUDY INTERSECTION LOS SUMMARY

Intersection	Traffic Control	Peak Hour	Near-Term (2018) No Project		Near-Term (2018) Plus Project		Significant Impact?
			Delay[1] (seconds)	LOS[1]	Delay[1] (seconds)	LOS[1]	
City of Alameda							
1. Webster Street/ Willie Stargell Avenue	Signal	AM	19.1	B	19.8	B	No
		PM	19.3	B	19.6	B	No
2. Main Street/ Atlantic Avenue	Signal	AM	11.2	B	11.9	B	No
		PM	11.6	B	11.9	B	No
3. Third Street/ Atlantic Avenue	Signal	AM	22.2	C	22.4	C	No
		PM	40.7	D	38.3	D	No
4. Webster Street/ Atlantic Avenue	Signal	AM	42.9	D	45.3	D	No
		PM	31.6	C	34.6	C	No
5. Constitution Way/ Atlantic Street	Signal	AM	22.7	C	23.0	C	No
		PM	25.8	C	26.0	C	No
6. Main Street/ Pacific Avenue	Signal	AM	20.4	C	23.1	C	No
		PM	16.0	B	19.5	B	No
7. Webster Street/ Lincoln Avenue	Signal	AM	16.0	B	16.2	B	No
		PM	14.5	B	14.5	B	No
8. Constitution Way/ Lincoln Avenue	Signal	AM	22.0	C	22.4	C	No
		PM	23.0	C	23.1	C	No
9. 8th Street/ Central Avenue	Signal	AM	38.0	D	39.3	D	No
		PM	44.8	D	45.0	D	No
City of Oakland							
10. Broadway/ 5th Street	Signal	AM	26.4	C	27.4	C	No
		PM	35.2	D	35.3	D	No
11. Webster Street/ 8th Street	Signal	AM	15.9	B	16.0	B	No
		PM	17.3	B	17.3	B	No
12. Harrison Street/ 7th Street	Signal	AM	**100.5 (v/c=0.74)**	**F**	**104.2 (v/c=0.75)**	**F**	Yes
		PM	**>120 (v/c=0.86)**	**F**	**>120 (v/c=0.90)**	**F**	Yes
13. Jackson Street/ 7th Street	Signal	AM	16.8	B	16.7	B	No
		PM	70.9	E	69.4	E	No

Notes: **Bold** indicates intersection operating at unacceptable LOS E/ F in Alameda or unacceptable LOS F in Oakland.
1. For signalized intersections, average intersection delay and LOS based on the 2000 HCM method is shown.
Source: Fehr & Peers.

1

TABLE 3-6
ALAMEDA POINT
NEAR-TERM (2018) CONDITIONS – FREEWAY SEGMENT LOS SUMMARY

Freeway Segment	Type[1]	Dir[2]	Near-Term (2018) No Project				Near-Term (2018) Plus Project				Significant Impact?
			AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour		
			Density[3]	LOS	Density[3]	LOS	Density[3]	LOS	Density[3]	LOS	
1. I-880, west of I-980	Basic	NB	--	F	--	F	--	F	--	F	No
	Basic	SB	--	F	--	F	--	F	--	F	No
2. I-880, between I-980 and Oak Street	Basic	NB	35.7	E	38.8	E	35.7	E	39.3	E	No
	Basic	SB	--	F	--	F	--	F	--	F	No
3. I-880, south of Oak Street	Basic	NB	34.2	D	35.8	E	34.5	D	35.8	E	No
	Basic	SB	34.0	D	38.7	E	34.1	D	39.1	E	No
4. Webster/Posey Tubes	Basic	NB	23.4	C	20.7	C	23.5	C	21.5	C	No
	Basic	SB	17.0	B	23.7	C	17.9	B	23.9	C	No

1. Segments with auxiliary lanes are classified as weave segments, and were analyzed based on the Leisch Method. Basic segments are analyzed as basic segments using the 2000 HCM methodologies.
2. NB = Northbound; SB = Southbound
3. Density is presented in passenger cars per lane per mile (pc/ln/mi).

Source: Fehr & Peers.

In Oakland, Project generated traffic would contribute to LOS F conditions at the Harrison Street/7th Street intersection during both AM and PM peak hours.

Project generated traffic would also contribute to LOS E conditions at the Jackson Street/7th Street intersection in Oakland during the PM peak hour; however, the Project would not cause an increase in the average delay for any of the critical movements by six seconds or more. Based on City of Oakland's significance criteria, the Project would not cause an impact at the Jackson Street/7th Street intersection under Near-Term (2018) No Project conditions.

The Project would cause a significant impact at one intersection in Oakland which is summarized under Impact 3-1 discussion.

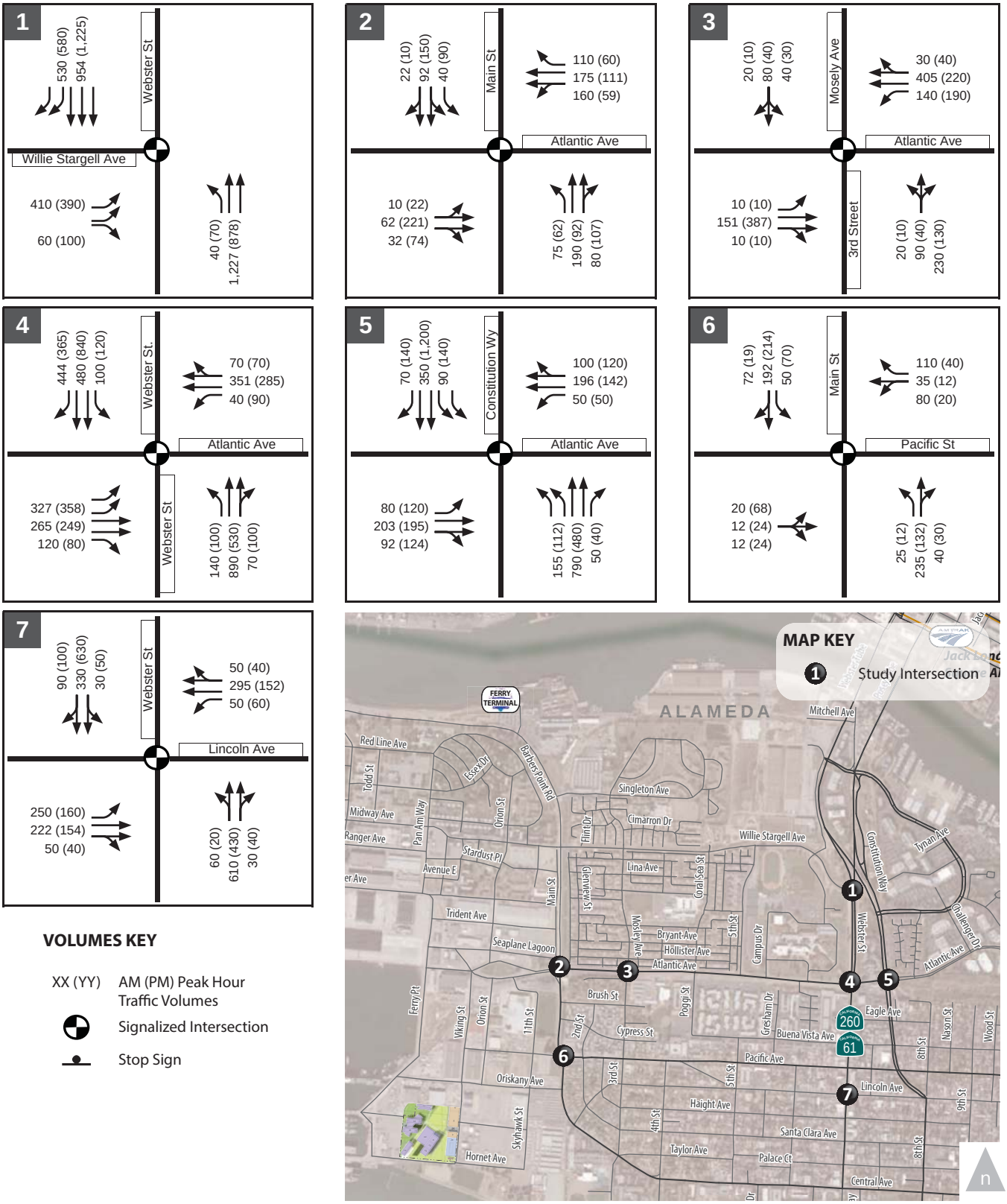
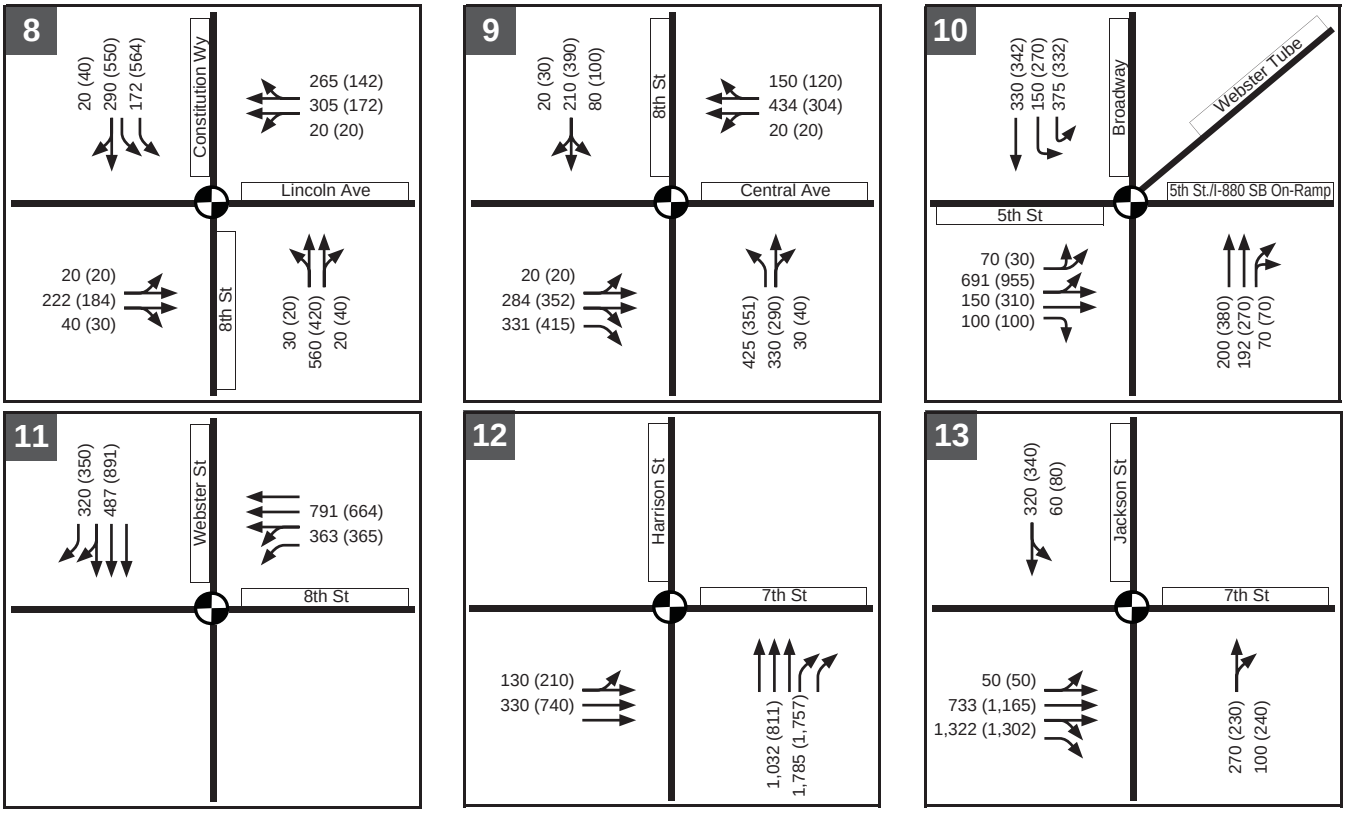


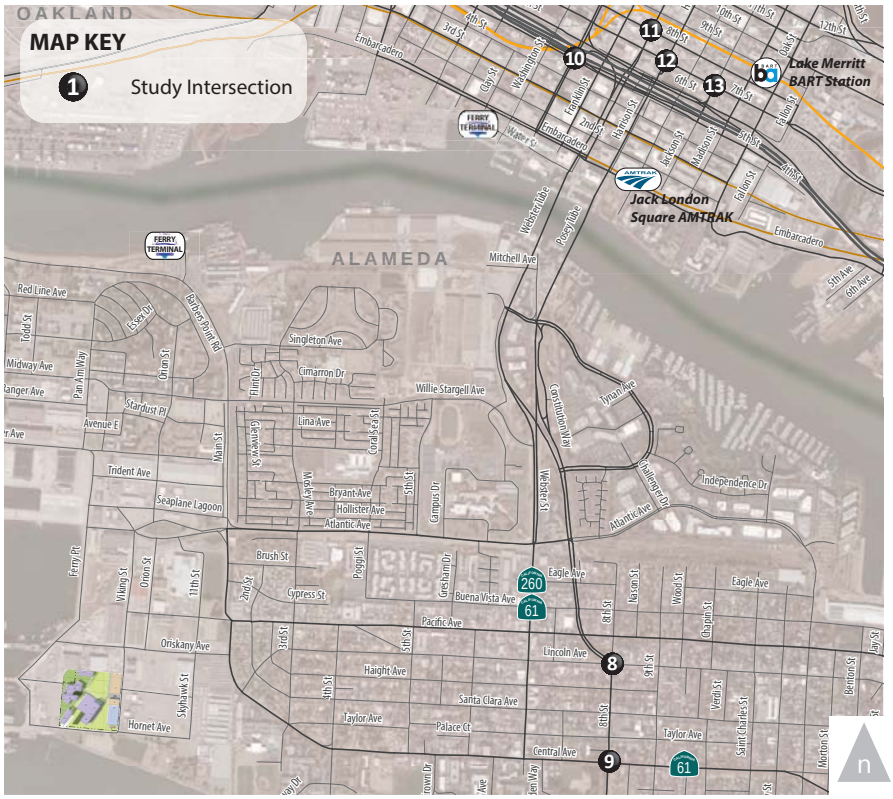
Figure 3-9A.

Alameda Point Campus
Near-Term (2018) Plus Phase 1 Peak Hour Traffic Volumes

WC12-2953_3-9A_NT2018+Ph1vols

FEHR PEERS





VOLUMES KEY

XX (YY)	AM (PM) Peak Hour Traffic Volumes
	Signalized Intersection
	Stop Sign

Figure 3-9B.

Alameda Point Campus
Near-Term (2018) Plus Phase 1 Peak Hour Traffic Volumes

WC12-2953_3-9B_NT2018+Ph1vols

FEHR PEERS

IMPACT 3-1: NEAR-TERM (2018) PLUS PROJECT CONDITIONS INTERSECTION OPERATIONS

The proposed Project at Alameda Point would cause a significant impact at the following intersection under Near-Term (2018) Plus Project conditions:

A. The Project would cause a significant impact at the signalized **Harrison Street/7th Street** (Intersection 12) because it would increase the overall intersection v/c ratio by 0.01 or more and increase critical movement v/c ratio by 0.02 or more during both AM and PM peak hours at an intersection in downtown Oakland operating at LOS F regardless of the Project.

Mitigation Measure 3-1: Implement the following:

A. **Harrison Street/7th Street** (Intersection 12): Implement the following which requires coordination with City of Oakland:

- Increase traffic signal cycle length to 75 seconds and optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would continue to operate at LOS F during both AM and PM peak hours after the implementation of this mitigation measure. However, this mitigation measure would reduce the overall intersection v/c ratio and the critical movement v/c ratio to the same level or less than under Near-Term (2018) No Project conditions. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

3.4.2.2 Freeway Operations

Table 3-6 summarizes the AM and PM peak hour freeway LOS analysis results under Near-Term (2018) Plus Project conditions. **Appendix F** provides the detailed calculation work sheets.

All freeway segments are projected to continue to operate at the same LOS as under Near-Term (2018) No Project conditions during both AM and PM peak hours. The proposed Project would not increase the peak hour volume by five percent or more at the study freeway segments that are projected to operate at LOS F. Therefore, the proposed Project would not cause a significant impact at the study freeway segments under Near-Term (2018) Plus Project conditions.

3.5 CUMULATIVE (2035) ANALYSIS

This section summarizes traffic operations under Cumulative (2035) No Project and Cumulative (2035) Plus Project conditions.

3.5.1 CUMULATIVE (2035) NO PROJECT CONDITIONS

Traffic forecasts to the year 2035 were developed based on the results of the ACTC Countywide Travel Demand Model. The most recent version of the ACTC Model, released in June 2011, which reflects assumptions in residential and non-residential land use growth consistent with ABAG *Projections 2009,* served as the basis for developing AM and PM peak hour intersection turning movement forecasts for the year 2035. The Model land use database and roadway network were checked for accuracy in the vicinity of the Project. The forecasting process involved running the 2010 and 2035 models and using the model produced volumes and existing turning movement count data, to estimate year 2035 intersection turn movements using the Furness[5] method. The 2035 model run did not assume any growth at the proposed Project site. **Figures 3-10A and 3-10B** show the Cumulative (2035) No Project traffic volumes.

Similar to the Near-Term (2018) No Project conditions, the Cumulative (2035) No Project analysis assumes that signal timing parameters at the signalized study intersections in Alameda would be optimized, while signal timing parameters at the study intersection in Oakland would remain the same. No other roadway modifications are assumed in the study area under the Cumulative (2035) No Project scenario.

3.5.1.1 Intersection Operations

Table 3-7 summarizes the Cumulative (2035) No Project intersection LOS analysis results. **Appendix E** provides the detailed calculation work sheets.

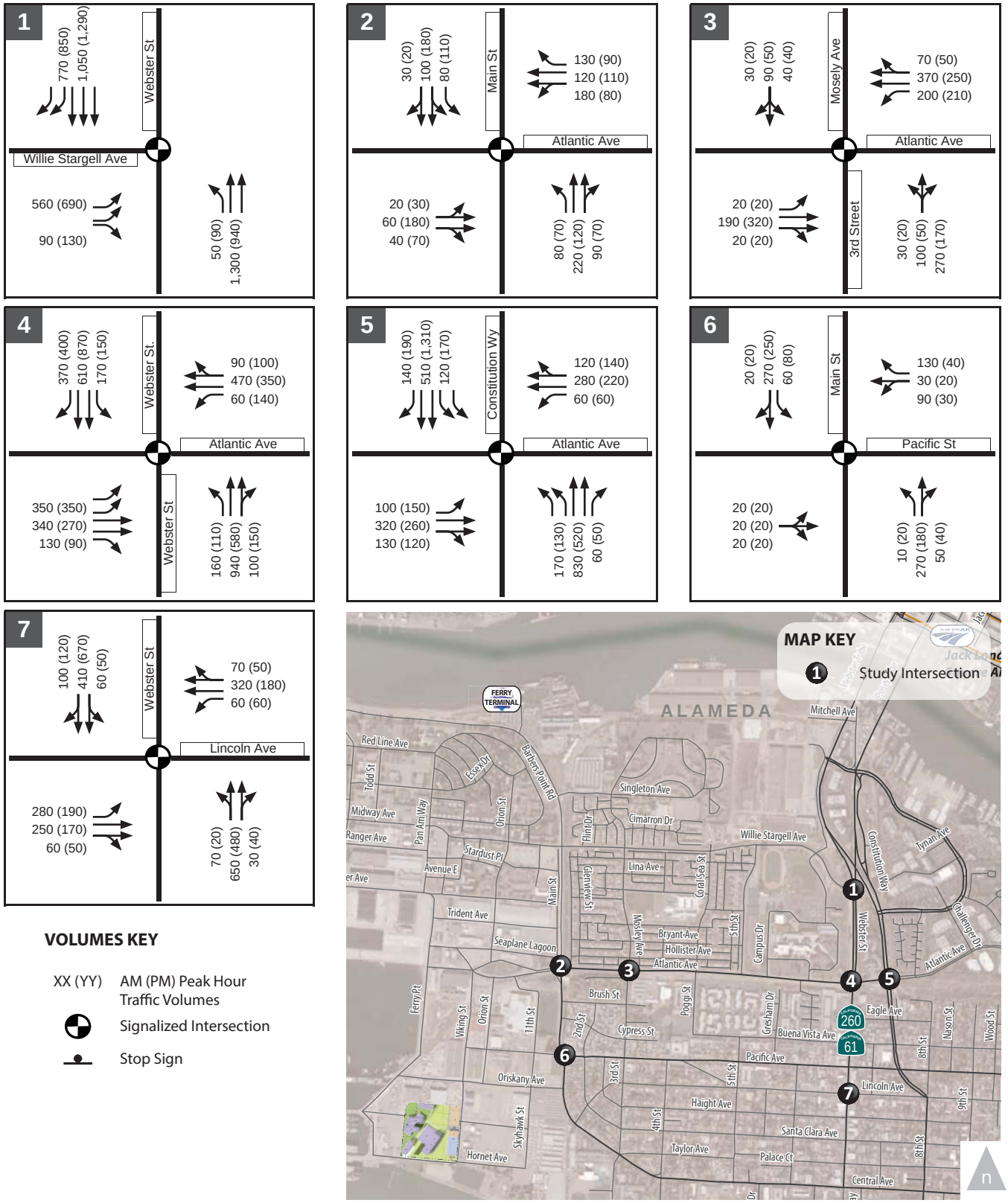
All but one study intersection in Alameda would continue to operate at LOS D or better during both AM and PM peak hours under Cumulative (2035) No Project conditions.

In Oakland, the Harrison Street/7th Street intersection during both AM and PM peak hours and the Jackson Street/7th Street intersection during the PM peak hour would operate at LOS F. The other study intersections in Oakland would continue to operate at LOS E or better during both AM and PM peak hours.

3.5.1.2 Freeway Operations

Table 3-8 summarizes the AM and PM peak hour freeway LOS analysis results under Cumulative (2035) No Project conditions. **Appendix F** provides the detailed calculation work sheets. All freeway segments are projected to continue to operate at LOS D or better during both AM and PM peak hours.

[5] Furnessing is an iterative process that develops future turning movements by applying the difference between the base model volumes and the existing counts to future model approach and departure volumes.



VOLUMES KEY

XX (YY) AM (PM) Peak Hour Traffic Volumes

Signalized Intersection

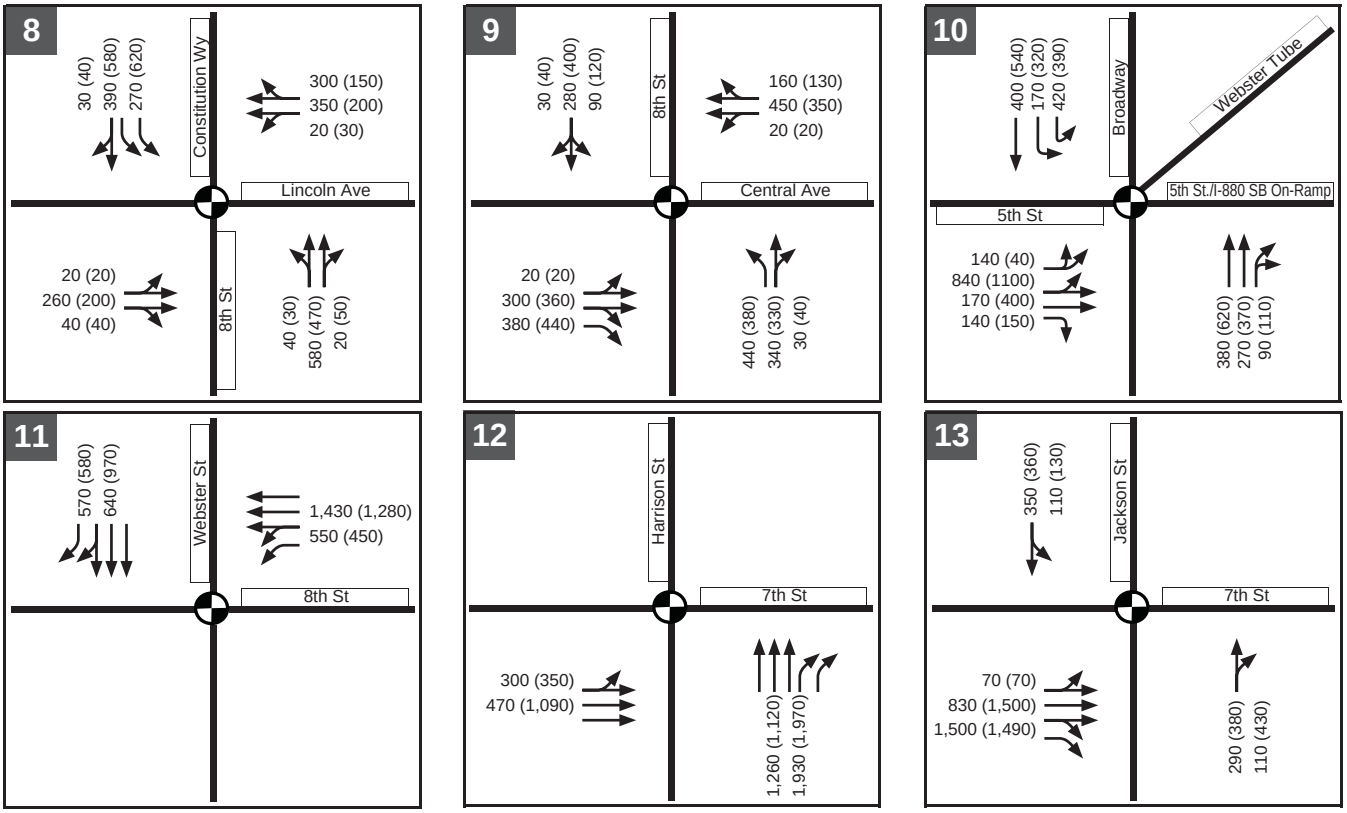
Stop Sign

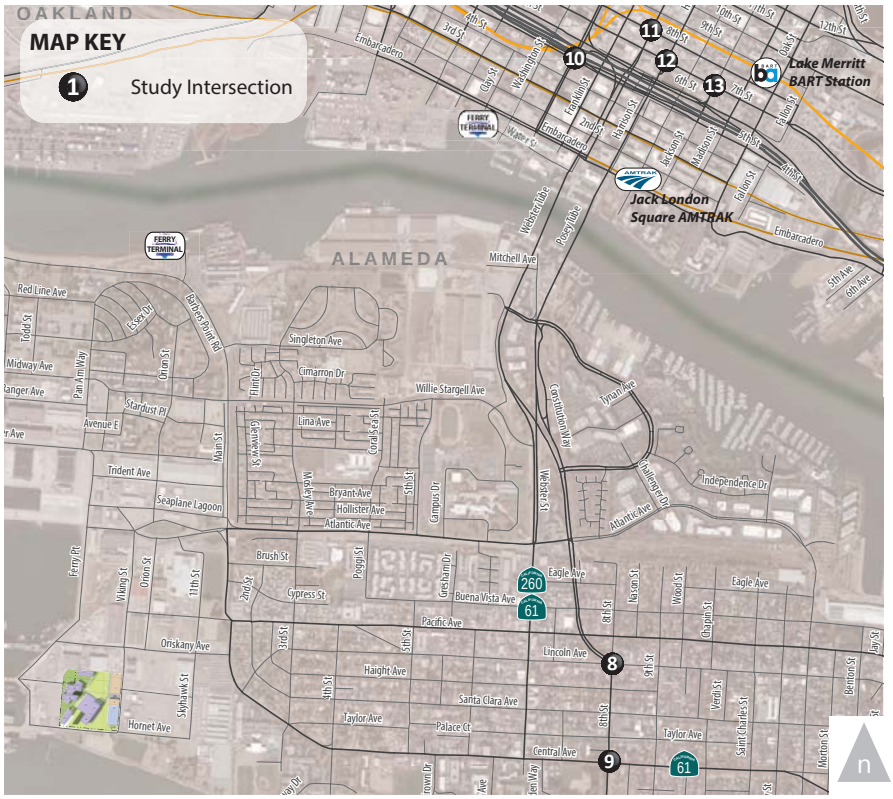
Figure 3-10A.

Alameda Point Campus
Cumulative (2035) No Project Peak Hour Traffic Volumes

WC12-2953_3-10A_Cumu2035NPvols

FEHR PEERS





VOLUMES KEY

XX (YY)	AM (PM) Peak Hour Traffic Volumes
	Signalized Intersection
	Stop Sign

Figure 3-10B.

Alameda Point Campus
Cumulative (2035) No Project Peak Hour Traffic Volumes

WC12-2953_3-10B_Cumu2035NPvols

FEHR PEERS

TABLE 3-7
ALAMEDA POINT
CUMULATIVE (2035) CONDITIONS – STUDY INTERSECTION LOS SUMMARY

Intersection	Traffic Control	Peak Hour	Cumulative (2035) No Project		Cumulative (2035) Plus Project		Significant Impact?
			Delay[1] (seconds)	LOS[1]	Delay[1] (seconds)	LOS[1]	
City of Alameda							
1. Webster Street/ Willie Stargell Avenue	Signal	AM	21.7	C	23.0	C	No
		PM	21.0	C	21.5	C	No
2. Main Street/ Atlantic Avenue	Signal	AM	12.1	B	13.1	B	No
		PM	11.9	B	12.6	B	No
3. Third Street/ Atlantic Avenue	Signal	AM	39.3	D	38.6	D	No
		PM	45.6	D	45.6	D	No
4. Webster Street/ Atlantic Avenue	Signal	AM	53.6	D	54.7	D	No
		PM	40.8	D	46.3	D	No
5. Constitution Way/ Atlantic Street	Signal	AM	28.0	C	28.6	C	No
		PM	47.0	D	49.2	D	No
6. Main Street/ Pacific Avenue	Signal	AM	26.6	C	30.2	C	No
		PM	19.9	B	23.8	C	No
7. Webster Street/ Lincoln Avenue	Signal	AM	19.5	B	20.0	B	No
		PM	15.2	B	15.2	B	No
8. Constitution Way/ Lincoln Avenue	Signal	AM	27.6	C	28.1	C	No
		PM	27.1	C	27.4	C	No
9. 8th Street/ Central Avenue	Signal	AM	44.3	D	46.5	D	No
		PM	53.4	D	53.8	D	No
City of Oakland							
10. Broadway/ 5th Street	Signal	AM	44.6	D	47.8	D	No
		PM	60.4	E	60.6	E	No
11. Webster Street/ 8th Street	Signal	AM	19.3	B	19.5	B	No
		PM	19.9	B	19.9	B	No
12. Harrison Street/ 7th Street	Signal	AM	**>120 (v/c=0.95)**	**F**	**>120 (v/c=0.95)**	**F**	No
		PM	**>120 (v/c=1.17)**	**F**	**>120 (v/c=1.21)**	**F**	**Yes**
13. Jackson Street/ 7th Street	Signal	AM	70.9	E	70.6	E	No
		PM	**>120 (v/c=2.89)**	**F**	**>120 (v/c=2.90)**	**F**	Yes

Notes: **Bold** indicates intersection operating at unacceptable LOS E/F in Alameda or unacceptable LOS F in Oakland.
1. For signalized intersections, average intersection delay and LOS based on the 2000 HCM method is shown.
Source: Fehr & Peers.

1

TABLE 3-8
ALAMEDA POINT
CUMULATIVE (2035) CONDITIONS – FREEWAY SEGMENT LOS SUMMARY

Freeway Segment	Type[1]	Dir[2]	Cumulative (2035) No Project				Cumulative (2035) Plus Project				Significant Impact?
			AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour		
			Density[3]	LOS	Density[3]	LOS	Density[3]	LOS	Density[3]	LOS	
1. I-880, west of I-980	Basic	NB	--	F	--	F	--	F	--	F	No
	Basic	SB	--	F	--	F	--	F	--	F	No
2. I-880, between I-980 and Oak Street	Basic	NB	38.8	E	--	F	38.9	E	--	F	No
	Basic	SB	--	F	--	F	--	F	--	F	No
3. I-880, south of Oak Street	Basic	NB	37.8	E	--	F	38.2	E	--	F	No
	Basic	SB	39.3	E	--	F	39.3	E	--	F	No
4. Webster/Posey Tubes	Basic	NB	26.6	D	25.7	C	26.7	D	26.6	D	No
	Basic	SB	23.1	C	29.2	D	24.0	C	29.3	D	No

1. Segments with auxiliary lanes are classified as weave segments, and were analyzed based on the Leisch Method. Basic segments are analyzed as basic segments using the 2000 HCM methodologies.
2. NB = Northbound; SB = Southbound
3. Density is presented in passenger cars per lane per mile (pc/ln/mi).

Source: Fehr & Peers.

2 All three study freeway segments on I-880 would operate at LOS F during one or both peak hours. The
3 Webster/Posey Tubes would operate at LOS D or better during both peak hours.

4 3.5.2 CUMULATIVE (2035) PLUS PROJECT CONDITIONS

5 **Figures 3-11A and 3-11B** show the Cumulative (2035) Plus Project traffic volumes, which consist of traffic
6 volumes under Cumulative (2035) No Project conditions (Figures 3-10 and 3-10B) plus Project traffic
7 assignment (Figures 3-7A and 3-7B). This analysis assumes no roadway modifications under this scenario.

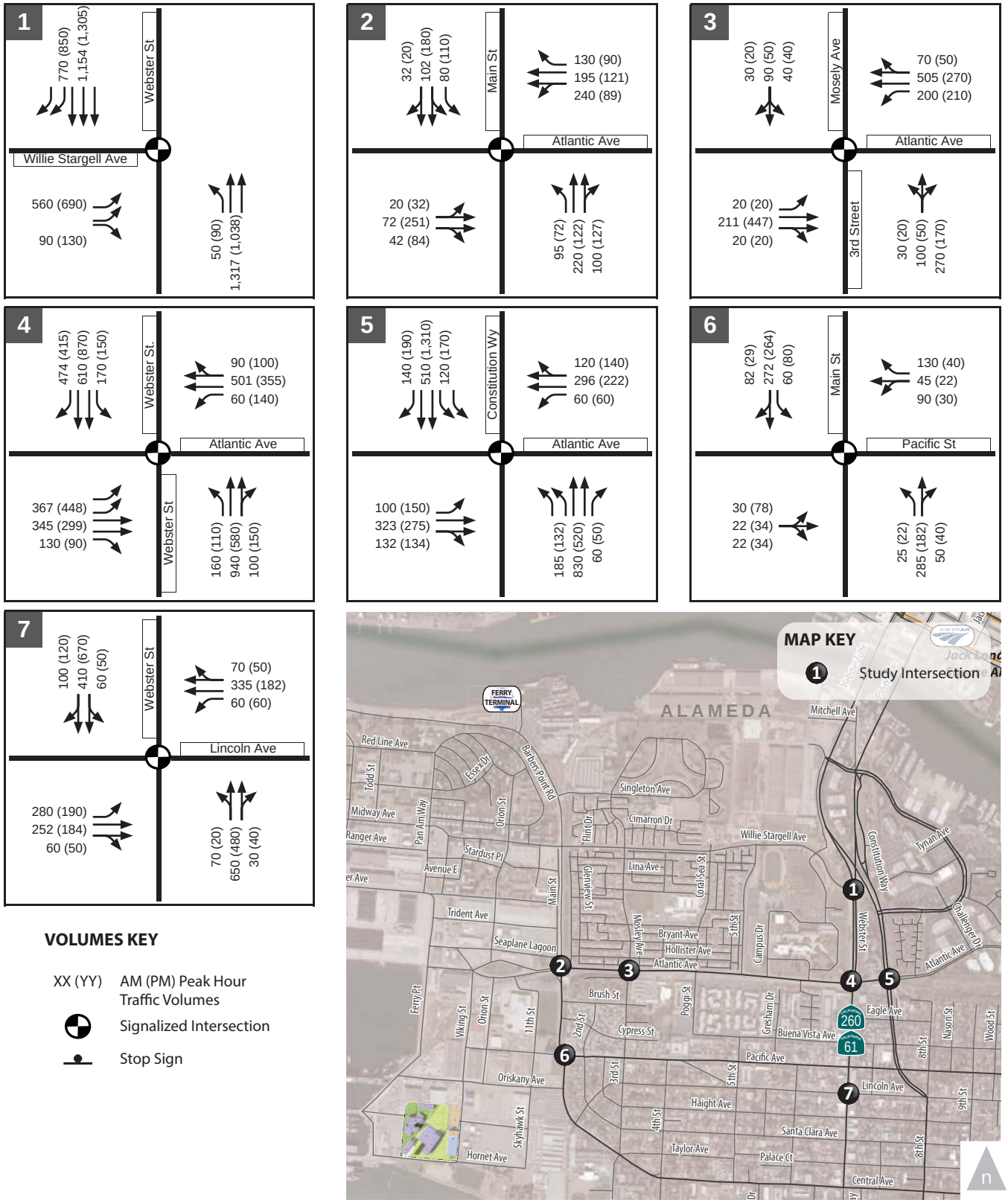
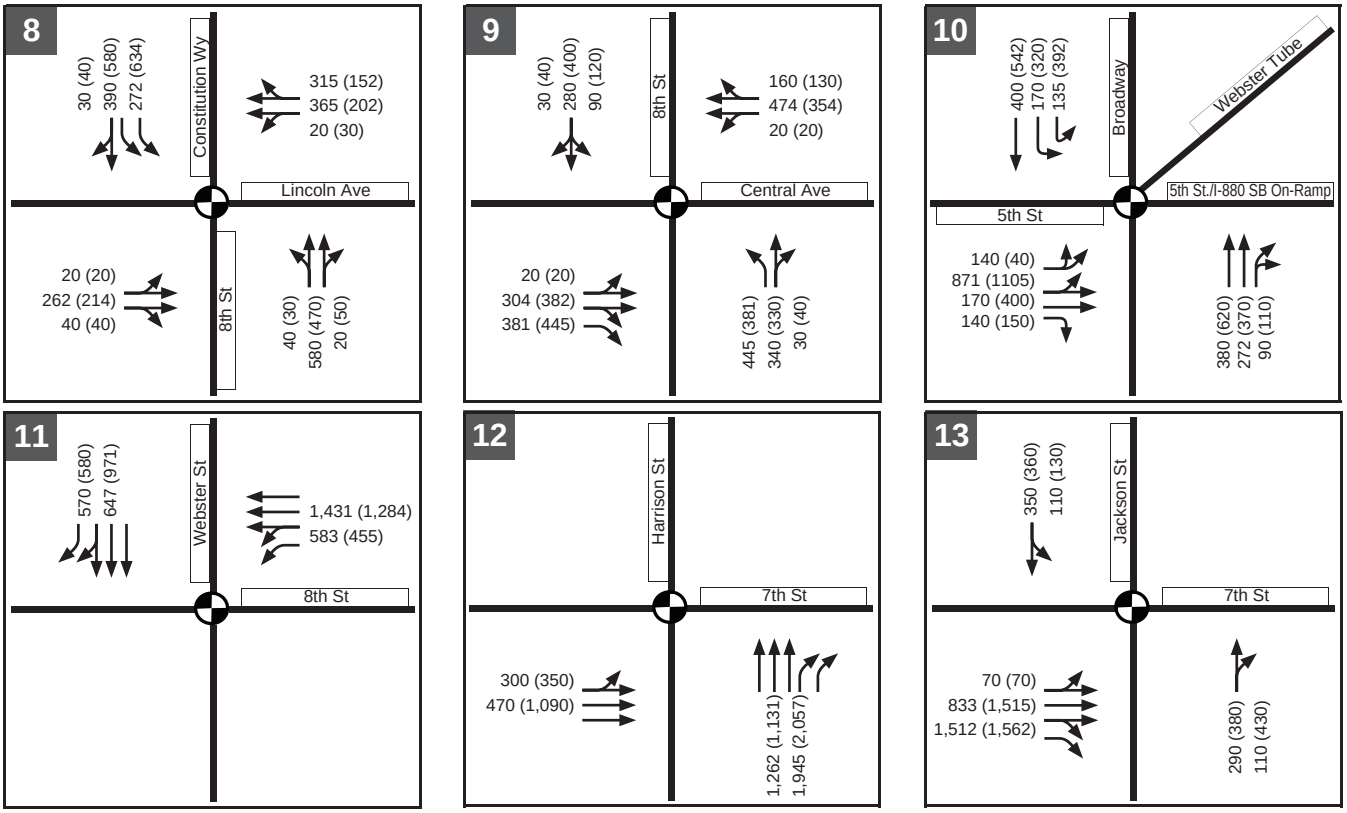
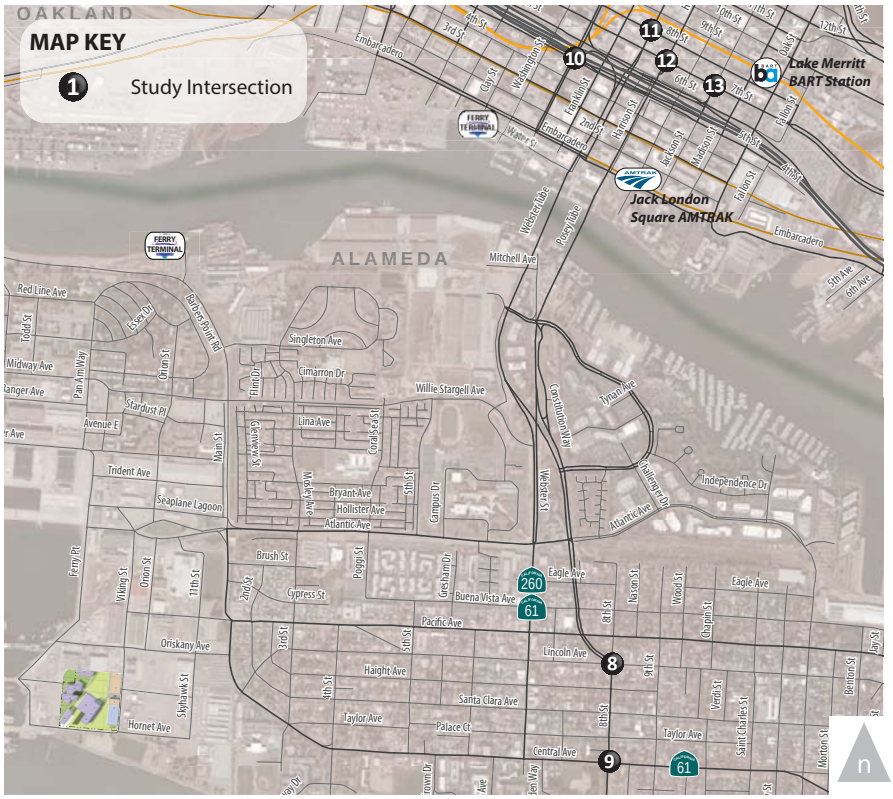


Figure 3-11A.

Alameda Point Campus
Cumulative (2035) Plus Phase 1 Peak Hour Traffic Volumes

WC12-2953_3-11A_Cumu2035+Ph1vols





VOLUMES KEY

XX (YY)	AM (PM) Peak Hour Traffic Volumes
	Signalized Intersection
	Stop Sign

Figure 3-11B.

Alameda Point Campus
Cumulative (2035) No Project Peak Hour Traffic Volumes

WC12-2953_3-11B_Cumu2035+PH1vols

FEHR PEERS

3.5.2.1 Intersection Operations

Table 3-7 summarizes intersection operations at the study intersections under the Cumulative (2035) Plus Project conditions. **Appendix E** provides the detailed calculation work sheets.

All study intersections in Alameda would continue to operate at LOS D or better during both AM and PM peak hours under the Cumulative (2035) Plus Project conditions. The Project would not cause a significant impact at the study intersections in Alameda.

In Oakland, Project generated traffic would contribute to LOS F conditions at the Harrison Street/7th Street intersection during both AM and PM peak hours and Jackson Street/7th Street intersection during the PM peak hour. The proposed project would not increase the overall intersection v/c ratio by 0.01 or more or increase critical movement v/c ratio by 0.02 or more at the Harrison Street/7th Street intersection during the AM peak hour. Therefore, the Project would not cause a significant impact at this intersection during the AM peak hour.

Project generated traffic would also contribute to LOS E conditions at the Jackson Street/7th Street intersection during the AM peak hour and at Broadway/5th Street during the PM peak hour; however, the Project would not cause an increase in the average delay for any of the critical movements by six seconds or more at either intersection. Based on City of Oakland's significance criteria, the Project would not cause a significant impact at the Jackson Street/7th Street or Broadway/5th Street intersections under Cumulative (2035) Plus Project conditions.

The Project would cause a significant impact at two intersections which are summarized under Impact 3-2 discussion.

IMPACT 3-2: CUMULATIVE (2035) PLUS PROJECT CONDITIONS INTERSECTION OPERATIONS

The proposed Project at Alameda Point would cause a significant impact at the following intersections under Cumulative (2035) Plus Project conditions:

A. The Project would cause a significant impact at the signalized **Harrison Street/7th Street** (Intersection 12) because it would increase the overall intersection v/c ratio by 0.01 or more and increase critical movement v/c ratio by 0.02 or more during the PM peak hour at an intersection in downtown Oakland operating at LOS F regardless of the Project.

B. The Project would cause a significant impact at the signalized **Jackson Street/7th Street** (Intersection 13) because it would increase the overall intersection v/c ratio by 0.01 or more and increase critical movement v/c ratio by 0.02 or more during the PM peak hour at an intersection in downtown Oakland operating at LOS F regardless of the Project.

Mitigation Measure 3-2: Implement the following:

A. **Harrison Street/7th Street** (Intersection 12): Implement the following which requires coordination with City of Oakland (Same as Mitigation Measure 3-1A):

- Increase traffic signal cycle length to 80 seconds and optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would continue to operate at LOS F during the PM peak hour. However, this mitigation measure would reduce the overall intersection v/c ratio and the critical movement v/c ratio to the same level or less than under Cumulative (2035) No Project conditions. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

B. **Jackson Street/7th Street** (Intersection 13): Implement the following which requires coordination with City of Oakland:

- Increase traffic signal cycle length to 80 seconds and optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would continue to operate at LOS F during the PM peak hour. However, this mitigation measure would reduce the overall intersection v/c ratio and the critical movement v/c ratio to the same level or less than under Cumulative (2035) No Project conditions. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

3.5.2.2 Freeway Operations

Table 3-8 summarizes the AM and PM peak hour freeway LOS analysis results under Cumulative (2035) Plus Project conditions. **Appendix F** provides the detailed calculation work sheets.

All freeway segments are projected to continue to operate at the same LOS as under Cumulative (2035) No Project conditions during both AM and PM peak hours. The proposed Project would not increase the peak hour volume by five percent or more at the study freeway segments that are projected to operate at LOS F. Therefore, the proposed Project would not cause a significant impact at the study freeway segments under Cumulative (2035) Plus Project conditions.

3.6 ADDITIONAL EMPLOYMENT ALTERNATIVE ANALYSIS

This section presents trip generation for the Additional Employment Alternative scenario and summarizes traffic operations under the Near-Term (2018) Plus Additional Employment Alternative conditions. The Additional Employment Alternative would consist of an additional 200,000 square feet of space and accommodate an additional 700 employees at the Alameda Point site.

3.6.1 TRIP GENERATION

Table 3-9 shows the estimated vehicle trip generation for the Additional Employment Alternative at the Alameda Point site. The trip generation estimates is based on the same methodology used to estimate trip generation for the Alameda Point Project as documented in section 3.3.1. The 700 additional employees under this Alternative at the Alameda Point site are expected to increase trip generation to about 3,500 daily, 360 AM peak hour, and 340 PM peak hour automobile trips.

TABLE 3-9
ALAMEDA POINT
ADDITIONAL EMPLOYMENT ALTERNATIVE VEHICLE TRIP GENERATION SUMMARY

	Average Daily Population	Daily	AM Peak Hour			PM Peak Hour		
			In	Out	Total	In	Out	Total
Alameda Point Project [1]	1,000	2,079	182	29	211	27	172	199
Additional Employees [1]	700	1,455	127	20	147	18	121	139
Additional Employment Alternative Total	1,700	3,534	309	49	358	45	293	338

1. Based on following trip generation rates:
Daily = 2.08 trips per Average Daily Population (ADP); AM Peak Hour = 0.21 trips per ADP (86% in, 14% out); PM Peak Hour = 0.20 trips per ADP (13% in, 87% out)

Source: Fehr & Peers, based on trip generation rate per average daily population at the existing LBNL site in Berkeley adjusted to reflect the different characteristics of the RBC.

3.6.2 NEAR-TERM (2018) PLUS ADDITIONAL EMPLOYMENT ALTERNATIVE CONDITIONS

Figures 3-12A and 3-12B show the traffic volumes under the Near-Term (2018) Plus Additional Employment Alternative conditions, which consist of traffic volumes under Near-Term (2018) No Project conditions plus traffic generated by the 1,000 Project employees and the 700 additional employees under the Additional Employment Alternative.

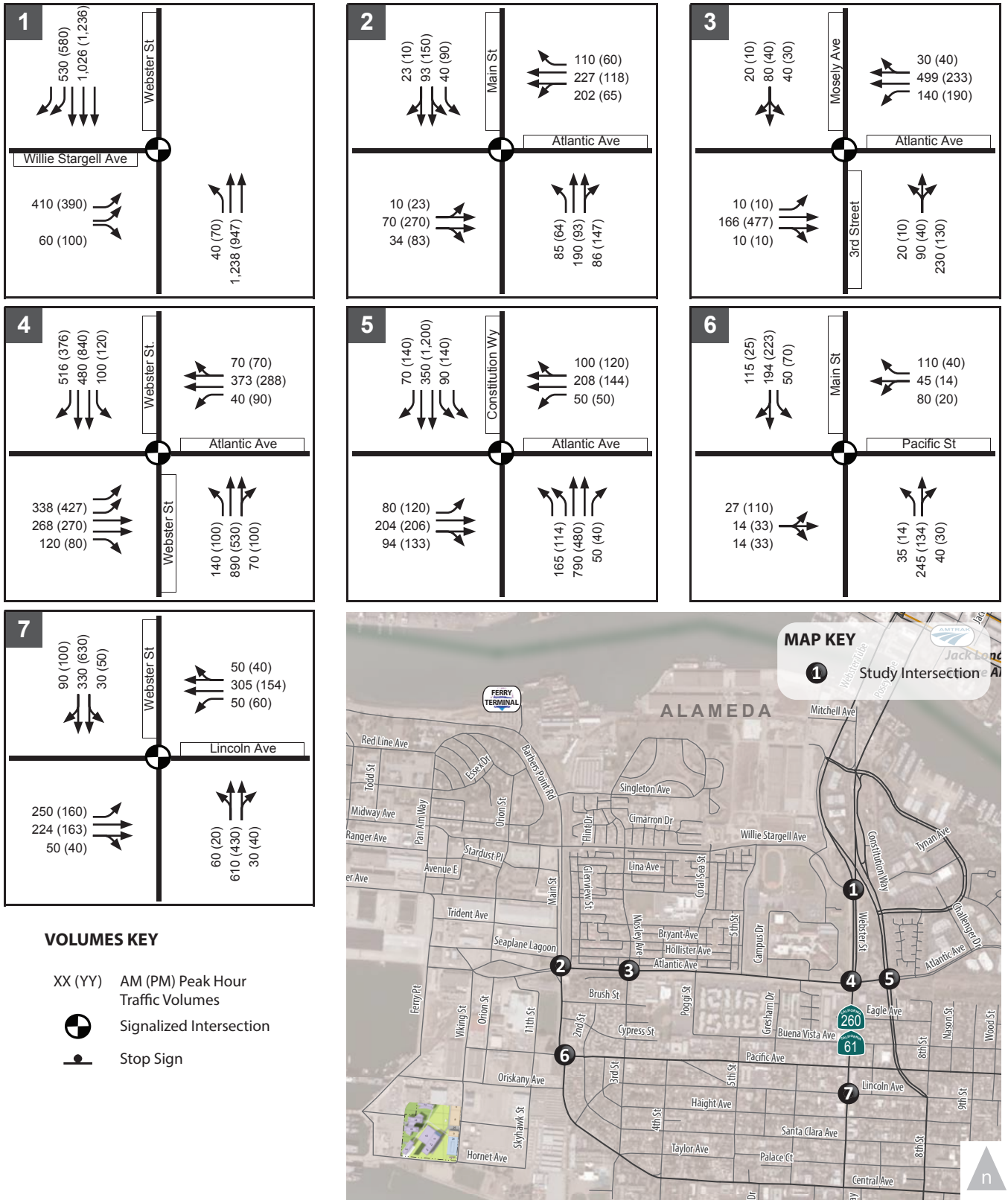
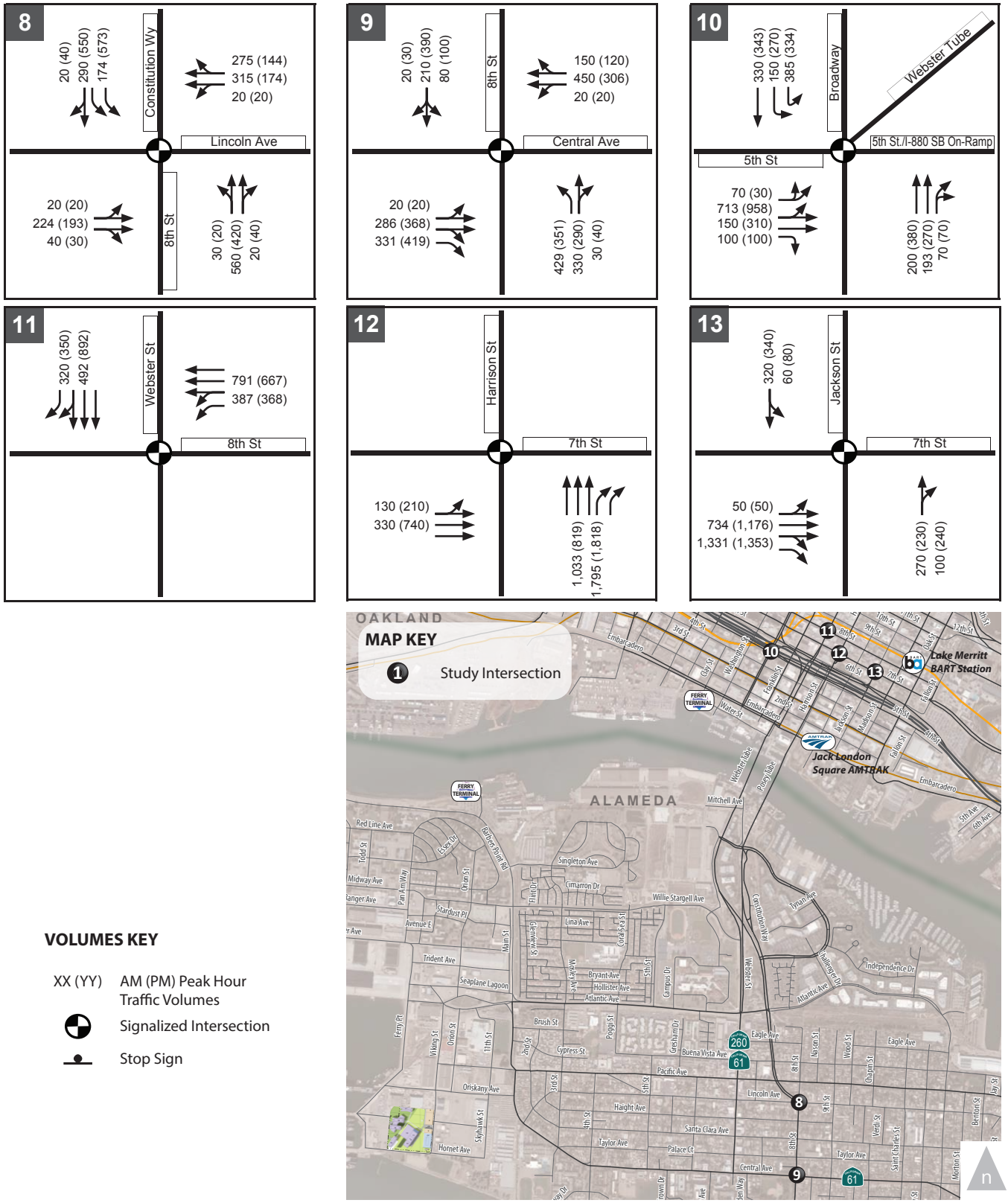


Figure 3-12A.

Alameda Point Campus Near-Term (2018)
Plus Additional Employment Alternative Peak Hour Traffic Volumes

WC12-2953_3-12A_NT2018+AEAvols

FEHR & PEERS



VOLUMES KEY

XX (YY)	AM (PM) Peak Hour Traffic Volumes
	Signalized Intersection
	Stop Sign

Figure 3-12B.

Alameda Point Campus Near-Term (2018) Plus Additional Employment Alternative Peak Hour Traffic Volumes

WC12-2953_3-12B_NT2018+AEAvols

FEHR & PEERS

3.6.2.1 Intersection Operations

Table 3-10 summarizes intersection operations at the study intersections under the Near-Term (2018) Plus Additional Employment Alternative conditions. **Appendix E** provides the detailed calculation work sheets.

Similar to the Near-Term (2018) Plus Project conditions, all study intersections in Alameda would continue to operate at LOS D or better during both AM and PM peak hours under the Near-Term (2018) Plus Additional Employment Alternative conditions. The Additional Employment Alternative would not cause a significant impact at the study intersections in Alameda.

In Oakland, traffic generated by the Additional Employment Alternative would contribute to LOS F conditions at the Harrison Street/7th Street intersection during both AM and PM peak hours.

Traffic generated by the Additional Employment Alternative would also contribute to LOS E conditions at the Jackson Street/7th Street intersection in Oakland during the PM peak hour; however, the Cumulative Alternative would not cause an increase in the average delay for any of the critical movements by six seconds or more. Based on City of Oakland's significance criteria, the Cumulative Alternative would not cause an impact at the Jackson Street/7th Street intersection under Near-Term (2018) conditions.

The Cumulative Alternative would cause a significant impact at one intersection in Oakland which is summarized under Impact 3-3 discussion.

IMPACT 3-3: NEAR-TERM (2018) PLUS ADDITIONAL EMPLOYMENT ALTERNATIVE CONDITIONS INTERSECTION OPERATIONS

The Additional Employment Alternative at Alameda Point would cause a significant impact at the following intersection under Near-Term (2018) Plus Additional Employment Alternative conditions:

A. The Additional Employment Alternative would cause a significant impact at the signalized **Harrison Street/7th Street** (Intersection 12) because it would increase the overall intersection v/c ratio by 0.01 or more and increase critical movement v/c ratio by 0.02 or more during both AM and PM peak hours at an intersection in downtown Oakland operating at LOS F regardless of the Alternative.

Mitigation Measure 3-3: Implement the following:

TABLE 3-10
ALAMEDA POINT
ADDITIONAL EMPLOYMENT ALTERNATIVE (2018) CONDITIONS –
STUDY INTERSECTION LOS SUMMARY

Intersection	Traffic Control	Peak Hour	Near-Term (2018) No Project		Near-Term (2018) Plus Additional Employment Alternative		Significant Impact?
			Delay[1] (seconds)	LOS[1]	Delay[1] (seconds)	LOS[1]	
City of Alameda							
1. Webster Street/ Willie Stargell Avenue	Signal	AM	19.1	B	20.4	C	No
		PM	19.3	B	19.9	B	No
2. Main Street/ Atlantic Avenue	Signal	AM	11.2	B	12.4	B	No
		PM	11.6	B	12.1	B	No
3. Third Street/ Atlantic Avenue	Signal	AM	22.2	C	23.0	C	No
		PM	40.7	D	37.4	D	No
4. Webster Street/ Atlantic Avenue	Signal	AM	42.9	D	47.4	D	No
		PM	31.6	C	37.1	D	No
5. Constitution Way/ Atlantic Street	Signal	AM	22.7	C	23.3	C	No
		PM	25.8	C	26.1	C	No
6. Main Street/ Pacific Avenue	Signal	AM	20.4	C	25.1	C	No
		PM	16.0	B	21.8	C	No
7. Webster Street/ Lincoln Avenue	Signal	AM	16.0	B	16.4	B	No
		PM	14.5	B	14.5	B	No
8. Constitution Way/ Lincoln Avenue	Signal	AM	22.0	C	22.6	C	No
		PM	23.0	C	23.4	C	No
9. 8th Street/ Central Avenue	Signal	AM	38.0	D	40.3	D	No
		PM	44.8	D	45.3	D	No
City of Oakland							
10. Broadway/ 5th Street	Signal	AM	26.4	C	28.7	C	No
		PM	35.2	D	38.4	D	No
11. Webster Street/ 8th Street	Signal	AM	15.9	B	16.0	B	No
		PM	17.3	B	17.3	B	No
12. Harrison Street/ 7th Street	Signal	AM	**100.5 (v/c=0.74)**	**F**	**106.5 (v/c=0.75)**	**F**	Yes
		PM	**>120 (v/c=0.86)**	**F**	**>120 (v/c=0.93)**	**F**	Yes
13. Jackson Street/ 7th Street	Signal	AM	16.8	B	16.7	B	No
		PM	70.9	E	68.4	E	No

Notes: **Bold** indicates intersection operating at unacceptable LOS E/ F in Alameda or unacceptable LOS F in Oakland.
1. For signalized intersections, average intersection delay and LOS based on the 2000 HCM method is shown.
Source: Fehr & Peers.

A. **Harrison Street/7th Street** (Intersection 12): Implement the following which requires coordination with City of Oakland (same as Mitigation Measure 3-1A):

- Increase traffic signal cycle length to 75 seconds and optimize traffic signal timing parameters (i.e., the amount of green signal time allocated to each intersection approach).

The intersection would continue to operate at LOS F during both AM and PM peak hours after the implementation of this mitigation measure. However, this mitigation measure would reduce the overall intersection v/c ratio and the critical movement v/c ratio to the same level or less than under Near-Term (2018) No Project conditions. Therefore, the mitigation measure would reduce the impact to less than significant if implemented.

3.6.2.2 Freeway Operations

Table 3-6 summarizes the AM and PM peak hour freeway LOS analysis results under Near-Term (2018) Plus Additional Employment Alternative conditions. **Appendix F** provides the detailed calculation work sheets.

All freeway segments operating at acceptable LOS E or better under Near-Term (2018) No Project conditions are projected to continue to operate at an acceptable LOS under Near-Term (2018) Plus Additional Employment Alternative conditions. The Additional Employment Alternative would not increase the peak hour volume by five percent or more at the study freeway segments that are projected to operate at LOS F. Therefore, the Additional Employment Alternative would not cause a significant impact at the study freeway segments under Near-Term (2018) Plus Additional Employment Alternative conditions.

1

TABLE 3-11
ALAMEDA POINT
ADDITIONAL EMPLOYMENT ALTERNATIVE (2018) CONDITIONS –
FREEWAY SEGMENT LOS SUMMARY

Freeway Segment	Type[1]	Dir[2]	Near-Term (2018) No Project				Near-Term (2018) Plus Additional Employment Alternative				Significant Impact?
			AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour		
			Density[3]	LOS	Density[3]	LOS	Density[3]	LOS	Density[3]	LOS	
1. I-880, west of I-980	Basic	NB	--	F	--	F	--	F	--	F	No
	Basic	SB	--	F	--	F	--	F	--	F	No
2. I-880, between I-980 and Oak Street	Basic	NB	35.7	E	38.8	E	35.8	E	39.6	E	No
	Basic	SB	--	F	--	F	--	F	--	F	No
3. I-880, south of Oak Street	Basic	NB	34.2	D	35.8	E	34.7	D	35.8	E	No
	Basic	SB	34.0	D	38.7	E	34.1	D	39.4	E	No
4. Webster/Posey Tubes	Basic	NB	23.4	C	20.7	C	23.6	C	22.1	C	No
	Basic	SB	17.0	B	23.7	C	18.5	C	24.0	C	No

1. Segments with auxiliary lanes are classified as weave segments, and were analyzed based on the Leisch Method. Basic segments are analyzed as basic segments using the 2000 HCM methodologies.
2. NB = Northbound; SB = Southbound
3. Density is presented in passenger cars per lane per mile (pc/ln/mi).

Source: Fehr & Peers.

2

4.0 LBNL SITE ALTERNATIVE

This chapter describes existing transportation conditions for the existing LBNL site and identifies impacts and mitigation measures of Phase 1 development of the proposed LRDP at LBNL under Near-Term (2018) and Cumulative (2035) conditions.

4.1 EXISTING CONDITIONS

Existing transportation conditions at LBNL and vicinity are described below.

4.1.1 EXISTING ROADWAY NETWORK

Figure 4-1 shows the existing LBNL site, the surrounding roadway system, and intersections analyzed as part of this analysis. The regional and local roadways serving the project site, as well as the internal circulation within the site are described below.

4.1.1.1 Regional Roadways

Interstate 80 (I-80) connects the San Francisco Bay Area with the Sacramento region and continues east. Within Berkeley, I-80 is oriented in a north-south direction along the western edge of the city and provides five lanes of travel in each direction. Access from I-80 to the city of Berkeley is provided through interchanges at Ashby Avenue, University Avenue, and Gilman Street. I-80 and the nearby I-80/I-580 interchange operate at capacity during the peak commute hours. I-80 between Emeryville and Albany is also I-580. I-80 has an AADT of 256,000 vehicles (Caltrans, 2011) between the University Avenue and Gilman Street interchanges.

State Route 24 (SR 24) links I-680 in Contra Costa County to I-80/I-580 and I-980. SR 24 provides four travel lanes in each direction near Berkeley. This is the primary route used by Berkeley-bound travelers from Contra Costa County. The primary access routes from SR 24 to the LBNL area are SR 13 (Ashby Avenue) to the Belrose-Derby-Warring-Piedmont corridor, and Telegraph Avenue. SR 24 has an AADT of 148,000 vehicles (Caltrans, 2011) east of SR 13.

State Route 13/Ashby Avenue (SR 13) connects I-580 in east Oakland to I-80, with a partial access interchange at SR 24. In Berkeley, SR 13 is Tunnel Road/Ashby Avenue, a generally east-west two to four-lane arterial through the city. Ashby Avenue intersects the major north-south roadways in Berkeley, providing several routes toward LBNL and UC Berkeley campus. It is about 1.25 miles south of the LBNL.

Figure 4-1.

LBNL Site Study Locations

WC12-2953_4-1_LBNLStudy

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During the peak commute hours, on-street parking restrictions on the north side of Ashby Avenue in the morning and the south side in the evening provide an additional travel lane for commuters. Ashby Avenue provides sidewalks on both sides of the roadway. SR 13 has an AADT of 28,500 vehicles (Caltrans, 2011) north of SR 24.

University Avenue provides one of Berkeley's three connections to I-80 to the west (along with Gilman Street and Ashby Avenue). It is an east-west major arterial that extends from the Berkeley Marina and I-80 in the west to the UC Berkeley campus in the east. The divided roadway provides a center median and left-turn pockets at major intersections. Left turns from University Avenue onto cross-streets generally are not served by a separate left-turn signal phase. University Avenue is a four-lane arterial, with parallel parking and sidewalks on both sides of the roadway.

Belrose-Derby-Warring-Piedmont Corridor. This is a heavily used route connecting SR 24 with Berkeley's Southside area (i.e., the area just south of the UC Berkeley campus), UC Berkeley, and LBNL. With a single travel lane in each direction, the route is at or near capacity for several hours during the morning and evening commute periods. The roadways in this corridor provide sidewalks on both sides of the street. Using roadway signs and notices in official mailings, the City of Berkeley and UC Berkeley have been encouraging travelers to use other routes, like Telegraph Avenue.

Hearst Avenue is a two- to four-lane, east-west street that extends between west Berkeley and LBNL's main entrance at Cyclotron Road, which diverges from Hearst Avenue just east of Gayley Road along the northern boundary of the UC Berkeley campus. Between Gayley Road/La Loma Avenue and LeRoy Avenue, Hearst Avenue provides one travel lane in each direction, with parallel parking on both sides. During the peak commute hours, on-street parking restrictions on the south side of the street in the morning and the north side in the evening provide an additional travel lane. Hearst Avenue generally provides sidewalks on both sides of the street, except between Arch Street and Euclid Avenue, where sidewalk is only provided on the north side of the roadway. Hearst Avenue is designated as a bicycle lane (Class 2 west of Shattuck Avenue and a bicycle route (Class 3) east of Shattuck Avenue.

4.1.1.2 Local Roadways

Bancroft Way is an east-west roadway extending from downtown Berkeley through the Southside area, along the southern boundary of the UC Berkeley campus. The roadway is one-way westbound, with two travel lanes from Piedmont Avenue to Telegraph Avenue and three travel lanes from Telegraph Avenue to the Bancroft Way/Oxford Street intersection. Bancroft Way provides sidewalks on both sides of the roadway.

Durant Avenue is a major east-west roadway extending from downtown Berkeley through the Southside area. East of Shattuck Avenue, the roadway is one-way eastbound with three travel lanes. Durant Avenue serves as a "one-way couplet" with Bancroft Way for east-west travel on the south side of the UC Berkeley campus. Durant Avenue provides sidewalks on both sides of the roadway.

La Loma Avenue/Gayley Road is a two-lane, north-south street that extends from Hearst Avenue through north Berkeley. South of Hearst Avenue, La Loma Avenue becomes Gayley Road and borders the east side of the UC Berkeley campus. Parking is allowed on both sides of the street north of Hearst Avenue, but is not allowed south of Hearst Avenue until the vicinity of Memorial Stadium, where Gayley Road becomes Piedmont Avenue. Both streets provide sidewalks on both sides of the roadway. Gayley Road, just north of Banroft Way, provides Class 2 bicycle lanes.

Stadium Rim Way wraps around the east and north sides of Memorial Stadium and connects the west end of Panoramic Way to Gayley Road near the Greek Theater. It provides access from Gayley Road and Prospect Street to the east side of Memorial Stadium and surrounding parking facilities. Stadium Rim Way also intersects with Centennial Drive, indirectly providing access to the Lawrence Hall of Science (LHS), the Botanical Garden, the Strawberry Canyon Recreational Area, and the LBNL gates on Centennial Drive. Stadium Rim Way generally provides pedestrian facilities on the south side of the roadway consisting of sidewalks or an at-grade path separated from the roadway with bollards.

Centennial Drive borders the east and south perimeters of LBNL. It connects Grizzly Peak Boulevard and Stadium Rim Way and provides access to LBNL through the Strawberry Canyon and Grizzly Peak gates. Centennial Drive also provides access to LHS, the Botanical Garden, Strawberry Canyon Recreational Area, and Tilden Regional Park. In the vicinity of LBNL, the speed limit is 25 miles per hour. Several sections of the roadway have steep grades and sharp curves, where the speed limit is reduced to 15 miles per hour. Centennial Drive provides intermittent sidewalks or parallel unpaved path along specific segments.

Grizzly Peak Boulevard is a two-lane, two-way roadway located in the hills of Berkeley, connecting Skyline Boulevard in the Sibley Volcanic Regional Preserve in the south, to Spruce Street near the Summit Reservoir in north Berkeley. The narrow and curvy roadway does not provide any pedestrian or bicyclist amenities south of Centennial Drive; however, it is signed as a Class 3 bicycle route. The roadway provides access to parking facilities and trails in Tilden Regional Park, and to SR 24.

4.1.1.3 Internal Circulation

The LBNL campus is served by an east-west traffic circulation system that generally conforms to the contours of the site's topography. Employees and visitors access the site through three gates. The

Blackberry Canyon Gate, on the west of the site, is accessed via Cyclotron Road and connects to Hearst Avenue. The Strawberry Canyon and Grizzly Peak Gates, on the east of the site, are accessed via Centennial Road. The three gates are attended by security personnel during business hours; the Blackberry Canyon Gate is the only one accessible by a card access system at other times. The site's main vehicle routes are two-way, except for three sections where roadside parking reduces the width, permitting only one-way travel.

4.1.2 TRAFFIC OPERATIONS ANALYSIS

This study analyzes existing traffic operations during typical weekday AM and PM peak hours at the following 14 intersections in the City of Berkeley:

1. Grizzly Peak Boulevard/Centennial Drive
2. Hearst Avenue/Shattuck Avenue
3. Hearst Avenue/Oxford Street
4. Hearst Avenue/Euclid Avenue
5. Hearst Avenue/Gayley Road/La Loma Avenue
6. University Avenue/Shattuck Avenue
7. University Avenue/Oxford Street
8. Gayley Road/Stadium Rim Way
9. Centennial Drive/Stadium Rim Way
10. Panoramic Way/Canyon Road/ Stadium Rim Way
11. Bancroft Way/Gayley Road/Piedmont Avenue
12. Durant Avenue/Piedmont Avenue
13. Channing Way/Piedmont Avenue
14. Dwight Way/Piedmont Avenue

These intersections were selected for analysis because they are most likely to be affected by the proposed Alternative. **Figure 4-1** shows the location of the study intersections and their configuration and control.

4.1.2.1 Existing Intersection Volumes

The intersection operations analysis presented in this study are based on AM and PM peak period (7:00 to 10:00 AM and 4:00 to 7:00 PM) intersection turning movement, pedestrian, and bicycle volumes collected on Wednesday, September 12, 2012, and Thursday, January 31, 2013, while UC Berkeley was in regular session. These time periods were selected because trips generated by the proposed Project, in combination with background traffic, are expected to represent typical worst traffic conditions. Within the peak periods, the peak hours (i.e., the hour with the highest traffic volumes observed in the study area) are from 8:00 AM to 9:00 AM (AM peak hour) and 5:00 PM to 6:00 PM (PM peak hour).

Figures 4-2A and 4-2B present the existing AM and PM peak hour intersection vehicle turn movement volumes at the study intersections. **Figures 4-3A and 4-3B** present the existing AM and PM peak hour pedestrian and bicycle volumes at the study intersections. **Appendix G** presents the detailed count sheets at the study intersections.

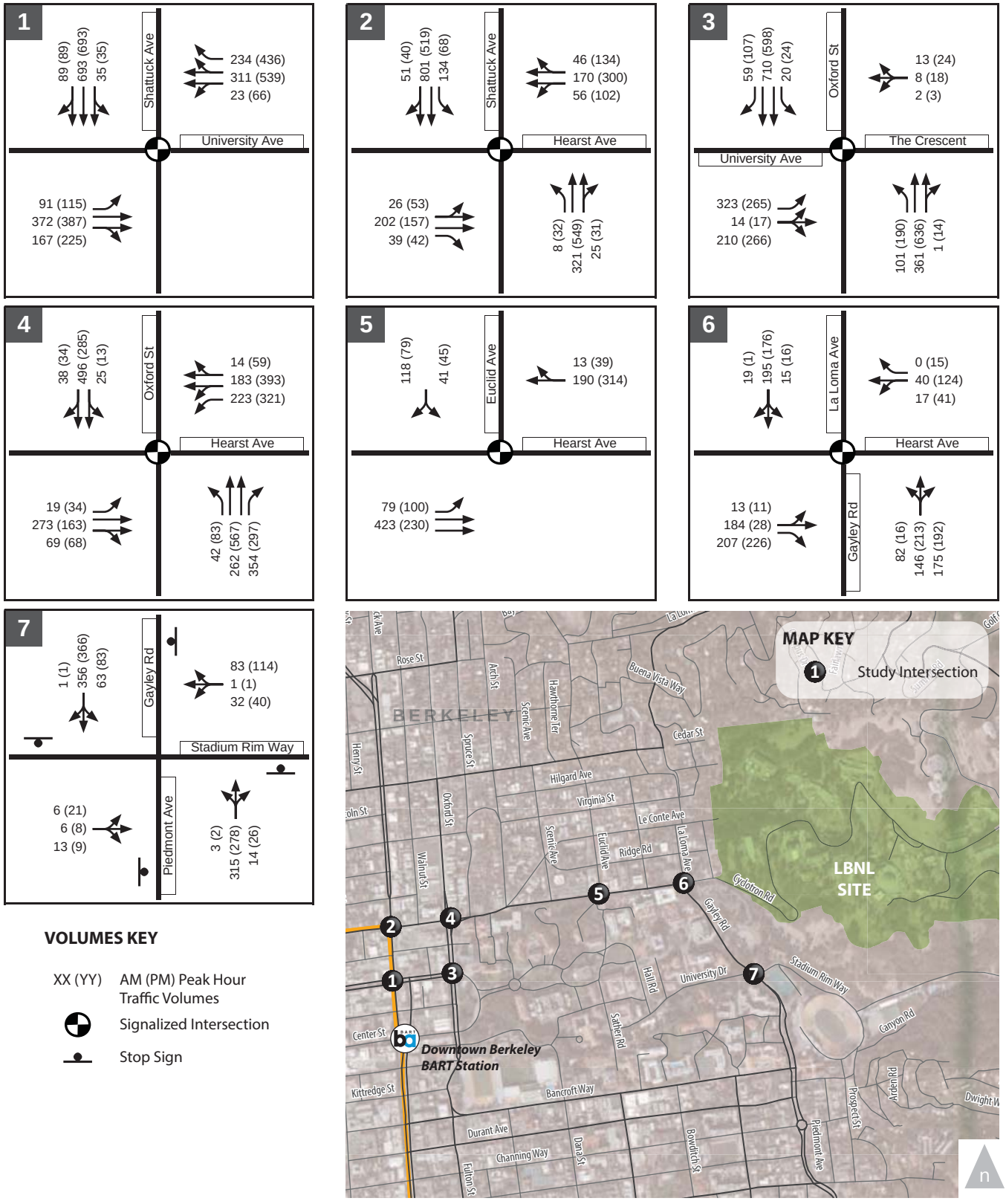

Figure 4-2A.

LBNL Site Existing
Peak Hour Traffic Volumes, Lane Configurations and Traffic Control

WC12-2953_4-2A_ExVol

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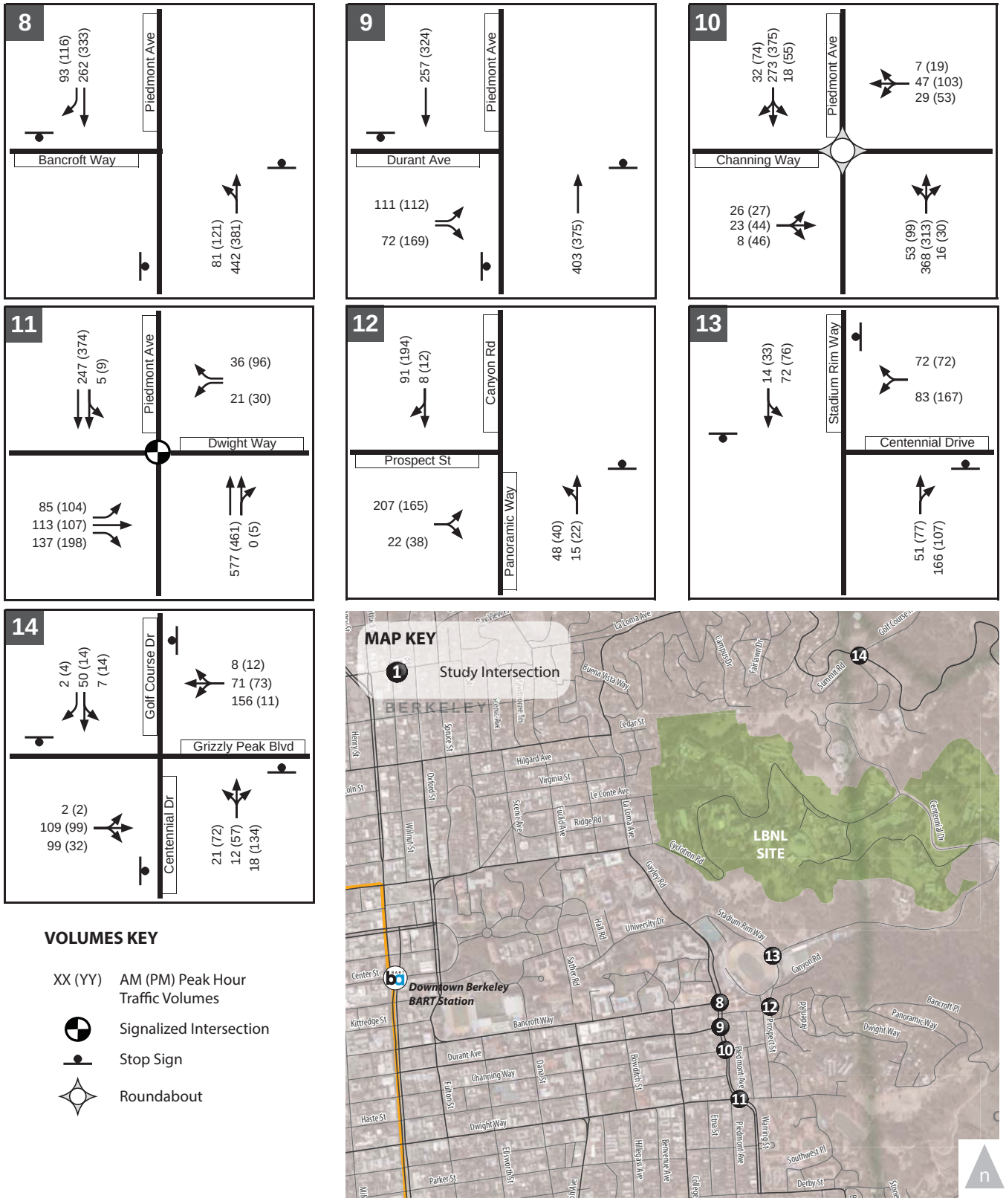

Figure 4-2B.

LBNL Site Existing
Peak Hour Traffic Volumes, Lane Configurations and Traffic Control

WC12-2953_4-2B_ExVol

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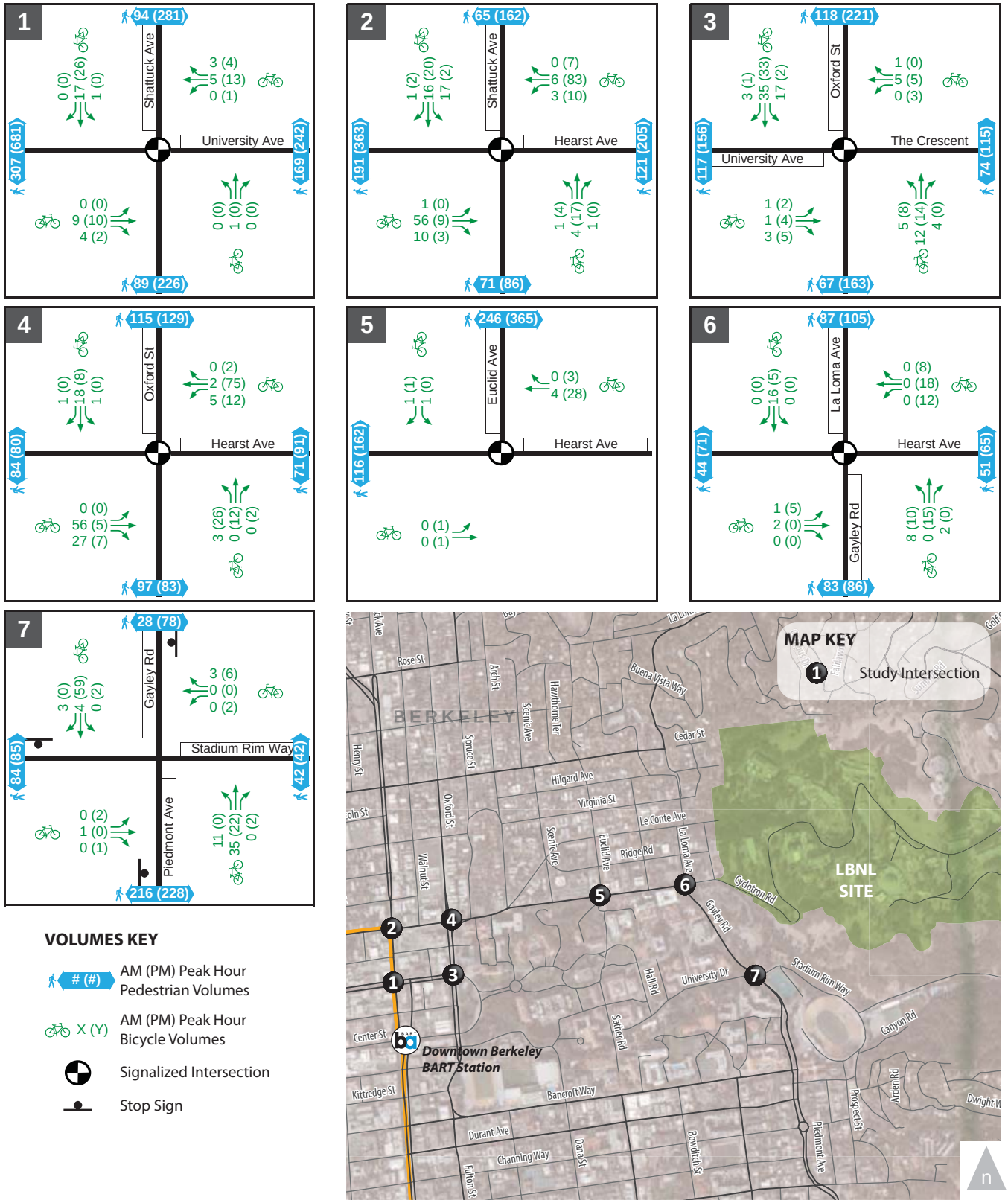

Figure 4-3A.

LBNL Site Existing
Pedestrian and Bicycle Peak Hour Volumes

WC12-2953_4-3A_BikePedVol

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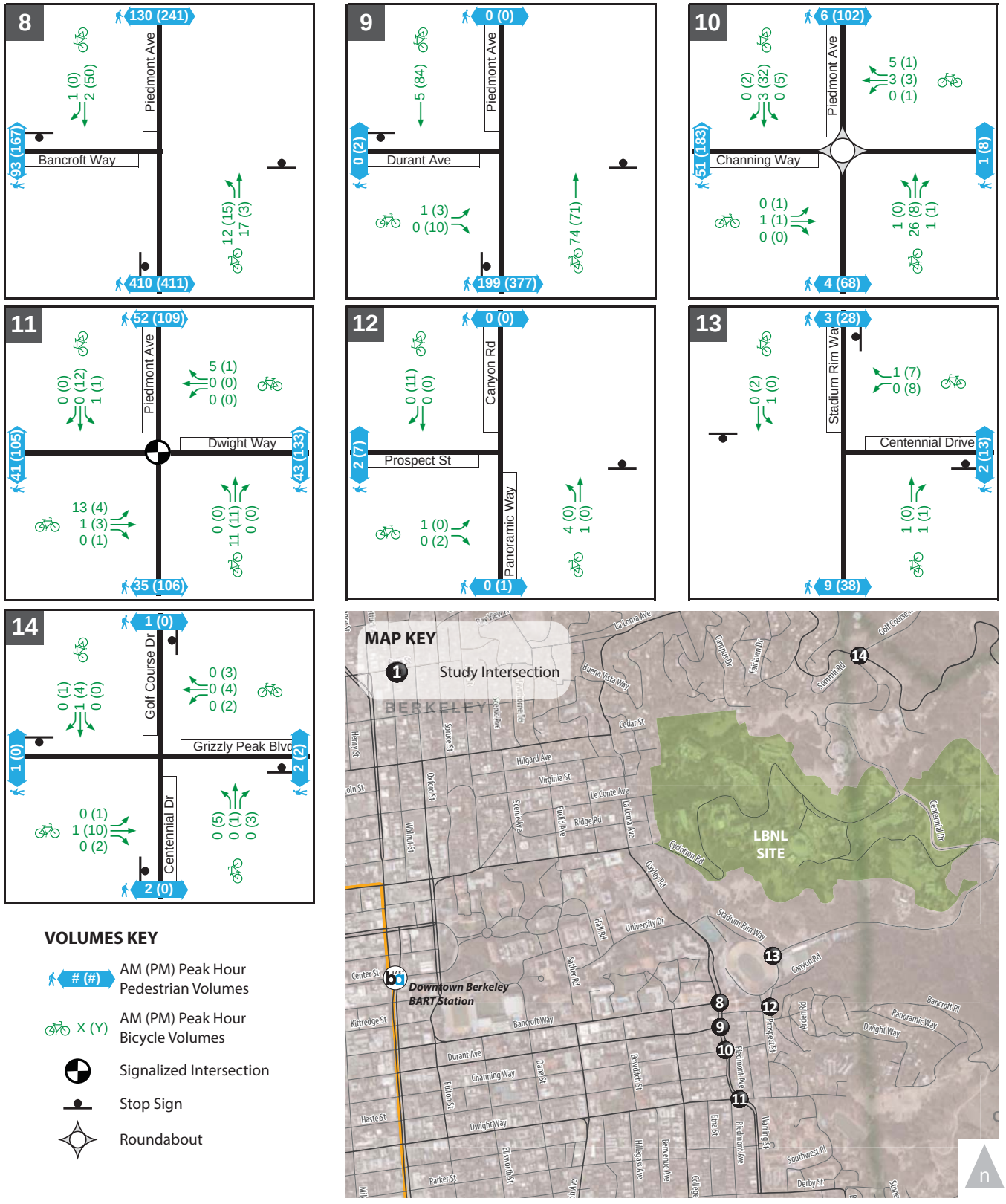

Figure 4-3B.

LBNL Site Existing
Pedestrian and Bicycle Peak Hour Volumes

WC12-2953_4-3B_ExVol

FEHR PEERS

4.1.2.2 Existing Intersection Operations

Table 4-1 summarizes existing weekday peak hour intersection LOS analysis results. **Appendix H** provides the detailed calculation work sheets. As shown in the table, all study intersections currently operate at LOS D or better during the AM peak hour; and 12 of the 14 study intersections currently operate at LOS C or better during the PM peak hour.

Based on the analysis and verified by observations, the all-way stop-controlled Bancroft Way/Piedmont Avenue and Durant Avenue/Piedmont Avenue intersections operate at LOS F during the PM peak hour. Northbound and southbound vehicle flows at these intersections are impeded by the high pedestrian volumes crossing Piedmont Avenue.

4.1.3 EXISTING TRANSIT AND SHUTTLE SERVICES

The LBNL site is served indirectly by BART, AC Transit, and UC Berkeley Shuttle Service (BEAR Transit) and directly by the LBNL shuttle service. **Figure 4-4** shows the transit routes in the vicinity of the project site. Each transit service is described below.

4.1.3.1 BART

BART provides regional commuter rail transit in Alameda, Contra Costa, San Francisco, and San Mateo counties. Currently, BART trains operate on weekdays from 4:00 AM to midnight, on Saturdays from 6:00 AM to midnight, and on Sundays from 8:00 AM to midnight. The nearest BART station to the LBNL site is the Downtown Berkeley station located one block west of the UC Berkeley campus at the Center Street/ Shattuck Avenue intersection (approximately 1.25 miles east of the project site). The LBNL shuttle service provides access between the LBNL site and the Downtown Berkeley BART Station.

The Downtown Berkeley BART Station is served by the Richmond-Fremont and Richmond-Daly City/ Millbrae lines. Other destinations in the BART system can be reached by transferring at stations in Oakland. Typically, Downtown Berkeley BART Station is served by a train every seven (peak weekday commute periods) to 20 minutes (Sundays). The Downtown Berkeley BART station is one of the most highly used stations within the BART system with average weekday exits and entries of approximately 23,000 passengers in January 2013.

4.1.3.2 AC Transit

Local bus service in Berkeley is provided by AC Transit. Within the City of Berkeley, at least one AC Transit route provides service within walking distance (0.25 mile) of nearly every resident in the city. **Figure 4-4** illustrates the existing AC Transit routes in the vicinity of LBNL. Although these routes do not directly serve LBNL, the LBNL shuttle service provides access to them.

TABLE 4-1
LBNL SITE
EXISTING CONDITIONS – STUDY INTERSECTION LOS SUMMARY

Intersection	Control	AM Peak Hour		PM Peak Hour	
		Delay (Seconds)[1]	LOS[1]	Delay (Seconds)[1]	LOS[1]
1. University Avenue/ Shattuck Avenue	Signal	16.6	B	21.6	C
2. Hearst Avenue/ Shattuck Avenue	Signal	16.0	B	21.1	C
3. University Avenue/ Oxford Street	Signal	19.8	B	20.2	C
4. Hearst Avenue/ Oxford Street	Signal	28.7	C	33.7	C
5. Hearst Avenue/ Euclid Avenue	Signal	14.9	B	19.8	B
6. Hearst Avenue/Gayley Road/La Loma Avenue	Signal	13.1	B	13.8	B
7. Stadium Rim Way/ Gayley Road	All-Way Stop	13.7	B	13.8	B
8. Bancroft Way/ Piedmont Avenue[2]	All-Way Stop	34.3	D	**76.4**	**F**
9. Durant Avenue/ Piedmont Avenue[2]	All-Way Stop	16.2	C	**53.2**	**F**
10. Channing Way/ Piedmont Avenue	Roundabout	8.0	A	11.4	B
11. Dwight Way/ Piedmont Avenue	Signal	13.8	B	13.0	B
12. Panoramic Way/Canyon Road/ Stadium Rim Way	Side-Street Stop	2.0 (11.4)	A (B)	1.7 (11.4)	A (B)
13. Centennial Drive/ Stadium Rim Way	All-Way Stop	8.5	A	9.7	A
14. Centennial Drive/Grizzly Peak Boulevard	All-Way Stop	9.3	A	9.0	A

Notes: **Bold** indicates an intersection operating at unacceptable LOS E or LOS F.
1. For signalized, all-way stop-controlled, and roundabout intersections, average intersection delay and LOS based on the 2000 HCM method is shown. For side-street stop-controlled intersections, delays for worst movement and average intersection delay are shown: intersection average (worst movement).
2. Intersection analyzed using SimTraffic software because of unique conditions including heavy pedestrian volumes. Field observations validate the results shown in the table.

Source: Fehr & Peers.

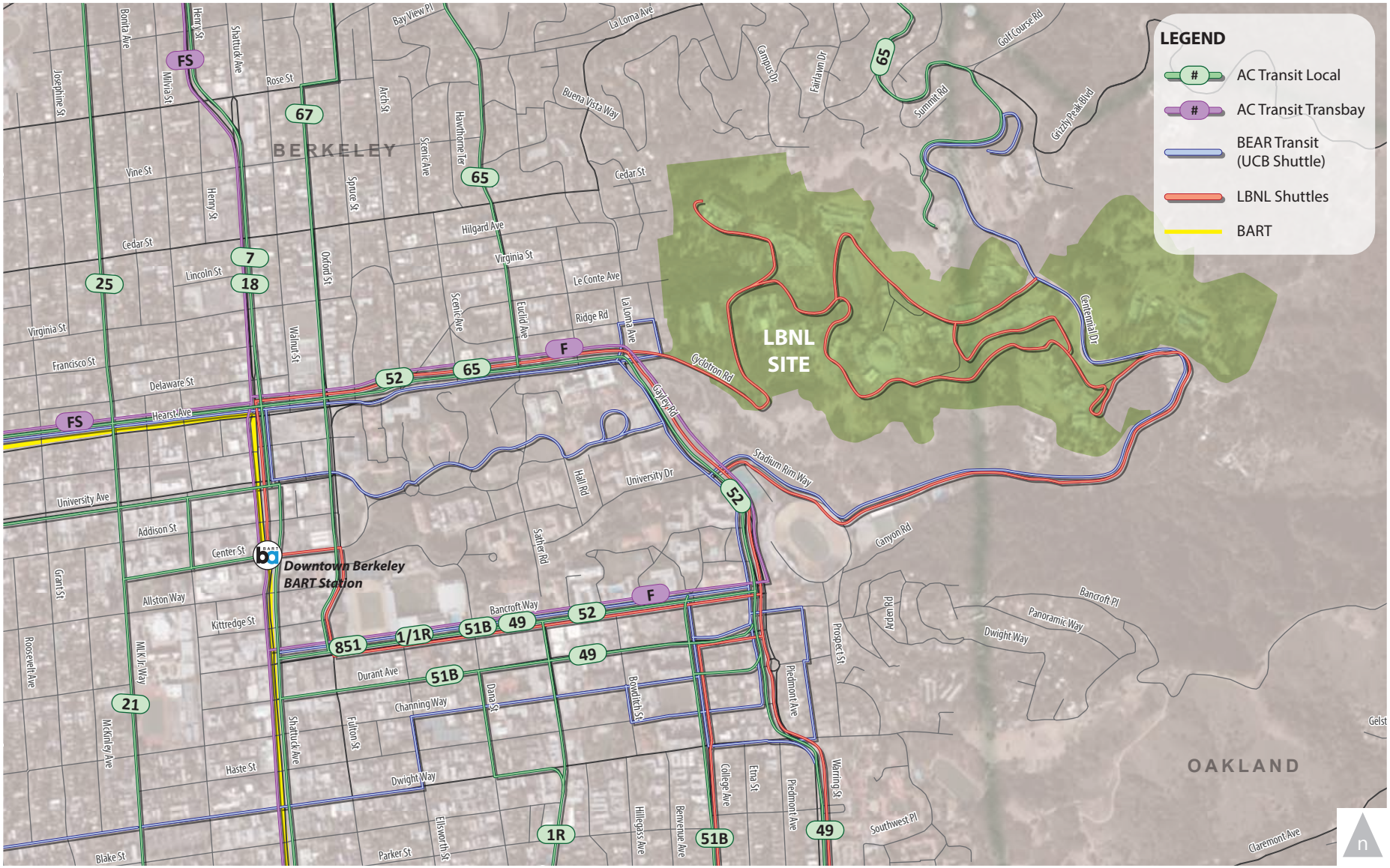

Figure 4-4.

LBNL Site Existing Transit Service

WC12-2953_4-4_LBNLTransit

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Table 4-2 describes the major bus routes serving the project area. Additional AC Transit routes can be accessed in downtown Berkeley and Southside area through the LBNL shuttles.

4.1.3.3 LBNL Shuttles

LBNL provides a free on-site and off-site shuttle service connecting LBNL to UC Berkeley, BART, AC Transit, and local neighborhoods. These shuttles are described below.

- The Orange Route operates in a clockwise loop between the LBNL Strawberry Gate, the UC Berkeley campus and the Downtown Berkeley BART Station through Hearst Avenue, Gayley Road Centennial Drive, and Bancroft Way on weekdays with 10 to 15-minute headways from 6:30 AM to 7:00 PM.

- The Blue Route operates in a clockwise loop between the Downtown Berkeley BART Station, north side of the UC Berkeley campus, and LBNL through Hearst Avenue, and Cyclotron Road on weekdays with 10-minute headways from 6:20 AM to 7:30 PM.

- The Rockridge Shuttle operates between and the Rockridge BART Station on one-hour headways from 6:40 AM to 8:40 AM and from 3:35 PM to 6:35 PM.

- The Potter Street/JBEI Route operates between LBNL, UC Berkeley Campus, Downtown Berkeley BART Station, and LBNL's remote sites in Emeryville and West Berkeley on 30-minute headways from 8:00 AM to 8:00 PM.

Although the LBNL shuttles are free, they are restricted to LBNL employees and visitors and shuttle riders are required to provide a valid identification to the driver. Shuttle stops are coordinated with AC Transit bus lines serving downtown Berkeley. The LBNL shuttles are equipped with bicycle racks for the ride up the hill. The shuttles listed above serve the project vicinity via stops on Alvarez Road near Building 56A.

4.1.3.4 BEAR Transit

BEAR Transit, operated by UC Berkeley, primarily serves the UC Berkeley community, providing service between the UC Berkeley campus, surrounding neighborhoods, and select destinations, including the Richmond Field Station (RFS) (See Section 2.1.4.4 for more detail on the RFS shuttle). In general, the daytime shuttles operate on a fixed route and schedule between 6:45 AM and 7:30 PM. The night shuttles operate on a fixed schedule between 7:30 PM and 2:00 AM, and provide door-to-door service throughout the service area between 2:00 AM and 6:00 AM.

All BEAR Transit shuttle buses, except the RFS shuttle line, are free to UC Berkeley students, faculty, staff, post-docs, and visiting scholars, who have valid university identification. Others must pay a fair of $1.00. The Bear Transit Line H serves destinations along Centennial Drive including the UC Berkeley Botanical Garden and LHS.

TABLE 4-2
LBNL SITE
AC TRANSIT SERVICE SUMMARY

Line	Route	Nearest Stop [1]	Weekday		Weekend	
			Hours	Frequency	Hours	Frequency
Local Routes						
1/1R	Between Berkeley and Bay Fair BART Stations via Telegraph Ave., International Blvd., and East 14th St.	Telegraph Avenue/ Bancroft Way (About 1.0 miles)	5:00 AM to 1:00 AM	15 minutes	5:00 AM to 1:00 AM	20 minutes
49	Loop starting at Rockridge BART via Ashby Ave., Dwight Way, Bancroft Way, Durant Ave. and Claremont Ave.	Piedmont Avenue/ Bancroft Way (About 0.9 miles)	6:00 AM to 8:15 PM	30 minutes	7:00 AM to 8:00 PM	40 minutes
51B	Between Rockridge BART and Berkeley Amtrak Station via College Ave., Bancroft Way/Durant Ave. and University Ave.	College Avenue/ Bancroft Way (About 0.9 miles)	5:00 AM to 12:30 AM	10 to 20 minutes	5:00 AM to 12:30 AM	15 to 20 minutes
52	Between UC Berkeley and Albany University Village via Bancroft Way, University Ave., San Pablo Ave., and Hearst Ave.	Leroy Avenue/ Hearst Avenue (About 0.4 miles)	6:00 AM to 12:00 AM	15 to 30 minutes	8:00 AM to 8:15 PM	30 to 40 minutes
65	Between Berkeley BART and Lawrence Hall of Science via Euclid Ave. and Grizzly Peak Blvd.	Euclid Avenue/ Hearst Avenue (About 0.5 miles)	5:30 AM to 9:00 PM	30 to 60 minutes	7:30 AM to 7:30 PM	60 minutes
Night Routes						
851	Between Fruitvale and Berkeley BART Stations via, Fruitvale Ave., Santa Clara Ave., Webster St., Broadway, College Ave., and Bancroft Way/ Durant Ave.	College Avenue/ Bancroft Way (About 0.9 miles)	12:00 AM to 5:00 AM	60 minutes	12:00 AM to 5:00 AM	60 minutes
Transbay Routes						
F	Between UC Berkeley and San Francisco Transbay Terminal	Leroy Avenue/ Hearst Avenue (About 0.4 miles)	5:00 AM to 1:00 AM	30 minutes	5:00 AM to 1:00 AM	30 minutes

1. Distance shown is current walking distance between bus stop and Blackberry Gate.

Source: AC Transit, 2013.

4.1.4 EXISTING PEDESTRIAN AND BICYCLE CIRCULATION

Most LBNL employees and visitors either drive or use transit to access the site. The hilly terrain and steep grades make walking or biking to the site rather difficult. Most walking and biking trips to the LBNL site are through the Blackberry Canyon Gate which connects to the City's sidewalks and bicycle facilities through Cyclotron Road and Hearst Avenue. The Strawberry Canyon and Grizzly Peak Gates can also be accessed by bicyclists using Centennial Drive and pedestrians using the intermittent paved sidewalks and unpaved paths along Centennial Drive. Many bicyclists also use the LBNL shuttles that are equipped with bike racks for their uphill inbound trip to the site and use their bicycles for the outbound downhill trip.

Within the site, pedestrian and bicycle paths meander and have many discontinuities. Pedestrian pathways primarily connect parking facilities and buildings. Although these paths are used for shorter trips within the site, the on-site shuttle service is typically used for longer trips.

Within the City of Berkeley, all non-residential and most residential streets provide sidewalks and crosswalks for pedestrians.

Based on the *City of Berkeley Bicycle Master Plan* (February 2005), bicycle facilities can be classified into several types, including:

- ***Bicycle Paths (Class 1)*** – These facilities are located off-street and can serve both bicyclists and pedestrians.

- ***Bicycle Lanes (Class 2)*** – These facilities provide a dedicated area for bicyclists within the paved street width through the use of striping and appropriate signage.

- ***Bicycle Routes (Class 3)*** – These facilities are found along streets that do not provide sufficient width for dedicated bicycle lanes. The street is then designated as a bicycle route through the use of signage informing drivers to expect bicyclists.

- ***Shared Bikeways (Class 2.5)*** – These facilities are found along streets with high bicycle volumes where bicycle lanes are not feasible. Typically, shared lane bicycle stencils, wide curb lanes, signage, and low speed limits are used to encourage shared use.

- ***Bicycle Boulevards*** – These facilities are installed along residential streets with low traffic volumes and prioritize bicycle travel. Assignment of right-of-way to the route, traffic calming measures and bicycle traffic signal actuation are used to prioritize through-trips for bicycles.

Figure 4-5 identifies existing and proposed bicycle facilities in the study area. Currently, bicyclists are allowed on all roadways within the study area. Existing bicycle facilities near the project site include Class 2 bicycle lanes on Gayley Road adjacent to the California Memorial Stadium and Class 3 bicycle routes on Grizzly Peak Boulevard south of Centennial Drive. The 2005 Berkeley Bicycle Plan Update identifies Gayley Road, Piedmont Avenue, and Bancroft Way as future Class 2.5 facilities (shared roadways where full bicycle lanes cannot be implemented but other improvements and amenities can be provided). Stadium Rim Way and Centennial Drive are identified as future Class 3 facilities (signed bike routes). In addition, the 2006 UC Berkeley Campus Bicycle Plan recommends Gayley Road and Stadium Rim Way as future Class 2.5 facilities. The 2005 Berkeley Bicycle Plan Update proposes Hearst Avenue as a combination of Class 2.5 and Class 3 facilities. City of Berkeley and UC Berkeley completed the *Hearst Avenue Complete Street Study* (Fehr & Peers 2012) to identify improvements along the Hearst Avenue corridor between Shattuck Avenue and Gayley Road/LaLoma Avenue that primarily benefit bicyclists and pedestrians.

As previously shown on Figures 4-3A and 4-3B, intersections in the vicinity of LBNL generally experience moderate to high pedestrian and bicycle activity.

4.2 REGULATORY CONSIDERATIONS

The LBNL campus is located within Berkeley and Oakland City boundaries. This section summarizes relevant principles, polices and guidelines contained in the Cities of Berkeley and Oakland General Plans.

4.2.1 CITY OF BERKELEY GENERAL PLAN

About 95 acres, or almost half of the LBNL site, is within the City of Berkeley. The Land Use Element of the Berkeley General Plan contains comprehensive objectives and policies that guide physical development in the city. One objective of the Land Use Element is to "minimize the negative impacts and maximize the benefits of University of California on the citizens of Berkeley."

The Transportation Element of the Berkeley General Plan contains the following policies relevant to the proposed alternative:

Transportation Objective 1: Maintain and improve public transportation services throughout the city.

Transportation Objective 2: Reduce automobile use and vehicle miles traveled in Berkeley, and the related impacts, by providing and advocating for transportation alternatives and subsidies that facilitate voluntary decisions to drive less.

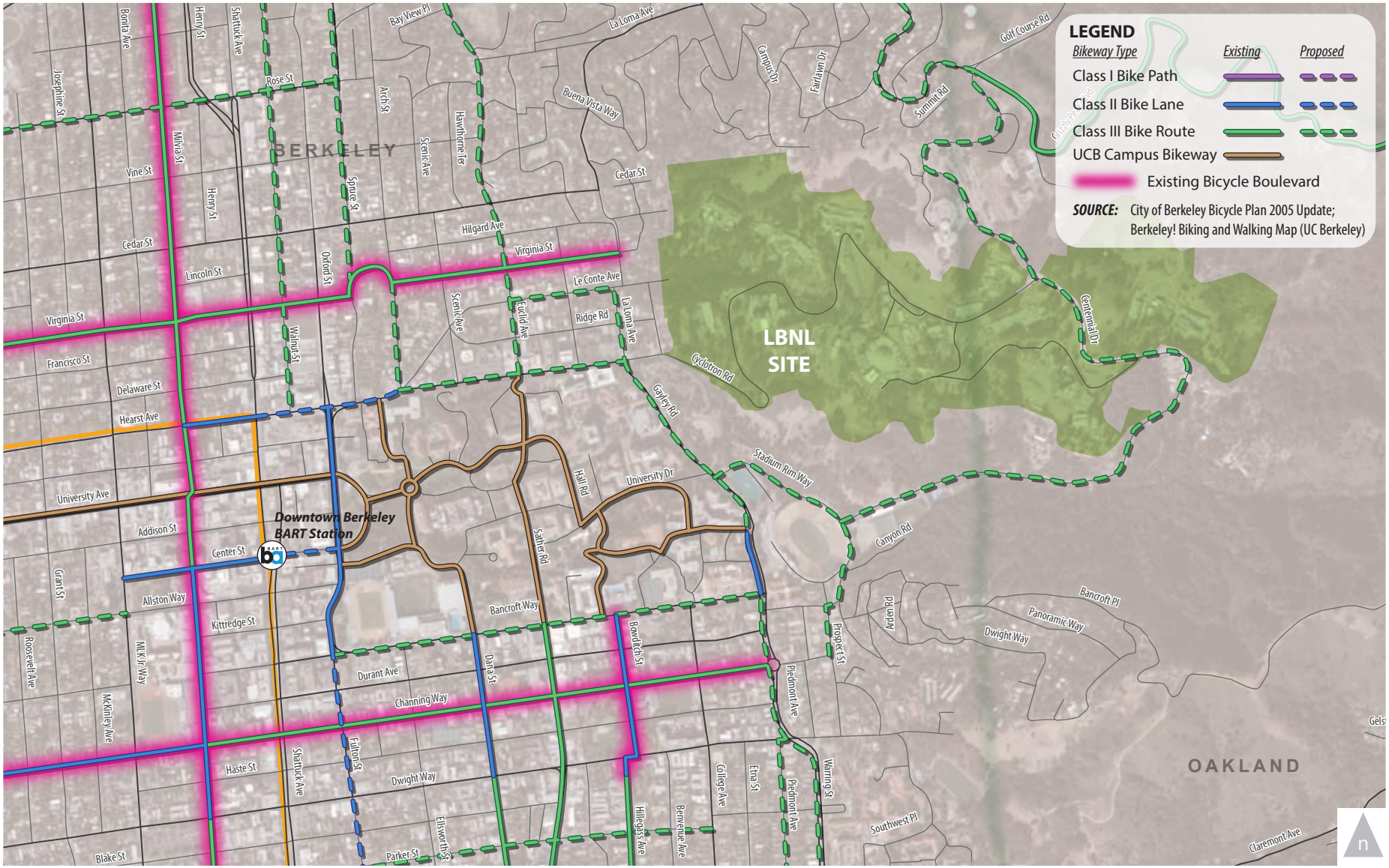

Figure 4-5.

LBNL Site Existing and Future Bicycle Network

WC12-2953_4-5_LBNLBikeNet

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Transportation Objective 6: Create a model bicycle- and pedestrian-friendly city where bicycling and walking are safe, attractive, easy, and convenient forms of transportation and recreation for people of all ages and abilities.

Policy T-2 Public Transportation Improvements: Encourage regional and local efforts to maintain and enhance public transportation services and seek additional regional funding for public and alternative transportation improvements.

Action T-2 D: Improve shuttle and transit services by:

1. Increasing shuttle and transit services from Rockridge and the Rockridge BART station to downtown BART and the UCB campus.
3. Promoting express shuttle services to complement local transit service and ensure that Berkeley residents and commuters have information about shuttle services readily available.
5. Encouraging transportation providers to coordinate and consolidate the installation of new jointly used shelters.

Policy T-10 Trip Reduction: To reduce automobile traffic and congestion and increase transit use and alternative modes in Berkeley, support, and when appropriate require, programs to encourage Berkeley citizens and commuters to reduce automobile trips, such as:

2. Participation in the Commuter Check Program.
3. Carpooling and provision of carpool parking and other necessary facilities.
4. Telecommuting programs.
8. Programs to encourage neighborhood-level initiatives to reduce traffic by encouraging residents to combine trips, carpool, telecommute, reduce the number of cars owned, shop locally, and use alternative modes.
9. Programs to reward Berkeley citizens and neighborhoods that can document reduced car use.
10. Limitations on the supply of long-term commuter parking and elimination of subsidies for commuter parking.

Policy T-13 Major Public Institutions: Work with other agencies and institutions, such as the University of California, the Berkeley Unified School District, Lawrence Berkeley Laboratory, Vista Community College, the Alameda County Court, and neighboring cities to promote Eco-Pass and to pursue other efforts to reduce automobile trips.

Action T-13A: Encourage other agencies and institutions to match or exceed the City of Berkeley's trip reduction and emission reduction programs for their employees.

Action T-13C: Encourage the University of California:

1. To maintain and improve its facilities and programs that support and encourage pedestrians, bicyclists, and transit riders.
2. To provide bicycle facilities, "all hour" bicycle paths, and timely pavement maintenance.

Action T-13H: Encourage the University of California, the Berkeley Unified School District, and other major institutions to cap parking at current levels while seeking to reduce automobile use.

Action T-13I: Encourage institutions to create incentives for their employees and students to live locally.

Action T-13J: Encourage all public and private institutions, including schools, health clubs, recreation centers, and other community destinations to organize carpools and shuttles.

Policy T-18 Level of Service: When considering transportation impacts under the California Environmental Quality Act, the City shall consider how a plan or project affects all modes of transportation, including transit riders, bicyclists, pedestrians, and motorists, to determine the transportation impacts of a plan or project. Significant beneficial pedestrian, bicycle, or transit impacts, or significant beneficial impacts on air quality, noise, visual quality, or safety in residential areas may offset or mitigate a significant adverse impact on vehicle Level of Service (LOS) to a level of insignificance. The number of transit riders, pedestrians, and bicyclists potentially affected will be considered when evaluating a degradation of LOS for motorists.

Policy T-28 Emergency Access: Provide for emergency access to all parts of the city and safe evacuation routes.

Policy T-37 University of California and Large Employer Parking: Encourage large employers, such as the University of California and Berkeley Unified School District, to allocate existing employee parking on the basis of a) need for a vehicle on the job, b) number of passengers carried, c) disability, and d) lack of alternative public transportation.

Action T-37A: Encourage the University of California to cap its parking supply at current levels, to postpone any plans to expand its existing (year 2000) parking supply and instead encourage transit use and alternative modes of transportation, and better manage and utilize existing parking.

Policy T-38 Inter-Jurisdictional Coordination: Establish partnerships with adjacent jurisdictions and agencies, such as the University of California and the Berkeley Unified School District, to reduce parking demand and encourage alternative modes of transportation.

Policy T-41 Structured Parking: Encourage consolidation of surface parking lots into structured parking facilities and redevelopment of surface lots with residential or commercial development where allowed by zoning.

Policy T-42 Bicycle Planning: Integrate the consideration of bicycle travel into City planning activities and capital improvement projects, and coordinate with other agencies to improve bicycle facilities and access within and connecting to Berkeley.

Policy T-54 Pathways: Develop and improve the public pedestrian pathway system.

4.2.2 CITY OF OAKLAND GENERAL PLAN

About half of the LBNL site is within the City of Oakland. The following transportation-related policies in the Oakland General Plan Land Use and Transportation Element are applicable to the proposed Project:

Policy T2.5 Linking Transportation and Activities: Link transportation facilities and infrastructure improvements to recreational uses, job centers, commercial nodes, and social services (i.e., hospitals, parks, or community centers).

Policy T3.2 Promoting Strategies to Address Congestion: The City should promote and participate in both local and regional strategies to manage traffic supply and demand where unacceptable levels of service exist or are forecast to exist.

Policy T3.6 Including Bikeways and Pedestrian Walks: The City should include bikeways and pedestrian walks in the planning of new, reconstructed, or realigned streets, wherever possible.

Policy T4.2 Creating Transportation Incentives: Through cooperation with other agencies, the City should create incentives to encourage travelers to use alternative transportation options.

Policy D3.2 Incorporating Parking Facilities: New parking facilities for cars and bicycles should be incorporated into the design of any project in a manner that encourages and promotes safe pedestrian activity.

Policies in the Open Space, Conservation, and Recreation (OSCAR) Element of the Oakland General Plan pertaining to transportation relevant to the proposed Project include the following:

Policy CO-12.1: Promote land use patterns and densities which help improve regional air quality conditions by: (a) minimizing dependence on single passenger autos; (b) promoting projects which minimize quick auto starts and stops, such as live-work development, and office development with ground-floor retail space; (c) separating land uses which are sensitive to pollution from the sources of air pollution; and (d) supporting telecommuting, flexible work hours, and behavioral changes which reduce the percentage of people in Oakland who must drive to work on a daily basis.

Policy CO-12.3: Expand existing transportation systems management and transportation demand management strategies which reduce congestion, vehicle idling, and travel in single-passenger autos.

4.3 PROJECT TRANSPORTATION CHARACTERISTICS

Similar to the Phase 1 development at the RBC site (described in Section 2.3), the proposed development at the existing LBNL site would provide up to 600,000 square feet of space and accommodate up to 1,000 new employees in four new buildings by 2018. Vehicular access to and from LBNL would continue be provided through the existing three gates. The proposed Project is not expected to modify the internal roadway system in LBNL.

It is expected that as buildings are constructed and the number of employees is increased, LBNL would increase the current parking supply and shuttle service proportionally to meet the increase demand.

4.3.1 TRIP GENERATION

Table 4-3 shows the estimated vehicle trip generation for the proposed Project at the existing LBNL site. This analysis assumes that the Project employees at the LBNL site would have the same trip making characteristics as the employees at the current LBNL site. Thus, the trip generation for the Project is based on current observed trip generation at LBNL based on data collected in 2011. It is estimated that the proposed development at LBNL would generate about 1,590 daily automobile trips, 160 AM peak hour trips, and 150 PM peak hour trips.

TABLE 4-3
EXISTING LBNL SITE
PROJECT VEHICLE TRIP GENERATION SUMMARY

	Average Daily Population	Daily	AM Peak Hour			PM Peak Hour		
			In	Out	Total	In	Out	Total
Existing LBNL [1]	4,200	6,640	581	93	674	85	551	636
LBNL Alternative [2]	1,000	1,585	139	22	161	20	132	152

1. Based on counts at existing LBNL gates conducted in April 2011.
2. Based on the following current trip generation rate per at the existing LBNL site:
   Daily = 1.58 trips per Average Daily Population (ADP); AM Peak Hour = 0.14 trips per ADP (86% in, 14% out); PM Peak Hour = 0.15 trips per ADP (13% in, 87% out)

Source: Fehr & Peers.

4.3.2 TRIP DISTRIBUTION AND ASSIGNMENT

Trip distribution is defined as the directions of approach and departure that vehicles would use to arrive at and depart from the Project site. As previously stated, this analysis assumes that the Project employees at the LBNL site would have the same trip making characteristics as the employees at the current LBNL site. Thus, the trip distribution for the proposed Project is based on the current trip distribution of current LBNL employees. **Figure 4-6** shows the resulting trip distribution. **Figures 4-7A and 4-7B** show the Project Phase 1 trip assignment at the study intersections, based on the distribution.

4.4 NEAR-TERM (2018) ANALYSIS

This section summarizes traffic operations under Near-Term (2018) No Project and Near-Term (2018) Plus Project conditions.

4.4.1 NEAR-TERM (2018) NO PROJECT TRAFFIC CONDITIONS

The Near-Term (2018) No Project traffic volumes were developed by interpolating between the existing volumes (Figure 4-2) and the projected 2035 volumes (Figure 4-10), which were prepared using the ACTC Countywide Travel Demand Model and described in Section 4.5. Since the ACTC Model did not include any growth at the LBNL site or UC Berkeley, the traffic volume forecasts were adjusted to account for the expected traffic generated by projects currently under construction or planned at both sites, which include Solar Energy Research Center (SERC), Computational Research and Theory (CRT) Facility, and Seismic Phase 1 and 2 General Purpose Lab (GPL) at LBNL, and the Maxwell Family Field Garage at UV Berkeley. **Figures 4-8A and 4-8B** show the Near-Term (2018) No Project traffic volumes.

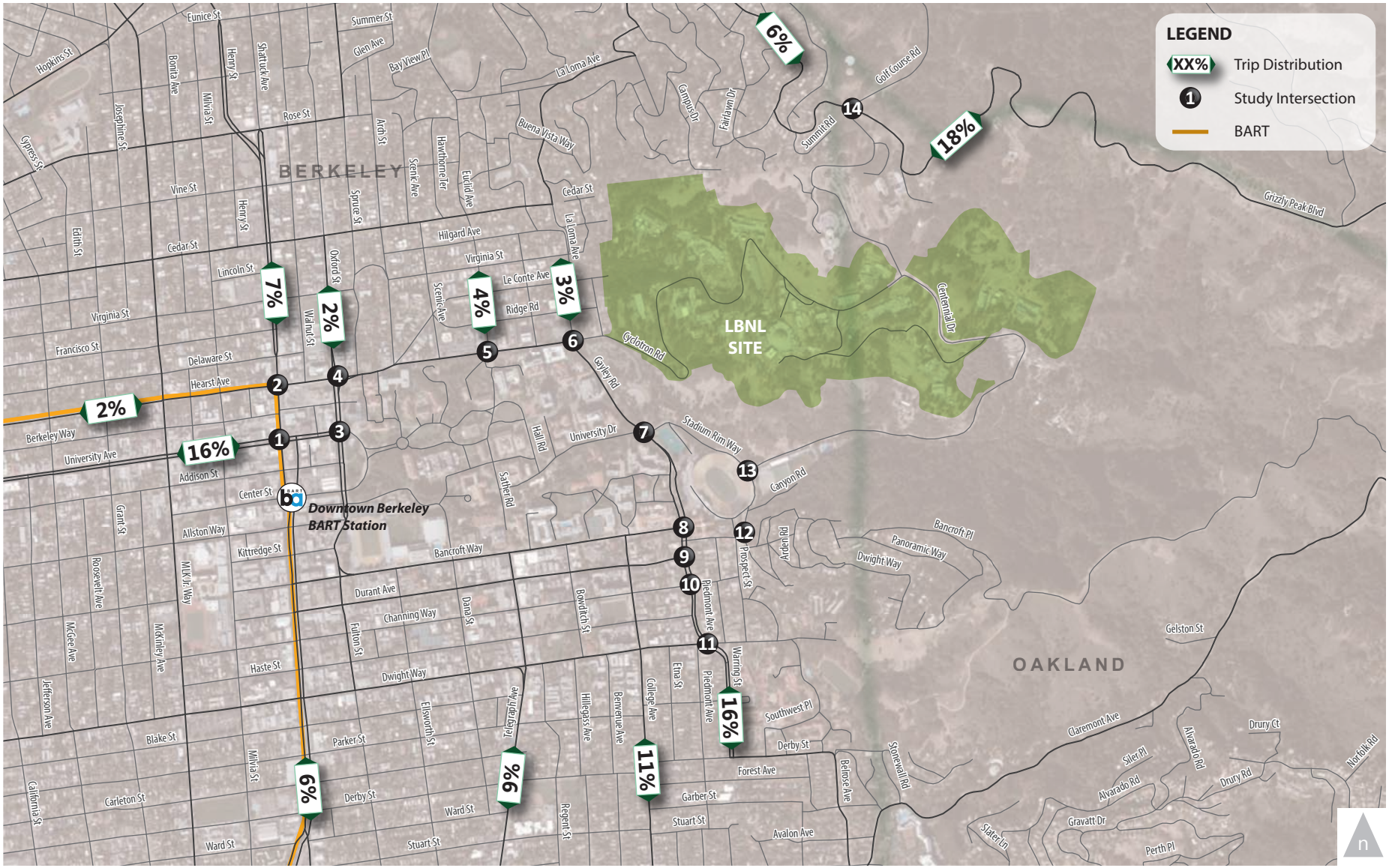


Figure 4-6.

LBNL Site Project Trip Distribution

WC12-2953_4-6_LBNLTripDistro

FEHR & PEERS

Figure 4-7A.

LBNL Site
Project Trip Assignment (Phase 1)

WC12-2953_4-7A_PTA

FEHR PEERS

Figure 4-7B.

LBNL Site
Project Trip Assignment (Phase 1)

WC12-2953_4-7B_PTA

FEHR PEERS

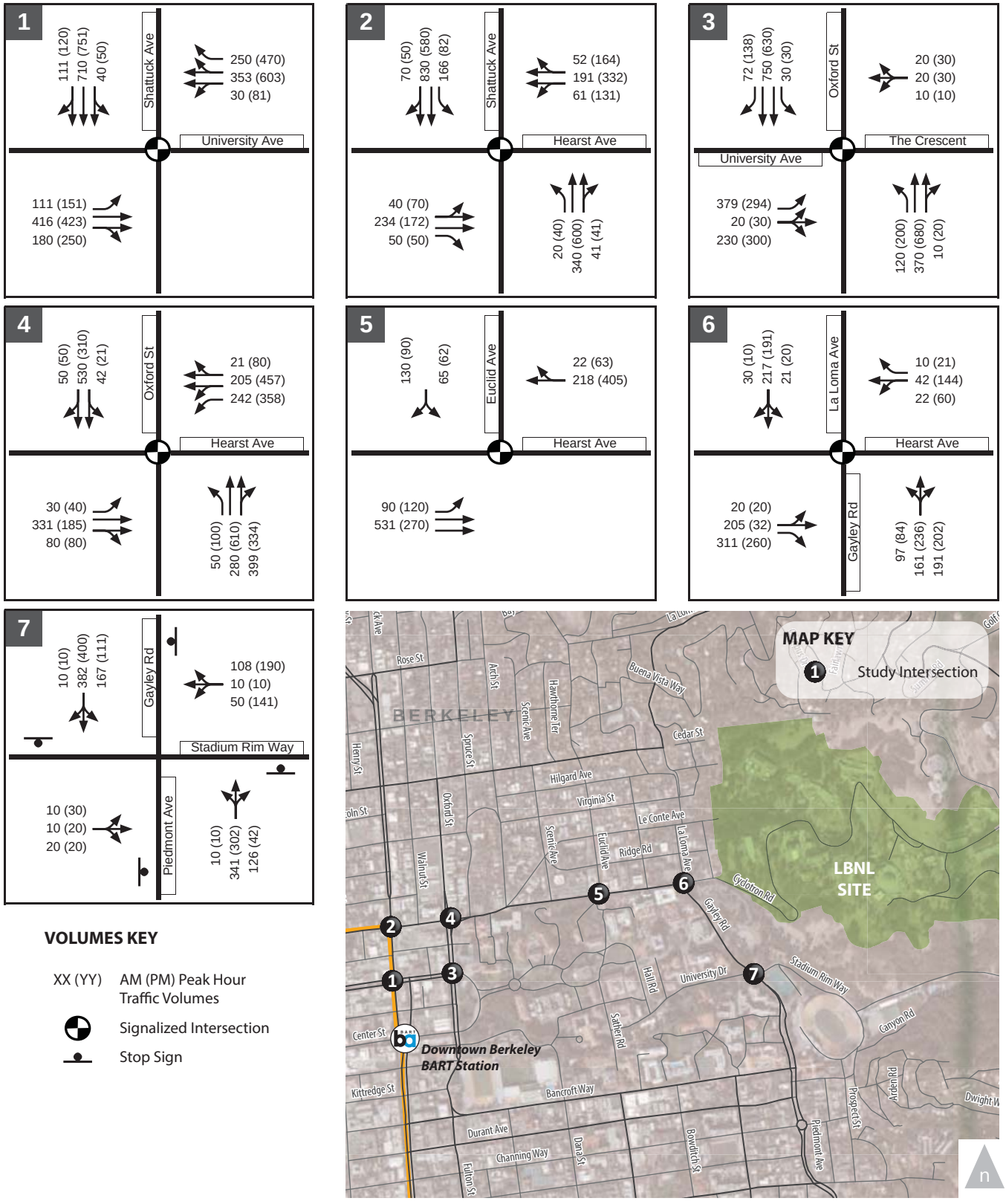


Figure 4-8A.

LBNL Site Near-Term (2018) No Project Peak Hour Traffic Volumes

WC12-2953_4-8A_NT2018NPvol

FEHR PEERS

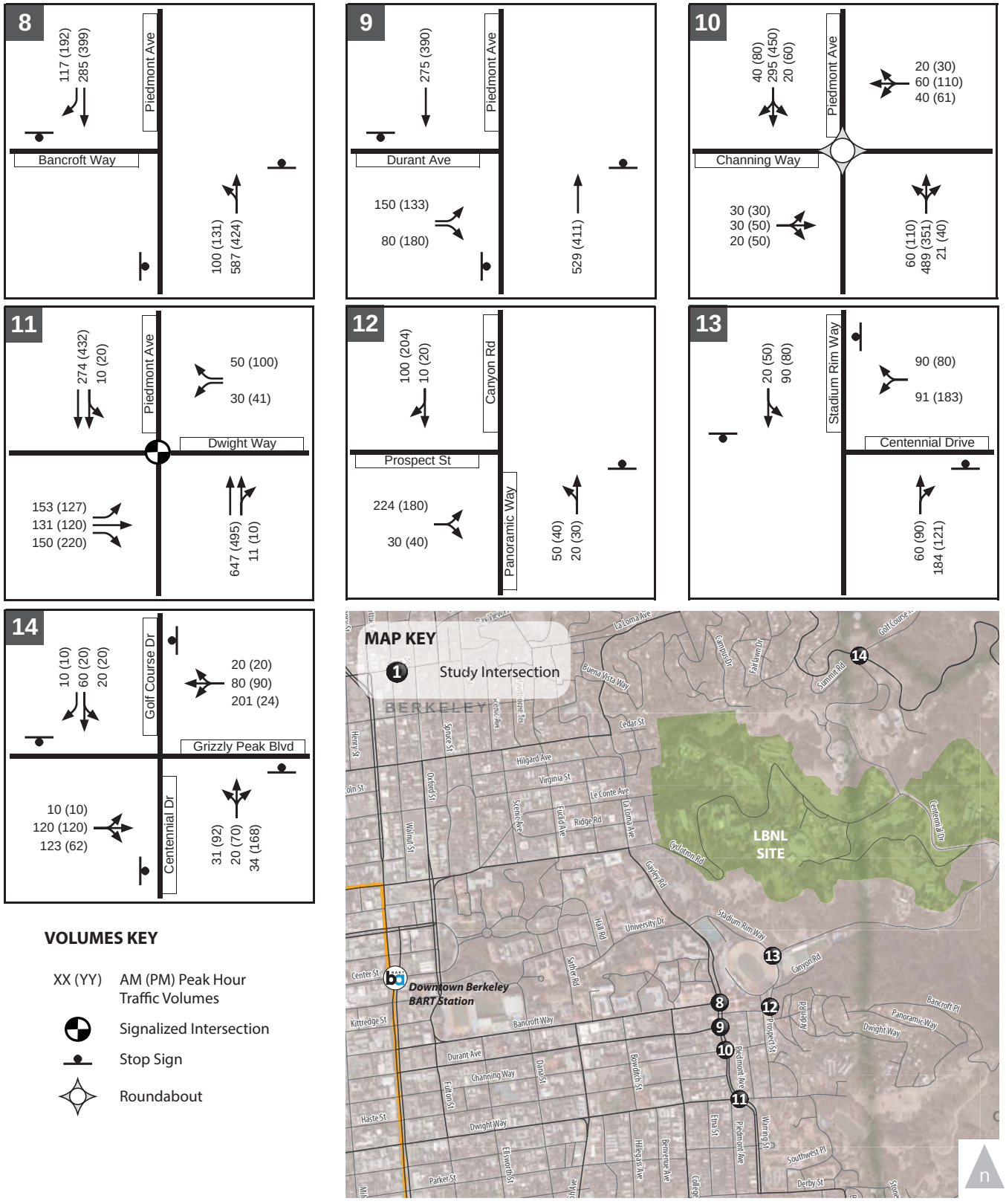


Figure 4-8B.

LBNL Site Near-Term (2018) No Project Peak Hour Traffic Volumes

WC12-2953_4-8A_NT2018NPvol

FEHR PEERS

The Near-Term (2018) No Project scenario assumes that signal timing parameters at the signalized study intersections would be optimized to reflect typical signal timing updates due to changing traffic flow over time. No other roadway modifications are assumed at any of the study intersections in Berkeley under the Near-Term (2018) No Project scenario.

Table 4-4 summarizes the Near-Term (2018) No Project intersection LOS analysis results. **Appendix H** provides the detailed calculation work sheets. In comparison to Existing Conditions, both all-way stop-controlled Bancroft Way/Piedmont Avenue and Durant Avenue/Piedmont Avenue intersections would continue to operate at LOS F during the PM peak hour. In addition, the Durant Avenue/Piedmont Avenue intersection would deteriorate to LOS F during the AM peak hour. All other study intersections would continue to operate at LOS D or better during both AM and PM peak hours.

4.4.2 NEAR-TERM (2018) PLUS PROJECT CONDITIONS

Figures 4-9A and 4-9B show the Near-Term (2018) Plus Project traffic volumes, which consist of traffic volumes under Near-Term (2018) No Project conditions (Figures 4-8A and 4-8B) plus Project traffic assignment (Figures 4-7A and 4-7B). This analysis assumes no roadway modifications under this scenario.

Table 4-4 summarizes intersection operations at the study intersections under the Near-Term (2018) Plus Project conditions. **Appendix H** provides the detailed calculation work sheets.

All signalized intersections would continue to operate at LOS D or better during both AM and PM peak hours under the Near-Term (2018) Plus Project conditions. All but two of the unsignalized study intersections would operate at LOS F during one or both peak hours.

The all-way stop-controlled Bancroft Avenue/Piedmont Avenue intersection during the PM peak hour and the all-way stop-controlled Durant Avenue/Piedmont Avenue intersection during both AM and PM peak hours would operate at LOS F under the Near-Term (2018) Plus Project conditions. However, the Project would not cause an impact at these intersections because neither intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

The Project would cause a significant impact at one intersection which is summarized under Impact 4-1 discussion.

TABLE 4-4
LBNL SITE
NEAR-TERM (2018) CONDITIONS – STUDY INTERSECTION LOS SUMMARY

Intersection	Traffic Control	Peak Hour	Near-Term (2018) No Project		Near-Term (2018) Plus Project		Significant Impact?
			Delay[1] (seconds)	LOS[1]	Delay[1] (seconds)	LOS[1]	
1. University Avenue/ Shattuck Avenue	Signal	AM	17.3	B	17.4	B	No
		PM	23.2	C	23.6	C	No
2. Hearst Avenue/ Shattuck Avenue	Signal	AM	16.7	B	16.8	B	No
		PM	22.6	C	23.1	C	No
3. University Avenue/ Oxford Street	Signal	AM	26.1	C	27.0	C	No
		PM	22.1	C	22.0	C	No
4. Hearst Avenue/ Oxford Street	Signal	AM	31.4	C	32.0	C	No
		PM	41.0	D	41.5	D	No
5. Hearst Avenue/ Euclid Avenue	Signal	AM	15.6	B	15.7	B	No
		PM	25.8	C	29.4	C	No
6. Hearst Avenue/Gayley Road/La Loma Avenue	Signal	AM	14.3	B	15.3	B	No
		PM	16.3	B	17.3	B	No
7. Stadium Rim Way/ Gayley Road	All-Way Stop	AM	33.1	C	38.7	E	No
		PM	31.4	C	38.7	E	**Yes**
8. Bancroft Way/ Piedmont Avenue [2]	All-Way Stop	AM	39.7	E	41.2	E	No
		PM	**>120**	**F**	**>120**	**F**	No
9. Durant Avenue/ Piedmont Avenue [2]	All-Way Stop	AM	**>120**	**F**	**>120**	**F**	No
		PM	**>120**	**F**	**>120**	**F**	No
10. Channing Way/ Piedmont Avenue	Round-about	AM	10.1	B	10.8	B	No
		PM	15.1	C	16.6	C	No
11. Dwight Way/ Piedmont Avenue	Signal	AM	14.8	B	15.1	B	No
		PM	13.8	B	14.0	B	No
12. Panoramic Way/ Canyon Road/Stadium Rim Way	Side-Street Stop	AM	2.1 (11.9)	A (B)	2.1 (12.0)	A (B)	No
		PM	2.0 (11.8)	A (B)	2.1 (11.9)	A (B)	No
13. Centennial Drive/ Stadium Rim Way	All-way Stop	AM	8.9	A	9.0	A	No
		PM	10.4	B	10.6	B	No
14. Centennial Drive/ Grizzly Peak Boulevard	All-way Stop	AM	10.8	B	11.4	B	No
		PM	10.4	B	11.0	B	No

Notes: **Bold** indicates an intersection operating at unacceptable LOS E or LOS F.
1. For signalized, all-way stop-controlled, and roundabout intersections, average intersection delay and LOS based on the 2000 HCM method is shown. For side-street stop-controlled intersections, delays for worst movement and average intersection delay are shown: intersection average (worst movement).
2. Intersection analyzed using SimTraffic software because of unique conditions including heavy pedestrian volumes.

Source: Fehr & Peers.

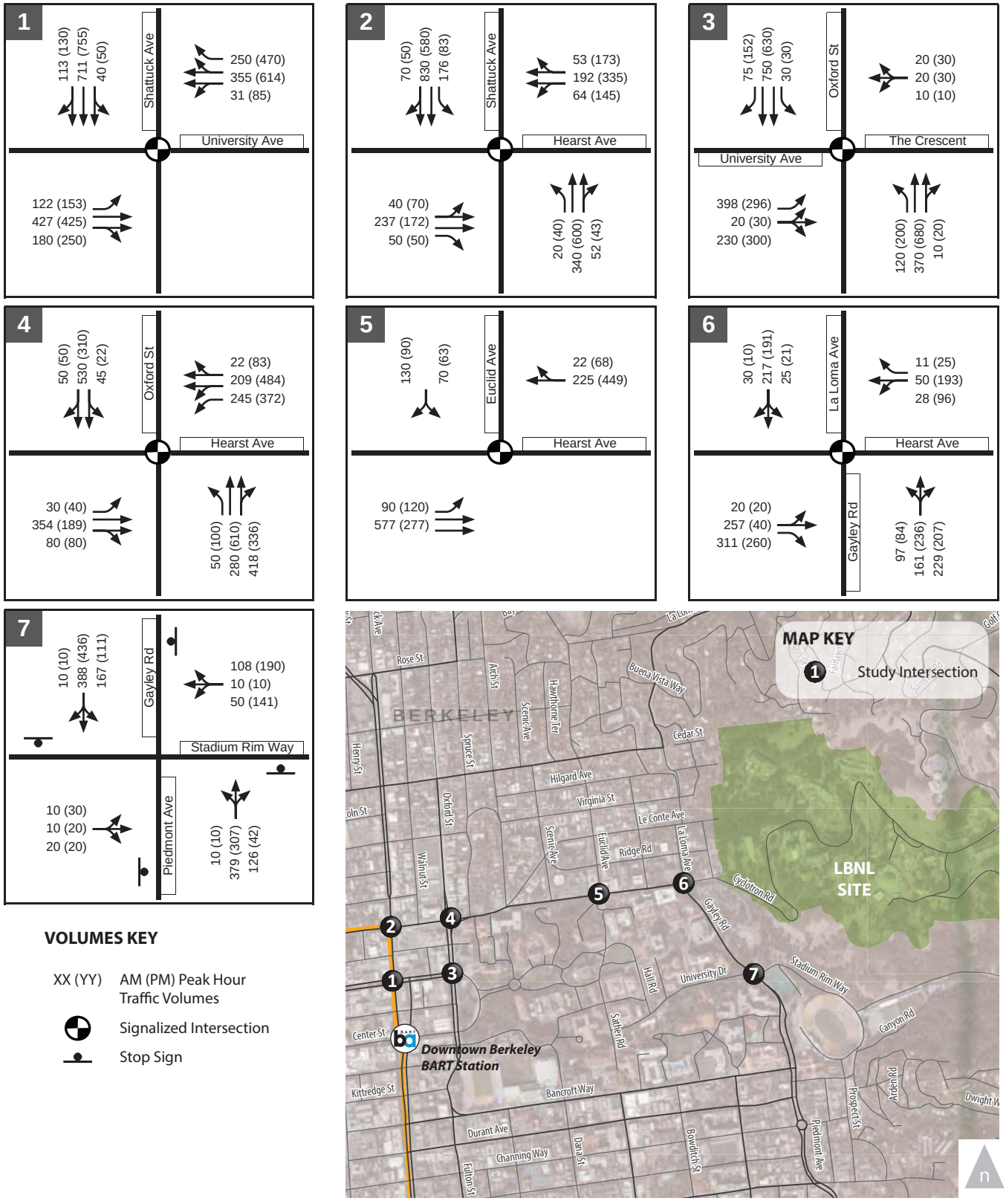


Figure 4-9A.

LBNL Site Near-Term (2018) Plus Phase 1 Project Peak Hour Traffic Volumes

WC12-2953_4-9A_NT2018+PH1vol

FEHR PEERS

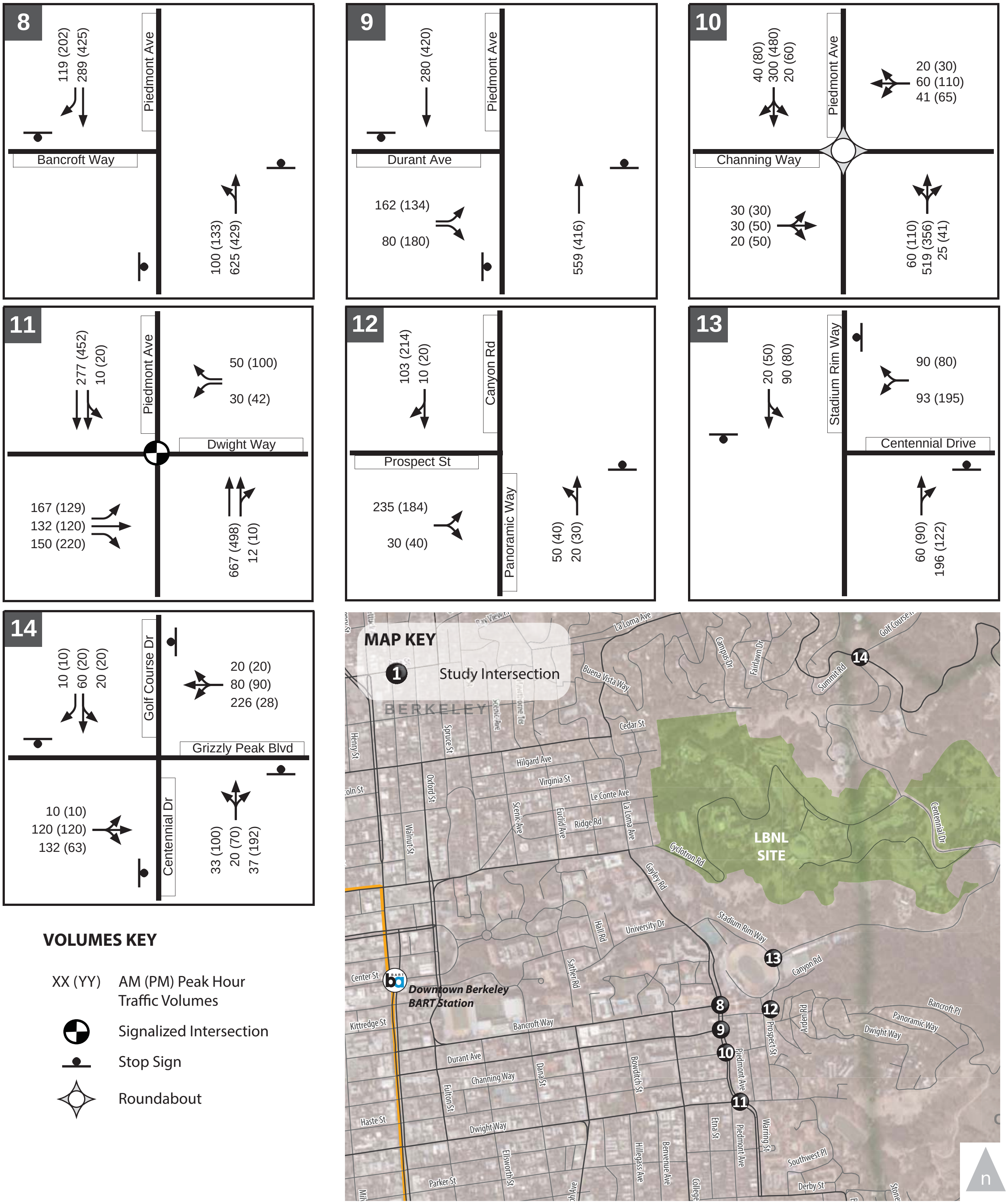


Figure 4-9B.

LBNL Site Near-Term (2018) Plus Phase 1 Project Peak Hour Traffic Volumes

WC12-2953_4-9B_NT2018+PH1vol

FEHR & PEERS

IMPACT 4-1: NEAR-TERM (2018) PLUS PROJECT CONDITIONS INTERSECTION OPERATIONS

The proposed Project at LBNL site would cause a significant impact at the following intersection under Near-Term (2035) Plus Project conditions:

A. The Project would cause a significant impact at the all-way stop-controlled **Stadium Rim Way/Gayley Road** (Intersection 4) because the Project would contribute to LOS F operations for a critical movement during the PM peak hour and the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

Mitigation Measure 4-1: Implement the following:

A. **Stadium Rim Way/Gayley Road** (Intersection 4): Implement the following which requires coordination with City of Berkeley and UC Berkeley:

- Install a traffic signal at the intersection.

The intersection would improve to LOS C or better during both AM and PM peak hours after implementation of this improvement. If found to be feasible and implemented, this mitigation measure would reduce the impact to less than significant.

4.5 CUMULATIVE (2035) ANALYSIS

This section summarizes traffic operations under Cumulative (2035) No Project and Cumulative (2035) Plus Project conditions.

4.5.1 CUMULATIVE (2035) NO PROJECT CONDITIONS

Traffic forecasts to the year 2035 were developed based on the results of the ACTC Countywide Travel Demand Model. The most recent version of the ACTC Model, released in June 2011, which reflects assumptions in residential and non-residential land use growth consistent with ABAG *Projections 2009,* served as the basis for developing AM and PM peak hour intersection turning movement forecasts for the year 2035. The Model land use database and roadway network were checked for accuracy in the vicinity of the LBNL. The forecasting process involved running the 2010 and 2035 models and using the model produced volumes and existing turning movement count data, to estimate year 2035 intersection turn movements using the Furness[6] method. Since the ACTC Model did not include any growth at the LBNL site, similar to the Near-Term (2018) No Project conditions, the traffic volume forecasts were adjusted to

[6] Furnessing is an iterative process that develops future turning movements by applying the difference between the base model volumes and the existing counts to future model approach and departure volumes.

account for the expected traffic generated by projects currently under construction or planned at LBNL and UC Berkeley. **Figures 4-10A and 4-10B** shows the Cumulative (2035) No Project traffic volumes.

Similar to the Near-Term (2018) No Project conditions, the Cumulative (2035) No Project analysis assumes that signal timing parameters at the signalized study intersections would be optimized. No other roadway modifications are assumed in the study area under the Cumulative (2035) No Project scenario.

Table 4-5 summarizes the Cumulative (2035) No Project intersection LOS analysis results. **Appendix H** provides the detailed calculation work sheets.

All but one signalized study intersection would continue to operate at LOS D or better during both AM and PM peak hours under Cumulative (2035) No Project conditions. The Hearst Avenue/Oxford Street intersection would operate at LOS E during the PM peak hour.

All but three of the unsignalized intersections would continue to operate at LOS E or better during both AM and PM peak hours under Cumulative (2035) No Project conditions. The all-way stop-controlled Stadium Rim Way/Gayley Road intersection during both AM and PM peak hours, the all-way stop-controlled Bancroft Avenue/Piedmont Avenue intersection during the PM peak hour, and the all-way stop-controlled Durant Avenue/Piedmont Avenue intersection during both AM and PM peak hours would operate at LOS F.

4.5.2 CUMULATIVE (2035) PLUS PROJECT CONDITIONS

Figures 4-11A and 4-11B show the Cumulative (2035) Plus Project traffic volumes, which consist of traffic volumes under Cumulative (2035) No Project conditions (Figures 4-10A and 4-10B) plus Project traffic assignment (Figures 4-7A and 4-7B). This analysis assumes no roadway modifications under this scenario.

Table 4-5 summarizes intersection operations at the study intersections under the Cumulative (2035) Plus Project conditions. **Appendix H** provides the detailed calculation work sheets.

All but one signalized study intersection would continue to operate at LOS D or better and all but three unsignalized study intersections would continue to operate at LOS E or better during both AM and PM peak hours under Cumulative (2035) Plus Project conditions.

The signalized Hearst Avenue/Oxford Street intersection would operate at LOS E during the PM peak hour under the Cumulative (2035) Plus Project conditions. However, the Project would not cause an impact at this intersection because it would not increase intersection average delay by more than three seconds.

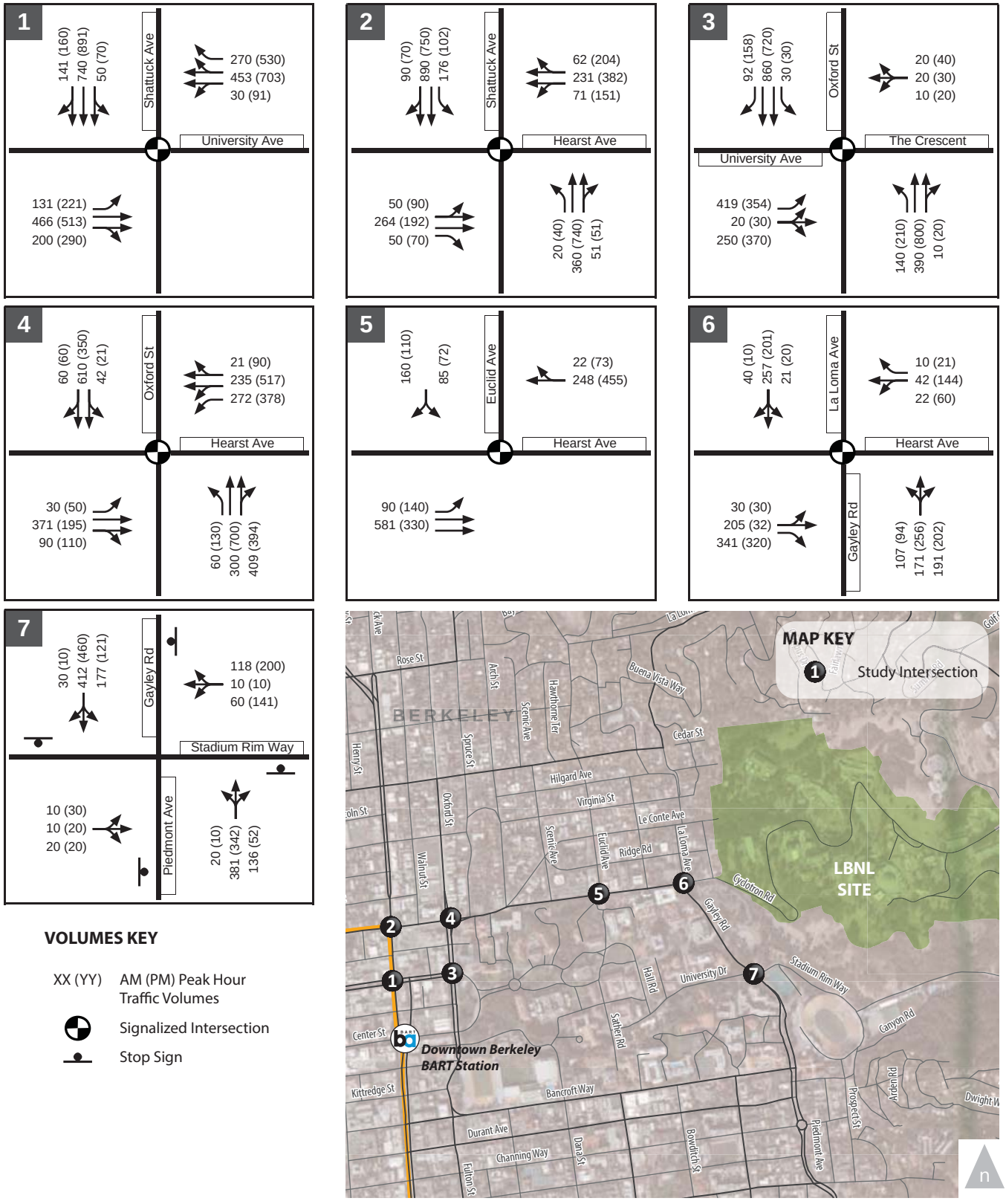


Figure 4-10A.

LBNL Site Cumulative (2035) No Project Peak Hour Traffic Volumes

WC12-2953_4-10A_Cumu2035NPvol

FEHR PEERS

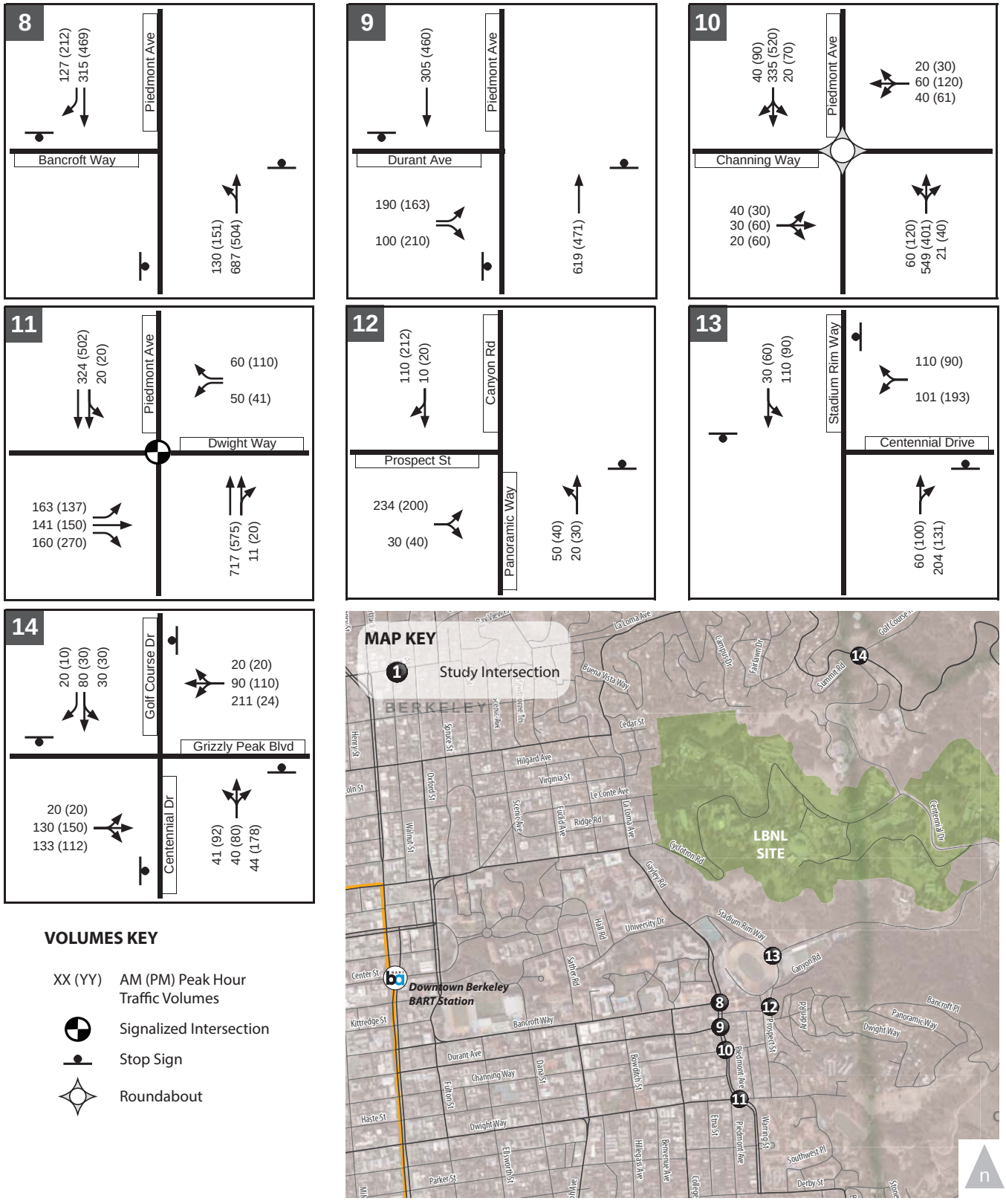


Figure 4-10B.

LBNL Site Cumulative (2035) No Project Peak Hour Traffic Volumes

WC12-2953_4-10B_Cumu2035NPvol

FEHR PEERS

TABLE 4-5
LBNL SITE
CUMULATIVE (2035) CONDITIONS – STUDY INTERSECTION LOS SUMMARY

Intersection	Traffic Control	Peak Hour	Cumulative (2035) No Project		Cumulative (2035) Plus Project		Significant Impact?
			Delay[1] (seconds)	LOS[1]	Delay[1] (seconds)	LOS[1]	
1. University Avenue/ Shattuck Avenue	Signal	AM	18.5	B	18.6	B	No
		PM	33.0	C	34.2	C	No
2. Hearst Avenue/ Shattuck Avenue	Signal	AM	17.4	B	17.6	B	No
		PM	24.1	C	24.8	C	No
3. University Avenue/ Oxford Street	Signal	AM	34.8	C	35.9	D	No
		PM	27.7	C	27.8	C	No
4. Hearst Avenue/ Oxford Street	Signal	AM	34.3	C	34.8	C	No
		PM	**65.4**	**E**	**65.9**	**E**	No
5. Hearst Avenue/ Euclid Avenue	Signal	AM	16.0	B	16.1	B	No
		PM	36.0	D	48.5	D	No
6. Hearst Avenue/Gayley Road/La Loma Avenue	Signal	AM	15.0	B	16.2	B	No
		PM	17.5	B	18.5	B	No
7. Stadium Rim Way/ Gayley Road	All-Way Stop	AM	**56.0**	**F**	**65.5**	**F**	**Yes**
		PM	**52.7**	**F**	**64.1**	**F**	**Yes**
8. Bancroft Way/ Piedmont Avenue [2]	All-Way Stop	AM	41.7	E	44.6	E	No
		PM	**>120**	**F**	**>120**	**F**	No
9. Durant Avenue/ Piedmont Avenue [2]	All-Way Stop	AM	**>120**	**F**	**>120**	**F**	**Yes**
		PM	**>120**	**F**	**>120**	**F**	**Yes**
10. Channing Way/ Piedmont Avenue	Round-about	AM	11.7	B	12.5	B	No
		PM	22.6	C	26.3	D	No
11. Dwight Way/ Piedmont Avenue	Signal	AM	16.1	B	16.6	B	No
		PM	15.2	B	15.4	B	No
12. Panoramic Way/ Canyon Road/Stadium Rim Way	Side-Street Stop	AM	2.1 (12.1)	A (B)	2.1 (12.3)	A (B)	No
		PM	1.9 (12.1)	A (B)	1.9 (12.3)	A (B)	No
13. Centennial Drive/ Stadium Rim Way	All-way Stop	AM	9.4	A	9.5	A	No
		PM	11.1	B	11.3	B	No
14. Centennial Drive/ Grizzly Peak Boulevard	All-way Stop	AM	12.4	B	13.2	B	No
		PM	12.2	B	12.9	B	No

Notes: **Bold** indicates an intersection operating at unacceptable LOS E or LOS F.
1. For signalized, all-way stop-controlled, and roundabout intersections, average intersection delay and LOS based on the 2000 HCM method is shown. For side-street stop-controlled intersections, delays for worst movement and average intersection delay are shown: intersection average (worst movement).
2. Intersection analyzed using SimTraffic software because of unique conditions including heavy pedestrian volumes.

Source: Fehr & Peers.

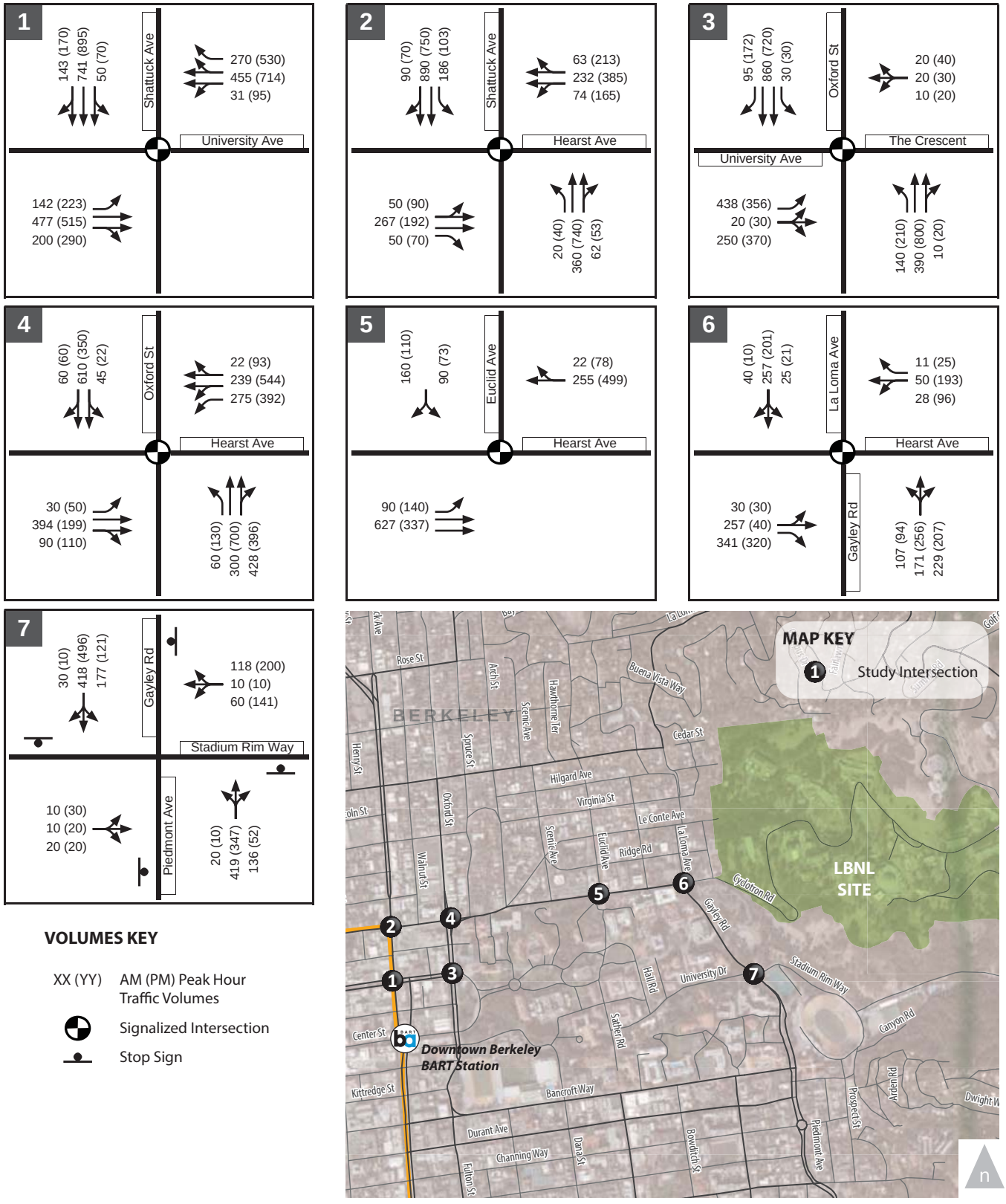


Figure 4-11A.

LBNL Site Cumulative (2035) Plus Phase 1 Project Peak Hour Traffic Volumes

WC12-2953_4-11A_Cumu2035+PH1vol

FEHR PEERS

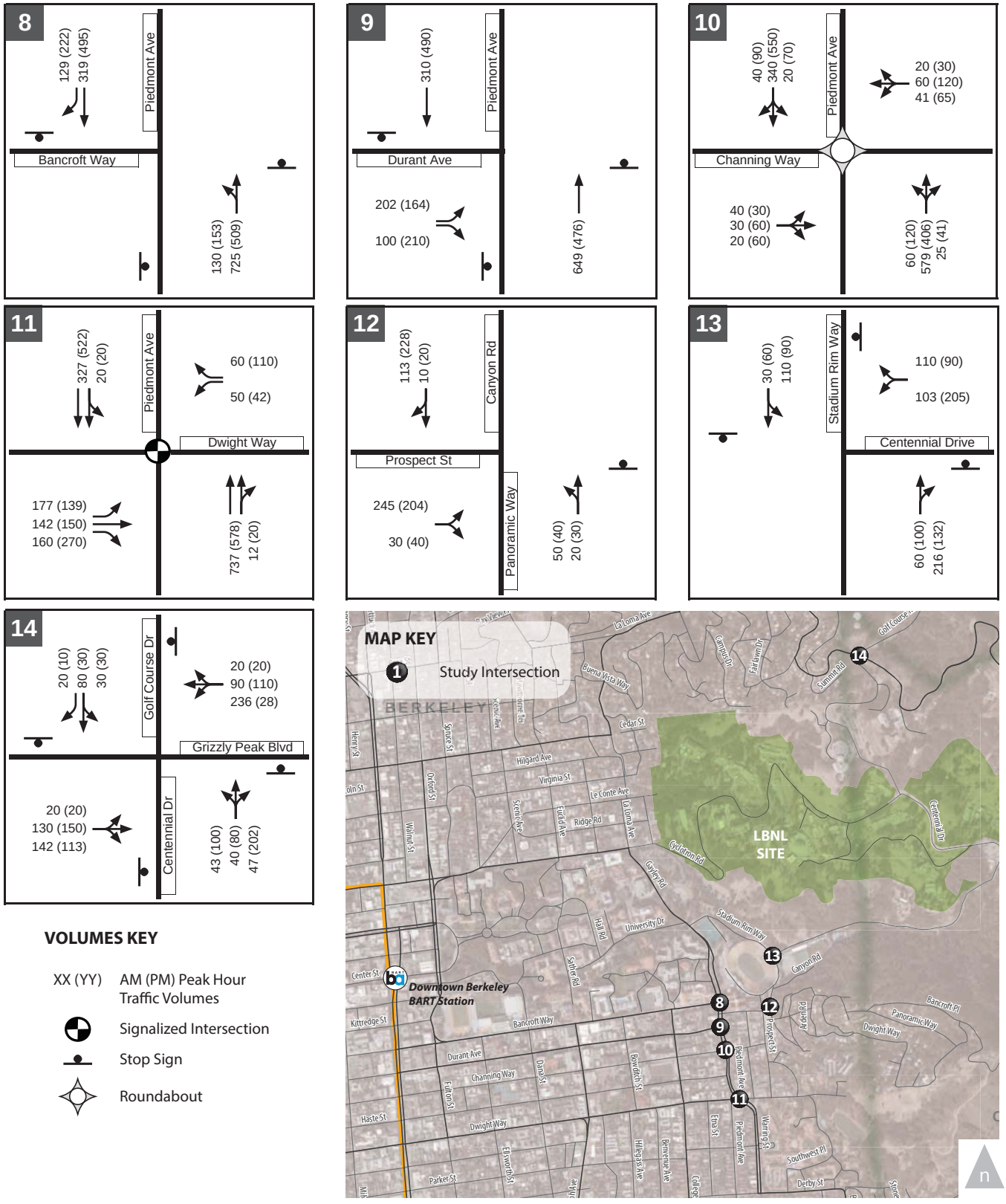


Figure 4-11B.

LBNL Site Cumulative (2035) Plus Phase 1 Project Peak Hour Traffic Volumes

WC12-2953_4-11B_Cumu2035+PH1vol

FEHR PEERS

The all-way stop-controlled Bancroft Avenue/Piedmont Avenue intersection would operate at LOS F during the PM peak hour under the Cumulative (2035) Plus Project conditions. However, the Project would not cause an impact at this intersection because the intersection would not satisfy the Caltrans peak hour traffic volume signal warrant.

The Project would cause a significant impact at two intersections which are summarized under Impact 4-2 discussion.

IMPACT 4-2: CUMULATIVE (2035) PLUS PROJECT CONDITIONS INTERSECTION OPERATIONS

The proposed Project at LBNL site would cause a significant impact at the following intersections under Cumulative (2035) Plus Project conditions:

A. The Project would cause a significant impact at the all-way stop-controlled **Stadium Rim Way/Gayley Road** (Intersection 4) because the Project would contribute to LOS F operations during both AM and PM peak hours and the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

B. The Project would cause a significant impact at the all-way stop-controlled **Durant Avenue/Piedmont Avenue** (Intersection 9) because the Project would contribute to LOS F operations during both AM and PM peak hours and the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

Mitigation Measure 4-2: Implement the following:

A. **Stadium Rim Way/Gayley Road** (Intersection 4): Implement the following which requires coordination with City of Berkeley and UC Berkeley (Same as Mitigation Measure 4-1A):

- Install a traffic signal at the intersection.

The intersection would improve to LOS C or better during both AM and PM peak hours after implementation of this improvement. If found to be feasible and implemented, this mitigation measure would reduce the impact to less than significant.

B. **Durant Avenue/Piedmont Avenue** (Intersection 9): Implement the following which requires coordination with City of Berkeley:

- Install a traffic signal at the intersection.

The intersection would improve to LOS B or better during both AM and PM peak hours after implementation of this improvement. If found to be feasible and implemented, this mitigation measure would reduce the impact to less than significant.

4.6 ADDITIONAL EMPLOYMENT ALTERNATIVE ANALYSIS

This section presents trip generation for the Additional Employment Alternative scenario and summarizes traffic operations under the Near-Term (2018) Plus Additional Employment Alternative conditions. The Additional Employment Alternative would consist of an additional 200,000 square feet of space and accommodate an additional 700 employees at the existing LBNL site.

4.6.1 TRIP GENERATION

Table 4-6 shows the estimated vehicle trip generation for the Additional Employment Alternative at the existing LBNL site. The trip generation estimates is based on the same methodology used to estimate trip generation for the Project at the LBNL site as documented in section 4.3.1. The 700 additional employees under the Alternative at the existing LBNL site are expected to increase trip generation to about 2,700 daily, 270 AM peak hour, and 260 PM peak hour automobile trips.

TABLE 4-6
EXISTING LBNL SITE
ADDITIONAL EMPLOYMENT ALTERNATIVE
VEHICLE TRIP GENERATION SUMMARY

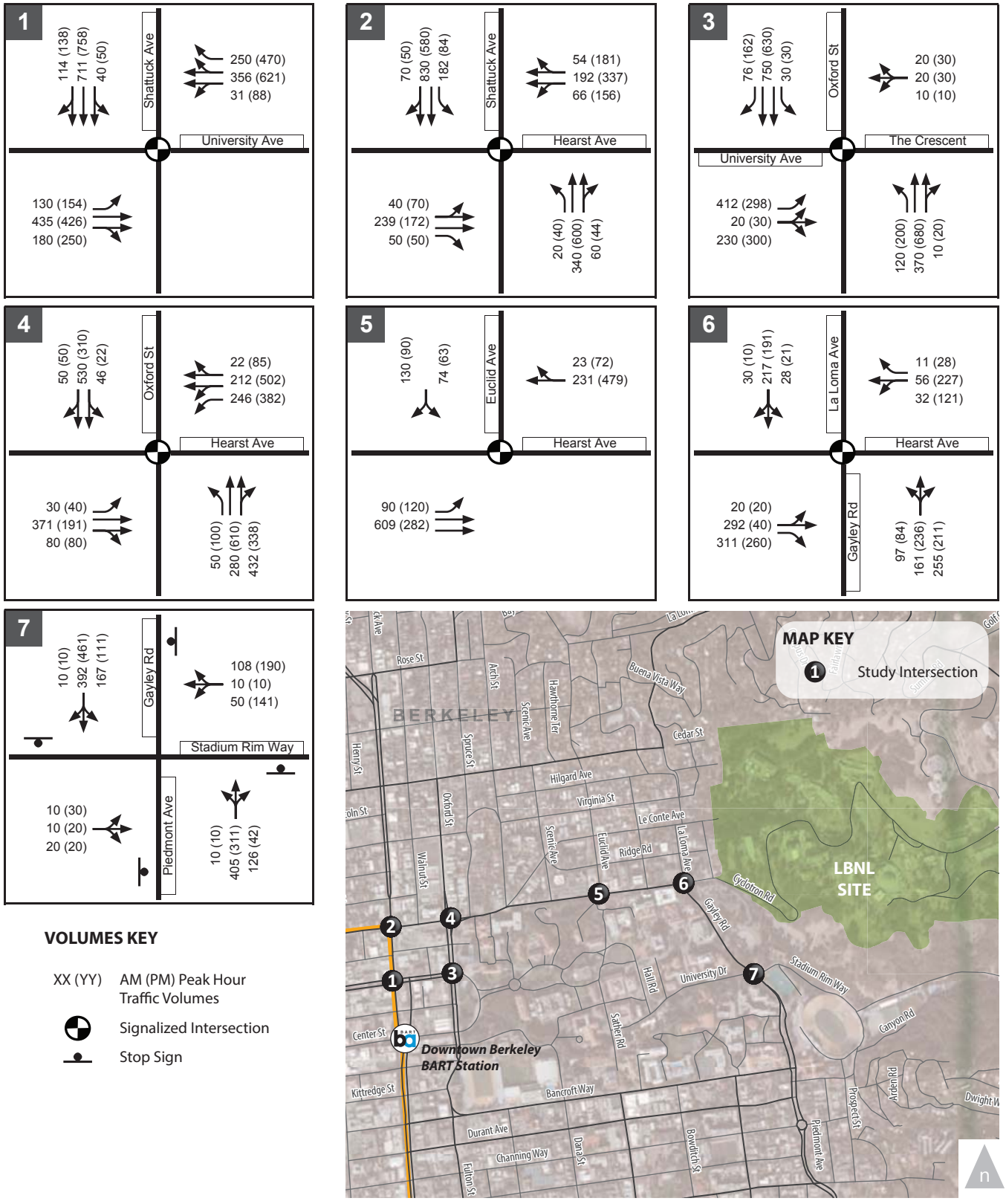
	Average Daily Population	Daily	AM Peak Hour			PM Peak Hour		
			In	Out	Total	In	Out	Total
LBNL Project [1]	1,000	1,585	139	22	161	20	132	152
Additional Employees [1]	700	1,109	97	16	123	14	92	106
Additional Employment Alternative Total	1,700	2,694	236	38	274	34	224	258

1. Based on the following current trip generation rate per at the existing LBNL site:
Daily = 1.58 trips per Average Daily Population (ADP); AM Peak Hour = 0.14 trips per ADP (86% in, 14% out); PM Peak Hour = 0.15 trips per ADP (13% in, 87% out)

Source: Fehr & Peers.

4.6.2 NEAR-TERM (2018) PLUS CUMULATIVE ALTERNATIVE CONDITIONS

Figures 4-12A and 4-12B show the traffic volumes under the Near-Term (2018) Plus Additional Employment Alternative conditions, which consist of traffic volumes under Near-Term (2018) No Project conditions plus traffic generated by the 1,000 Project employees and the 700 additional employees under the Additional Employment Alternative.



VOLUMES KEY

XX (YY)	AM (PM) Peak Hour Traffic Volumes
	Signalized Intersection
	Stop Sign

Figure 4-12A.

LBNL Site Near-Term (2018)
Plus Additional Employment Alternative Peak Hour Traffic Volumes

WC12-2953_4-12A_NT2018+AEAvol

FEHR & PEERS

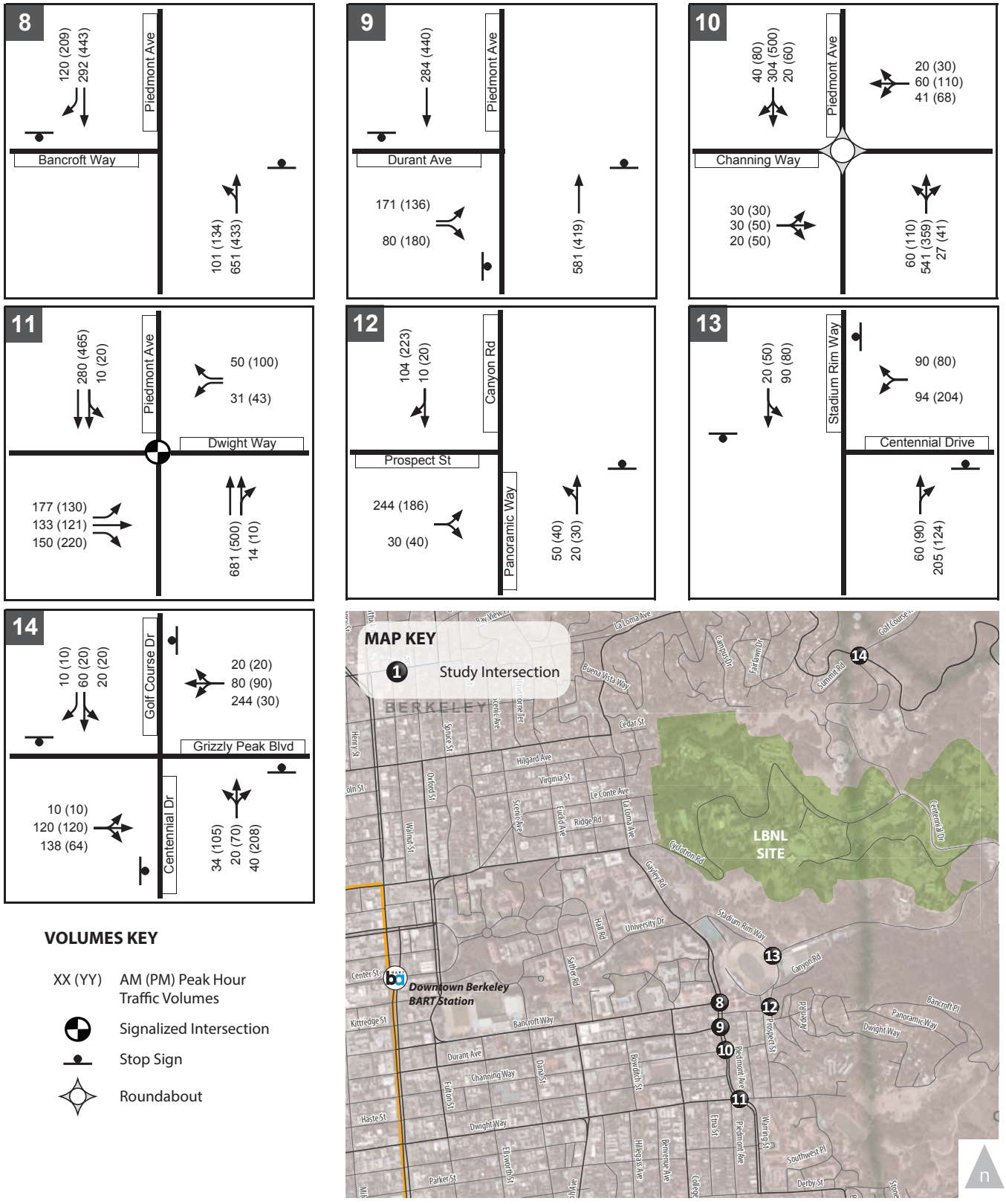


Figure 4-12B.

LBNL Site Near-Term (2018)
Plus Additional Employment Alternative Peak Hour Traffic Volumes

WC12-2953_4-12B_NT2018+AEAvol

FEHR PEERS

Table 4-7 summarizes intersection operations at the study intersections under the Near-Term (2018) Plus Additional Employment Alternative conditions. **Appendix H** provides the detailed calculation work sheets.

All signalized intersections would continue to operate at LOS D or better during both AM and PM peak hours under the Near-Term (2018) Plus Additional Employment Alternative conditions. All but two of the unsignalized study intersections would operate at LOS F during one or both peak hours.

The all-way stop-controlled Bancroft Avenue/Piedmont Avenue and Durant Avenue/Piedmont Avenue intersections during both AM and PM peak hours would operate at LOS F under the Near-Term (2018) Plus Additional Employment Alternative conditions. However, the Additional Employment Alternative would not cause an impact at these intersections because neither intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

The Additional Employment Alternative would cause a significant impact at one intersection which is summarized under Impact 4-3 discussion.

IMPACT 4-3: NEAR-TERM (2018) PLUS ADDITIONAL EMPLOYMENT ALTERNATIVE CONDITIONS INTERSECTION OPERATIONS

The Additional Employment Alternative at LBNL site would cause a significant impact at the following intersection under Near-Term (2035) Plus Additional Employment Alternative conditions:

A. The Additional Employment Alternative would cause a significant impact at the all-way stop-controlled **Stadium Rim Way/Gayley Road** (Intersection 4) because the Alternative would contribute to LOS F operations for a critical movement during the PM peak hour and the intersection would satisfy the Caltrans peak hour traffic volume signal warrant.

Mitigation Measure 4-3: Implement the following:

A. **Stadium Rim Way/Gayley Road** (Intersection 4): Implement the following which requires coordination with City of Berkeley and UC Berkeley (Same as Mitigation Measure 4-1A):

- Install a traffic signal at the intersection.

The intersection would improve to LOS C or better during both AM and PM peak hours after implementation of this improvement. If found to be feasible and implemented, this mitigation measure would reduce the impact to less than significant.

TABLE 4-7
LBNL SITE
ADDITIONAL EMPLOYMENT ALTERNATIVE (2018) CONDITIONS –
STUDY INTERSECTION LOS SUMMARY

Intersection	Traffic Control	Peak Hour	Near-Term (2018) No Project		Near-Term (2018) Plus Additional Employment Alternative		Significant Impact?
			Delay[1] (seconds)	LOS[1]	Delay[1] (seconds)	LOS[1]	
1. University Avenue/ Shattuck Avenue	Signal	AM	17.3	B	17.4	B	No
		PM	23.2	C	23.8	C	No
2. Hearst Avenue/ Shattuck Avenue	Signal	AM	16.7	B	16.9	B	No
		PM	22.6	C	23.5	C	No
3. University Avenue/ Oxford Street	Signal	AM	26.1	C	28.0	C	No
		PM	22.1	C	22.0	C	No
4. Hearst Avenue/ Oxford Street	Signal	AM	31.4	C	32.5	C	No
		PM	41.0	D	42.2	D	No
5. Hearst Avenue/ Euclid Avenue	Signal	AM	15.6	B	15.7	B	No
		PM	25.8	C	33.7	C	No
6. Hearst Avenue/Gayley Road/La Loma Avenue	Signal	AM	14.3	B	16.1	B	No
		PM	16.3	B	18.7	B	No
7. Stadium Rim Way/ Gayley Road	All-Way Stop	AM	33.1	C	43.7	E	No
		PM	31.4	C	44.3	E	**Yes**
8. Bancroft Way/ Piedmont Avenue [2]	All-Way Stop	AM	39.7	E	**75.0**	**F**	No
		PM	**>120**	**F**	**>120**	**F**	No
9. Durant Avenue/ Piedmont Avenue [2]	All-Way Stop	AM	**>120**	**F**	**>120**	**F**	No
		PM	**>120**	**F**	**>120**	**F**	No
10. Channing Way/ Piedmont Avenue	Round-about	AM	10.1	B	11.3	B	No
		PM	15.1	C	18.0	C	No
11. Dwight Way/ Piedmont Avenue	Signal	AM	14.8	B	15.4	B	No
		PM	13.8	B	14.1	B	No
12. Panoramic Way/ Canyon Road/Stadium Rim Way	Side-Street Stop	AM	2.1 (11.9)	A (B)	2.4 (12.0)	A (B)	No
		PM	2.0 (11.8)	A (B)	2.2 (12.0)	A (B)	No
13. Centennial Drive/ Stadium Rim Way	All-way Stop	AM	8.9	A	9.1	A	No
		PM	10.4	B	10.8	B	No
14. Centennial Drive/ Grizzly Peak Boulevard	All-way Stop	AM	10.8	B	11.9	B	No
		PM	10.4	B	11.4	B	No

Notes: **Bold** indicates an intersection operating at unacceptable LOS E or LOS F.
1. For signalized, all-way stop-controlled, and roundabout intersections, average intersection delay and LOS based on the 2000 HCM method is shown. For side-street stop-controlled intersections, delays for worst movement and average intersection delay are shown: intersection average (worst movement).

TABLE 4-7
LBNL SITE
ADDITIONAL EMPLOYMENT ALTERNATIVE (2018) CONDITIONS –
STUDY INTERSECTION LOS SUMMARY

2. Intersection analyzed using SimTraffic software because of unique conditions including heavy pedestrian volumes.

Source: Fehr & Peers.

5.0 REFERENCES

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Federal Railroad Administration, Crossing Inventory and Accident Reports database, at safetydata.fra.dot.gov/OfficeofSafety/Default.aspx, accessed January 2013.

Fehr & Peers, *Hearst Avenue Complete Street Study-Final,* November 2012.

Transportation Research Board, *2000 Highway Capacity Manual*, 2000.

Appendix A: Intersection Count Data Sheets
Richmond Bay Campus

FEHR PEERS

Study Name WC12-2953_1 Cutting Boulevard-23rd Street
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:30 AM	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
8:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 PM	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
4:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:30 PM	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_1 Cutting Boulevard-23rd Street
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	1	1	0	1	0	0	2	0
7:15 AM	1	0	0	0	0	0	0	0
7:30 AM	1	1	0	0	2	2	0	1
7:45 AM	0	0	0	0	1	2	0	1
8:00 AM	6	5	1	3	1	4	1	0
8:15 AM	0	1	0	0	1	0	0	1
8:30 AM	0	0	0	0	3	1	1	0
8:45 AM	1	0	1	0	2	2	0	1
4:00 PM	0	0	1	1	0	3	0	0
4:15 PM	0	0	0	2	3	2	0	0
4:30 PM	0	0	2	3	5	5	0	0
4:45 PM	1	1	1	2	3	0	0	1
5:00 PM	2	2	0	0	1	0	3	0
5:15 PM	0	0	3	0	1	0	0	0
5:30 PM	1	0	1	1	4	2	1	0
5:45 PM	0	0	3	6	4	7	0	0

Study Name WC12-2953_1 Cutting Boulevard-23rd Street
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	10	180	7	0	10	64	47	0	15	48	10	0	21	50	12	0
7:15 AM	5	191	10	0	16	57	72	0	29	46	11	0	15	38	8	0
7:30 AM	9	215	10	0	8	51	63	0	37	52	8	0	12	39	9	0
7:45 AM	4	142	13	0	22	80	50	0	27	65	12	0	17	66	11	1
8:00 AM	13	114	19	0	30	82	65	0	34	57	12	0	15	68	15	0
8:15 AM	15	119	26	0	25	106	60	0	34	52	11	0	17	97	24	0
8:30 AM	11	87	14	0	24	111	56	0	25	39	12	0	18	75	19	0
8:45 AM	8	86	19	0	24	90	69	0	32	55	9	0	8	51	16	0
4:00 PM	8	85	11	0	30	89	32	0	41	147	25	0	16	109	16	0
4:15 PM	10	68	13	0	27	83	30	0	52	146	19	0	14	72	16	0
4:30 PM	8	78	14	0	23	85	31	0	54	127	17	0	14	76	31	0
4:45 PM	4	71	16	0	25	81	33	0	46	186	27	0	8	81	17	0
5:00 PM	9	65	13	1	21	88	31	0	40	182	24	0	10	95	21	0
5:15 PM	11	84	16	0	36	92	53	0	48	180	27	0	19	78	20	0
5:30 PM	12	55	16	0	22	72	33	0	42	175	17	0	13	93	21	0
5:45 PM	9	52	14	0	26	86	33	0	35	174	28	0	11	67	19	0

Totals

Study Name WC12-2953_2 I-580 WB Ramps-23rd Street
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound			Westbound Street Westbound			Northbound Street Northbound		
Start Time	Right	Thru	U-Turn	Right	Thru	Left	Right	Thru	U-Turn
7:00 AM	0	0	0	1	0	0	0	0	0
7:15 AM	0	0	0	1	0	0	0	2	0
7:30 AM	0	1	0	1	0	0	0	1	0
7:45 AM	0	0	0	1	0	0	0	1	0
8:00 AM	0	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0	0
4:00 PM	0	0	0	0	0	0	0	0	0
4:15 PM	0	0	0	0	0	0	0	0	0
4:30 PM	0	1	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_2 I-580 WB Ramps-23rd Street
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	1	0	0	0	0	1	1	0
7:15 AM	0	0	0	0	0	0	0	0
7:30 AM	1	0	0	0	0	0	1	1
7:45 AM	0	0	0	1	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0
4:00 PM	3	0	0	0	0	0	0	0
4:15 PM	0	1	0	0	0	0	0	0
4:30 PM	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0

Study Name WC12-2953_2 I-580 WB Ramps-23rd Street
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound			Westbound Street Westbound			Northbound Street Northbound		
Start Time	Right	Thru	U-Turn	Right	Thru	Left	Right	Thru	U-Turn
7:00 AM	71	194	0	39	0	38	20	32	0
7:15 AM	87	227	0	38	0	54	31	49	0
7:30 AM	69	203	0	41	0	64	17	64	0
7:45 AM	57	177	0	37	0	85	15	58	0
8:00 AM	54	146	0	40	0	79	33	61	0
8:15 AM	51	159	0	45	2	80	28	52	0
8:30 AM	53	107	0	28	0	70	19	42	0
8:45 AM	42	138	0	41	0	86	28	46	0
4:00 PM	31	124	0	137	0	55	23	102	0
4:15 PM	22	99	0	129	0	57	23	111	0
4:30 PM	28	114	0	115	0	49	25	115	0
4:45 PM	23	91	0	129	3	65	31	105	0
5:00 PM	30	81	0	173	1	62	44	121	0
5:15 PM	42	110	0	130	0	68	25	113	0
5:30 PM	19	81	0	169	0	86	18	98	0
5:45 PM	22	87	0	141	1	91	26	96	0

Totals

Study Name WC12-2953_3 I-580 EB Ramps-23rd Street TMC
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound			Westbound Street Westbound		Northbound Street Northbound		
Start Time	Right	Thru	U-Turn	Right	Left	Right	Thru	U-Turn
7:00 AM	0	0	0	0	0	0	1	0
7:15 AM	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	1	0
8:15 AM	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0

Study Name WC12-2953_3 I-580 EB Ramps-23rd Street TMC
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	0	0	0	1	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	1	0	0	0	0
7:45 AM	0	0	2	0	0	0	0	1
8:00 AM	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0

Study Name WC12-2953_3 I-580 EB Ramps-23rd Street TMC
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound			Westbound Street Westbound		Northbound Street Northbound		
Start Time	Right	Thru	U-Turn	Right	Left	Right	Thru	U-Turn
7:00 AM	87	58	0	15	7	166	70	0
7:15 AM	91	44	0	14	12	180	89	0
7:30 AM	74	60	0	16	19	173	88	0
7:45 AM	18	14	0	32	14	118	133	0
8:00 AM	107	94	0	24	15	98	135	0
8:15 AM	69	52	0	21	19	105	175	0
8:30 AM	57	55	0	33	20	70	131	0
8:45 AM	74	52	0	18	22	78	132	0

Totals

Study Name WC12-2953_3 I-580 EB Ramps-23rd Street
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound			Northbound Street Northbound			Eastbound Street Eastbound	
Start Time	Right	Thru	U-Turn	Right	Thru	U-Turn	Right	Left
4:00 PM	0	0	0	0	0	0	0	0
4:15 PM	0	0	0	0	0	0	0	0
4:30 PM	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	1	0	0	0
5:30 PM	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	2	0	0	0

Study Name WC12-2953_3 I-580 EB Ramps-23rd Street
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
4:00 PM	0	0	0	0	0	0	2	3
4:15 PM	0	0	1	0	0	0	0	1
4:30 PM	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	1
5:00 PM	0	0	0	1	0	0	0	3
5:15 PM	0	0	0	1	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	1

Study Name WC12-2953_3 I-580 EB Ramps-23rd Street
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound			Northbound Street Northbound			Eastbound Street Eastbound	
Start Time	Right	Thru	U-Turn	Right	Thru	U-Turn	Right	Left
4:00 PM	76	101	0	75	85	0	24	51
4:15 PM	53	99	0	78	76	0	25	49
4:30 PM	70	82	0	110	76	0	29	65
4:45 PM	49	97	0	90	90	0	29	56
5:00 PM	64	98	0	151	105	0	31	52
5:15 PM	63	113	0	98	83	0	26	66
5:30 PM	52	122	0	64	54	0	40	49
5:45 PM	47	124	0	68	73	0	34	46

Totals

Study Name WC12-2953_4 Mekker Avenue-23rd Street-Marina Bay Parkway
Start Date 12/13/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 AM	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
8:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_4 Mekker Avenue-23rd Street-Marina Bay Parkway
Start Date 12/13/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	1	0	0	0	0	0	0	0
7:15 AM	0	1	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0	0	1
7:45 AM	1	0	0	0	0	0	1	0
8:00 AM	0	0	0	0	0	0	0	0
8:15 AM	2	0	0	0	0	0	0	0
8:30 AM	0	2	0	0	0	0	0	0
8:45 AM	1	1	0	0	0	0	0	1

Study Name WC12-2953_4 Mekker Avenue-23rd Street-Marina Bay Parkway
Start Date 12/13/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	8	49	23	2	4	0	0	0	4	127	6	1	4	0	11	0
7:15 AM	15	35	50	2	3	0	1	0	2	122	6	0	2	0	11	0
7:30 AM	15	48	34	0	3	0	0	0	3	126	1	0	3	1	8	0
7:45 AM	22	40	72	5	8	0	0	0	0	0	0	0	2	2	11	0
8:00 AM	20	70	73	2	4	1	0	0	4	189	10	0	7	2	12	0
8:15 AM	37	75	81	0	6	0	0	0	3	115	4	0	3	2	10	0
8:30 AM	17	72	66	1	8	0	0	0	5	101	3	0	2	0	6	0
8:45 AM	15	67	60	1	6	0	0	0	8	106	6	0	5	1	14	0

Totals

Study Name WC12-2953_4 Mekker Avenue-23rd Street-Marina Bay Parkway TMC
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
4:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:15 PM	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:30 PM	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
5:30 PM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

Study Name WC12-2953_4 Mekker Avenue-23rd Street-Marina Bay Parkway T
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
4:00 PM	1	2	0	0	0	0	0	4
4:15 PM	3	0	0	0	0	0	2	0
4:30 PM	0	0	0	0	0	0	0	0
4:45 PM	0	2	0	0	0	0	0	2
5:00 PM	1	0	0	2	0	2	0	0
5:15 PM	0	0	0	1	0	1	0	0
5:30 PM	0	0	1	0	0	0	0	0
5:45 PM	0	0	1	0	0	0	0	0

Study Name WC12-2953_4 Mekker Avenue-23rd Street-Marina Bay Parkway TMC
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
4:00 PM	5	102	5	3	53	1	0	0	1	80	8	0	11	1	22	0
4:15 PM	3	96	5	1	60	2	0	0	0	62	3	0	7	0	29	0
4:30 PM	4	102	4	1	65	3	1	0	0	91	2	1	11	0	25	0
4:45 PM	3	98	3	2	66	3	1	0	1	74	6	0	10	0	39	0
5:00 PM	6	95	2	2	96	3	2	0	0	81	6	0	20	1	60	0
5:15 PM	3	117	4	1	51	1	1	0	0	93	6	0	9	0	32	0
5:30 PM	3	123	2	2	38	2	3	0	0	57	6	0	14	0	17	0
5:45 PM	2	142	7	1	31	2	3	0	0	72	3	0	16	0	37	0

Totals

Study Name WC12-2953_5 Regatta Boulevard - Marina Bay Parkway TMC
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:45 AM	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_5 Regatta Boulevard - Marina Bay Parkway TMC
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	0	1	1	0	0	0	0	1
7:15 AM	0	0	0	0	0	0	0	0
7:30 AM	0	3	0	0	0	0	0	3
7:45 AM	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	1
8:15 AM	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0

Study Name WC12-2953_5 Regatta Boulevard - Marina Bay Parkway TMC
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	18	12	11	0	3	1	0	0	9	76	1	0	1	1	35	0
7:15 AM	27	14	5	0	2	1	1	0	23	85	1	0	2	5	40	0
7:30 AM	23	17	5	0	6	0	0	0	21	69	1	0	2	13	40	0
7:45 AM	4	12	11	0	10	2	3	0	36	83	0	0	2	6	47	0
8:00 AM	65	22	6	0	2	3	3	0	26	99	3	0	6	2	43	0
8:15 AM	38	20	5	0	2	0	3	0	13	51	1	0	1	5	49	0
8:30 AM	31	24	4	0	2	3	4	0	16	61	2	0	5	1	32	0
8:45 AM	31	31	4	0	1	3	3	0	5	72	3	0	1	4	30	0

Totals

Study Name WC12-2953_5 Regatta Boulevard - Marina Bay Parkway
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
4:00 PM	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:15 PM	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:30 PM	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:45 PM	1	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0
5:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
5:15 PM	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
5:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_5 Regatta Boulevard - Marina Bay Parkway
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
4:00 PM	0	0	2	0	0	0	0	0
4:15 PM	0	1	0	0	0	0	0	1
4:30 PM	0	0	0	0	0	0	0	0
4:45 PM	1	0	0	0	0	0	0	1
5:00 PM	0	0	1	0	0	0	4	0
5:15 PM	0	0	0	0	0	0	3	0
5:30 PM	0	0	0	0	0	0	0	1
5:45 PM	0	0	0	0	0	0	5	3

Study Name WC12-2953_5 Regatta Boulevard - Marina Bay Parkway
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
4:00 PM	31	57	4	0	6	1	7	0	4	34	2	0	5	0	28	0
4:15 PM	30	56	4	0	2	2	10	0	3	27	3	0	5	0	24	0
4:30 PM	43	48	2	0	11	4	7	0	4	27	1	0	5	0	51	0
4:45 PM	43	64	1	0	4	2	8	0	1	39	2	0	4	3	20	0
5:00 PM	34	65	0	0	6	2	9	0	5	37	2	0	6	4	51	0
5:15 PM	33	81	2	1	6	1	3	0	5	41	5	0	4	0	49	0
5:30 PM	49	80	1	0	3	3	3	0	1	30	3	0	2	0	28	0
5:45 PM	49	91	2	0	7	2	11	0	4	33	4	0	1	3	28	0

Totals

Study Name WC12-2953_6 I-580 WB Ramps - Juliga Woods Street
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound			Northbound Street Northbound			Eastbound Street Eastbound		
Start Time	Right	Thru	U-Turn	Thru	Left	U-Turn	Right	Left	U-Turn
7:00 AM	0	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0	0	0	0
8:00 AM	0	1	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0	0
8:45 AM	0	1	0	0	0	0	0	0	0
4:00 PM	0	0	0	0	0	0	0	0	0
4:15 PM	0	0	0	0	0	0	0	0	0
4:30 PM	0	0	0	1	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0	0
5:00 PM	0	1	0	0	0	0	0	0	0
5:15 PM	0	0	0	1	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_6 I-580 WB Ramps - Juliga Woods

Start Date 12/12/2012

Start Time 7:00 AM

Site Code

	Southbound Street Southbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0
4:00 PM	0	0	0	0	0	0
4:15 PM	0	0	0	0	0	0
4:30 PM	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0

Study Name WC12-2953_6 I-580 WB Ramps - Juliga Woods Street
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound			Northbound Street Northbound			Eastbound Street Eastbound				
Start Time	Right	Thru	U-Turn	Thru	Left	U-Turn	Right	Left	U-Turn	Hourly Total	15-min Total
7:00 AM	25	41	0	14	3	0	10	5	0	417	98
7:15 AM	33	60	0	9	3	0	16	10	0	429	131
7:30 AM	36	33	0	15	2	0	12	10	0	398	108
7:45 AM	19	25	0	12	3	0	12	9	0	390	80
8:00 AM	21	35	0	25	5	0	11	13	0	373	110
8:15 AM	31	32	0	13	3	0	8	13	0		100
8:30 AM	26	25	0	18	8	0	14	8	1		100
8:45 AM	15	15	0	10	5	0	5	13	0		63
4:00 PM	12	16	0	38	17	1	11	17	0	404	112
4:15 PM	9	15	0	27	9	0	7	27	1	392	95
4:30 PM	11	20	0	28	10	0	5	20	2	405	96
4:45 PM	14	18	0	33	6	1	7	22	0	423	101
5:00 PM	7	20	0	37	6	0	4	26	0	413	100
5:15 PM	14	14	0	38	2	0	10	28	2		108
5:30 PM	10	11	0	41	5	0	6	40	1		114
5:45 PM	9	11	1	26	3	0	7	34	0		91

Totals

Study Name WC12-2953_7 I-580 EB Ramps - Regatta Boulevard - Meade Street
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
4:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:30 PM	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 AM	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
8:15 AM	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_7 I-580 EB Ramps - Regatta Boulevard - Meade Stree
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
4:00 PM	0	0	0	0	0	0	0	0
4:15 PM	0	0	0	0	0	0	0	0
4:30 PM	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0
7:00 AM	0	0	0	0	0	0	0	0
7:15 AM	0	0	1	2	0	0	0	0
7:30 AM	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	1	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	1	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0

Study Name WC12-2953_7 I-580 EB Ramps - Regatta Boulevard - Meade Street
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
4:00 PM	16	3	10	0	21	10	0	0	0	15	3	0	0	1	18	0
4:15 PM	7	0	13	0	12	5	2	0	1	6	2	0	2	4	16	1
4:30 PM	18	0	6	0	16	7	0	0	0	6	4	0	1	4	14	1
4:45 PM	11	5	9	0	10	6	1	0	2	6	2	0	0	2	26	1
5:00 PM	16	2	7	0	17	9	1	0	0	4	2	0	0	1	20	0
5:15 PM	10	4	8	0	8	2	0	0	2	2	2	0	0	3	29	0
5:30 PM	11	1	6	0	10	8	0	0	0	5	3	0	0	1	38	0
5:45 PM	7	1	12	0	7	8	0	0	0	0	1	0	1	3	19	0
7:00 AM	30	4	21	0	7	7	0	0	1	0	0	0	2	2	11	0
7:15 AM	33	20	15	0	3	7	1	0	0	5	1	0	4	2	4	0
7:30 AM	36	7	8	0	4	7	0	0	1	1	0	0	3	3	5	1
7:45 AM	19	6	4	0	15	5	2	0	3	3	1	0	5	6	10	7
8:00 AM	26	0	19	0	24	24	4	0	1	4	1	0	4	6	7	0
8:15 AM	17	8	17	0	7	5	1	0	3	3	1	0	1	3	15	0
8:30 AM	16	0	16	0	2	8	0	0	3	1	1	0	5	3	7	0
8:45 AM	12	5	12	0	8	3	0	0	2	2	1	0	0	6	10	0

Totals

Study Name WC12-2953_8 Meade Street - Seaver Avenue
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound			Northbound Street Northbound			Eastbound Street Eastbound		
Start Time	Right	Thru	U-Turn	Thru	Left	U-Turn	Right	Left	U-Turn
7:00 AM	0	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	1	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	1	0	0	0	0
8:45 AM	1	0	0	0	0	0	0	0	0
4:00 PM	0	0	0	0	0	0	0	0	0
4:15 PM	0	0	0	0	0	0	0	0	0
4:30 PM	0	0	0	0	0	0	0	1	0
4:45 PM	0	0	0	2	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_8 Meade Street - Seaver Avenue
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0
4:00 PM	0	0	0	0	0	0
4:15 PM	0	0	0	0	0	0
4:30 PM	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0

Study Name WC12-2953_8 Meade Street - Seaver Avenue
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound			Northbound Street Northbound			Eastbound Street Eastbound				
Start Time	Right	Thru	U-Turn	Thru	Left	U-Turn	Right	Left	U-Turn	Hourly Total	15-min Total
7:00 AM	2	13	0	4	8	0	0	0	0	174	27
7:15 AM	2	23	0	9	5	0	0	0	0	206	39
7:30 AM	1	35	0	2	4	0	2	0	0	217	44
7:45 AM	3	46	0	5	9	0	1	0	0	216	64
8:00 AM	3	38	0	4	12	0	1	1	0	186	59
8:15 AM	3	29	0	8	9	0	0	1	0		50
8:30 AM	1	18	0	11	11	0	1	1	0		43
8:45 AM	2	13	0	2	14	0	1	2	0		34
4:00 PM	3	15	0	10	2	0	5	2	0	157	37
4:15 PM	0	13	1	14	1	0	10	1	0	160	40
4:30 PM	1	17	0	12	2	0	9	3	0	157	44
4:45 PM	0	10	0	14	0	0	11	1	0	130	36
5:00 PM	0	10	0	12	2	0	12	4	0	125	40
5:15 PM	2	14	0	4	0	0	14	3	0		37
5:30 PM	0	5	0	6	1	0	2	3	0		17
5:45 PM	0	9	0	12	1	0	8	1	0		31

Totals

Study Name WC12-2953_9 Seaprot Avenue - I-580 EB Ramps
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
4:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
4:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
5:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
5:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
8:30 AM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_9 Seaprot Avenue - I-580 EB Ramps
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
4:00 PM	0	0	0	2	0	1	0	0
4:15 PM	0	0	0	0	0	0	0	0
4:30 PM	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	1	1	0	0
5:15 PM	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0
7:00 AM	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0

Study Name WC12-2953_9 Seaprot Avenue - I-580 EB Ramps
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
4:00 PM	3	1	70	0	18	12	0	1	9	1	0	0	0	16	7	1
4:15 PM	1	1	74	0	18	16	1	1	7	2	1	0	0	19	12	0
4:30 PM	0	1	122	0	21	16	3	0	12	8	0	0	0	16	19	0
4:45 PM	0	0	89	0	16	9	2	0	8	0	0	0	1	14	11	1
5:00 PM	2	0	110	0	16	15	5	0	3	6	0	0	0	19	12	0
5:15 PM	1	0	115	0	15	1	2	1	1	3	0	0	0	17	12	2
5:30 PM	1	0	83	0	15	8	0	1	2	0	0	0	1	17	7	0
5:45 PM	1	0	92	0	16	11	0	0	1	1	0	0	2	12	7	1
7:00 AM	0	1	28	0	36	13	7	0	3	1	0	0	0	9	4	0
7:15 AM	0	0	48	0	55	20	5	0	2	1	0	0	1	9	9	0
7:30 AM	3	1	95	2	58	29	12	0	0	2	1	0	0	29	18	0
7:45 AM	6	2	125	5	46	34	4	1	0	0	2	0	2	39	32	0
8:00 AM	3	2	135	2	31	29	2	0	3	1	2	0	0	45	30	0
8:15 AM	3	2	90	0	37	26	12	0	4	3	0	0	1	19	13	1
8:30 AM	1	0	65	0	37	28	10	0	2	3	2	0	1	11	13	1
8:45 AM	1	1	42	0	34	32	3	0	0	1	1	0	0	13	9	0

Totals

Study Name WC12-2953_10 Bayview Avenue - I-580 WB Ramps
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound			Westbound Street Westbound			Northbound Street Northbound		
Start Time	Right	Thru	U-Turn	Right	Thru	Left	Thru	Left	U-Turn
7:00 AM	0	0	0	0	0	0	0	0	0
7:15 AM	0	1	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0	0	0	0
7:45 AM	0	1	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	2	0	0
8:30 AM	0	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0	0
4:00 PM	0	2	0	0	0	0	1	0	0
4:15 PM	0	0	0	0	0	0	1	0	0
4:30 PM	0	0	0	0	0	0	1	0	0
4:45 PM	0	1	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	1	1	0	0
5:30 PM	0	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_10 Bayview Avenue - I-580 WB Ramps
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	1	0
8:15 AM	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	1	0
8:45 AM	0	0	0	0	0	0	0	0
4:00 PM	0	0	2	0	0	0	0	0
4:15 PM	0	0	0	0	0	0	0	0
4:30 PM	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0
5:00 PM	0	0	1	0	0	0	1	0
5:15 PM	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	1	0	0	0	0

Study Name WC12-2953_10 Bayview Avenue - I-580 WB Ramps
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound			Westbound Street Westbound			Northbound Street Northbound				
Start Time	Right	Thru	U-Turn	Right	Thru	Left	Thru	Left	U-Turn	Hourly Total	15-min Total
7:00 AM	59	58	0	13	0	9	49	1	0	1058	189
7:15 AM	71	77	0	9	0	13	62	2	0	1184	234
7:30 AM	96	65	0	11	0	9	107	4	0	1204	292
7:45 AM	96	54	0	15	0	17	159	2	0	1161	343
8:00 AM	103	46	0	17	0	15	132	2	0	1024	315
8:15 AM	78	44	0	20	0	22	90	0	0		254
8:30 AM	87	73	0	18	1	17	51	2	0		249
8:45 AM	68	57	0	13	0	8	58	2	0		206
4:00 PM	48	25	0	61	1	9	92	4	0	1072	240
4:15 PM	49	29	0	64	1	9	99	1	0	1165	252
4:30 PM	54	30	0	64	0	3	153	2	0	1241	306
4:45 PM	54	23	0	77	2	8	109	1	0	1277	274
5:00 PM	65	23	0	106	0	10	127	2	0	1303	333
5:15 PM	60	18	0	113	0	4	133	0	0		328
5:30 PM	80	29	1	117	0	2	109	4	0		342
5:45 PM	82	17	0	96	0	8	97	0	0		300

Totals

Study Name WC12-2953_11 Carlson Boulevard - Bayview Avenue
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
8:00 AM	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:30 AM	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 PM	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
4:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:45 PM	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_11 Carlson Boulevard - Bayview Avenue
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	1	0	0	0	0
7:45 AM	1	0	0	0	0	0	0	0
8:00 AM	0	0	1	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0
8:45 AM	2	0	0	0	0	0	0	0
4:00 PM	0	1	0	0	0	0	0	0
4:15 PM	0	0	0	0	0	0	0	0
4:30 PM	2	0	0	0	0	1	0	0
4:45 PM	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	1	0	0	0	0
5:15 PM	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	1	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0

Study Name WC12-2953_11 Carlson Boulevard - Bayview Avenue
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	21	4	0	5	13	58	1	32	12	8	0	35	33	2	0
7:15 AM	6	26	11	0	3	10	59	0	59	11	7	0	59	52	0	0
7:30 AM	2	23	13	0	5	15	82	1	81	11	8	0	47	87	0	0
7:45 AM	2	35	6	0	6	13	70	0	148	17	13	0	39	101	3	0
8:00 AM	5	40	16	0	6	22	68	0	127	11	15	0	40	101	2	0
8:15 AM	6	27	10	0	1	28	66	1	75	19	14	0	27	74	3	0
8:30 AM	3	30	7	0	6	30	72	1	46	13	16	0	38	61	4	0
8:45 AM	5	28	7	0	4	19	59	0	57	4	15	0	28	41	3	0
4:00 PM	9	11	4	0	8	44	38	0	72	30	44	0	20	32	6	0
4:15 PM	3	11	3	0	4	43	51	1	92	18	48	0	23	27	5	0
4:30 PM	10	13	7	0	14	40	45	0	121	32	53	0	17	37	6	0
4:45 PM	8	11	3	0	8	48	51	1	99	38	64	0	18	25	4	1
5:00 PM	7	13	3	0	10	54	58	1	109	44	78	0	15	40	4	0
5:15 PM	13	8	3	0	9	54	52	0	112	48	74	0	12	46	7	0
5:30 PM	8	1	6	0	13	75	80	0	93	44	71	0	15	41	8	0
5:45 PM	10	13	3	0	7	69	71	0	97	36	79	0	14	36	6	0

Totals

Study Name WC12-2953_12 Carlson Boulevard - I-80 EB Ramps
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound			Westbound Street Westbound			Eastbound Street Eastbound		
Start Time	Right	Thru	Left	Thru	Left	U-Turn	Right	Thru	U-Turn
7:00 AM	0	0	0	0	0	0	0	1	0
7:15 AM	0	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	1	0	0	0	0	0
7:45 AM	0	0	0	1	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	1	0
4:00 PM	0	0	0	0	0	0	0	2	0
4:15 PM	0	0	0	0	0	0	0	1	0
4:30 PM	0	0	0	1	0	0	0	0	0
4:45 PM	0	0	0	1	0	0	0	0	0
5:00 PM	0	0	0	2	0	0	0	0	0
5:15 PM	0	0	0	1	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_12 Carlson Boulevard - I-80 EB Ramps
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	1	0	0	0
7:30 AM	0	0	0	0	6	0	0	0
7:45 AM	1	2	0	0	0	0	0	0
8:00 AM	0	0	0	0	1	1	0	0
8:15 AM	1	1	0	0	1	0	0	0
8:30 AM	2	1	1	0	0	0	1	0
8:45 AM	0	1	0	0	0	0	0	0
4:00 PM	0	0	0	0	1	2	0	0
4:15 PM	2	0	0	0	1	0	0	0
4:30 PM	1	1	0	0	0	0	0	0
4:45 PM	1	0	1	0	0	0	0	0
5:00 PM	0	0	0	0	1	2	0	0
5:15 PM	2	1	0	0	2	0	0	0
5:30 PM	0	0	0	0	2	0	0	0
5:45 PM	0	0	0	0	0	1	0	0

Study Name WC12-2953_12 Carlson Boulevard - I-80 EB Ramps
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound			Westbound Street Westbound			Eastbound Street Eastbound				
Start Time	Right	Thru	Left	Thru	Left	U-Turn	Right	Thru	U-Turn	Hourly Total	15-min Total
7:00 AM	54	3	43	47	21	0	18	63	0	1490	249
7:15 AM	41	5	73	31	17	1	18	108	0	1765	294
7:30 AM	51	2	93	68	20	0	32	163	0	1928	429
7:45 AM	43	9	112	67	16	0	33	238	0	1885	518
8:00 AM	40	5	87	85	20	0	34	253	0	1689	524
8:15 AM	47	7	96	87	22	0	23	175	0		457
8:30 AM	42	6	77	95	24	0	20	122	0		386
8:45 AM	46	7	71	59	16	0	15	108	0		322
4:00 PM	46	1	57	72	12	0	17	128	0	1400	333
4:15 PM	37	0	64	86	18	0	12	121	0	1453	338
4:30 PM	41	0	59	87	15	0	13	149	0	1515	364
4:45 PM	32	0	50	100	10	0	22	151	0	1574	365
5:00 PM	46	0	67	95	13	0	16	149	0	1623	386
5:15 PM	43	0	74	101	14	0	16	152	0		400
5:30 PM	51	1	67	131	11	0	23	139	0		423
5:45 PM	47	0	75	121	15	0	15	141	0		414

Totals

Study Name WC12-2953_13 Carlson Boulevard - I-80 WB Ramps
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Westbound Street Westbound			Northbound Street Northbound			Eastbound Street Eastbound		
Start Time	Right	Thru	U-Turn	Right	Thru	Left	Thru	Left	U-Turn
7:00 AM	1	0	0	0	0	0	1	0	0
7:15 AM	0	1	0	0	0	0	0	0	0
7:30 AM	0	1	0	0	0	0	0	0	0
7:45 AM	0	2	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	1	0	0
4:00 PM	0	2	0	0	0	0	1	1	0
4:15 PM	0	1	0	0	0	0	1	0	0
4:30 PM	0	1	0	0	0	0	0	0	0
4:45 PM	0	1	0	0	0	0	0	1	0
5:00 PM	0	0	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_13 Carlson Boulevard - I-80 WB Ramps
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	0	1	0	0	1	0	0	0
7:15 AM	0	1	0	0	4	0	0	0
7:30 AM	0	0	0	0	4	0	0	0
7:45 AM	1	2	0	0	0	0	0	0
8:00 AM	0	0	0	0	1	1	0	0
8:15 AM	1	1	0	1	1	0	0	0
8:30 AM	2	1	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0
4:00 PM	0	1	0	0	0	2	0	0
4:15 PM	1	0	0	0	1	0	0	0
4:30 PM	0	1	0	0	0	0	0	0
4:45 PM	1	1	0	0	0	0	0	0
5:00 PM	1	0	0	0	1	2	0	0
5:15 PM	1	0	0	0	2	0	0	0
5:30 PM	0	0	0	0	2	0	0	0
5:45 PM	0	0	0	0	0	0	0	0

Study Name WC12-2953_13 Carlson Boulevard - I-80 WB Ramps
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Westbound Street Westbound			Northbound Street Northbound			Eastbound Street Eastbound				
Start Time	Right	Thru	U-Turn	Right	Thru	Left	Thru	Left	U-Turn	Hourly Total	15-min Total
7:00 AM	40	58	0	10	1	4	78	37	0	1551	228
7:15 AM	44	56	0	8	0	2	155	34	0	1876	299
7:30 AM	73	76	0	11	0	5	218	63	0	2051	446
7:45 AM	107	94	0	11	0	3	317	46	0	2009	578
8:00 AM	114	108	0	12	1	9	251	58	0	1756	553
8:15 AM	87	102	0	20	1	6	215	43	0		474
8:30 AM	77	98	0	25	2	4	158	40	0		404
8:45 AM	71	61	0	18	2	9	126	38	0		325
4:00 PM	107	79	0	18	13	10	101	49	0	1672	377
4:15 PM	76	82	0	27	21	17	117	75	1	1774	416
4:30 PM	101	94	0	26	27	14	140	82	0	1866	484
4:45 PM	75	77	0	26	20	21	112	64	0	1895	395
5:00 PM	98	94	0	30	23	12	158	64	0	1967	479
5:15 PM	98	98	0	21	43	19	173	56	0		508
5:30 PM	104	132	0	26	41	14	148	48	0		513
5:45 PM	77	112	0	23	34	16	162	43	0		467

Totals

Study Name WC12-2953_4 Mekker Avenue-23rd Street-Marina Bay Parkway TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#4

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
7:15 AM	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:30 AM	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:45 AM	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 PM	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
4:15 PM	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
4:30 PM	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:45 PM	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 PM	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0
5:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_4 Mekker Avenue-23rd Street-Marina Bay Parkway T
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#4

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	0	0	0	0	0	0	0	1
7:15 AM	1	1	1	0	0	0	1	0
7:30 AM	0	0	0	1	0	0	0	1
7:45 AM	1	1	0	0	0	0	0	0
8:00 AM	2	0	0	0	0	0	0	0
8:15 AM	0	3	0	0	0	0	1	1
8:30 AM	0	0	0	1	0	0	1	1
8:45 AM	4	0	0	0	0	0	0	1
4:00 PM	1	2	0	0	0	1	1	4
4:15 PM	1	0	0	0	0	0	3	0
4:30 PM	0	0	1	0	0	0	1	0
4:45 PM	0	0	0	0	0	0	0	1
5:00 PM	2	0	0	0	0	1	0	4
5:15 PM	0	2	0	0	0	0	3	0
5:30 PM	0	1	0	0	0	0	0	1
5:45 PM	0	0	0	0	0	0	0	1

Study Name WC12-2953_4 Mekker Avenue-23rd Street-Marina Bay Parkway TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#4

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	7	46	29	0	2	0	0	0	0	115	4	0	5	1	8	0
7:15 AM	17	34	34	1	3	0	0	0	2	134	4	0	2	2	16	0
7:30 AM	10	54	55	1	4	0	0	0	2	150	2	0	0	2	13	0
7:45 AM	21	73	74	1	7	2	0	0	2	117	8	0	3	3	9	0
8:00 AM	27	51	90	0	7	0	1	0	3	143	8	0	4	4	19	0
8:15 AM	25	75	63	5	5	1	1	0	3	139	1	0	4	0	9	0
8:30 AM	18	75	72	2	4	0	1	0	3	86	1	0	4	1	8	0
8:45 AM	16	57	63	0	9	0	1	0	3	89	3	0	5	0	7	0
4:00 PM	8	86	7	2	37	2	0	0	0	86	5	0	12	0	33	0
4:15 PM	9	100	3	1	43	1	2	0	0	80	6	0	12	1	25	0
4:30 PM	13	106	6	1	78	5	0	0	1	99	4	0	5	1	22	0
4:45 PM	6	96	3	1	50	1	0	0	1	63	6	0	18	0	26	0
5:00 PM	7	113	2	4	98	1	3	0	1	90	10	0	19	0	73	0
5:15 PM	5	102	5	1	55	3	3	0	0	79	2	0	14	1	28	0
5:30 PM	6	117	2	3	46	2	3	0	0	80	6	0	15	1	34	0
5:45 PM	4	125	3	1	23	2	1	0	0	79	9	0	9	0	32	0

Totals

Study Name Regatta Blvd-Meade St/Regatta Blvd TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#8

	Westbound Street Westbound			Northbound Street Northbound			Eastbound Street Eastbound		
Start Time	Thru	Left	U-Turn	Right	Left	U-Turn	Right	Thru	U-Turn
7:00 AM	0	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	1	0	0
7:30 AM	0	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	4	0	0
8:15 AM	0	1	0	2	0	0	1	1	0
8:30 AM	0	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	1	0
4:00 PM	0	0	0	1	0	0	0	0	0
4:15 PM	0	0	0	1	0	0	0	0	0
4:30 PM	0	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0	0
5:45 PM	1	0	0	0	0	0	0	0	0

Study Name Regatta Blvd-Meade St/Regatta Blvd TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#8

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0
4:00 PM	0	0	0	0	0	0	0	0
4:15 PM	0	0	0	0	0	0	0	0
4:30 PM	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0

Study Name Regatta Blvd-Meade St/Regatta Blvd TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#8

	Westbound Street Westbound			Northbound Street Northbound			Eastbound Street Eastbound						
Start Time	Thru	Left	U-Turn	Right	Left	U-Turn	Right	Thru	U-Turn	Hourly Total	15-min Total		
7:00 AM	0	9	0	17	7	0	17	1	0	289	51		
7:15 AM	1	6	0	23	7	0	22	4	0	336	63		
7:30 AM	0	7	0	32	14	0	13	7	0	346	73		
7:45 AM	2	4	0	39	16	0	27	14	0	337	102		
8:00 AM	0	6	0	44	17	0	28	3	0	321	98		
8:15 AM	0	7	0	30	12	0	18	6	0		73	10	40
8:30 AM	1	7	0	24	18	0	10	4	0		64	11	5
8:45 AM	4	5	0	26	17	0	28	6	0		86	94	5
4:00 PM	6	13	0	20	28	0	8	2	0	233	77	88	30
4:15 PM	4	13	0	10	11	0	11	2	0	220	51	10	23
4:30 PM	6	3	0	16	18	0	9	4	0	214	56	64	35
4:45 PM	1	6	0	10	14	0	13	5	0	199	49		
5:00 PM	4	8	0	18	25	0	7	2	0	177	64		
5:15 PM	6	10	0	8	8	0	9	4	0		45		
5:30 PM	5	10	0	7	11	0	8	0	0		41	0.249097473	
5:45 PM	3	8	0	4	2	0	6	4	0		27	0.282608696	

Totals

Study Name Carlson Blvd/Bayview Ave TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#12

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
8:00 AM	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
8:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
8:30 AM	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
4:15 PM	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0
4:30 PM	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Study Name Carlson Blvd/Bayview Ave TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#12

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	1	0	0	0	0
8:00 AM	0	1	0	0	0	0	0	0
8:15 AM	0	0	1	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0
8:45 AM	1	0	1	0	0	0	0	0
4:00 PM	5	1	1	0	0	0	0	0
4:15 PM	0	0	1	0	0	0	0	0
4:30 PM	3	3	0	0	0	0	0	0
4:45 PM	2	4	1	1	0	0	0	0
5:00 PM	1	0	3	1	0	0	0	0
5:15 PM	0	0	0	0	0	0	0	0
5:30 PM	1	1	1	1	0	0	0	0
5:45 PM	0	0	1	0	0	0	0	0

Study Name Carlson Blvd/Bayview Ave TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#12

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	6	19	1	0	5	8	71	0	29	8	11	0	35	35	2	1
7:15 AM	2	24	6	0	3	6	88	1	59	14	7	0	60	44	4	0
7:30 AM	4	27	11	0	6	13	68	0	69	11	11	0	68	85	0	0
7:45 AM	2	22	10	0	8	17	70	3	116	21	12	0	43	105	2	0
8:00 AM	8	33	15	0	3	18	83	0	100	16	18	0	38	84	1	0
8:15 AM	5	33	16	0	1	24	78	1	58	19	14	0	50	67	4	0
8:30 AM	3	34	12	0	5	18	64	1	61	15	18	0	44	59	5	0
8:45 AM	1	25	7	0	6	24	60	0	53	12	18	0	23	51	2	0
4:00 PM	7	13	6	0	11	50	66	1	96	37	47	0	17	33	8	0
4:15 PM	7	9	11	0	10	40	52	1	97	27	49	0	19	42	6	0
4:30 PM	10	17	10	0	9	45	46	0	110	43	48	0	16	29	10	0
4:45 PM	15	23	17	0	3	21	16	3	99	42	64	0	22	37	4	0
5:00 PM	6	23	14	0	6	30	18	2	113	49	71	0	18	37	4	0
5:15 PM	9	22	6	0	11	34	31	1	118	36	66	0	24	26	4	0
5:30 PM	4	14	8	0	10	49	54	3	102	44	69	0	14	39	7	0
5:45 PM	8	12	8	0	7	49	60	1	81	36	60	0	11	24	3	1

Totals

Appendix B: Intersection LOS Calculation
Richmond Bay Campus

FEHR PEERS

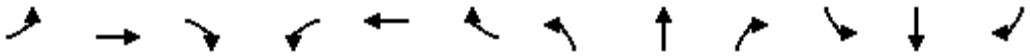
Existing Conditions

FEHR PEERS

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	60	270	61	238	319	85	43	226	132	68	590	41
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frpb, ped/bikes	1.00	1.00	0.98	1.00	1.00	0.98	1.00	1.00	0.98	1.00	1.00	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1736	3471	1517	1736	3471	1514	1736	3471	1529	1736	3434	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1736	3471	1517	1736	3471	1514	1736	3471	1529	1736	3434	
Peak-hour factor, PHF	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Adj. Flow (vph)	66	297	67	262	351	93	47	248	145	75	648	45
RTOR Reduction (vph)	0	0	30	0	0	42	0	0	108	0	4	0
Lane Group Flow (vph)	66	297	37	262	351	51	47	248	37	75	689	0
Confl. Peds. (#/hr)	14		13	13		14	4		4	4		4
Confl. Bikes (#/hr)						1						1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases			2			6			8			
Actuated Green, G (s)	6.3	16.7	16.7	16.6	25.0	25.0	4.1	18.4	18.4	6.7	21.0	
Effective Green, g (s)	6.3	16.7	16.7	16.6	25.0	25.0	4.1	18.4	18.4	6.7	21.0	
Actuated g/C Ratio	0.09	0.23	0.23	0.23	0.35	0.35	0.06	0.26	0.26	0.09	0.29	
Clearance Time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Vehicle Extension (s)	2.0	4.0	4.0	2.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	
Lane Grp Cap (vph)	153	812	355	404	1215	530	100	894	394	163	1010	
v/s Ratio Prot	0.04	c0.09		c0.15	0.10		0.03	0.07		c0.04	c0.20	
v/s Ratio Perm			0.02			0.03			0.02			
v/c Ratio	0.43	0.37	0.10	0.65	0.29	0.10	0.47	0.28	0.09	0.46	0.68	
Uniform Delay, d1	30.9	22.9	21.5	24.8	16.8	15.6	32.6	21.2	20.2	30.6	22.3	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	0.7	0.4	0.2	2.7	0.2	0.1	1.3	0.1	0.0	0.8	1.5	
Delay (s)	31.6	23.3	21.7	27.4	17.0	15.7	33.9	21.2	20.2	31.4	23.8	
Level of Service	C	C	C	C	B	B	C	C	C	C	C	
Approach Delay (s)		24.3			20.7			22.3			24.5	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	22.9	HCM Level of Service	C
HCM Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	71.4	Sum of lost time (s)	13.0
Intersection Capacity Utilization	60.3%	ICU Level of Service	B
Analysis Period (min)	15		

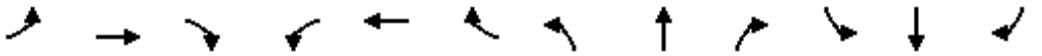
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	308	2	163	0	235	130	0	685	231
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0	4.0		4.0	4.0		4.0	
Lane Util. Factor				0.95	0.91	0.95		0.91	1.00		0.91	
Frpb, ped/bikes				1.00	1.00	0.99		1.00	0.98		0.99	
Flpb, ped/bikes				1.00	1.00	1.00		1.00	1.00		1.00	
Frt				1.00	0.99	0.85		1.00	0.85		0.96	
Flt Protected				0.95	0.96	1.00		1.00	1.00		1.00	
Satd. Flow (prot)				1665	1582	1471		5036	1535		4817	
Flt Permitted				0.95	0.96	1.00		1.00	1.00		1.00	
Satd. Flow (perm)				1665	1582	1471		5036	1535		4817	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	328	2	173	0	250	138	0	729	246
RTOR Reduction (vph)	0	0	0	0	8	103	0	0	0	0	86	0
Lane Group Flow (vph)	0	0	0	174	165	53	0	250	138	0	889	0
Confl. Peds. (#/hr)	1					1	2		1	1		2
Confl. Bikes (#/hr)									2			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type				Split		Perm			Free			
Protected Phases				8	8			2			6	
Permitted Phases						8			Free			
Actuated Green, G (s)				12.1	12.1	12.1		15.7	35.8		15.7	
Effective Green, g (s)				12.1	12.1	12.1		15.7	35.8		15.7	
Actuated g/C Ratio				0.34	0.34	0.34		0.44	1.00		0.44	
Clearance Time (s)				4.0	4.0	4.0		4.0			4.0	
Vehicle Extension (s)				3.0	3.0	3.0		3.0			3.0	
Lane Grp Cap (vph)				563	535	497		2209	1535		2112	
v/s Ratio Prot				c0.10	0.10			0.05			c0.18	
v/s Ratio Perm						0.04			0.09			
v/c Ratio				0.31	0.31	0.11		0.11	0.09		0.42	
Uniform Delay, d1				8.8	8.8	8.1		5.9	0.0		6.9	
Progression Factor				1.00	1.00	1.00		1.00	1.00		1.00	
Incremental Delay, d2				0.3	0.3	0.1		0.0	0.1		0.1	
Delay (s)				9.1	9.1	8.2		6.0	0.1		7.1	
Level of Service				A	A	A		A	A		A	
Approach Delay (s)		0.0			8.8			3.9			7.1	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	6.9	HCM Level of Service	A
HCM Volume to Capacity ratio	0.37		
Actuated Cycle Length (s)	35.8	Sum of lost time (s)	8.0
Intersection Capacity Utilization	35.9%	ICU Level of Service	A
Analysis Period (min)	15		

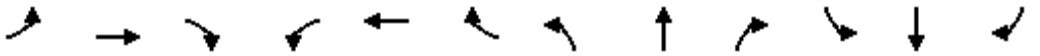
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	67	0	93	0	0	0	0	298	313	0	521	472
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0					4.0			4.0	4.0
Lane Util. Factor	1.00		1.00					0.91			0.95	1.00
Frpb, ped/bikes	1.00		1.00					0.99			1.00	0.98
Flpb, ped/bikes	1.00		1.00					1.00			1.00	1.00
Frt	1.00		0.85					0.92			1.00	0.85
Flt Protected	0.95		1.00					1.00			1.00	1.00
Satd. Flow (prot)	1752		1568					4593			3505	1536
Flt Permitted	0.95		1.00					1.00			1.00	1.00
Satd. Flow (perm)	1752		1568					4593			3505	1536
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	76	0	106	0	0	0	0	339	356	0	592	536
RTOR Reduction (vph)	0	0	84	0	0	0	0	179	0	0	0	0
Lane Group Flow (vph)	76	0	22	0	0	0	0	516	0	0	592	536
Confl. Peds. (#/hr)							1		3	3		1
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Split		Perm									Free
Protected Phases	8	8						2			6	
Permitted Phases			8									Free
Actuated Green, G (s)	5.6		5.6					13.5			13.5	27.1
Effective Green, g (s)	5.6		5.6					13.5			13.5	27.1
Actuated g/C Ratio	0.21		0.21					0.50			0.50	1.00
Clearance Time (s)	4.0		4.0					4.0			4.0	
Vehicle Extension (s)	3.0		3.0					3.0			3.0	
Lane Grp Cap (vph)	362		324					2288			1746	1536
v/s Ratio Prot	0.04							0.11			0.17	
v/s Ratio Perm			0.01									c0.35
v/c Ratio	0.21		0.07					0.23			0.34	0.35
Uniform Delay, d1	8.9		8.6					3.8			4.1	0.0
Progression Factor	1.00		1.00					1.00			1.00	1.00
Incremental Delay, d2	0.3		0.1					0.1			0.1	0.6
Delay (s)	9.2		8.7					3.9			4.2	0.6
Level of Service	A		A					A			A	A
Approach Delay (s)		8.9			0.0			3.9			2.5	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	3.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.35		
Actuated Cycle Length (s)	27.1	Sum of lost time (s)	0.0
Intersection Capacity Utilization	26.9%	ICU Level of Service	A
Analysis Period (min)	15		

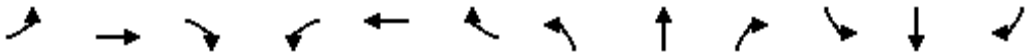
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	41	7	15	0	1	21	15	549	10	267	233	94
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0			4.0		4.0	4.0	
Lane Util. Factor		1.00			1.00			0.95		1.00	0.95	
Frpb, ped/bikes		1.00			0.99			1.00		1.00	0.99	
Flpb, ped/bikes		1.00			1.00			1.00		1.00	1.00	
Frt		0.97			0.85			1.00		1.00	0.96	
Flt Protected		0.97			1.00			1.00		0.95	1.00	
Satd. Flow (prot)		1711			1542			3457		1736	3299	
Flt Permitted		1.00			1.00			0.94		0.95	1.00	
Satd. Flow (perm)		1767			1542			3248		1736	3299	
Peak-hour factor, PHF	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Adj. Flow (vph)	57	10	21	0	1	29	21	762	14	371	324	131
RTOR Reduction (vph)	0	12	0	0	26	0	0	1	0	0	26	0
Lane Group Flow (vph)	0	76	0	0	4	0	0	796	0	371	429	0
Confl. Peds. (#/hr)	3					3	2					2
Confl. Bikes (#/hr)												1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm			Perm			Perm			Prot		
Protected Phases		3			4			2		1	6	
Permitted Phases	3			4			2					
Actuated Green, G (s)		2.2			6.8			22.1		12.0	38.1	
Effective Green, g (s)		2.2			6.8			22.1		12.0	38.1	
Actuated g/C Ratio		0.04			0.12			0.37		0.20	0.64	
Clearance Time (s)		4.0			4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		66			177			1215		352	2127	
v/s Ratio Prot					c0.00					c0.21	0.13	
v/s Ratio Perm		c0.04						c0.25				
v/c Ratio		1.16			0.02			0.65		1.05	0.20	
Uniform Delay, d1		28.4			23.2			15.3		23.6	4.3	
Progression Factor		1.00			1.00			1.00		1.00	1.00	
Incremental Delay, d2		160.0			0.1			1.3		62.9	0.0	
Delay (s)		188.5			23.3			16.6		86.4	4.3	
Level of Service		F			C			B		F	A	
Approach Delay (s)		188.5			23.3			16.6			41.2	
Approach LOS		F			C			B			D	

Intersection Summary			
HCM Average Control Delay	37.1	HCM Level of Service	D
HCM Volume to Capacity ratio	0.69		
Actuated Cycle Length (s)	59.1	Sum of lost time (s)	16.0
Intersection Capacity Utilization	51.3%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



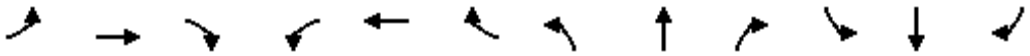
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	179	26	11	9	5	30	5	352	96	27	71	130
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00	1.00	1.00	0.99		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	0.87		1.00	0.97		1.00	0.90	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	3045		1767	3416		1770	3165	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	3045		1767	3416		1770	3165	
Peak-hour factor, PHF	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
Adj. Flow (vph)	227	33	14	11	6	38	6	446	122	34	90	165
RTOR Reduction (vph)	0	0	11	0	34	0	0	27	0	0	100	0
Lane Group Flow (vph)	227	33	3	11	10	0	6	541	0	34	155	0
Confl. Peds. (#/hr)	3					3	4					4
Confl. Bikes (#/hr)									1			1
Turn Type	Prot		Perm	Prot			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4									
Actuated Green, G (s)	5.5	9.8	9.8	0.2	4.5		0.2	15.8		1.6	17.2	
Effective Green, g (s)	5.5	9.8	9.8	0.2	4.5		0.2	15.8		1.6	17.2	
Actuated g/C Ratio	0.13	0.23	0.23	0.00	0.10		0.00	0.36		0.04	0.40	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	224	799	357	8	316		8	1244		65	1254	
v/s Ratio Prot	c0.13	c0.01		0.01	0.00		0.00	c0.16		c0.02	0.05	
v/s Ratio Perm			0.00									
v/c Ratio	1.01	0.04	0.01	1.38	0.03		0.75	0.44		0.52	0.12	
Uniform Delay, d1	18.9	13.1	13.0	21.6	17.5		21.6	10.4		20.5	8.3	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	63.6	0.0	0.0	466.9	0.0		166.2	0.2		7.4	0.0	
Delay (s)	82.6	13.2	13.0	488.5	17.5		187.8	10.7		27.9	8.4	
Level of Service	F	B	B	F	B		F	B		C	A	
Approach Delay (s)		70.7			111.7			12.5			10.7	
Approach LOS		E			F			B			B	

Intersection Summary			
HCM Average Control Delay	30.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.43		
Actuated Cycle Length (s)	43.4	Sum of lost time (s)	12.0
Intersection Capacity Utilization	42.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	135	107	19	87	45	50
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90
Hourly flow rate (vph)	150	119	21	97	50	56
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				1133		
pX, platoon unblocked						
vC, conflicting volume			269		289	150
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			269		289	150
tC, single (s)			4.2		6.5	6.3
tC, 2 stage (s)						
tF (s)			2.3		3.6	3.4
p0 queue free %			98		93	94
cM capacity (veh/h)			1250		673	876

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2
Volume Total	150	119	21	97	50	56
Volume Left	0	0	21	0	50	0
Volume Right	0	119	0	0	0	56
cSH	1700	1700	1250	1700	673	876
Volume to Capacity	0.09	0.07	0.02	0.06	0.07	0.06
Queue Length 95th (ft)	0	0	1	0	6	5
Control Delay (s)	0.0	0.0	7.9	0.0	10.8	9.4
Lane LOS			A		B	A
Approach Delay (s)	0.0		1.4		10.0	
Approach LOS					B	

Intersection Summary			
Average Delay	2.5		
Intersection Capacity Utilization	23.8%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	45	36	13	7	41	50	3	11	15	65	21	99
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	0.99			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.96		1.00	0.92		1.00	0.91			0.93	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.98	
Satd. Flow (prot)	1556	1573		1556	1503		1556	1471			1492	
Flt Permitted	0.95	1.00		0.95	1.00		0.74	1.00			0.88	
Satd. Flow (perm)	1556	1573		1556	1503		1206	1471			1330	
Peak-hour factor, PHF	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Adj. Flow (vph)	59	47	17	9	54	66	4	14	20	86	28	130
RTOR Reduction (vph)	0	13	0	0	55	0	0	14	0	0	64	0
Lane Group Flow (vph)	59	51	0	9	65	0	4	20	0	0	180	0
Confl. Peds. (#/hr)									2	2		
Confl. Bikes (#/hr)									2			
Heavy Vehicles (%)	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	1.9	5.7		0.8	4.6		8.5	8.5			8.5	
Effective Green, g (s)	1.9	5.7		0.8	4.6		8.5	8.5			8.5	
Actuated g/C Ratio	0.07	0.21		0.03	0.17		0.31	0.31			0.31	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	109	332		46	256		380	463			419	
v/s Ratio Prot	c0.04	0.03		0.01	c0.04			0.01				
v/s Ratio Perm							0.00				c0.14	
v/c Ratio	0.54	0.15		0.20	0.25		0.01	0.04			0.43	
Uniform Delay, d1	12.1	8.7		12.8	9.7		6.4	6.4			7.3	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	5.4	0.2		2.1	0.5		0.0	0.0			0.7	
Delay (s)	17.5	8.9		14.9	10.2		6.4	6.5			8.0	
Level of Service	B	A		B	B		A	A			A	
Approach Delay (s)		13.0			10.6			6.5			8.0	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	9.7	HCM Level of Service	A
HCM Volume to Capacity ratio	0.39		
Actuated Cycle Length (s)	27.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	33.3%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	30	86	24	20	78	126
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.85	0.85	0.85	0.85	0.85	0.85
Hourly flow rate (vph)	35	101	28	24	92	148
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)	322					
pX, platoon unblocked						
vC, conflicting volume			35		166	86
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			35		166	86
tC, single (s)			4.2		6.5	6.3
tC, 2 stage (s)						
tF (s)			2.3		3.6	3.4
p0 queue free %			98		88	84
cM capacity (veh/h)			1514		787	946

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	136	28	24	240
Volume Left	0	28	0	92
Volume Right	101	0	0	148
cSH	1700	1514	1700	878
Volume to Capacity	0.08	0.02	0.01	0.27
Queue Length 95th (ft)	0	1	0	28
Control Delay (s)	0.0	7.4	0.0	10.6
Lane LOS		A		B
Approach Delay (s)	0.0	4.0		10.6
Approach LOS				B

Intersection Summary			
Average Delay	6.4		
Intersection Capacity Utilization	26.7%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	148	10	34	42	2	4
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.85	0.85	0.85	0.85	0.85	0.85
Hourly flow rate (vph)	174	12	40	49	2	5
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			186		309	180
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			186		309	180
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			97		100	99
cM capacity (veh/h)			1371		657	855

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	186	40	49	7
Volume Left	0	40	0	2
Volume Right	12	0	0	5
cSH	1700	1371	1700	777
Volume to Capacity	0.11	0.03	0.03	0.01
Queue Length 95th (ft)	0	2	0	1
Control Delay (s)	0.0	7.7	0.0	9.7
Lane LOS		A		A
Approach Delay (s)	0.0	3.4		9.7
Approach LOS				A

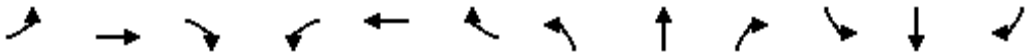
Intersection Summary			
Average Delay	1.3		
Intersection Capacity Utilization	25.1%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay (sec/veh)	27.6
Intersection LOS	D

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Volume (vph)	5	6	7	412	7	15	26	100	146	94	122	3
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Heavy Vehicles(%)	4	4	4	4	4	4	4	4	4	4	4	4
Movement Flow Rate	6	7	8	468	8	17	30	114	166	107	139	3
Number of Lanes	0	1	0	1	1	0	1	2	0	1	2	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	2	1	3	3
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	3	3	1	2
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	3	3	2	1
HCM Control Delay	11	45.1	13	12.4
HCM LOS	B	E	B	B

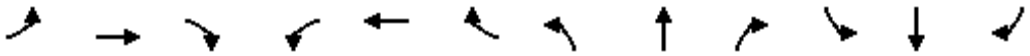
Lane	NBLn1	NBLn2	NBLn3	EBLn1	WBLn1	WBLn2	SBLn1	SBLn2	SBLn3
Volume Left (%)	100%	0%	0%	28%	100%	0%	100%	0%	0%
Volume Thru (%)	0%	100%	19%	33%	0%	32%	0%	100%	93%
Volume Right (%)	0%	0%	81%	39%	0%	68%	0%	0%	7%
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Traffic Volume by Lane	26	67	179	18	412	22	94	81	44
Left Turning Volume	0	67	33	6	0	7	0	81	41
Through Volume	0	0	146	7	0	15	0	0	3
Right Turning Volume	26	0	0	5	412	0	94	0	0
Lane Flow Rate	30	76	204	20	468	25	107	92	50
Geometry Group	8	8	8	8	8	8	8	8	8
Degree of Utilization, X	0.065	0.156	0.388	0.045	0.909	0.042	0.239	0.194	0.103
Departure Headway, Hd	7.948	7.434	6.848	7.873	7.097	6.119	8.056	7.542	7.492
Convergence(Y/N)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capacity	453	485	528	456	515	589	448	478	480
Service Time	5.661	5.147	4.561	5.602	4.797	3.819	5.772	5.257	5.207
HCM Lane V/C Ratio	0.066	0.157	0.386	0.044	0.909	0.042	0.239	0.192	0.104
HCM Control Delay	11.2	11.5	13.8	11	47	9.1	13.3	12.1	11.1
HCM Lane LOS	B	B	B	B	E	A	B	B	B
HCM 95th Percentile Queue	0.2	0.6	1.9	0.1	27.7	0.1	0.9	0.7	0.3



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	63	0	63	10	531	0	0	209	373
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor				1.00	1.00		1.00	0.95			0.95	
Frpb, ped/bikes				1.00	1.00		1.00	1.00			0.99	
Flpb, ped/bikes				1.00	1.00		1.00	1.00			1.00	
Frt				1.00	0.85		1.00	1.00			0.90	
Flt Protected				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)				1736	1553		1736	3471			3093	
Flt Permitted				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (perm)				1736	1553		1736	3471			3093	
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	0	0	0	72	0	72	11	603	0	0	238	424
RTOR Reduction (vph)	0	0	0	0	68	0	0	0	0	0	241	0
Lane Group Flow (vph)	0	0	0	72	4	0	11	603	0	0	421	0
Confl. Peds. (#/hr)							1					1
Confl. Bikes (#/hr)									2			1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type				Split			Prot					
Protected Phases				8	8		5	2			6	
Permitted Phases												
Actuated Green, G (s)				1.7	1.7		1.8	17.6			11.8	
Effective Green, g (s)				1.7	1.7		1.8	17.6			11.8	
Actuated g/C Ratio				0.06	0.06		0.07	0.64			0.43	
Clearance Time (s)				4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)				3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)				108	97		114	2238			1337	
v/s Ratio Prot				c0.04	0.00		0.01	c0.17			0.14	
v/s Ratio Perm												
v/c Ratio				0.67	0.05		0.10	0.27			0.32	
Uniform Delay, d1				12.5	12.0		12.0	2.1			5.1	
Progression Factor				1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2				14.5	0.2		0.4	0.1			0.1	
Delay (s)				27.0	12.2		12.4	2.2			5.2	
Level of Service				C	B		B	A			A	
Approach Delay (s)		0.0			19.6			2.3			5.2	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	5.4	HCM Level of Service	A
HCM Volume to Capacity ratio	0.30		
Actuated Cycle Length (s)	27.3	Sum of lost time (s)	8.0
Intersection Capacity Utilization	28.4%	ICU Level of Service	A
Analysis Period (min)	15		

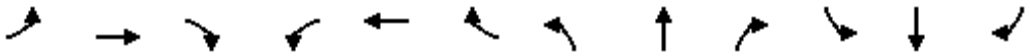
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	8	363	157	296	78	18	55	64	475	45	129	15
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		0.95	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	0.99		1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Frt	1.00	0.95		1.00	0.99		1.00	1.00	0.85		0.99	
Flt Protected	0.95	1.00		0.95	0.97		0.95	1.00	1.00		0.99	
Satd. Flow (prot)	1752	3333		1595	3217		1665	1746	1547		1801	
Flt Permitted	0.95	1.00		0.95	0.97		0.95	1.00	1.00		0.99	
Satd. Flow (perm)	1752	3333		1595	3217		1665	1746	1547		1801	
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	9	403	174	329	87	20	61	71	528	50	143	17
RTOR Reduction (vph)	0	48	0	0	6	0	0	0	436	0	3	0
Lane Group Flow (vph)	9	529	0	164	266	0	55	77	92	0	207	0
Confl. Peds. (#/hr)	1					1			2	2		
Confl. Bikes (#/hr)			1			1						1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Split			Split			Split		Perm	Split		
Protected Phases	4	4		8	8		2	2		6	6	
Permitted Phases									2			
Actuated Green, G (s)	16.0	16.0		12.7	12.7		12.1	12.1	12.1		13.0	
Effective Green, g (s)	16.0	16.0		12.7	12.7		12.1	12.1	12.1		13.0	
Actuated g/C Ratio	0.23	0.23		0.18	0.18		0.17	0.17	0.17		0.19	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	402	764		290	585		289	303	268		335	
v/s Ratio Prot	0.01	c0.16		c0.10	0.08		0.03	0.04			c0.11	
v/s Ratio Perm									c0.06			
v/c Ratio	0.02	0.69		0.57	0.46		0.19	0.25	0.34		0.62	
Uniform Delay, d1	20.8	24.6		26.0	25.5		24.7	24.9	25.3		26.1	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Incremental Delay, d2	0.0	2.7		2.5	0.6		0.3	0.4	0.8		3.4	
Delay (s)	20.9	27.4		28.6	26.0		25.0	25.4	26.1		29.5	
Level of Service	C	C		C	C		C	C	C		C	
Approach Delay (s)		27.3			27.0			25.9			29.5	
Approach LOS		C			C			C			C	

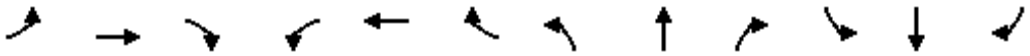
Intersection Summary			
HCM Average Control Delay	27.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	69.8	Sum of lost time (s)	16.0
Intersection Capacity Utilization	64.9%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	826	122	78	316	0	0	0	0	388	23	181
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		0.95			0.95						1.00	
Frpb, ped/bikes		1.00			1.00						1.00	
Flpb, ped/bikes		1.00			1.00						1.00	
Frt		0.98			1.00						0.96	
Flt Protected		1.00			0.99						0.97	
Satd. Flow (prot)		3456			3503						1729	
Flt Permitted		1.00			0.62						0.97	
Satd. Flow (perm)		3456			2198						1729	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	898	133	85	343	0	0	0	0	422	25	197
RTOR Reduction (vph)	0	27	0	0	0	0	0	0	0	0	15	0
Lane Group Flow (vph)	0	1004	0	0	428	0	0	0	0	0	629	0
Confl. Peds. (#/hr)	5		9	9		5						
Confl. Bikes (#/hr)						2						
Turn Type				Perm						Split		
Protected Phases		4			8					6	6	
Permitted Phases				8								
Actuated Green, G (s)		33.2			33.2						33.8	
Effective Green, g (s)		33.2			33.2						33.8	
Actuated g/C Ratio		0.44			0.44						0.45	
Clearance Time (s)		4.0			4.0						4.0	
Vehicle Extension (s)		3.0			3.0						3.0	
Lane Grp Cap (vph)		1530			973						779	
v/s Ratio Prot		c0.29									c0.36	
v/s Ratio Perm					0.19							
v/c Ratio		0.66			0.44						0.81	
Uniform Delay, d1		16.4			14.5						17.8	
Progression Factor		1.00			0.87						1.00	
Incremental Delay, d2		1.0			0.3						8.8	
Delay (s)		17.4			12.9						26.6	
Level of Service		B			B						C	
Approach Delay (s)		17.4			12.9			0.0			26.6	
Approach LOS		B			B			A			C	

Intersection Summary			
HCM Average Control Delay	19.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.73		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	83.1%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



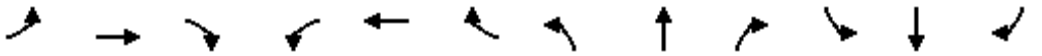
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	210	1004	0	0	371	381	23	2	54	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor		0.95			0.95		0.95	0.95	1.00			
Frpb, ped/bikes		1.00			0.99		1.00	1.00	1.00			
Flpb, ped/bikes		1.00			1.00		1.00	1.00	1.00			
Frt		1.00			0.92		1.00	1.00	0.85			
Flt Protected		0.99			1.00		0.95	0.96	1.00			
Satd. Flow (prot)		3508			3229		1681	1697	1583			
Flt Permitted		0.64			1.00		0.95	0.96	1.00			
Satd. Flow (perm)		2255			3229		1681	1697	1583			
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	236	1128	0	0	417	428	26	2	61	0	0	0
RTOR Reduction (vph)	0	0	0	0	134	0	0	0	48	0	0	0
Lane Group Flow (vph)	0	1364	0	0	711	0	14	14	13	0	0	0
Confl. Peds. (#/hr)	5		7	7		5			1	1		
Confl. Bikes (#/hr)						3						
Turn Type	Perm						Split		Prot			
Protected Phases		4			8		2	2	2			
Permitted Phases	4											
Actuated Green, G (s)		51.5			51.5		15.5	15.5	15.5			
Effective Green, g (s)		51.5			51.5		15.5	15.5	15.5			
Actuated g/C Ratio		0.69			0.69		0.21	0.21	0.21			
Clearance Time (s)		4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)		3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)		1548			2217		347	351	327			
v/s Ratio Prot					0.22		c0.01	0.01	0.01			
v/s Ratio Perm		c0.60										
v/c Ratio		0.88			0.32		0.04	0.04	0.04			
Uniform Delay, d1		9.3			4.7		23.8	23.8	23.8			
Progression Factor		0.86			1.00		1.00	1.00	1.00			
Incremental Delay, d2		5.4			0.1		0.2	0.2	0.2			
Delay (s)		13.4			4.8		24.0	24.0	24.0			
Level of Service		B			A		C	C	C			
Approach Delay (s)		13.4			4.8			24.0			0.0	
Approach LOS		B			A			C			A	

Intersection Summary			
HCM Average Control Delay	10.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.69		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	83.1%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	81	333	53	150	338	105	96	711	165	60	256	41
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frpb, ped/bikes	1.00	1.00	0.97	1.00	1.00	0.98	1.00	1.00	0.98	1.00	1.00	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.98	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1770	3539	1538	1770	3539	1556	1770	3539	1544	1770	3458	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1770	3539	1538	1770	3539	1556	1770	3539	1544	1770	3458	
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	90	370	59	167	376	117	107	790	183	67	284	46
RTOR Reduction (vph)	0	0	20	0	0	54	0	0	59	0	10	0
Lane Group Flow (vph)	90	370	39	167	376	63	107	790	124	67	320	0
Confl. Peds. (#/hr)	5		19	19		5	4		14	14		4
Confl. Bikes (#/hr)						1			1			
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases			2			6			8			
Actuated Green, G (s)	7.0	17.6	17.6	12.1	20.7	20.7	7.6	23.6	23.6	6.1	22.1	
Effective Green, g (s)	7.0	17.6	17.6	12.1	20.7	20.7	7.6	23.6	23.6	6.1	22.1	
Actuated g/C Ratio	0.10	0.24	0.24	0.17	0.29	0.29	0.10	0.33	0.33	0.08	0.31	
Clearance Time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Vehicle Extension (s)	2.0	4.0	4.0	2.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	
Lane Grp Cap (vph)	171	860	374	296	1012	445	186	1154	503	149	1056	
v/s Ratio Prot	0.05	c0.10		c0.09	0.11		c0.06	c0.22		0.04	0.09	
v/s Ratio Perm			0.03			0.04			0.08			
v/c Ratio	0.53	0.43	0.10	0.56	0.37	0.14	0.58	0.68	0.25	0.45	0.30	
Uniform Delay, d1	31.1	23.2	21.3	27.7	20.7	19.2	30.9	21.2	17.9	31.6	19.3	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	1.3	0.5	0.2	1.5	0.3	0.2	2.7	1.4	0.1	0.8	0.1	
Delay (s)	32.5	23.6	21.4	29.2	21.0	19.4	33.5	22.5	18.0	32.3	19.3	
Level of Service	C	C	C	C	C	B	C	C	B	C	B	
Approach Delay (s)		24.9			22.8			22.8			21.5	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	23.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	72.4	Sum of lost time (s)	10.0
Intersection Capacity Utilization	59.3%	ICU Level of Service	B
Analysis Period (min)	15		

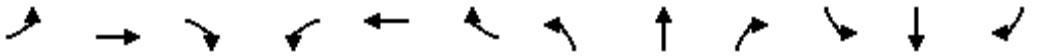
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	307	2	613	0	406	108	0	359	113
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0	4.0		4.0	4.0		4.0	
Lane Util. Factor				0.95	0.91	0.95		0.91	1.00		0.91	
Frt				1.00	0.87	0.85		1.00	0.85		0.96	
Flt Protected				0.95	1.00	1.00		1.00	1.00		1.00	
Satd. Flow (prot)				1698	1474	1519		5136	1599		4951	
Flt Permitted				0.95	1.00	1.00		1.00	1.00		1.00	
Satd. Flow (perm)				1698	1474	1519		5136	1599		4951	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	327	2	652	0	432	115	0	382	120
RTOR Reduction (vph)	0	0	0	0	138	138	0	0	0	0	85	0
Lane Group Flow (vph)	0	0	0	294	210	201	0	432	115	0	417	0
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Split		Perm			Free			
Protected Phases				8	8			2			6	
Permitted Phases						8			Free			
Actuated Green, G (s)				14.4	14.4	14.4		9.2	31.6		9.2	
Effective Green, g (s)				14.4	14.4	14.4		9.2	31.6		9.2	
Actuated g/C Ratio				0.46	0.46	0.46		0.29	1.00		0.29	
Clearance Time (s)				4.0	4.0	4.0		4.0			4.0	
Vehicle Extension (s)				3.0	3.0	3.0		3.0			3.0	
Lane Grp Cap (vph)				774	672	692		1495	1599		1441	
v/s Ratio Prot				c0.17	0.14			0.08			c0.08	
v/s Ratio Perm						0.13			0.07			
v/c Ratio				0.38	0.31	0.29		0.29	0.07		0.29	
Uniform Delay, d1				5.7	5.5	5.4		8.7	0.0		8.7	
Progression Factor				1.00	1.00	1.00		1.00	1.00		1.00	
Incremental Delay, d2				0.3	0.3	0.2		0.1	0.1		0.1	
Delay (s)				6.0	5.7	5.6		8.8	0.1		8.8	
Level of Service				A	A	A		A	A		A	
Approach Delay (s)		0.0			5.8			6.9			8.8	
Approach LOS		A			A			A			A	

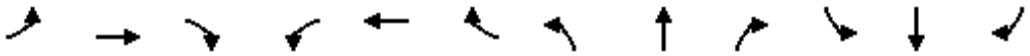
Intersection Summary			
HCM Average Control Delay	6.8	HCM Level of Service	A
HCM Volume to Capacity ratio	0.34		
Actuated Cycle Length (s)	31.6	Sum of lost time (s)	8.0
Intersection Capacity Utilization	39.8%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	213	0	131	0	0	0	0	301	364	0	446	220
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0					4.0			4.0	4.0
Lane Util. Factor	1.00		1.00					0.91			0.95	1.00
Frpb, ped/bikes	1.00		1.00					0.99			1.00	0.98
Flpb, ped/bikes	1.00		1.00					1.00			1.00	1.00
Frt	1.00		0.85					0.92			1.00	0.85
Flt Protected	0.95		1.00					1.00			1.00	1.00
Satd. Flow (prot)	1770		1583					4602			3539	1549
Flt Permitted	0.95		1.00					1.00			1.00	1.00
Satd. Flow (perm)	1770		1583					4602			3539	1549
Peak-hour factor, PHF	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Adj. Flow (vph)	248	0	152	0	0	0	0	350	423	0	519	256
RTOR Reduction (vph)	0	0	94	0	0	0	0	269	0	0	0	0
Lane Group Flow (vph)	248	0	58	0	0	0	0	504	0	0	519	256
Confl. Peds. (#/hr)							4		2	2		4
Confl. Bikes (#/hr)									3			
Turn Type	Split		Perm									Free
Protected Phases	8	8						2			6	
Permitted Phases			8									Free
Actuated Green, G (s)	11.9		11.9					11.4			11.4	31.3
Effective Green, g (s)	11.9		11.9					11.4			11.4	31.3
Actuated g/C Ratio	0.38		0.38					0.36			0.36	1.00
Clearance Time (s)	4.0		4.0					4.0			4.0	
Vehicle Extension (s)	3.0		3.0					3.0			3.0	
Lane Grp Cap (vph)	673		602					1676			1289	1549
v/s Ratio Prot	c0.14							0.11			c0.15	
v/s Ratio Perm			0.04									0.17
v/c Ratio	0.37		0.10					0.30			0.40	0.17
Uniform Delay, d1	7.0		6.2					7.1			7.4	0.0
Progression Factor	1.00		1.00					1.00			1.00	1.00
Incremental Delay, d2	0.3		0.1					0.1			0.2	0.2
Delay (s)	7.3		6.3					7.2			7.6	0.2
Level of Service	A		A					A			A	A
Approach Delay (s)		6.9			0.0			7.2			5.2	
Approach LOS		A			A			A			A	

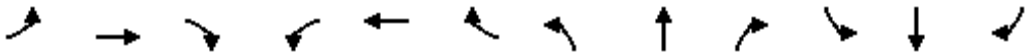
Intersection Summary			
HCM Average Control Delay	6.3	HCM Level of Service	A
HCM Volume to Capacity ratio	0.39		
Actuated Cycle Length (s)	31.3	Sum of lost time (s)	8.0
Intersection Capacity Utilization	32.6%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	146	1	59	9	8	216	21	303	0	11	475	91
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Lane Util. Factor		1.00		1.00	1.00			0.95		1.00	0.95	
Frpb, ped/bikes		0.99		1.00	0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00		1.00	1.00			1.00		0.94	1.00	
Frt		0.96		1.00	0.86			1.00		1.00	0.98	
Flt Protected		0.97		0.95	1.00			1.00		0.95	1.00	
Satd. Flow (prot)		1699		1751	1557			3493		1643	3409	
Flt Permitted		1.00		0.61	1.00			0.90		0.95	1.00	
Satd. Flow (perm)		1759		1122	1557			3141		1643	3409	
Peak-hour factor, PHF	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Adj. Flow (vph)	172	1	69	11	9	254	25	356	0	13	559	107
RTOR Reduction (vph)	0	14	0	0	191	0	0	0	0	0	15	0
Lane Group Flow (vph)	0	228	0	11	72	0	0	381	0	13	651	0
Confl. Peds. (#/hr)	1		3	3		1			5	5		
Confl. Bikes (#/hr)						1			2			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Perm			Prot		
Protected Phases		3			4			2		1	6	
Permitted Phases	3			4			2					
Actuated Green, G (s)		2.4		11.1	11.1			14.6		0.7	19.3	
Effective Green, g (s)		2.4		11.1	11.1			14.6		0.7	19.3	
Actuated g/C Ratio		0.05		0.25	0.25			0.33		0.02	0.43	
Clearance Time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		94		278	386			1024		26	1469	
v/s Ratio Prot					c0.05					0.01	c0.19	
v/s Ratio Perm		c0.13		0.01				0.12				
v/c Ratio		2.42		0.04	0.19			0.37		0.50	0.44	
Uniform Delay, d1		21.2		12.8	13.3			11.6		21.9	9.0	
Progression Factor		1.00		1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		671.6		0.1	0.2			0.2		14.3	0.2	
Delay (s)		692.8		12.9	13.5			11.8		36.2	9.2	
Level of Service		F		B	B			B		D	A	
Approach Delay (s)		692.8			13.5			11.8			9.7	
Approach LOS		F			B			B			A	

Intersection Summary			
HCM Average Control Delay	115.8	HCM Level of Service	F
HCM Volume to Capacity ratio	0.50		
Actuated Cycle Length (s)	44.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	60.9%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group



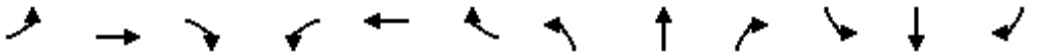
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	156	7	13	26	8	22	14	141	15	6	317	165
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00	1.00	1.00	0.99		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		0.99	1.00	
Frt	1.00	1.00	0.85	1.00	0.89		1.00	0.99		1.00	0.95	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	3100		1764	3483		1756	3336	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	3100		1764	3483		1756	3336	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	164	7	14	27	8	23	15	148	16	6	334	174
RTOR Reduction (vph)	0	0	11	0	23	0	0	9	0	0	77	0
Lane Group Flow (vph)	164	7	3	27	8	0	15	155	0	6	431	0
Confl. Peds. (#/hr)							16		1	1		16
Confl. Bikes (#/hr)						1			1			
Turn Type	Prot		Perm	Prot			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4									
Actuated Green, G (s)	5.9	6.4	6.4	0.2	0.7		0.2	10.9		0.2	10.9	
Effective Green, g (s)	5.9	6.4	6.4	0.2	0.7		0.2	10.9		0.2	10.9	
Actuated g/C Ratio	0.18	0.19	0.19	0.01	0.02		0.01	0.32		0.01	0.32	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	310	672	301	11	64		10	1127		10	1079	
v/s Ratio Prot	c0.09	0.00		0.02	c0.00		c0.01	0.04		0.00	c0.13	
v/s Ratio Perm			0.00									
v/c Ratio	0.53	0.01	0.01	2.45	0.13		1.50	0.14		0.60	0.40	
Uniform Delay, d1	12.6	11.1	11.1	16.8	16.2		16.8	8.1		16.7	8.9	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	1.6	0.0	0.0	863.8	0.9		478.8	0.1		70.6	0.2	
Delay (s)	14.3	11.1	11.1	880.5	17.1		495.5	8.1		87.3	9.1	
Level of Service	B	B	B	F	B		F	A		F	A	
Approach Delay (s)		13.9			419.1			49.0			10.0	
Approach LOS		B			F			D			B	

Intersection Summary			
HCM Average Control Delay	43.6	HCM Level of Service	D
HCM Volume to Capacity ratio	0.44		
Actuated Cycle Length (s)	33.7	Sum of lost time (s)	16.0
Intersection Capacity Utilization	38.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	68	40	16	143	131	32
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.91	0.91	0.91	0.91	0.91	0.91
Hourly flow rate (vph)	75	44	18	157	144	35
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				1133		
pX, platoon unblocked						
vC, conflicting volume			119		267	75
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			119		267	75
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			99		80	96
cM capacity (veh/h)			1457		709	981

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2
Volume Total	75	44	18	157	144	35
Volume Left	0	0	18	0	144	0
Volume Right	0	44	0	0	0	35
cSH	1700	1700	1457	1700	709	981
Volume to Capacity	0.04	0.03	0.01	0.09	0.20	0.04
Queue Length 95th (ft)	0	0	1	0	19	3
Control Delay (s)	0.0	0.0	7.5	0.0	11.4	8.8
Lane LOS			A		B	A
Approach Delay (s)	0.0		0.8		10.9	
Approach LOS					B	

Intersection Summary			
Average Delay	4.4		
Intersection Capacity Utilization	21.5%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	106	8	1	1	27	42	8	11	2	48	8	44
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.98		1.00	0.91		1.00	0.98			0.94	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.98	
Satd. Flow (prot)	1626	1686		1626	1556		1626	1675			1572	
Flt Permitted	0.95	1.00		0.95	1.00		0.98	1.00			0.84	
Satd. Flow (perm)	1626	1686		1626	1556		1670	1675			1352	
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	120	9	1	1	31	48	9	12	2	55	9	50
RTOR Reduction (vph)	0	1	0	0	42	0	0	2	0	0	41	0
Lane Group Flow (vph)	120	9	0	1	37	0	9	12	0	0	73	0
Heavy Vehicles (%)	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	3.6	5.6		0.8	2.8		4.1	4.1			4.1	
Effective Green, g (s)	3.6	5.6		0.8	2.8		4.1	4.1			4.1	
Actuated g/C Ratio	0.16	0.25		0.04	0.12		0.18	0.18			0.18	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	260	420		58	194		304	305			246	
v/s Ratio Prot	c0.07	c0.01		0.00	c0.02			0.01				
v/s Ratio Perm							0.01				c0.05	
v/c Ratio	0.46	0.02		0.02	0.19		0.03	0.04			0.30	
Uniform Delay, d1	8.6	6.4		10.5	8.8		7.6	7.6			8.0	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	1.3	0.0		0.1	0.5		0.0	0.1			0.7	
Delay (s)	9.9	6.4		10.6	9.3		7.6	7.6			8.6	
Level of Service	A	A		B	A		A	A			A	
Approach Delay (s)		9.6			9.3			7.6			8.6	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	9.1	HCM Level of Service	A
HCM Volume to Capacity ratio	0.43		
Actuated Cycle Length (s)	22.5	Sum of lost time (s)	16.0
Intersection Capacity Utilization	31.6%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	19	39	36	21	49	37
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.69	0.69	0.69	0.69	0.69	0.69
Hourly flow rate (vph)	28	57	52	30	71	54
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)	322					
pX, platoon unblocked						
vC, conflicting volume			28		191	56
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			28		191	56
tC, single (s)			4.2		6.5	6.3
tC, 2 stage (s)						
tF (s)			2.3		3.6	3.4
p0 queue free %			97		91	95
cM capacity (veh/h)			1530		752	986

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	84	52	30	125
Volume Left	0	52	0	71
Volume Right	57	0	0	54
cSH	1700	1530	1700	837
Volume to Capacity	0.05	0.03	0.02	0.15
Queue Length 95th (ft)	0	3	0	13
Control Delay (s)	0.0	7.4	0.0	10.0
Lane LOS		A		B
Approach Delay (s)	0.0	4.7		10.0
Approach LOS				B

Intersection Summary			
Average Delay	5.6		
Intersection Capacity Utilization	20.3%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	54	2	4	46	11	36
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.78	0.78	0.78	0.78	0.78	0.78
Hourly flow rate (vph)	69	3	5	59	14	46
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			72		140	71
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			72		140	71
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			100		98	95
cM capacity (veh/h)			1528		850	992

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	72	5	59	60
Volume Left	0	5	0	14
Volume Right	3	0	0	46
cSH	1700	1528	1700	955
Volume to Capacity	0.04	0.00	0.03	0.06
Queue Length 95th (ft)	0	0	0	5
Control Delay (s)	0.0	7.4	0.0	9.0
Lane LOS		A		A
Approach Delay (s)	0.0	0.6		9.0
Approach LOS				A

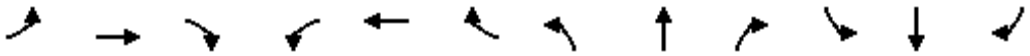
Intersection Summary			
Average Delay	3.0		
Intersection Capacity Utilization	13.3%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay (sec/veh)	20
Intersection LOS	C

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Volume (vph)	0	10	7	400	0	5	9	35	62	41	65	3
Peak Hour Factor	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Heavy Vehicles(%)	2	2	2	2	2	2	2	2	2	2	2	2
Movement Flow Rate	0	12	8	471	0	6	11	41	73	48	76	4
Number of Lanes	0	1	0	1	1	0	1	2	0	1	2	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	2	1	3	3
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	3	3	1	2
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	3	3	2	1
HCM Control Delay	9.2	25.8	9.8	10.1
HCM LOS	A	D	A	B

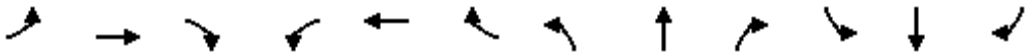
Lane	NBLn1	NBLn2	NBLn3	EBLn1	WBLn1	WBLn2	SBLn1	SBLn2	SBLn3
Volume Left (%)	100%	0%	0%	0%	100%	0%	100%	0%	0%
Volume Thru (%)	0%	100%	16%	59%	0%	0%	0%	100%	88%
Volume Right (%)	0%	0%	84%	41%	0%	100%	0%	0%	12%
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Traffic Volume by Lane	9	23	74	17	400	5	41	43	25
Left Turning Volume	0	23	12	10	0	0	0	43	22
Through Volume	0	0	62	7	0	5	0	0	3
Right Turning Volume	9	0	0	0	400	0	41	0	0
Lane Flow Rate	11	27	87	20	471	6	48	51	29
Geometry Group	8	8	8	8	8	8	8	8	8
Degree of Utilization, X	0.021	0.051	0.145	0.035	0.774	0.008	0.095	0.093	0.052
Departure Headway, Hd	7.134	6.624	6.023	6.256	5.921	4.723	7.104	6.594	6.507
Convergence(Y/N)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capacity	502	541	595	572	612	759	505	543	550
Service Time	4.874	4.364	3.763	3.996	3.64	2.442	4.844	4.334	4.247
HCM Lane V/C Ratio	0.022	0.05	0.146	0.035	0.77	0.008	0.095	0.094	0.053
HCM Control Delay	10	9.7	9.8	9.2	26	7.5	10.6	10	9.6
HCM Lane LOS	A	A	A	A	D	A	B	A	A
HCM 95th Percentile Queue	0.1	0.2	0.5	0.1	10.2	0	0.3	0.3	0.2



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	24	0	432	6	466	0	0	82	287
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor				1.00	1.00		1.00	0.95			0.95	
Frpb, ped/bikes				1.00	1.00		1.00	1.00			0.98	
Flpb, ped/bikes				1.00	1.00		1.00	1.00			1.00	
Frt				1.00	0.85		1.00	1.00			0.88	
Flt Protected				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)				1787	1599		1787	3574			3104	
Flt Permitted				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (perm)				1787	1599		1787	3574			3104	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	25	0	455	6	491	0	0	86	302
RTOR Reduction (vph)	0	0	0	0	414	0	0	0	0	0	193	0
Lane Group Flow (vph)	0	0	0	25	41	0	6	491	0	0	195	0
Confl. Peds. (#/hr)							1		2	2		1
Confl. Bikes (#/hr)			1						1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Split			Prot					
Protected Phases				8	8		5	2			6	
Permitted Phases												
Actuated Green, G (s)				2.3	2.3		2.0	15.2			9.2	
Effective Green, g (s)				2.3	2.3		2.0	15.2			9.2	
Actuated g/C Ratio				0.09	0.09		0.08	0.60			0.36	
Clearance Time (s)				4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)				3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)				161	144		140	2130			1120	
v/s Ratio Prot				0.01	c0.03		0.00	c0.14			0.06	
v/s Ratio Perm												
v/c Ratio				0.16	0.28		0.04	0.23			0.17	
Uniform Delay, d1				10.7	10.8		10.9	2.4			5.6	
Progression Factor				1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2				0.5	1.1		0.1	0.1			0.1	
Delay (s)				11.2	11.9		11.0	2.5			5.6	
Level of Service				B	B		B	A			A	
Approach Delay (s)		0.0			11.9			2.6			5.6	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	6.7	HCM Level of Service	A
HCM Volume to Capacity ratio	0.24		
Actuated Cycle Length (s)	25.5	Sum of lost time (s)	8.0
Intersection Capacity Utilization	46.5%	ICU Level of Service	A
Analysis Period (min)	15		

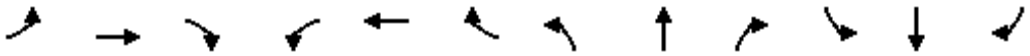
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	25	163	59	273	252	39	306	175	417	15	37	38
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		0.95	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	0.99		1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Frt	1.00	0.96		1.00	0.98		1.00	1.00	0.85		0.94	
Flt Protected	0.95	1.00		0.95	0.99		0.95	0.99	1.00		0.99	
Satd. Flow (prot)	1787	3431		1626	3333		1698	1762	1576		1759	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	0.99	1.00		0.99	
Satd. Flow (perm)	1787	3431		1626	3333		1698	1762	1576		1759	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	26	168	61	281	260	40	315	180	430	15	38	39
RTOR Reduction (vph)	0	40	0	0	9	0	0	0	308	0	31	0
Lane Group Flow (vph)	26	189	0	191	381	0	243	252	122	0	61	0
Confl. Peds. (#/hr)									2	2		
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Split			Split			Split		Perm	Split		
Protected Phases	4	4		8	8		2	2		6	6	
Permitted Phases									2			
Actuated Green, G (s)	9.5	9.5		14.0	14.0		18.1	18.1	18.1		6.3	
Effective Green, g (s)	9.5	9.5		14.0	14.0		18.1	18.1	18.1		6.3	
Actuated g/C Ratio	0.15	0.15		0.22	0.22		0.28	0.28	0.28		0.10	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	266	510		356	730		481	499	446		173	
v/s Ratio Prot	0.01	c0.06		c0.12	0.11		c0.14	0.14			c0.03	
v/s Ratio Perm									0.08			
v/c Ratio	0.10	0.37		0.54	0.52		0.51	0.51	0.27		0.35	
Uniform Delay, d1	23.5	24.5		22.1	22.0		19.2	19.2	17.8		26.9	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Incremental Delay, d2	0.2	0.5		1.6	0.7		0.8	0.8	0.3		1.3	
Delay (s)	23.7	25.0		23.6	22.7		20.0	20.0	18.1		28.2	
Level of Service	C	C		C	C		B	B	B		C	
Approach Delay (s)		24.8			23.0			19.1			28.2	
Approach LOS		C			C			B			C	

Intersection Summary			
HCM Average Control Delay	21.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.47		
Actuated Cycle Length (s)	63.9	Sum of lost time (s)	16.0
Intersection Capacity Utilization	47.5%	ICU Level of Service	A
Analysis Period (min)	15		

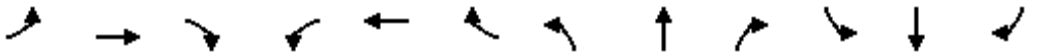
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	581	70	53	446	0	0	0	0	283	1	187
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		0.95			0.95						1.00	
Frpb, ped/bikes		1.00			1.00						1.00	
Flpb, ped/bikes		1.00			1.00						1.00	
Frt		0.98			1.00						0.95	
Flt Protected		1.00			0.99						0.97	
Satd. Flow (prot)		3505			3554						1728	
Flt Permitted		1.00			0.74						0.97	
Satd. Flow (perm)		3505			2627						1728	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	0	605	73	55	465	0	0	0	0	295	1	195
RTOR Reduction (vph)	0	28	0	0	0	0	0	0	0	0	16	0
Lane Group Flow (vph)	0	650	0	0	520	0	0	0	0	0	475	0
Confl. Peds. (#/hr)	3		8	8		3						
Confl. Bikes (#/hr)						3						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Perm						Split		
Protected Phases		4			8					6	6	
Permitted Phases				8								
Actuated Green, G (s)		21.3			21.3						45.7	
Effective Green, g (s)		21.3			21.3						45.7	
Actuated g/C Ratio		0.28			0.28						0.61	
Clearance Time (s)		4.0			4.0						4.0	
Vehicle Extension (s)		3.0			3.0						3.0	
Lane Grp Cap (vph)		995			746						1053	
v/s Ratio Prot		0.19									c0.28	
v/s Ratio Perm					c0.20							
v/c Ratio		0.65			0.70						0.45	
Uniform Delay, d1		23.6			24.0						7.9	
Progression Factor		1.00			0.86						1.00	
Incremental Delay, d2		1.6			2.7						1.4	
Delay (s)		25.2			23.3						9.3	
Level of Service		C			C						A	
Approach Delay (s)		25.2			23.3			0.0			9.3	
Approach LOS		C			C			A			A	

Intersection Summary			
HCM Average Control Delay	20.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.53		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	70.7%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	214	650	0	0	438	377	61	141	100	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor		0.95			0.95		0.95	0.95	1.00			
Frpb, ped/bikes		1.00			0.99		1.00	1.00	1.00			
Flpb, ped/bikes		1.00			1.00		1.00	1.00	1.00			
Frt		1.00			0.93		1.00	1.00	0.85			
Flt Protected		0.99			1.00		0.95	1.00	1.00			
Satd. Flow (prot)		3530			3290		1698	1784	1599			
Flt Permitted		0.59			1.00		0.95	1.00	1.00			
Satd. Flow (perm)		2096			3290		1698	1784	1599			
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	223	677	0	0	456	393	64	147	104	0	0	0
RTOR Reduction (vph)	0	0	0	0	162	0	0	0	72	0	0	0
Lane Group Flow (vph)	0	900	0	0	687	0	58	153	32	0	0	0
Confl. Peds. (#/hr)	2		7	7		2						
Confl. Bikes (#/hr)						3						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm						Split		Prot			
Protected Phases		4			8		2	2	2			
Permitted Phases	4											
Actuated Green, G (s)		44.0			44.0		23.0	23.0	23.0			
Effective Green, g (s)		44.0			44.0		23.0	23.0	23.0			
Actuated g/C Ratio		0.59			0.59		0.31	0.31	0.31			
Clearance Time (s)		4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)		3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)		1230			1930		521	547	490			
v/s Ratio Prot					0.21		0.03	c0.09	0.02			
v/s Ratio Perm		c0.43										
v/c Ratio		0.73			0.36		0.11	0.28	0.07			
Uniform Delay, d1		11.2			8.1		18.7	19.7	18.4			
Progression Factor		0.51			1.00		1.00	1.00	1.00			
Incremental Delay, d2		2.2			0.1		0.4	1.3	0.3			
Delay (s)		7.9			8.2		19.1	21.0	18.6			
Level of Service		A			A		B	C	B			
Approach Delay (s)		7.9			8.2			19.9			0.0	
Approach LOS		A			A			B			A	

Intersection Summary			
HCM Average Control Delay	9.8	HCM Level of Service	A
HCM Volume to Capacity ratio	0.58		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	67.8%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

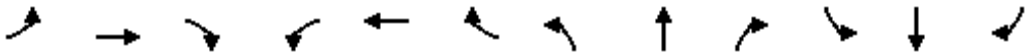
Existing Plus Phase 1 Project Conditions

FEHR PEERS

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	60	272	65	238	319	86	44	227	132	72	597	41
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frpb, ped/bikes	1.00	1.00	0.98	1.00	1.00	0.98	1.00	1.00	0.98	1.00	1.00	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1736	3471	1516	1736	3471	1514	1736	3471	1529	1736	3434	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1736	3471	1516	1736	3471	1514	1736	3471	1529	1736	3434	
Peak-hour factor, PHF	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Adj. Flow (vph)	66	299	71	262	351	95	48	249	145	79	656	45
RTOR Reduction (vph)	0	0	31	0	0	42	0	0	108	0	4	0
Lane Group Flow (vph)	66	299	40	262	351	53	48	249	37	79	697	0
Confl. Peds. (#/hr)	14		13	13		14	4		4	4		4
Confl. Bikes (#/hr)						1						1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases			2			6			8			
Actuated Green, G (s)	6.3	16.7	16.7	16.7	25.1	25.1	4.1	18.5	18.5	6.9	21.3	
Effective Green, g (s)	6.3	16.7	16.7	16.7	25.1	25.1	4.1	18.5	18.5	6.9	21.3	
Actuated g/C Ratio	0.09	0.23	0.23	0.23	0.35	0.35	0.06	0.26	0.26	0.10	0.30	
Clearance Time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Vehicle Extension (s)	2.0	4.0	4.0	2.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	
Lane Grp Cap (vph)	152	807	353	404	1213	529	99	894	394	167	1019	
v/s Ratio Prot	0.04	c0.09		c0.15	0.10		0.03	0.07		c0.05	c0.20	
v/s Ratio Perm			0.03			0.03			0.02			
v/c Ratio	0.43	0.37	0.11	0.65	0.29	0.10	0.48	0.28	0.09	0.47	0.68	
Uniform Delay, d1	31.1	23.1	21.7	24.9	16.9	15.7	32.8	21.3	20.3	30.7	22.3	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	0.7	0.4	0.2	2.7	0.2	0.1	1.4	0.1	0.0	0.8	1.5	
Delay (s)	31.8	23.5	21.9	27.6	17.1	15.8	34.2	21.4	20.3	31.5	23.8	
Level of Service	C	C	C	C	B	B	C	C	C	C	C	
Approach Delay (s)		24.5			20.8			22.4			24.6	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	23.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	71.8	Sum of lost time (s)	13.0
Intersection Capacity Utilization	60.5%	ICU Level of Service	B
Analysis Period (min)	15		

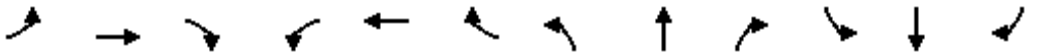
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	308	2	164	0	236	130	0	696	231
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0	4.0		4.0	4.0		4.0	
Lane Util. Factor				0.95	0.91	0.95		0.91	1.00		0.91	
Frpb, ped/bikes				1.00	1.00	0.99		1.00	0.98		0.99	
Flpb, ped/bikes				1.00	1.00	1.00		1.00	1.00		1.00	
Frt				1.00	0.99	0.85		1.00	0.85		0.96	
Flt Protected				0.95	0.96	1.00		1.00	1.00		1.00	
Satd. Flow (prot)				1665	1581	1471		5036	1535		4820	
Flt Permitted				0.95	0.96	1.00		1.00	1.00		1.00	
Satd. Flow (perm)				1665	1581	1471		5036	1535		4820	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	328	2	174	0	251	138	0	740	246
RTOR Reduction (vph)	0	0	0	0	8	104	0	0	0	0	84	0
Lane Group Flow (vph)	0	0	0	174	165	53	0	251	138	0	902	0
Confl. Peds. (#/hr)	1					1	2		1	1		2
Confl. Bikes (#/hr)									2			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type				Split		Perm			Free			
Protected Phases				8	8			2			6	
Permitted Phases						8			Free			
Actuated Green, G (s)				12.2	12.2	12.2		15.7	35.9		15.7	
Effective Green, g (s)				12.2	12.2	12.2		15.7	35.9		15.7	
Actuated g/C Ratio				0.34	0.34	0.34		0.44	1.00		0.44	
Clearance Time (s)				4.0	4.0	4.0		4.0			4.0	
Vehicle Extension (s)				3.0	3.0	3.0		3.0			3.0	
Lane Grp Cap (vph)				566	537	500		2202	1535		2108	
v/s Ratio Prot				c0.10	0.10			0.05			c0.19	
v/s Ratio Perm						0.04			0.09			
v/c Ratio				0.31	0.31	0.11		0.11	0.09		0.43	
Uniform Delay, d1				8.7	8.7	8.1		6.0	0.0		7.0	
Progression Factor				1.00	1.00	1.00		1.00	1.00		1.00	
Incremental Delay, d2				0.3	0.3	0.1		0.0	0.1		0.1	
Delay (s)				9.0	9.1	8.2		6.0	0.1		7.1	
Level of Service				A	A	A		A	A		A	
Approach Delay (s)		0.0			8.8			3.9			7.1	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	6.9	HCM Level of Service	A
HCM Volume to Capacity ratio	0.38		
Actuated Cycle Length (s)	35.9	Sum of lost time (s)	8.0
Intersection Capacity Utilization	36.1%	ICU Level of Service	A
Analysis Period (min)	15		

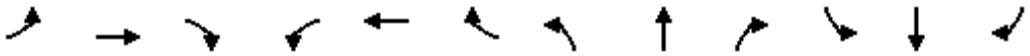
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	67	0	93	0	0	0	0	299	313	0	526	477
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0					4.0			4.0	4.0
Lane Util. Factor	1.00		1.00					0.91			0.95	1.00
Frpb, ped/bikes	1.00		1.00					0.99			1.00	0.98
Flpb, ped/bikes	1.00		1.00					1.00			1.00	1.00
Frt	1.00		0.85					0.92			1.00	0.85
Flt Protected	0.95		1.00					1.00			1.00	1.00
Satd. Flow (prot)	1752		1568					4593			3505	1536
Flt Permitted	0.95		1.00					1.00			1.00	1.00
Satd. Flow (perm)	1752		1568					4593			3505	1536
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	76	0	106	0	0	0	0	340	356	0	598	542
RTOR Reduction (vph)	0	0	84	0	0	0	0	178	0	0	0	0
Lane Group Flow (vph)	76	0	22	0	0	0	0	518	0	0	598	542
Confl. Peds. (#/hr)							1		3	3		1
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Split		Perm									Free
Protected Phases	8	8						2			6	
Permitted Phases			8									Free
Actuated Green, G (s)	5.6		5.6					13.6			13.6	27.2
Effective Green, g (s)	5.6		5.6					13.6			13.6	27.2
Actuated g/C Ratio	0.21		0.21					0.50			0.50	1.00
Clearance Time (s)	4.0		4.0					4.0			4.0	
Vehicle Extension (s)	3.0		3.0					3.0			3.0	
Lane Grp Cap (vph)	361		323					2297			1753	1536
v/s Ratio Prot	0.04							0.11			0.17	
v/s Ratio Perm			0.01									c0.35
v/c Ratio	0.21		0.07					0.23			0.34	0.35
Uniform Delay, d1	9.0		8.7					3.8			4.1	0.0
Progression Factor	1.00		1.00					1.00			1.00	1.00
Incremental Delay, d2	0.3		0.1					0.1			0.1	0.6
Delay (s)	9.3		8.8					3.9			4.2	0.6
Level of Service	A		A					A			A	A
Approach Delay (s)		9.0			0.0			3.9			2.5	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	3.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.35		
Actuated Cycle Length (s)	27.2	Sum of lost time (s)	0.0
Intersection Capacity Utilization	27.1%	ICU Level of Service	A
Analysis Period (min)	15		

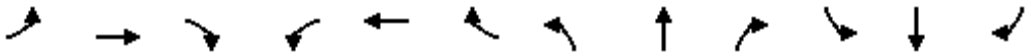
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	41	7	15	0	1	21	15	550	10	267	238	94
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0			4.0		4.0	4.0	
Lane Util. Factor		1.00			1.00			0.95		1.00	0.95	
Frpb, ped/bikes		1.00			0.99			1.00		1.00	0.99	
Flpb, ped/bikes		1.00			1.00			1.00		1.00	1.00	
Frt		0.97			0.85			1.00		1.00	0.96	
Flt Protected		0.97			1.00			1.00		0.95	1.00	
Satd. Flow (prot)		1711			1542			3457		1736	3302	
Flt Permitted		1.00			1.00			0.94		0.95	1.00	
Satd. Flow (perm)		1767			1542			3247		1736	3302	
Peak-hour factor, PHF	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Adj. Flow (vph)	57	10	21	0	1	29	21	764	14	371	331	131
RTOR Reduction (vph)	0	12	0	0	26	0	0	1	0	0	25	0
Lane Group Flow (vph)	0	76	0	0	4	0	0	798	0	371	437	0
Confl. Peds. (#/hr)	3					3	2					2
Confl. Bikes (#/hr)												1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm			Perm			Perm			Prot		
Protected Phases		3			4			2		1	6	
Permitted Phases	3			4			2					
Actuated Green, G (s)		2.2			6.8			22.1		12.0	38.1	
Effective Green, g (s)		2.2			6.8			22.1		12.0	38.1	
Actuated g/C Ratio		0.04			0.12			0.37		0.20	0.64	
Clearance Time (s)		4.0			4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		66			177			1214		352	2129	
v/s Ratio Prot					c0.00					c0.21	0.13	
v/s Ratio Perm		c0.04						c0.25				
v/c Ratio		1.16			0.02			0.66		1.05	0.21	
Uniform Delay, d1		28.4			23.2			15.4		23.6	4.3	
Progression Factor		1.00			1.00			1.00		1.00	1.00	
Incremental Delay, d2		160.0			0.1			1.3		62.9	0.0	
Delay (s)		188.5			23.3			16.7		86.4	4.3	
Level of Service		F			C			B		F	A	
Approach Delay (s)		188.5			23.3			16.7			40.9	
Approach LOS		F			C			B			D	

Intersection Summary			
HCM Average Control Delay	36.9	HCM Level of Service	D
HCM Volume to Capacity ratio	0.69		
Actuated Cycle Length (s)	59.1	Sum of lost time (s)	16.0
Intersection Capacity Utilization	51.4%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



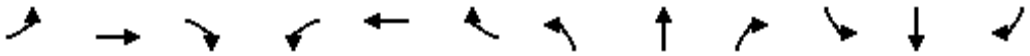
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	179	30	11	10	6	31	5	352	100	32	71	130
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00	1.00	1.00	0.99		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	0.88		1.00	0.97		1.00	0.90	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	3064		1767	3412		1770	3165	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	3064		1767	3412		1770	3165	
Peak-hour factor, PHF	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
Adj. Flow (vph)	227	38	14	13	8	39	6	446	127	41	90	165
RTOR Reduction (vph)	0	0	11	0	35	0	0	27	0	0	95	0
Lane Group Flow (vph)	227	38	3	13	12	0	6	546	0	41	160	0
Confl. Peds. (#/hr)	3					3	4					4
Confl. Bikes (#/hr)									1			1
Turn Type	Prot		Perm	Prot			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4									
Actuated Green, G (s)	5.1	9.6	9.6	0.2	4.7		0.2	17.3		2.2	19.3	
Effective Green, g (s)	5.1	9.6	9.6	0.2	4.7		0.2	17.3		2.2	19.3	
Actuated g/C Ratio	0.11	0.21	0.21	0.00	0.10		0.00	0.38		0.05	0.43	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	199	750	335	8	318		8	1303		86	1348	
v/s Ratio Prot	c0.13	c0.01		0.01	0.00		0.00	c0.16		c0.02	0.05	
v/s Ratio Perm			0.00									
v/c Ratio	1.14	0.05	0.01	1.62	0.04		0.75	0.42		0.48	0.12	
Uniform Delay, d1	20.1	14.2	14.1	22.5	18.3		22.5	10.3		21.0	7.9	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	106.8	0.0	0.0	569.9	0.0		166.2	0.2		4.1	0.0	
Delay (s)	126.9	14.2	14.1	592.5	18.3		188.7	10.5		25.1	7.9	
Level of Service	F	B	B	F	B		F	B		C	A	
Approach Delay (s)		105.9			142.7			12.4			10.3	
Approach LOS		F			F			B			B	

Intersection Summary			
HCM Average Control Delay	39.8	HCM Level of Service	D
HCM Volume to Capacity ratio	0.43		
Actuated Cycle Length (s)	45.3	Sum of lost time (s)	12.0
Intersection Capacity Utilization	42.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	157	107	27	90	45	50
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90
Hourly flow rate (vph)	174	119	30	100	50	56
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				1133		
pX, platoon unblocked						
vC, conflicting volume			293		334	174
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			293		334	174
tC, single (s)			4.2		6.5	6.3
tC, 2 stage (s)						
tF (s)			2.3		3.6	3.4
p0 queue free %			98		92	93
cM capacity (veh/h)			1224		629	849

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2
Volume Total	174	119	30	100	50	56
Volume Left	0	0	30	0	50	0
Volume Right	0	119	0	0	0	56
cSH	1700	1700	1224	1700	629	849
Volume to Capacity	0.10	0.07	0.02	0.06	0.08	0.07
Queue Length 95th (ft)	0	0	2	0	6	5
Control Delay (s)	0.0	0.0	8.0	0.0	11.2	9.5
Lane LOS			A		B	A
Approach Delay (s)	0.0		1.8		10.3	
Approach LOS					B	

Intersection Summary			
Average Delay	2.5		
Intersection Capacity Utilization	24.9%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	45	83	13	7	41	61	3	11	15	87	21	99
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	0.99			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.98		1.00	0.91		1.00	0.91			0.94	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.98	
Satd. Flow (prot)	1556	1605		1556	1491		1556	1472			1499	
Flt Permitted	0.95	1.00		0.95	1.00		0.67	1.00			0.86	
Satd. Flow (perm)	1556	1605		1556	1491		1104	1472			1321	
Peak-hour factor, PHF	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Adj. Flow (vph)	59	109	17	9	54	80	4	14	20	114	28	130
RTOR Reduction (vph)	0	13	0	0	67	0	0	12	0	0	46	0
Lane Group Flow (vph)	59	113	0	9	67	0	4	22	0	0	226	0
Confl. Peds. (#/hr)									2	2		
Confl. Bikes (#/hr)									2			
Heavy Vehicles (%)	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	1.9	5.9		0.8	4.8		11.9	11.9			11.9	
Effective Green, g (s)	1.9	5.9		0.8	4.8		11.9	11.9			11.9	
Actuated g/C Ratio	0.06	0.19		0.03	0.16		0.39	0.39			0.39	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	97	309		41	234		429	572			514	
v/s Ratio Prot	c0.04	c0.07		0.01	0.04			0.01				
v/s Ratio Perm							0.00				c0.17	
v/c Ratio	0.61	0.37		0.22	0.28		0.01	0.04			0.44	
Uniform Delay, d1	14.0	10.7		14.6	11.4		5.7	5.8			6.9	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	10.3	0.7		2.7	0.7		0.0	0.0			0.6	
Delay (s)	24.3	11.5		17.3	12.1		5.7	5.8			7.5	
Level of Service	C	B		B	B		A	A			A	
Approach Delay (s)		15.6			12.4			5.8			7.5	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	10.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.38		
Actuated Cycle Length (s)	30.6	Sum of lost time (s)	8.0
Intersection Capacity Utilization	34.5%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	99	86	26	31	78	139
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.80	0.80	0.80	0.80	0.80	0.80
Hourly flow rate (vph)	124	108	32	39	98	174
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)	322					
pX, platoon unblocked						
vC, conflicting volume			124		281	178
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			124		281	178
tC, single (s)			4.3		6.6	6.4
tC, 2 stage (s)						
tF (s)			2.3		3.6	3.4
p0 queue free %			98		85	79
cM capacity (veh/h)			1381		664	831

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	231	32	39	271
Volume Left	0	32	0	98
Volume Right	108	0	0	174
cSH	1700	1381	1700	762
Volume to Capacity	0.14	0.02	0.02	0.36
Queue Length 95th (ft)	0	2	0	40
Control Delay (s)	0.0	7.7	0.0	12.3
Lane LOS		A		B
Approach Delay (s)	0.0	3.5		12.3
Approach LOS				B

Intersection Summary			
Average Delay	6.3		
Intersection Capacity Utilization	36.7%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	148	92	134	42	15	20
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.85	0.85	0.85	0.85	0.85	0.85
Hourly flow rate (vph)	174	108	158	49	18	24
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			282		593	228
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			282		593	228
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			88		96	97
cM capacity (veh/h)			1263		406	804

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	282	158	49	41
Volume Left	0	158	0	18
Volume Right	108	0	0	24
cSH	1700	1263	1700	566
Volume to Capacity	0.17	0.12	0.03	0.07
Queue Length 95th (ft)	0	11	0	6
Control Delay (s)	0.0	8.3	0.0	11.9
Lane LOS		A		B
Approach Delay (s)	0.0	6.3		11.9
Approach LOS				B

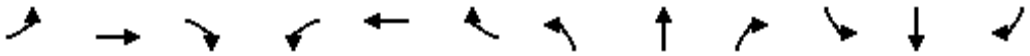
Intersection Summary			
Average Delay	3.4		
Intersection Capacity Utilization	34.2%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay (sec/veh)	33.3
Intersection LOS	D

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Volume (vph)	5	6	7	412	7	15	26	200	146	104	128	3
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Heavy Vehicles(%)	4	4	4	4	4	4	4	4	4	4	4	4
Movement Flow Rate	6	7	8	468	8	17	30	227	166	118	145	3
Number of Lanes	0	1	0	1	1	0	1	2	0	1	2	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	2	1	3	3
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	3	3	1	2
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	3	3	2	1
HCM Control Delay	11.7	60.5	15.2	13.4
HCM LOS	B	F	C	B

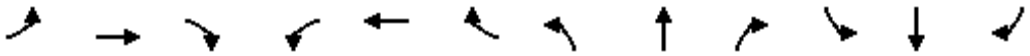
Lane	NBLn1	NBLn2	NBLn3	EBLn1	WBLn1	WBLn2	SBLn1	SBLn2	SBLn3
Volume Left (%)	100%	0%	0%	28%	100%	0%	100%	0%	0%
Volume Thru (%)	0%	100%	31%	33%	0%	32%	0%	100%	93%
Volume Right (%)	0%	0%	69%	39%	0%	68%	0%	0%	7%
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Traffic Volume by Lane	26	133	213	18	412	22	104	85	46
Left Turning Volume	0	133	67	6	0	7	0	85	43
Through Volume	0	0	146	7	0	15	0	0	3
Right Turning Volume	26	0	0	5	412	0	104	0	0
Lane Flow Rate	30	152	242	20	468	25	118	97	52
Geometry Group	8	8	8	8	8	8	8	8	8
Degree of Utilization, X	0.067	0.322	0.48	0.048	0.978	0.045	0.279	0.215	0.114
Departure Headway, Hd	8.161	7.645	7.15	8.453	7.517	6.537	8.491	7.974	7.927
Convergence(Y/N)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capacity	439	470	503	423	482	548	423	450	452
Service Time	5.912	5.396	4.9	6.224	5.26	4.28	6.246	5.729	5.681
HCM Lane V/C Ratio	0.068	0.323	0.481	0.047	0.971	0.046	0.279	0.216	0.115
HCM Control Delay	11.5	14	16.4	11.7	63.2	9.6	14.5	12.9	11.7
HCM Lane LOS	B	B	C	B	F	A	B	B	B
HCM 95th Percentile Queue	0.2	1.4	2.8	0.2	70.4	0.1	1.2	0.8	0.4



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	127	0	63	10	537	0	0	245	373
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor				1.00	1.00		1.00	0.95			0.95	
Frpb, ped/bikes				1.00	1.00		1.00	1.00			0.99	
Flpb, ped/bikes				1.00	1.00		1.00	1.00			1.00	
Frt				1.00	0.85		1.00	1.00			0.91	
Flt Protected				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)				1736	1553		1736	3471			3115	
Flt Permitted				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (perm)				1736	1553		1736	3471			3115	
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	0	0	0	144	0	72	11	610	0	0	278	424
RTOR Reduction (vph)	0	0	0	0	66	0	0	0	0	0	248	0
Lane Group Flow (vph)	0	0	0	144	6	0	11	610	0	0	454	0
Confl. Peds. (#/hr)							1					1
Confl. Bikes (#/hr)									2			1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type				Split			Prot					
Protected Phases				8	8		5	2			6	
Permitted Phases												
Actuated Green, G (s)				2.4	2.4		1.9	17.5			11.6	
Effective Green, g (s)				2.4	2.4		1.9	17.5			11.6	
Actuated g/C Ratio				0.09	0.09		0.07	0.63			0.42	
Clearance Time (s)				4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)				3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)				149	134		118	2177			1295	
v/s Ratio Prot				c0.08	0.00		0.01	c0.18			c0.15	
v/s Ratio Perm												
v/c Ratio				0.97	0.05		0.09	0.28			0.35	
Uniform Delay, d1				12.7	11.7		12.2	2.4			5.6	
Progression Factor				1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2				63.0	0.1		0.3	0.1			0.2	
Delay (s)				75.7	11.8		12.5	2.4			5.7	
Level of Service				E	B		B	A			A	
Approach Delay (s)		0.0			54.4			2.6			5.7	
Approach LOS		A			D			A			A	

Intersection Summary			
HCM Average Control Delay	11.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.46		
Actuated Cycle Length (s)	27.9	Sum of lost time (s)	12.0
Intersection Capacity Utilization	32.6%	ICU Level of Service	A
Analysis Period (min)	15		

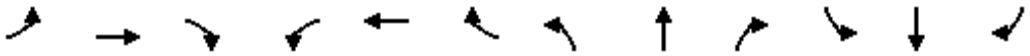
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	8	363	157	332	78	18	55	64	481	45	129	15
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		0.95	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	0.99		1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Frt	1.00	0.95		1.00	0.99		1.00	1.00	0.85		0.99	
Flt Protected	0.95	1.00		0.95	0.97		0.95	1.00	1.00		0.99	
Satd. Flow (prot)	1752	3333		1595	3215		1665	1746	1547		1801	
Flt Permitted	0.95	1.00		0.95	0.97		0.95	1.00	1.00		0.99	
Satd. Flow (perm)	1752	3333		1595	3215		1665	1746	1547		1801	
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	9	403	174	369	87	20	61	71	534	50	143	17
RTOR Reduction (vph)	0	48	0	0	6	0	0	0	443	0	3	0
Lane Group Flow (vph)	9	529	0	184	286	0	55	77	91	0	207	0
Confl. Peds. (#/hr)	1					1			2	2		
Confl. Bikes (#/hr)			1			1						1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Split			Split			Split		Perm	Split		
Protected Phases	4	4		8	8		2	2		6	6	
Permitted Phases									2			
Actuated Green, G (s)	16.0	16.0		13.6	13.6		12.1	12.1	12.1		13.0	
Effective Green, g (s)	16.0	16.0		13.6	13.6		12.1	12.1	12.1		13.0	
Actuated g/C Ratio	0.23	0.23		0.19	0.19		0.17	0.17	0.17		0.18	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	396	754		307	618		285	299	265		331	
v/s Ratio Prot	0.01	c0.16		c0.12	0.09		0.03	0.04			c0.11	
v/s Ratio Perm									c0.06			
v/c Ratio	0.02	0.70		0.60	0.46		0.19	0.26	0.34		0.62	
Uniform Delay, d1	21.3	25.2		26.1	25.3		25.1	25.4	25.8		26.6	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Incremental Delay, d2	0.0	3.0		3.1	0.6		0.3	0.5	0.8		3.6	
Delay (s)	21.3	28.1		29.2	25.9		25.4	25.9	26.6		30.2	
Level of Service	C	C		C	C		C	C	C		C	
Approach Delay (s)		28.0			27.2			26.4			30.2	
Approach LOS		C			C			C			C	

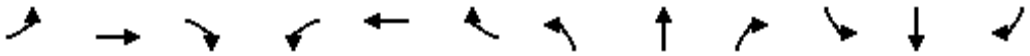
Intersection Summary			
HCM Average Control Delay	27.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.58		
Actuated Cycle Length (s)	70.7	Sum of lost time (s)	16.0
Intersection Capacity Utilization	65.2%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



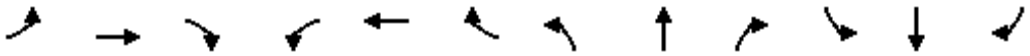
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	832	122	78	320	0	0	0	0	388	23	214
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		0.95			0.95						1.00	
Frpb, ped/bikes		1.00			1.00						1.00	
Flpb, ped/bikes		1.00			1.00						1.00	
Frt		0.98			1.00						0.95	
Flt Protected		1.00			0.99						0.97	
Satd. Flow (prot)		3456			3503						1723	
Flt Permitted		1.00			0.62						0.97	
Satd. Flow (perm)		3456			2198						1723	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	904	133	85	348	0	0	0	0	422	25	233
RTOR Reduction (vph)	0	27	0	0	0	0	0	0	0	0	18	0
Lane Group Flow (vph)	0	1010	0	0	433	0	0	0	0	0	662	0
Confl. Peds. (#/hr)	5		9	9		5						
Confl. Bikes (#/hr)						2						
Turn Type				Perm						Split		
Protected Phases		4			8					6	6	
Permitted Phases				8								
Actuated Green, G (s)		33.3			33.3						33.7	
Effective Green, g (s)		33.3			33.3						33.7	
Actuated g/C Ratio		0.44			0.44						0.45	
Clearance Time (s)		4.0			4.0						4.0	
Vehicle Extension (s)		3.0			3.0						3.0	
Lane Grp Cap (vph)		1534			976						774	
v/s Ratio Prot		c0.29									c0.38	
v/s Ratio Perm					0.20							
v/c Ratio		0.66			0.44						0.86	
Uniform Delay, d1		16.4			14.4						18.5	
Progression Factor		1.00			0.87						1.00	
Incremental Delay, d2		1.0			0.3						11.7	
Delay (s)		17.4			12.9						30.2	
Level of Service		B			B						C	
Approach Delay (s)		17.4			12.9			0.0			30.2	
Approach LOS		B			B			A			C	

Intersection Summary			
HCM Average Control Delay	20.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.76		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	85.4%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	215	1005	0	0	375	381	23	2	54	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor		0.95			0.95		0.95	0.95	1.00			
Frpb, ped/bikes		1.00			0.99		1.00	1.00	1.00			
Flpb, ped/bikes		1.00			1.00		1.00	1.00	1.00			
Frt		1.00			0.92		1.00	1.00	0.85			
Flt Protected		0.99			1.00		0.95	0.96	1.00			
Satd. Flow (prot)		3508			3230		1681	1697	1583			
Flt Permitted		0.63			1.00		0.95	0.96	1.00			
Satd. Flow (perm)		2243			3230		1681	1697	1583			
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	242	1129	0	0	421	428	26	2	61	0	0	0
RTOR Reduction (vph)	0	0	0	0	134	0	0	0	48	0	0	0
Lane Group Flow (vph)	0	1371	0	0	715	0	14	14	13	0	0	0
Confl. Peds. (#/hr)	5		7	7		5			1	1		
Confl. Bikes (#/hr)						3						
Turn Type	Perm						Split		Prot			
Protected Phases		4			8		2	2	2			
Permitted Phases	4											
Actuated Green, G (s)		51.5			51.5		15.5	15.5	15.5			
Effective Green, g (s)		51.5			51.5		15.5	15.5	15.5			
Actuated g/C Ratio		0.69			0.69		0.21	0.21	0.21			
Clearance Time (s)		4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)		3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)		1540			2218		347	351	327			
v/s Ratio Prot					0.22		c0.01	0.01	0.01			
v/s Ratio Perm		c0.61										
v/c Ratio		0.89			0.32		0.04	0.04	0.04			
Uniform Delay, d1		9.5			4.7		23.8	23.8	23.8			
Progression Factor		0.86			1.00		1.00	1.00	1.00			
Incremental Delay, d2		5.9			0.1		0.2	0.2	0.2			
Delay (s)		14.1			4.8		24.0	24.0	24.0			
Level of Service		B			A		C	C	C			
Approach Delay (s)		14.1			4.8			24.0			0.0	
Approach LOS		B			A			C			A	

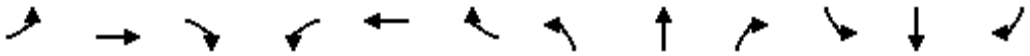
Intersection Summary			
HCM Average Control Delay	11.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.69		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	83.4%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	81	333	54	150	340	108	99	718	165	61	257	41
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frpb, ped/bikes	1.00	1.00	0.97	1.00	1.00	0.98	1.00	1.00	0.98	1.00	1.00	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.98	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1770	3539	1537	1770	3539	1556	1770	3539	1544	1770	3458	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1770	3539	1537	1770	3539	1556	1770	3539	1544	1770	3458	
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	90	370	60	167	378	120	110	798	183	68	286	46
RTOR Reduction (vph)	0	0	21	0	0	55	0	0	58	0	10	0
Lane Group Flow (vph)	90	370	39	167	378	65	110	798	125	68	322	0
Confl. Peds. (#/hr)	5		19	19		5	4		14	14		4
Confl. Bikes (#/hr)						1			1			
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases			2			6			8			
Actuated Green, G (s)	7.0	17.6	17.6	12.1	20.7	20.7	7.7	24.1	24.1	6.1	22.5	
Effective Green, g (s)	7.0	17.6	17.6	12.1	20.7	20.7	7.7	24.1	24.1	6.1	22.5	
Actuated g/C Ratio	0.10	0.24	0.24	0.17	0.28	0.28	0.11	0.33	0.33	0.08	0.31	
Clearance Time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Vehicle Extension (s)	2.0	4.0	4.0	2.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	
Lane Grp Cap (vph)	170	854	371	294	1005	442	187	1170	510	148	1067	
v/s Ratio Prot	0.05	c0.10		c0.09	0.11		c0.06	c0.23		0.04	0.09	
v/s Ratio Perm			0.03			0.04			0.08			
v/c Ratio	0.53	0.43	0.10	0.57	0.38	0.15	0.59	0.68	0.24	0.46	0.30	
Uniform Delay, d1	31.4	23.4	21.5	28.0	20.9	19.5	31.1	21.1	17.8	31.8	19.2	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	1.4	0.5	0.2	1.5	0.3	0.2	3.0	1.3	0.1	0.8	0.1	
Delay (s)	32.8	23.9	21.7	29.5	21.2	19.7	34.1	22.4	17.9	32.7	19.3	
Level of Service	C	C	C	C	C	B	C	C	B	C	B	
Approach Delay (s)		25.2			23.0			22.8			21.5	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	23.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	72.9	Sum of lost time (s)	10.0
Intersection Capacity Utilization	59.5%	ICU Level of Service	B
Analysis Period (min)	15		

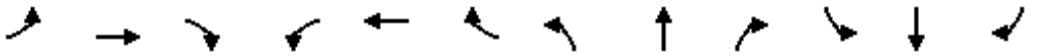
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	307	2	618	0	411	108	0	361	113
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0	4.0		4.0	4.0		4.0	
Lane Util. Factor				0.95	0.91	0.95		0.91	1.00		0.91	
Frt				1.00	0.86	0.85		1.00	0.85		0.96	
Flt Protected				0.95	1.00	1.00		1.00	1.00		1.00	
Satd. Flow (prot)				1698	1474	1519		5136	1599		4952	
Flt Permitted				0.95	1.00	1.00		1.00	1.00		1.00	
Satd. Flow (perm)				1698	1474	1519		5136	1599		4952	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	327	2	657	0	437	115	0	384	120
RTOR Reduction (vph)	0	0	0	0	134	134	0	0	0	0	85	0
Lane Group Flow (vph)	0	0	0	294	216	208	0	437	115	0	419	0
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Split		Perm			Free			
Protected Phases				8	8			2			6	
Permitted Phases						8			Free			
Actuated Green, G (s)				14.7	14.7	14.7		9.2	31.9		9.2	
Effective Green, g (s)				14.7	14.7	14.7		9.2	31.9		9.2	
Actuated g/C Ratio				0.46	0.46	0.46		0.29	1.00		0.29	
Clearance Time (s)				4.0	4.0	4.0		4.0			4.0	
Vehicle Extension (s)				3.0	3.0	3.0		3.0			3.0	
Lane Grp Cap (vph)				782	679	700		1481	1599		1428	
v/s Ratio Prot				c0.17	0.15			c0.09			0.08	
v/s Ratio Perm						0.14			0.07			
v/c Ratio				0.38	0.32	0.30		0.30	0.07		0.29	
Uniform Delay, d1				5.6	5.4	5.4		8.8	0.0		8.8	
Progression Factor				1.00	1.00	1.00		1.00	1.00		1.00	
Incremental Delay, d2				0.3	0.3	0.2		0.1	0.1		0.1	
Delay (s)				5.9	5.7	5.6		8.9	0.1		8.9	
Level of Service				A	A	A		A	A		A	
Approach Delay (s)		0.0			5.7			7.1			8.9	
Approach LOS		A			A			A			A	

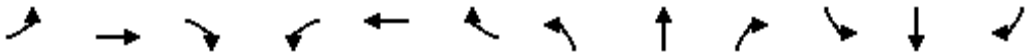
Intersection Summary			
HCM Average Control Delay	6.9	HCM Level of Service	A
HCM Volume to Capacity ratio	0.34		
Actuated Cycle Length (s)	31.9	Sum of lost time (s)	8.0
Intersection Capacity Utilization	40.1%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	213	0	131	0	0	0	0	306	364	0	447	221
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0					4.0			4.0	4.0
Lane Util. Factor	1.00		1.00					0.91			0.95	1.00
Frpb, ped/bikes	1.00		1.00					0.99			1.00	0.98
Flpb, ped/bikes	1.00		1.00					1.00			1.00	1.00
Frt	1.00		0.85					0.92			1.00	0.85
Flt Protected	0.95		1.00					1.00			1.00	1.00
Satd. Flow (prot)	1770		1583					4606			3539	1549
Flt Permitted	0.95		1.00					1.00			1.00	1.00
Satd. Flow (perm)	1770		1583					4606			3539	1549
Peak-hour factor, PHF	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Adj. Flow (vph)	248	0	152	0	0	0	0	356	423	0	520	257
RTOR Reduction (vph)	0	0	94	0	0	0	0	269	0	0	0	0
Lane Group Flow (vph)	248	0	58	0	0	0	0	510	0	0	520	257
Confl. Peds. (#/hr)							4		2	2		4
Confl. Bikes (#/hr)									3			
Turn Type	Split		Perm									Free
Protected Phases	8	8						2			6	
Permitted Phases			8									Free
Actuated Green, G (s)	11.9		11.9					11.4			11.4	31.3
Effective Green, g (s)	11.9		11.9					11.4			11.4	31.3
Actuated g/C Ratio	0.38		0.38					0.36			0.36	1.00
Clearance Time (s)	4.0		4.0					4.0			4.0	
Vehicle Extension (s)	3.0		3.0					3.0			3.0	
Lane Grp Cap (vph)	673		602					1678			1289	1549
v/s Ratio Prot	c0.14							0.11			c0.15	
v/s Ratio Perm			0.04									0.17
v/c Ratio	0.37		0.10					0.30			0.40	0.17
Uniform Delay, d1	7.0		6.2					7.1			7.4	0.0
Progression Factor	1.00		1.00					1.00			1.00	1.00
Incremental Delay, d2	0.3		0.1					0.1			0.2	0.2
Delay (s)	7.3		6.3					7.2			7.6	0.2
Level of Service	A		A					A			A	A
Approach Delay (s)		6.9			0.0			7.2			5.2	
Approach LOS		A			A			A			A	

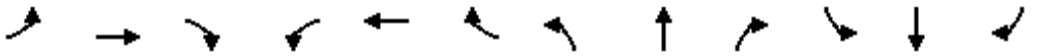
Intersection Summary			
HCM Average Control Delay	6.4	HCM Level of Service	A
HCM Volume to Capacity ratio	0.39		
Actuated Cycle Length (s)	31.3	Sum of lost time (s)	8.0
Intersection Capacity Utilization	32.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	146	1	59	9	8	216	21	308	0	11	476	91
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Lane Util. Factor		1.00		1.00	1.00			0.95		1.00	0.95	
Frpb, ped/bikes		0.99		1.00	0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00		1.00	1.00			1.00		0.94	1.00	
Frt		0.96		1.00	0.86			1.00		1.00	0.98	
Flt Protected		0.97		0.95	1.00			1.00		0.95	1.00	
Satd. Flow (prot)		1699		1751	1557			3494		1644	3409	
Flt Permitted		1.00		0.61	1.00			0.90		0.95	1.00	
Satd. Flow (perm)		1759		1122	1557			3144		1644	3409	
Peak-hour factor, PHF	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Adj. Flow (vph)	172	1	69	11	9	254	25	362	0	13	560	107
RTOR Reduction (vph)	0	14	0	0	191	0	0	0	0	0	15	0
Lane Group Flow (vph)	0	228	0	11	72	0	0	387	0	13	652	0
Confl. Peds. (#/hr)	1		3	3		1			5	5		
Confl. Bikes (#/hr)						1			2			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Perm			Prot		
Protected Phases		3			4			2		1	6	
Permitted Phases	3			4			2					
Actuated Green, G (s)		2.4		11.1	11.1			14.6		0.7	19.3	
Effective Green, g (s)		2.4		11.1	11.1			14.6		0.7	19.3	
Actuated g/C Ratio		0.05		0.25	0.25			0.33		0.02	0.43	
Clearance Time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		94		278	386			1025		26	1469	
v/s Ratio Prot					c0.05					0.01	c0.19	
v/s Ratio Perm		c0.13		0.01				0.12				
v/c Ratio		2.42		0.04	0.19			0.38		0.50	0.44	
Uniform Delay, d1		21.2		12.8	13.3			11.6		21.9	9.0	
Progression Factor		1.00		1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		671.6		0.1	0.2			0.2		14.3	0.2	
Delay (s)		692.8		12.9	13.5			11.8		36.2	9.2	
Level of Service		F		B	B			B		D	A	
Approach Delay (s)		692.8			13.5			11.8			9.7	
Approach LOS		F			B			B			A	

Intersection Summary			
HCM Average Control Delay	115.3	HCM Level of Service	F
HCM Volume to Capacity ratio	0.50		
Actuated Cycle Length (s)	44.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	61.0%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group



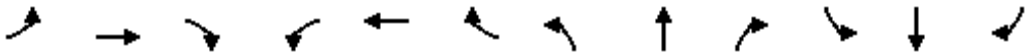
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	156	8	13	29	11	27	14	141	16	7	317	165
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00	1.00	1.00	0.99		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		0.99	1.00	
Frt	1.00	1.00	0.85	1.00	0.90		1.00	0.98		1.00	0.95	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	3124		1764	3480		1756	3336	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	3124		1764	3480		1756	3336	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	164	8	14	31	12	28	15	148	17	7	334	174
RTOR Reduction (vph)	0	0	11	0	27	0	0	10	0	0	77	0
Lane Group Flow (vph)	164	8	3	31	13	0	15	155	0	7	431	0
Confl. Peds. (#/hr)							16		1	1		16
Confl. Bikes (#/hr)						1			1			
Turn Type	Prot		Perm	Prot			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4									
Actuated Green, G (s)	5.9	6.4	6.4	0.2	0.7		0.2	10.8		0.2	10.8	
Effective Green, g (s)	5.9	6.4	6.4	0.2	0.7		0.2	10.8		0.2	10.8	
Actuated g/C Ratio	0.18	0.19	0.19	0.01	0.02		0.01	0.32		0.01	0.32	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	311	674	302	11	65		11	1119		10	1072	
v/s Ratio Prot	c0.09	0.00		0.02	c0.00		c0.01	0.04		0.00	c0.13	
v/s Ratio Perm			0.00									
v/c Ratio	0.53	0.01	0.01	2.82	0.19		1.36	0.14		0.70	0.40	
Uniform Delay, d1	12.6	11.0	11.0	16.7	16.2		16.7	8.1		16.7	8.9	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	1.6	0.0	0.0	1021.4	1.5		409.1	0.1		117.6	0.2	
Delay (s)	14.2	11.0	11.0	1038.1	17.6		425.8	8.2		134.3	9.1	
Level of Service	B	B	B	F	B		F	A		F	A	
Approach Delay (s)		13.8			463.2			43.0			10.8	
Approach LOS		B			F			D			B	

Intersection Summary			
HCM Average Control Delay	51.2	HCM Level of Service	D
HCM Volume to Capacity ratio	0.45		
Actuated Cycle Length (s)	33.6	Sum of lost time (s)	16.0
Intersection Capacity Utilization	38.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	71	40	61	164	131	32
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.91	0.91	0.91	0.91	0.91	0.91
Hourly flow rate (vph)	78	44	67	180	144	35
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				1133		
pX, platoon unblocked						
vC, conflicting volume			122		392	78
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			122		392	78
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			95		75	96
cM capacity (veh/h)			1453		580	977

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2
Volume Total	78	44	67	180	144	35
Volume Left	0	0	67	0	144	0
Volume Right	0	44	0	0	0	35
cSH	1700	1700	1453	1700	580	977
Volume to Capacity	0.05	0.03	0.05	0.11	0.25	0.04
Queue Length 95th (ft)	0	0	4	0	24	3
Control Delay (s)	0.0	0.0	7.6	0.0	13.2	8.8
Lane LOS			A		B	A
Approach Delay (s)	0.0		2.1		12.4	
Approach LOS					B	

Intersection Summary			
Average Delay	5.0		
Intersection Capacity Utilization	24.0%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	106	15	1	1	27	107	8	11	2	51	8	44
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.99		1.00	0.88		1.00	0.98			0.94	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.98	
Satd. Flow (prot)	1626	1697		1626	1507		1626	1675			1574	
Flt Permitted	0.95	1.00		0.95	1.00		1.00	1.00			0.84	
Satd. Flow (perm)	1626	1697		1626	1507		1712	1675			1348	
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	120	17	1	1	31	122	9	12	2	58	9	50
RTOR Reduction (vph)	0	1	0	0	90	0	0	2	0	0	42	0
Lane Group Flow (vph)	120	17	0	1	63	0	9	12	0	0	75	0
Heavy Vehicles (%)	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	3.4	9.4		0.8	6.8		4.0	4.0			4.0	
Effective Green, g (s)	3.4	9.4		0.8	6.8		4.0	4.0			4.0	
Actuated g/C Ratio	0.13	0.36		0.03	0.26		0.15	0.15			0.15	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	211	609		50	391		261	256			206	
v/s Ratio Prot	c0.07	c0.01		0.00	c0.04			0.01				
v/s Ratio Perm							0.01				c0.06	
v/c Ratio	0.57	0.03		0.02	0.16		0.03	0.05			0.36	
Uniform Delay, d1	10.7	5.4		12.3	7.5		9.5	9.5			10.0	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	3.5	0.0		0.2	0.2		0.1	0.1			1.1	
Delay (s)	14.2	5.5		12.5	7.7		9.5	9.6			11.0	
Level of Service	B	A		B	A		A	A			B	
Approach Delay (s)		13.1			7.7			9.5			11.0	
Approach LOS		B			A			A			B	

Intersection Summary			
HCM Average Control Delay	10.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.38		
Actuated Cycle Length (s)	26.2	Sum of lost time (s)	16.0
Intersection Capacity Utilization	36.5%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	29	39	48	86	49	39
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	32	42	52	93	53	42
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)	322					
pX, platoon unblocked						
vC, conflicting volume			32		251	53
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			32		251	53
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			97		93	96
cM capacity (veh/h)			1581		714	1015

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	74	52	93	96
Volume Left	0	52	0	53
Volume Right	42	0	0	42
cSH	1700	1581	1700	822
Volume to Capacity	0.04	0.03	0.05	0.12
Queue Length 95th (ft)	0	3	0	10
Control Delay (s)	0.0	7.4	0.0	10.0
Lane LOS		A		A
Approach Delay (s)	0.0	2.6		10.0
Approach LOS				A

Intersection Summary			
Average Delay	4.2		
Intersection Capacity Utilization	21.1%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	54	14	19	46	88	131
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.78	0.78	0.78	0.78	0.78	0.78
Hourly flow rate (vph)	69	18	24	59	113	168
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			87		186	78
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			87		186	78
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			98		86	83
cM capacity (veh/h)			1509		790	982

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	87	24	59	281
Volume Left	0	24	0	113
Volume Right	18	0	0	168
cSH	1700	1509	1700	895
Volume to Capacity	0.05	0.02	0.03	0.31
Queue Length 95th (ft)	0	1	0	34
Control Delay (s)	0.0	7.4	0.0	10.8
Lane LOS		A		B
Approach Delay (s)	0.0	2.2		10.8
Approach LOS				B

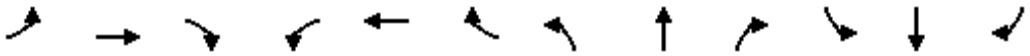
Intersection Summary			
Average Delay	7.2		
Intersection Capacity Utilization	27.3%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay (sec/veh)	22.9
Intersection LOS	C

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Volume (vph)	0	10	7	400	0	5	9	50	62	101	99	3
Peak Hour Factor	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Heavy Vehicles(%)	2	2	2	2	2	2	2	2	2	2	2	2
Movement Flow Rate	0	12	8	471	0	6	11	59	73	119	116	4
Number of Lanes	0	1	0	1	1	0	1	2	0	1	2	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	2	1	3	3
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	3	3	1	2
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	3	3	2	1
HCM Control Delay	9.8	32.9	10.5	11.4
HCM LOS	A	D	B	B

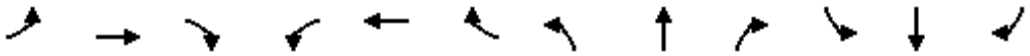
Lane	NBLn1	NBLn2	NBLn3	EBLn1	WBLn1	WBLn2	SBLn1	SBLn2	SBLn3
Volume Left (%)	100%	0%	0%	0%	100%	0%	100%	0%	0%
Volume Thru (%)	0%	100%	21%	59%	0%	0%	0%	100%	92%
Volume Right (%)	0%	0%	79%	41%	0%	100%	0%	0%	8%
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Traffic Volume by Lane	9	33	79	17	400	5	101	66	36
Left Turning Volume	0	33	17	10	0	0	0	66	33
Through Volume	0	0	62	7	0	5	0	0	3
Right Turning Volume	9	0	0	0	400	0	101	0	0
Lane Flow Rate	11	39	93	20	471	6	119	78	42
Geometry Group	8	8	8	8	8	8	8	8	8
Degree of Utilization, X	0.022	0.077	0.166	0.038	0.832	0.008	0.24	0.146	0.079
Departure Headway, Hd	7.549	7.037	6.472	6.785	6.362	5.164	7.281	6.77	6.711
Convergence(Y/N)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capacity	472	507	552	525	569	692	492	528	532
Service Time	5.323	4.81	4.245	4.559	4.101	2.903	5.047	4.536	4.476
HCM Lane V/C Ratio	0.023	0.077	0.168	0.038	0.828	0.009	0.242	0.148	0.079
HCM Control Delay	10.5	10.4	10.5	9.8	33.2	7.9	12.4	10.7	10.1
HCM Lane LOS	B	B	B	A	D	A	B	B	B
HCM 95th Percentile Queue	0.1	0.3	0.6	0.1	14.6	0	0.9	0.5	0.3



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	33	0	432	6	500	0	0	87	287
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor				1.00	1.00		1.00	0.95			0.95	
Frpb, ped/bikes				1.00	1.00		1.00	1.00			0.98	
Flpb, ped/bikes				1.00	1.00		1.00	1.00			1.00	
Frt				1.00	0.85		1.00	1.00			0.89	
Flt Protected				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)				1787	1599		1787	3574			3112	
Flt Permitted				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (perm)				1787	1599		1787	3574			3112	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	35	0	455	6	526	0	0	92	302
RTOR Reduction (vph)	0	0	0	0	400	0	0	0	0	0	189	0
Lane Group Flow (vph)	0	0	0	35	55	0	6	526	0	0	205	0
Confl. Peds. (#/hr)							1		2	2		1
Confl. Bikes (#/hr)			1						1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Split			Prot					
Protected Phases				8	8		5	2			6	
Permitted Phases												
Actuated Green, G (s)				2.3	2.3		2.0	15.7			9.7	
Effective Green, g (s)				2.3	2.3		2.0	15.7			9.7	
Actuated g/C Ratio				0.09	0.09		0.08	0.60			0.37	
Clearance Time (s)				4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)				3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)				158	141		137	2158			1161	
v/s Ratio Prot				0.02	c0.03		0.00	c0.15			0.07	
v/s Ratio Perm												
v/c Ratio				0.22	0.39		0.04	0.24			0.18	
Uniform Delay, d1				11.0	11.2		11.1	2.4			5.5	
Progression Factor				1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2				0.7	1.8		0.1	0.1			0.1	
Delay (s)				11.7	13.0		11.2	2.5			5.5	
Level of Service				B	B		B	A			A	
Approach Delay (s)		0.0			12.9			2.6			5.5	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	7.0	HCM Level of Service	A
HCM Volume to Capacity ratio	0.26		
Actuated Cycle Length (s)	26.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	47.4%	ICU Level of Service	A
Analysis Period (min)	15		

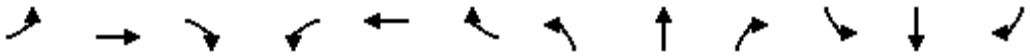
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	25	163	59	278	252	39	306	175	451	15	37	38
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		0.95	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	0.99		1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Frt	1.00	0.96		1.00	0.98		1.00	1.00	0.85		0.94	
Flt Protected	0.95	1.00		0.95	0.99		0.95	0.99	1.00		0.99	
Satd. Flow (prot)	1787	3431		1626	3332		1698	1762	1576		1759	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	0.99	1.00		0.99	
Satd. Flow (perm)	1787	3431		1626	3332		1698	1762	1576		1759	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	26	168	61	287	260	40	315	180	465	15	38	39
RTOR Reduction (vph)	0	40	0	0	9	0	0	0	332	0	31	0
Lane Group Flow (vph)	26	189	0	192	386	0	243	252	133	0	61	0
Confl. Peds. (#/hr)									2	2		
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Split			Split			Split		Perm	Split		
Protected Phases	4	4		8	8		2	2		6	6	
Permitted Phases									2			
Actuated Green, G (s)	9.5	9.5		14.0	14.0		18.3	18.3	18.3		6.3	
Effective Green, g (s)	9.5	9.5		14.0	14.0		18.3	18.3	18.3		6.3	
Actuated g/C Ratio	0.15	0.15		0.22	0.22		0.29	0.29	0.29		0.10	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	265	508		355	728		485	503	450		173	
v/s Ratio Prot	0.01	c0.06		c0.12	0.12		c0.14	0.14			c0.03	
v/s Ratio Perm									0.08			
v/c Ratio	0.10	0.37		0.54	0.53		0.50	0.50	0.30		0.35	
Uniform Delay, d1	23.6	24.6		22.2	22.1		19.1	19.1	17.9		27.0	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Incremental Delay, d2	0.2	0.5		1.7	0.7		0.8	0.8	0.4		1.3	
Delay (s)	23.8	25.1		23.9	22.9		19.9	19.9	18.2		28.3	
Level of Service	C	C		C	C		B	B	B		C	
Approach Delay (s)		24.9			23.2			19.1			28.3	
Approach LOS		C			C			B			C	

Intersection Summary			
HCM Average Control Delay	21.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.47		
Actuated Cycle Length (s)	64.1	Sum of lost time (s)	16.0
Intersection Capacity Utilization	49.6%	ICU Level of Service	A
Analysis Period (min)	15		

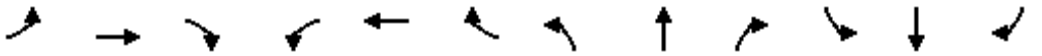
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	615	70	53	447	0	0	0	0	283	1	192
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		0.95			0.95						1.00	
Frpb, ped/bikes		1.00			1.00						1.00	
Flpb, ped/bikes		1.00			1.00						1.00	
Frt		0.98			1.00						0.95	
Flt Protected		1.00			0.99						0.97	
Satd. Flow (prot)		3508			3554						1727	
Flt Permitted		1.00			0.74						0.97	
Satd. Flow (perm)		3508			2633						1727	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	0	641	73	55	466	0	0	0	0	295	1	200
RTOR Reduction (vph)	0	25	0	0	0	0	0	0	0	0	17	0
Lane Group Flow (vph)	0	689	0	0	521	0	0	0	0	0	479	0
Confl. Peds. (#/hr)	3		8	8		3						
Confl. Bikes (#/hr)						3						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Perm						Split		
Protected Phases		4			8					6	6	
Permitted Phases				8								
Actuated Green, G (s)		22.6			22.6						44.4	
Effective Green, g (s)		22.6			22.6						44.4	
Actuated g/C Ratio		0.30			0.30						0.59	
Clearance Time (s)		4.0			4.0						4.0	
Vehicle Extension (s)		3.0			3.0						3.0	
Lane Grp Cap (vph)		1057			793						1022	
v/s Ratio Prot		0.20									c0.28	
v/s Ratio Perm					c0.20							
v/c Ratio		0.65			0.66						0.47	
Uniform Delay, d1		22.8			22.8						8.6	
Progression Factor		1.00			0.86						1.00	
Incremental Delay, d2		1.5			1.9						1.5	
Delay (s)		24.2			21.6						10.2	
Level of Service		C			C						B	
Approach Delay (s)		24.2			21.6			0.0			10.2	
Approach LOS		C			C			A			B	

Intersection Summary			
HCM Average Control Delay	19.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.53		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	71.7%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



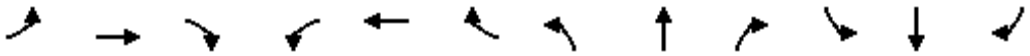
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	245	653	0	0	439	377	61	141	100	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor		0.95			0.95		0.95	0.95	1.00			
Frpb, ped/bikes		1.00			0.99		1.00	1.00	1.00			
Flpb, ped/bikes		1.00			1.00		1.00	1.00	1.00			
Frt		1.00			0.93		1.00	1.00	0.85			
Flt Protected		0.99			1.00		0.95	1.00	1.00			
Satd. Flow (prot)		3526			3291		1698	1784	1599			
Flt Permitted		0.58			1.00		0.95	1.00	1.00			
Satd. Flow (perm)		2074			3291		1698	1784	1599			
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	255	680	0	0	457	393	64	147	104	0	0	0
RTOR Reduction (vph)	0	0	0	0	154	0	0	0	74	0	0	0
Lane Group Flow (vph)	0	935	0	0	696	0	58	153	30	0	0	0
Confl. Peds. (#/hr)	2		7	7		2						
Confl. Bikes (#/hr)						3						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm						Split		Prot			
Protected Phases		4			8		2	2	2			
Permitted Phases	4											
Actuated Green, G (s)		45.6			45.6		21.4	21.4	21.4			
Effective Green, g (s)		45.6			45.6		21.4	21.4	21.4			
Actuated g/C Ratio		0.61			0.61		0.29	0.29	0.29			
Clearance Time (s)		4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)		3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)		1261			2001		484	509	456			
v/s Ratio Prot					0.21		0.03	c0.09	0.02			
v/s Ratio Perm		c0.45										
v/c Ratio		0.74			0.35		0.12	0.30	0.07			
Uniform Delay, d1		10.5			7.3		19.8	20.9	19.5			
Progression Factor		0.53			1.00		1.00	1.00	1.00			
Incremental Delay, d2		2.3			0.1		0.5	1.5	0.3			
Delay (s)		7.8			7.4		20.3	22.5	19.8			
Level of Service		A			A		C	C	B			
Approach Delay (s)		7.8			7.4			21.2			0.0	
Approach LOS		A			A			C			A	

Intersection Summary			
HCM Average Control Delay	9.7	HCM Level of Service	A
HCM Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	68.6%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Existing Plus Project Buildout Conditions

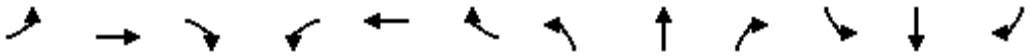
FEHR PEERS



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	60	270	114	238	319	85	51	243	132	68	696	41
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frpb, ped/bikes	1.00	1.00	0.98	1.00	1.00	0.97	1.00	1.00	0.98	1.00	1.00	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1736	3471	1515	1736	3471	1512	1736	3471	1529	1736	3439	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1736	3471	1515	1736	3471	1512	1736	3471	1529	1736	3439	
Peak-hour factor, PHF	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Adj. Flow (vph)	66	297	125	262	351	93	56	267	145	75	765	45
RTOR Reduction (vph)	0	0	56	0	0	43	0	0	101	0	3	0
Lane Group Flow (vph)	66	297	69	262	351	50	56	267	44	75	807	0
Confl. Peds. (#/hr)	14		13	13		14	4		4	4		4
Confl. Bikes (#/hr)						1						1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases			2			6			8			
Actuated Green, G (s)	6.4	17.2	17.2	17.3	26.1	26.1	5.9	23.8	23.8	6.8	24.7	
Effective Green, g (s)	6.4	17.2	17.2	17.3	26.1	26.1	5.9	23.8	23.8	6.8	24.7	
Actuated g/C Ratio	0.08	0.22	0.22	0.22	0.33	0.33	0.08	0.30	0.30	0.09	0.32	
Clearance Time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Vehicle Extension (s)	2.0	4.0	4.0	2.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	
Lane Grp Cap (vph)	142	764	334	385	1160	505	131	1058	466	151	1088	
v/s Ratio Prot	0.04	c0.09		c0.15	0.10		0.03	0.08		c0.04	c0.23	
v/s Ratio Perm			0.05			0.03			0.03			
v/c Ratio	0.46	0.39	0.21	0.68	0.30	0.10	0.43	0.25	0.09	0.50	0.74	
Uniform Delay, d1	34.2	26.0	24.9	27.9	19.3	17.9	34.5	20.4	19.4	34.0	23.8	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	0.9	0.4	0.4	3.9	0.2	0.1	0.8	0.0	0.0	0.9	2.4	
Delay (s)	35.1	26.4	25.3	31.8	19.5	18.0	35.3	20.5	19.5	35.0	26.3	
Level of Service	D	C	C	C	B	B	D	C	B	C	C	
Approach Delay (s)		27.3			23.8			21.9			27.0	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	25.3	HCM Level of Service	C
HCM Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	78.1	Sum of lost time (s)	10.0
Intersection Capacity Utilization	62.9%	ICU Level of Service	B
Analysis Period (min)	15		

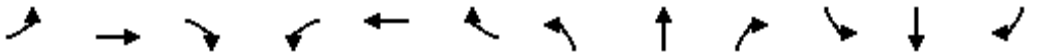
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	308	2	176	0	248	163	0	844	231
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0	4.0		4.0	4.0		4.0	
Lane Util. Factor				0.95	0.91	0.95		0.91	1.00		0.91	
Frpb, ped/bikes				1.00	1.00	0.99		1.00	0.98		1.00	
Flpb, ped/bikes				1.00	1.00	1.00		1.00	1.00		1.00	
Frt				1.00	0.98	0.85		1.00	0.85		0.97	
Flt Protected				0.95	0.96	1.00		1.00	1.00		1.00	
Satd. Flow (prot)				1665	1572	1471		5036	1535		4850	
Flt Permitted				0.95	0.96	1.00		1.00	1.00		1.00	
Satd. Flow (perm)				1665	1572	1471		5036	1535		4850	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	328	2	187	0	264	173	0	898	246
RTOR Reduction (vph)	0	0	0	0	13	109	0	0	0	0	66	0
Lane Group Flow (vph)	0	0	0	180	163	52	0	264	173	0	1078	0
Confl. Peds. (#/hr)	1					1	2		1	1		2
Confl. Bikes (#/hr)									2			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type				Split		Perm			Free			
Protected Phases				8	8			2			6	
Permitted Phases						8			Free			
Actuated Green, G (s)				12.5	12.5	12.5		18.2	38.7		18.2	
Effective Green, g (s)				12.5	12.5	12.5		18.2	38.7		18.2	
Actuated g/C Ratio				0.32	0.32	0.32		0.47	1.00		0.47	
Clearance Time (s)				4.0	4.0	4.0		4.0			4.0	
Vehicle Extension (s)				3.0	3.0	3.0		3.0			3.0	
Lane Grp Cap (vph)				538	508	475		2368	1535		2281	
v/s Ratio Prot				c0.11	0.10			0.05			c0.22	
v/s Ratio Perm						0.04			0.11			
v/c Ratio				0.33	0.32	0.11		0.11	0.11		0.47	
Uniform Delay, d1				9.9	9.9	9.2		5.7	0.0		7.0	
Progression Factor				1.00	1.00	1.00		1.00	1.00		1.00	
Incremental Delay, d2				0.4	0.4	0.1		0.0	0.1		0.2	
Delay (s)				10.3	10.3	9.3		5.8	0.1		7.1	
Level of Service				B	B	A		A	A		A	
Approach Delay (s)		0.0			10.0			3.5			7.1	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	7.1	HCM Level of Service	A
HCM Volume to Capacity ratio	0.42		
Actuated Cycle Length (s)	38.7	Sum of lost time (s)	8.0
Intersection Capacity Utilization	39.0%	ICU Level of Service	A
Analysis Period (min)	15		

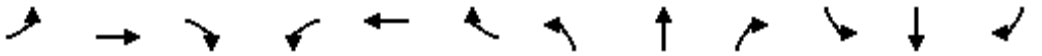
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	67	0	297	0	0	0	0	343	313	0	601	552
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0					4.0			4.0	4.0
Lane Util. Factor	1.00		1.00					0.91			0.95	1.00
Frpb, ped/bikes	1.00		1.00					0.99			1.00	0.98
Flpb, ped/bikes	1.00		1.00					1.00			1.00	1.00
Frt	1.00		0.85					0.93			1.00	0.85
Flt Protected	0.95		1.00					1.00			1.00	1.00
Satd. Flow (prot)	1752		1568					4621			3505	1536
Flt Permitted	0.95		1.00					1.00			1.00	1.00
Satd. Flow (perm)	1752		1568					4621			3505	1536
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	76	0	338	0	0	0	0	390	356	0	683	627
RTOR Reduction (vph)	0	0	116	0	0	0	0	207	0	0	0	0
Lane Group Flow (vph)	76	0	222	0	0	0	0	539	0	0	683	627
Confl. Peds. (#/hr)							1		3	3		1
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Split		Perm									Free
Protected Phases	8	8						2			6	
Permitted Phases			8									Free
Actuated Green, G (s)	11.5		11.5					14.1			14.1	33.6
Effective Green, g (s)	11.5		11.5					14.1			14.1	33.6
Actuated g/C Ratio	0.34		0.34					0.42			0.42	1.00
Clearance Time (s)	4.0		4.0					4.0			4.0	
Vehicle Extension (s)	3.0		3.0					3.0			3.0	
Lane Grp Cap (vph)	600		537					1939			1471	1536
v/s Ratio Prot	0.04							0.12			0.19	
v/s Ratio Perm			0.14									c0.41
v/c Ratio	0.13		0.41					0.28			0.46	0.41
Uniform Delay, d1	7.6		8.5					6.4			7.0	0.0
Progression Factor	1.00		1.00					1.00			1.00	1.00
Incremental Delay, d2	0.1		0.5					0.1			0.2	0.8
Delay (s)	7.7		9.0					6.5			7.3	0.8
Level of Service	A		A					A			A	A
Approach Delay (s)		8.7			0.0			6.5			4.2	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	5.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	33.6	Sum of lost time (s)	0.0
Intersection Capacity Utilization	41.7%	ICU Level of Service	A
Analysis Period (min)	15		

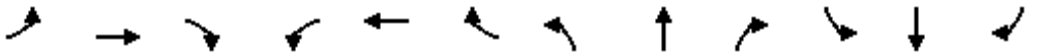
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	41	7	15	0	1	21	15	594	10	267	516	94
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0			4.0		4.0	4.0	
Lane Util. Factor		1.00			1.00			0.95		1.00	0.95	
Frpb, ped/bikes		1.00			0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00			1.00		1.00	1.00	
Frt		0.97			0.85			1.00		1.00	0.98	
Flt Protected		0.97			1.00			1.00		0.95	1.00	
Satd. Flow (prot)		1711			1542			3458		1736	3379	
Flt Permitted		1.00			1.00			0.93		0.95	1.00	
Satd. Flow (perm)		1767			1542			3205		1736	3379	
Peak-hour factor, PHF	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Adj. Flow (vph)	57	10	21	0	1	29	21	825	14	371	717	131
RTOR Reduction (vph)	0	12	0	0	26	0	0	1	0	0	9	0
Lane Group Flow (vph)	0	76	0	0	4	0	0	859	0	371	839	0
Confl. Peds. (#/hr)	3					3	2					2
Confl. Bikes (#/hr)												1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm			Perm			Perm			Prot		
Protected Phases		3			4			2		1	6	
Permitted Phases	3			4			2					
Actuated Green, G (s)		2.2			6.8			22.1		12.0	38.1	
Effective Green, g (s)		2.2			6.8			22.1		12.0	38.1	
Actuated g/C Ratio		0.04			0.12			0.37		0.20	0.64	
Clearance Time (s)		4.0			4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		66			177			1198		352	2178	
v/s Ratio Prot					c0.00					c0.21	0.25	
v/s Ratio Perm		c0.04						c0.27				
v/c Ratio		1.16			0.02			0.72		1.05	0.39	
Uniform Delay, d1		28.4			23.2			15.8		23.6	5.0	
Progression Factor		1.00			1.00			1.00		1.00	1.00	
Incremental Delay, d2		160.0			0.1			2.1		62.9	0.1	
Delay (s)		188.5			23.3			17.9		86.4	5.1	
Level of Service		F			C			B		F	A	
Approach Delay (s)		188.5			23.3			17.9			29.8	
Approach LOS		F			C			B			C	

Intersection Summary			
HCM Average Control Delay	31.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	59.1	Sum of lost time (s)	16.0
Intersection Capacity Utilization	54.9%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



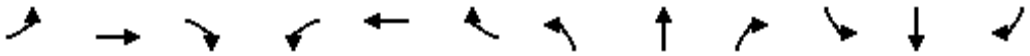
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	179	61	11	15	11	75	5	352	131	310	71	130
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00	1.00	1.00	0.99		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	0.87		1.00	0.96		1.00	0.90	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	3040		1767	3384		1770	3165	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	3040		1767	3384		1770	3165	
Peak-hour factor, PHF	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
Adj. Flow (vph)	227	77	14	19	14	95	6	446	166	392	90	165
RTOR Reduction (vph)	0	0	10	0	77	0	0	42	0	0	99	0
Lane Group Flow (vph)	227	77	4	19	32	0	6	570	0	392	156	0
Confl. Peds. (#/hr)	3					3	4					4
Confl. Bikes (#/hr)									1			1
Turn Type	Prot		Perm	Prot			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4									
Actuated Green, G (s)	3.3	12.4	12.4	0.2	9.3		0.2	17.4		2.2	19.4	
Effective Green, g (s)	3.3	12.4	12.4	0.2	9.3		0.2	17.4		2.2	19.4	
Actuated g/C Ratio	0.07	0.26	0.26	0.00	0.19		0.00	0.36		0.05	0.40	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	121	910	407	7	587		7	1222		81	1274	
v/s Ratio Prot	c0.13	c0.02		0.01	0.01		0.00	c0.17		c0.22	0.05	
v/s Ratio Perm			0.00									
v/c Ratio	1.88	0.08	0.01	2.71	0.06		0.86	0.47		4.84	0.12	
Uniform Delay, d1	22.5	13.6	13.3	24.0	15.9		24.0	11.8		23.0	9.1	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	423.8	0.0	0.0	1066.1	0.0		244.3	0.3		1755.3	0.0	
Delay (s)	446.3	13.6	13.3	1090.1	15.9		268.3	12.1		1778.3	9.1	
Level of Service	F	B	B	F	B		F	B		F	A	
Approach Delay (s)		322.5			175.3			14.6			1081.0	
Approach LOS		F			F			B			F	

Intersection Summary			
HCM Average Control Delay	487.1	HCM Level of Service	F
HCM Volume to Capacity ratio	0.64		
Actuated Cycle Length (s)	48.2	Sum of lost time (s)	16.0
Intersection Capacity Utilization	57.7%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	294	107	64	112	45	211
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90
Hourly flow rate (vph)	327	119	71	124	50	234
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				1133		
pX, platoon unblocked						
vC, conflicting volume			446		593	327
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			446		593	327
tC, single (s)			4.2		6.5	6.3
tC, 2 stage (s)						
tF (s)			2.3		3.6	3.4
p0 queue free %			93		88	66
cM capacity (veh/h)			1074		425	696

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2
Volume Total	327	119	71	124	50	234
Volume Left	0	0	71	0	50	0
Volume Right	0	119	0	0	0	234
cSH	1700	1700	1074	1700	425	696
Volume to Capacity	0.19	0.07	0.07	0.07	0.12	0.34
Queue Length 95th (ft)	0	0	5	0	10	37
Control Delay (s)	0.0	0.0	8.6	0.0	14.6	12.8
Lane LOS			A		B	B
Approach Delay (s)	0.0		3.1		13.1	
Approach LOS					B	

Intersection Summary			
Average Delay	4.7		
Intersection Capacity Utilization	35.2%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	45	319	13	7	67	121	3	11	15	385	21	99
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	0.99			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.99		1.00	0.90		1.00	0.91			0.97	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.96	
Satd. Flow (prot)	1556	1628		1556	1480		1556	1472			1533	
Flt Permitted	0.95	1.00		0.95	1.00		0.66	1.00			0.75	
Satd. Flow (perm)	1556	1628		1556	1480		1077	1472			1201	
Peak-hour factor, PHF	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Adj. Flow (vph)	59	420	17	9	88	159	4	14	20	507	28	130
RTOR Reduction (vph)	0	3	0	0	107	0	0	13	0	0	13	0
Lane Group Flow (vph)	59	434	0	9	140	0	4	21	0	0	652	0
Confl. Peds. (#/hr)									2	2		
Confl. Bikes (#/hr)									2			
Heavy Vehicles (%)	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	2.3	16.4		1.0	15.1		16.7	16.7			16.7	
Effective Green, g (s)	2.3	16.4		1.0	15.1		16.7	16.7			16.7	
Actuated g/C Ratio	0.05	0.36		0.02	0.33		0.36	0.36			0.36	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	78	579		34	485		390	533			435	
v/s Ratio Prot	c0.04	c0.27		0.01	0.09			0.01				
v/s Ratio Perm							0.00				c0.54	
v/c Ratio	0.76	0.75		0.26	0.29		0.01	0.04			1.50	
Uniform Delay, d1	21.6	13.1		22.2	11.5		9.4	9.5			14.7	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	33.5	5.4		4.1	0.3		0.0	0.0			236.5	
Delay (s)	55.1	18.5		26.3	11.8		9.4	9.5			251.2	
Level of Service	E	B		C	B		A	A			F	
Approach Delay (s)		22.8			12.4			9.5			251.2	
Approach LOS		C			B			A			F	

Intersection Summary			
HCM Average Control Delay	125.0	HCM Level of Service	F
HCM Volume to Capacity ratio	1.03		
Actuated Cycle Length (s)	46.1	Sum of lost time (s)	8.0
Intersection Capacity Utilization	66.0%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	554	166	27	104	91	144
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.80	0.80	0.80	0.80	0.80	0.80
Hourly flow rate (vph)	692	208	34	130	114	180
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)	322					
pX, platoon unblocked			0.80		0.80	0.80
vC, conflicting volume			692		994	796
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			492		868	621
tC, single (s)			4.3		6.6	6.4
tC, 2 stage (s)						
tF (s)			2.3		3.6	3.4
p0 queue free %			96		51	51
cM capacity (veh/h)			803		234	371

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	900	34	130	294
Volume Left	0	34	0	114
Volume Right	208	0	0	180
cSH	1700	803	1700	302
Volume to Capacity	0.53	0.04	0.08	0.97
Queue Length 95th (ft)	0	3	0	249
Control Delay (s)	0.0	9.7	0.0	82.9
Lane LOS		A		F
Approach Delay (s)	0.0	2.0		82.9
Approach LOS				F

Intersection Summary			
Average Delay	18.2		
Intersection Capacity Utilization	59.8%	ICU Level of Service	B
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	192	367	571	317	59	90
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.85	0.85	0.85	0.85	0.85	0.85
Hourly flow rate (vph)	226	432	672	373	69	106
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			658		2158	442
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			658		2158	442
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			27		0	83
cM capacity (veh/h)			916		14	609

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	658	672	373	175
Volume Left	0	672	0	69
Volume Right	432	0	0	106
cSH	1700	916	1700	33
Volume to Capacity	0.39	0.73	0.22	5.25
Queue Length 95th (ft)	0	169	0	Err
Control Delay (s)	0.0	18.9	0.0	Err
Lane LOS		C		F
Approach Delay (s)	0.0	12.2		Err
Approach LOS				F

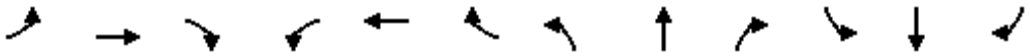
Intersection Summary			
Average Delay	940.3		
Intersection Capacity Utilization	83.1%	ICU Level of Service	E
Analysis Period (min)	15		

Intersection	
Intersection Delay (sec/veh)	60.2
Intersection LOS	F

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Volume (vph)	5	6	7	412	7	15	26	912	146	167	179	3
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Heavy Vehicles(%)	4	4	4	4	4	4	4	4	4	4	4	4
Movement Flow Rate	6	7	8	468	8	17	30	1036	166	190	203	3
Number of Lanes	0	1	0	1	1	0	1	2	0	1	2	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	2	1	3	3
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	3	3	1	2
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	3	3	2	1
HCM Control Delay	13.9	73.6	69.1	18.3
HCM LOS	B	F	F	C

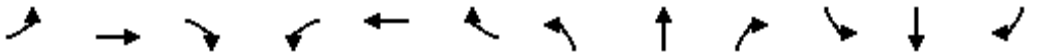
Lane	NBLn1	NBLn2	NBLn3	EBLn1	WBLn1	WBLn2	SBLn1	SBLn2	SBLn3
Volume Left (%)	100%	0%	0%	28%	100%	0%	100%	0%	0%
Volume Thru (%)	0%	100%	68%	33%	0%	32%	0%	100%	95%
Volume Right (%)	0%	0%	32%	39%	0%	68%	0%	0%	5%
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Traffic Volume by Lane	26	608	450	18	412	22	167	119	63
Left Turning Volume	0	608	304	6	0	7	0	119	60
Through Volume	0	0	146	7	0	15	0	0	3
Right Turning Volume	26	0	0	5	412	0	167	0	0
Lane Flow Rate	30	691	511	20	468	25	190	136	71
Geometry Group	8	8	8	8	8	8	8	8	8
Degree of Utilization, X	0.07	1	1	0.06	1	0.058	0.501	0.339	0.177
Departure Headway, Hd	8.525	8.027	7.801	10.518	9.313	8.34	9.5	9	8.967
Convergence(Y/N)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capacity	421	456	465	342	393	430	381	401	402
Service Time	6.256	5.758	5.532	8.25	7.049	6.076	7.213	6.714	6.68
HCM Lane V/C Ratio	0.071	1.515	1.099	0.058	1.191	0.058	0.499	0.339	0.177
HCM Control Delay	11.9	71	69.9	13.9	76.9	11.6	21.4	16.3	13.6
HCM Lane LOS	B	F	F	B	F	B	C	C	B
HCM 95th Percentile Queue	0.2	100.3	101.7	0.2	93.1	0.2	3	1.5	0.6



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	521	0	63	10	588	0	0	563	373
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor				1.00	1.00		1.00	0.95			0.95	
Frpb, ped/bikes				1.00	1.00		1.00	1.00			0.99	
Flpb, ped/bikes				1.00	1.00		1.00	1.00			1.00	
Frt				1.00	0.85		1.00	1.00			0.94	
Flt Protected				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)				1736	1553		1736	3471			3235	
Flt Permitted				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (perm)				1736	1553		1736	3471			3235	
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	0	0	0	592	0	72	11	668	0	0	640	424
RTOR Reduction (vph)	0	0	0	0	67	0	0	0	0	0	218	0
Lane Group Flow (vph)	0	0	0	592	5	0	11	668	0	0	846	0
Confl. Peds. (#/hr)							1					1
Confl. Bikes (#/hr)									2			1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type				Split			Prot					
Protected Phases				8	8		5	2			6	
Permitted Phases												
Actuated Green, G (s)				2.3	2.3		2.1	21.6			15.5	
Effective Green, g (s)				2.3	2.3		2.1	21.6			15.5	
Actuated g/C Ratio				0.07	0.07		0.07	0.68			0.49	
Clearance Time (s)				4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)				3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)				125	112		114	2350			1572	
v/s Ratio Prot				c0.34	0.00		0.01	c0.19			c0.26	
v/s Ratio Perm												
v/c Ratio				4.74	0.05		0.10	0.28			0.54	
Uniform Delay, d1				14.8	13.8		14.0	2.1			5.7	
Progression Factor				1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2				1699.3	0.2		0.4	0.1			0.4	
Delay (s)				1714.1	14.0		14.4	2.1			6.1	
Level of Service				F	B		B	A			A	
Approach Delay (s)		0.0			1529.7			2.3			6.1	
Approach LOS		A			F			A			A	

Intersection Summary			
HCM Average Control Delay	425.3	HCM Level of Service	F
HCM Volume to Capacity ratio	1.02		
Actuated Cycle Length (s)	31.9	Sum of lost time (s)	12.0
Intersection Capacity Utilization	63.1%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

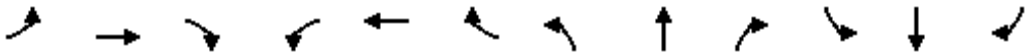


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	8	363	157	650	78	18	55	64	532	45	129	15
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		0.95	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	0.99		1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Frt	1.00	0.95		1.00	0.99		1.00	1.00	0.85		0.99	
Flt Protected	0.95	1.00		0.95	0.96		0.95	1.00	1.00		0.99	
Satd. Flow (prot)	1752	3333		1595	3209		1665	1746	1546		1801	
Flt Permitted	0.95	1.00		0.95	0.96		0.95	1.00	1.00		0.99	
Satd. Flow (perm)	1752	3333		1595	3209		1665	1746	1546		1801	
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	9	403	174	722	87	20	61	71	591	50	143	17
RTOR Reduction (vph)	0	49	0	0	3	0	0	0	493	0	3	0
Lane Group Flow (vph)	9	528	0	361	465	0	55	77	98	0	207	0
Confl. Peds. (#/hr)	1					1			2	2		
Confl. Bikes (#/hr)			1			1						1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Split			Split			Split		Perm	Split		
Protected Phases	4	4		8	8		2	2		6	6	
Permitted Phases									2			
Actuated Green, G (s)	16.2	16.2		18.4	18.4		12.7	12.7	12.7		13.2	
Effective Green, g (s)	16.2	16.2		18.4	18.4		12.7	12.7	12.7		13.2	
Actuated g/C Ratio	0.21	0.21		0.24	0.24		0.17	0.17	0.17		0.17	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	371	706		384	772		276	290	257		311	
v/s Ratio Prot	0.01	c0.16		c0.23	0.14		0.03	0.04			c0.11	
v/s Ratio Perm									c0.06			
v/c Ratio	0.02	0.75		0.94	0.90dl		0.20	0.27	0.38		0.66	
Uniform Delay, d1	23.9	28.2		28.5	25.8		27.5	27.8	28.4		29.6	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Incremental Delay, d2	0.0	4.3		31.0	1.3		0.4	0.5	0.9		5.3	
Delay (s)	23.9	32.6		59.5	27.1		27.9	28.3	29.4		34.9	
Level of Service	C	C		E	C		C	C	C		C	
Approach Delay (s)		32.5			41.2			29.1			34.9	
Approach LOS		C			D			C			C	

Intersection Summary			
HCM Average Control Delay	34.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	76.5	Sum of lost time (s)	16.0
Intersection Capacity Utilization	68.4%	ICU Level of Service	C
Analysis Period (min)	15		

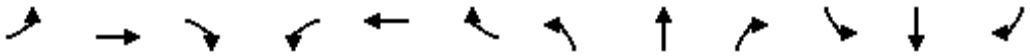
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

c Critical Lane Group



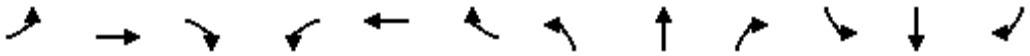
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	883	122	78	351	0	0	0	0	388	23	500
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		0.95			0.95						1.00	
Frpb, ped/bikes		1.00			1.00						1.00	
Flpb, ped/bikes		1.00			1.00						1.00	
Frt		0.98			1.00						0.93	
Flt Protected		1.00			0.99						0.98	
Satd. Flow (prot)		3461			3506						1689	
Flt Permitted		1.00			0.63						0.98	
Satd. Flow (perm)		3461			2212						1689	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	960	133	85	382	0	0	0	0	422	25	543
RTOR Reduction (vph)	0	24	0	0	0	0	0	0	0	0	43	0
Lane Group Flow (vph)	0	1069	0	0	467	0	0	0	0	0	947	0
Confl. Peds. (#/hr)	5		9	9		5						
Confl. Bikes (#/hr)						2						
Turn Type				Perm						Split		
Protected Phases		4			8					6	6	
Permitted Phases				8								
Actuated Green, G (s)		35.2			35.2						31.8	
Effective Green, g (s)		35.2			35.2						31.8	
Actuated g/C Ratio		0.47			0.47						0.42	
Clearance Time (s)		4.0			4.0						4.0	
Vehicle Extension (s)		3.0			3.0						3.0	
Lane Grp Cap (vph)		1624			1038						716	
v/s Ratio Prot		c0.31									c0.56	
v/s Ratio Perm					0.21							
v/c Ratio		0.66			0.45						1.32	
Uniform Delay, d1		15.3			13.4						21.6	
Progression Factor		1.00			0.86						1.00	
Incremental Delay, d2		1.0			0.3						155.1	
Delay (s)		16.3			11.8						176.7	
Level of Service		B			B						F	
Approach Delay (s)		16.3			11.8			0.0			176.7	
Approach LOS		B			B			A			F	

Intersection Summary			
HCM Average Control Delay	77.7	HCM Level of Service	E
HCM Volume to Capacity ratio	0.97		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	105.1%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	261	1010	0	0	406	381	23	2	54	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor		0.95			0.95		0.95	0.95	1.00			
Frpb, ped/bikes		1.00			0.99		1.00	1.00	1.00			
Flpb, ped/bikes		1.00			1.00		1.00	1.00	1.00			
Frt		1.00			0.93		1.00	1.00	0.85			
Flt Protected		0.99			1.00		0.95	0.96	1.00			
Satd. Flow (prot)		3503			3242		1681	1697	1583			
Flt Permitted		0.61			1.00		0.95	0.96	1.00			
Satd. Flow (perm)		2156			3242		1681	1697	1583			
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	293	1135	0	0	456	428	26	2	61	0	0	0
RTOR Reduction (vph)	0	0	0	0	131	0	0	0	49	0	0	0
Lane Group Flow (vph)	0	1428	0	0	753	0	14	14	12	0	0	0
Confl. Peds. (#/hr)	5		7	7		5			1	1		
Confl. Bikes (#/hr)						3						
Turn Type	Perm						Split		Prot			
Protected Phases		4			8		2	2	2			
Permitted Phases	4											
Actuated Green, G (s)		52.0			52.0		15.0	15.0	15.0			
Effective Green, g (s)		52.0			52.0		15.0	15.0	15.0			
Actuated g/C Ratio		0.69			0.69		0.20	0.20	0.20			
Clearance Time (s)		4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)		3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)		1495			2248		336	339	317			
v/s Ratio Prot					0.23		c0.01	0.01	0.01			
v/s Ratio Perm		c0.66										
v/c Ratio		0.96			0.33		0.04	0.04	0.04			
Uniform Delay, d1		10.4			4.6		24.2	24.2	24.2			
Progression Factor		0.90			1.00		1.00	1.00	1.00			
Incremental Delay, d2		10.8			0.1		0.2	0.2	0.2			
Delay (s)		20.2			4.7		24.4	24.4	24.4			
Level of Service		C			A		C	C	C			
Approach Delay (s)		20.2			4.7			24.4			0.0	
Approach LOS		C			A			C			A	

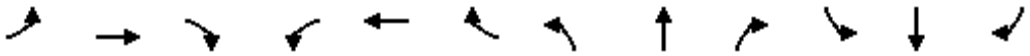
Intersection Summary			
HCM Average Control Delay	14.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	85.6%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	41	7	15	0	1	21	15	594	10	267	516	94
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0			4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00			1.00			0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00			0.99			1.00		1.00	1.00	
Flpb, ped/bikes	1.00	1.00			1.00			1.00		1.00	1.00	
Frt	1.00	0.90			0.85			1.00		1.00	0.98	
Flt Protected	0.95	1.00			1.00			1.00		0.95	1.00	
Satd. Flow (prot)	1736	1641			1542			3458		1736	3379	
Flt Permitted	0.95	1.00			1.00			0.92		0.95	1.00	
Satd. Flow (perm)	1736	1641			1542			3199		1736	3379	
Peak-hour factor, PHF	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Adj. Flow (vph)	57	10	21	0	1	29	21	825	14	371	717	131
RTOR Reduction (vph)	0	16	0	0	26	0	0	1	0	0	9	0
Lane Group Flow (vph)	57	15	0	0	4	0	0	859	0	371	839	0
Confl. Peds. (#/hr)	3					3	2					2
Confl. Bikes (#/hr)												1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Prot			Prot			Perm			Prot		
Protected Phases	3	8		7	4			2		1	6	
Permitted Phases							2					
Actuated Green, G (s)	4.0	14.8			6.8			18.3		13.4	35.7	
Effective Green, g (s)	4.0	14.8			6.8			18.3		13.4	35.7	
Actuated g/C Ratio	0.07	0.25			0.12			0.31		0.23	0.61	
Clearance Time (s)	4.0	4.0			4.0			4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0			3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)	119	415			179			1001		398	2062	
v/s Ratio Prot	c0.03	c0.01			0.00					c0.21	0.25	
v/s Ratio Perm								c0.27				
v/c Ratio	0.48	0.04			0.02			0.86		0.93	0.41	
Uniform Delay, d1	26.2	16.5			22.9			18.9		22.1	5.9	
Progression Factor	1.00	1.00			1.00			1.00		1.00	1.00	
Incremental Delay, d2	3.0	0.0			0.1			7.4		28.5	0.1	
Delay (s)	29.3	16.5			23.0			26.3		50.6	6.0	
Level of Service	C	B			C			C		D	A	
Approach Delay (s)		24.8			23.0			26.3			19.6	
Approach LOS		C			C			C			B	

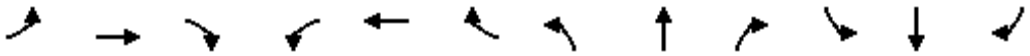
Intersection Summary			
HCM Average Control Delay	22.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.66		
Actuated Cycle Length (s)	58.5	Sum of lost time (s)	12.0
Intersection Capacity Utilization	53.7%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	179	61	11	15	11	75	5	352	131	310	71	130
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00	1.00	1.00	0.99		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	0.87		1.00	0.96		1.00	0.90	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	3037		1765	3383		1770	3162	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	3037		1765	3383		1770	3162	
Peak-hour factor, PHF	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
Adj. Flow (vph)	227	77	14	19	14	95	6	446	166	392	90	165
RTOR Reduction (vph)	0	0	10	0	83	0	0	39	0	0	82	0
Lane Group Flow (vph)	227	77	4	19	26	0	6	573	0	392	173	0
Confl. Peds. (#/hr)	3					3	4					4
Confl. Bikes (#/hr)									1			1
Turn Type	Prot		Perm	Prot			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4									
Actuated Green, G (s)	12.3	21.5	21.5	0.6	9.8		0.6	19.8		20.4	39.6	
Effective Green, g (s)	12.3	21.5	21.5	0.6	9.8		0.6	19.8		20.4	39.6	
Actuated g/C Ratio	0.16	0.27	0.27	0.01	0.13		0.01	0.25		0.26	0.51	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	278	972	435	14	380		14	855		461	1599	
v/s Ratio Prot	c0.13	c0.02		0.01	0.01		0.00	c0.17		c0.22	0.05	
v/s Ratio Perm			0.00									
v/c Ratio	0.82	0.08	0.01	1.36	0.07		0.43	0.67		0.85	0.11	
Uniform Delay, d1	31.9	21.1	20.7	38.9	30.2		38.7	26.3		27.5	10.1	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	16.7	0.0	0.0	371.9	0.1		19.7	2.1		14.0	0.0	
Delay (s)	48.6	21.1	20.7	410.7	30.3		58.4	28.4		41.5	10.1	
Level of Service	D	C	C	F	C		E	C		D	B	
Approach Delay (s)		40.7			86.8			28.7			29.1	
Approach LOS		D			F			C			C	

Intersection Summary			
HCM Average Control Delay	35.4	HCM Level of Service	D
HCM Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	78.3	Sum of lost time (s)	12.0
Intersection Capacity Utilization	57.7%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	45	319	13	7	67	121	3	11	15	385	21	99
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	0.99			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.99		1.00	0.90		1.00	0.91			0.97	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.96	
Satd. Flow (prot)	1556	1628		1556	1480		1556	1473			1534	
Flt Permitted	0.95	1.00		0.95	1.00		0.50	1.00			0.75	
Satd. Flow (perm)	1556	1628		1556	1480		814	1473			1202	
Peak-hour factor, PHF	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Adj. Flow (vph)	59	420	17	9	88	159	4	14	20	507	28	130
RTOR Reduction (vph)	0	1	0	0	59	0	0	8	0	0	6	0
Lane Group Flow (vph)	59	436	0	9	188	0	4	26	0	0	659	0
Confl. Peds. (#/hr)									2	2		
Confl. Bikes (#/hr)									2			
Heavy Vehicles (%)	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	7.3	31.2		1.4	25.3		62.1	62.1			62.1	
Effective Green, g (s)	7.3	31.2		1.4	25.3		62.1	62.1			62.1	
Actuated g/C Ratio	0.07	0.29		0.01	0.24		0.58	0.58			0.58	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	106	476		20	351		474	857			700	
v/s Ratio Prot	c0.04	c0.27		0.01	0.13			0.02				
v/s Ratio Perm							0.00				c0.55	
v/c Ratio	0.56	0.92		0.45	0.54		0.01	0.03			0.94	
Uniform Delay, d1	48.1	36.5		52.3	35.6		9.4	9.5			20.6	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	6.2	22.1		15.3	1.6		0.0	0.0			20.8	
Delay (s)	54.3	58.6		67.5	37.2		9.4	9.5			41.4	
Level of Service	D	E		E	D		A	A			D	
Approach Delay (s)		58.1			38.2			9.5			41.4	
Approach LOS		E			D			A			D	

Intersection Summary			
HCM Average Control Delay	45.7	HCM Level of Service	D
HCM Volume to Capacity ratio	0.94		
Actuated Cycle Length (s)	106.7	Sum of lost time (s)	12.0
Intersection Capacity Utilization	66.0%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

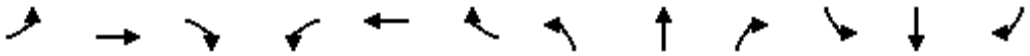
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	192	367	571	317	59	90
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0	4.0	4.0	4.0
Lane Util. Factor	1.00		1.00	1.00	1.00	1.00
Frt	0.91		1.00	1.00	1.00	0.85
Flt Protected	1.00		0.95	1.00	0.95	1.00
Satd. Flow (prot)	1649		1719	1810	1719	1538
Flt Permitted	1.00		0.11	1.00	0.95	1.00
Satd. Flow (perm)	1649		207	1810	1719	1538
Peak-hour factor, PHF	0.85	0.85	0.85	0.85	0.85	0.85
Adj. Flow (vph)	226	432	672	373	69	106
RTOR Reduction (vph)	73	0	0	0	0	95
Lane Group Flow (vph)	585	0	672	373	69	11
Heavy Vehicles (%)	5%	5%	5%	5%	5%	5%
Turn Type			pm+pt			Perm
Protected Phases	4		3	8	2	
Permitted Phases			8			2
Actuated Green, G (s)	31.0		65.0	65.0	8.6	8.6
Effective Green, g (s)	31.0		65.0	65.0	8.6	8.6
Actuated g/C Ratio	0.38		0.80	0.80	0.11	0.11
Clearance Time (s)	4.0		4.0	4.0	4.0	4.0
Vehicle Extension (s)	3.0		3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	626		721	1442	181	162
v/s Ratio Prot	0.36		c0.34	0.21	c0.04	
v/s Ratio Perm			c0.40			0.01
v/c Ratio	0.94		0.93	0.26	0.38	0.07
Uniform Delay, d1	24.3		20.3	2.1	34.0	32.9
Progression Factor	1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2	21.3		18.8	0.1	1.3	0.2
Delay (s)	45.6		39.1	2.2	35.4	33.1
Level of Service	D		D	A	D	C
Approach Delay (s)	45.6			25.9	34.0	
Approach LOS	D			C	C	

Intersection Summary			
HCM Average Control Delay	33.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.85		
Actuated Cycle Length (s)	81.6	Sum of lost time (s)	8.0
Intersection Capacity Utilization	77.6%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	5	6	7	412	7	15	26	912	146	167	179	3
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00		1.00	1.00		1.00	0.95		0.97	1.00	
Frpb, ped/bikes		1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Flpb, ped/bikes		1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Frt		0.95		1.00	0.90		1.00	0.98		1.00	1.00	
Flt Protected		0.99		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1700		1736	1641		1736	3399		3367	1822	
Flt Permitted		0.96		0.74	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)		1661		1359	1641		1736	3399		3367	1822	
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	6	7	8	468	8	17	30	1036	166	190	203	3
RTOR Reduction (vph)	0	5	0	0	11	0	0	14	0	0	1	0
Lane Group Flow (vph)	0	16	0	468	14	0	30	1188	0	190	205	0
Confl. Bikes (#/hr)			1									1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm			Perm			Prot			Prot		
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8								
Actuated Green, G (s)		32.2		32.2	32.2		3.4	35.8		6.1	38.5	
Effective Green, g (s)		32.2		32.2	32.2		3.4	35.8		6.1	38.5	
Actuated g/C Ratio		0.37		0.37	0.37		0.04	0.42		0.07	0.45	
Clearance Time (s)		4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		621		508	614		69	1413		239	815	
v/s Ratio Prot					0.01		0.02	c0.35		c0.06	c0.11	
v/s Ratio Perm		0.01		c0.34								
v/c Ratio		0.03		0.92	0.02		0.43	0.84		0.79	0.25	
Uniform Delay, d1		17.0		25.7	17.0		40.4	22.6		39.4	14.8	
Progression Factor		1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.0		22.2	0.0		4.3	4.7		16.5	0.2	
Delay (s)		17.1		48.0	17.0		44.8	27.3		55.9	15.0	
Level of Service		B		D	B		D	C		E	B	
Approach Delay (s)		17.1			46.4			27.7			34.6	
Approach LOS		B			D			C			C	

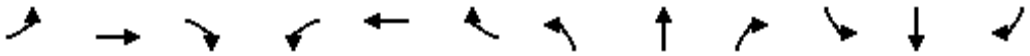
Intersection Summary			
HCM Average Control Delay	33.2	HCM Level of Service	C
HCM Volume to Capacity ratio	0.91		
Actuated Cycle Length (s)	86.1	Sum of lost time (s)	16.0
Intersection Capacity Utilization	74.1%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	521	0	63	10	588	0	0	563	373
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor				1.00	1.00		1.00	0.95			0.95	
Frpb, ped/bikes				1.00	1.00		1.00	1.00			0.99	
Flpb, ped/bikes				1.00	1.00		1.00	1.00			1.00	
Frt				1.00	0.85		1.00	1.00			0.94	
Flt Protected				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)				1736	1553		1736	3471			3235	
Flt Permitted				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (perm)				1736	1553		1736	3471			3235	
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	0	0	0	592	0	72	11	668	0	0	640	424
RTOR Reduction (vph)	0	0	0	0	42	0	0	0	0	0	86	0
Lane Group Flow (vph)	0	0	0	592	30	0	11	668	0	0	978	0
Confl. Peds. (#/hr)							1					1
Confl. Bikes (#/hr)									2			1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type				Split			Prot					
Protected Phases				8	8		5	2			6	
Permitted Phases												
Actuated Green, G (s)				36.7	36.7		3.9	42.6			34.7	
Effective Green, g (s)				36.7	36.7		3.9	42.6			34.7	
Actuated g/C Ratio				0.42	0.42		0.04	0.49			0.40	
Clearance Time (s)				4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)				3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)				730	653		78	1694			1286	
v/s Ratio Prot				c0.34	0.02		0.01	c0.19			c0.30	
v/s Ratio Perm												
v/c Ratio				0.81	0.05		0.14	0.39			0.76	
Uniform Delay, d1				22.2	15.0		40.1	14.2			22.7	
Progression Factor				1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2				6.8	0.0		0.8	0.2			2.7	
Delay (s)				29.1	15.0		40.9	14.3			25.4	
Level of Service				C	B		D	B			C	
Approach Delay (s)		0.0			27.5			14.8			25.4	
Approach LOS		A			C			B			C	

Intersection Summary			
HCM Average Control Delay	23.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.77		
Actuated Cycle Length (s)	87.3	Sum of lost time (s)	12.0
Intersection Capacity Utilization	63.1%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	883	122	78	351	0	0	0	0	388	23	500
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		0.95			0.95						1.00	
Frpb, ped/bikes		1.00			1.00						1.00	
Flpb, ped/bikes		1.00			1.00						1.00	
Frt		0.98			1.00						0.93	
Flt Protected		1.00			0.99						0.98	
Satd. Flow (prot)		3461			3506						1689	
Flt Permitted		1.00			0.55						0.98	
Satd. Flow (perm)		3461			1943						1689	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	960	133	85	382	0	0	0	0	422	25	543
RTOR Reduction (vph)	0	14	0	0	0	0	0	0	0	0	58	0
Lane Group Flow (vph)	0	1079	0	0	467	0	0	0	0	0	932	0
Confl. Peds. (#/hr)	5		9	9		5						
Confl. Bikes (#/hr)						2						
Turn Type				Perm						Split		
Protected Phases		4			8					6	6	
Permitted Phases				8								
Actuated Green, G (s)		25.9			25.9						41.1	
Effective Green, g (s)		25.9			25.9						41.1	
Actuated g/C Ratio		0.35			0.35						0.55	
Clearance Time (s)		4.0			4.0						4.0	
Vehicle Extension (s)		3.0			3.0						3.0	
Lane Grp Cap (vph)		1195			671						926	
v/s Ratio Prot		c0.31									c0.55	
v/s Ratio Perm					0.24							
v/c Ratio		0.90			0.86dl						1.01	
Uniform Delay, d1		23.4			21.2						16.9	
Progression Factor		1.00			0.94						1.00	
Incremental Delay, d2		9.6			3.0						31.1	
Delay (s)		33.0			22.9						48.0	
Level of Service		C			C						D	
Approach Delay (s)		33.0			22.9			0.0			48.0	
Approach LOS		C			C			A			D	

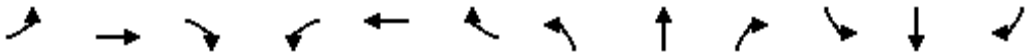
Intersection Summary			
HCM Average Control Delay	37.0	HCM Level of Service	D
HCM Volume to Capacity ratio	0.97		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	105.1%	ICU Level of Service	G
Analysis Period (min)	15		

dl Defacto Left Lane. Recode with 1 though lane as a left lane.

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	81	333	61	150	338	105	146	812	165	60	272	41
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frpb, ped/bikes	1.00	1.00	0.97	1.00	1.00	0.98	1.00	1.00	0.97	1.00	1.00	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.98	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1770	3539	1536	1770	3539	1555	1770	3539	1543	1770	3462	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1770	3539	1536	1770	3539	1555	1770	3539	1543	1770	3462	
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	90	370	68	167	376	117	162	902	183	67	302	46
RTOR Reduction (vph)	0	0	24	0	0	56	0	0	48	0	10	0
Lane Group Flow (vph)	90	370	44	167	376	61	162	902	135	67	338	0
Confl. Peds. (#/hr)	5		19	19		5	4		14	14		4
Confl. Bikes (#/hr)						1			1			
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases			2			6			8			
Actuated Green, G (s)	7.1	17.0	17.0	12.0	19.9	19.9	11.8	29.8	29.8	6.2	24.2	
Effective Green, g (s)	7.1	17.0	17.0	12.0	19.9	19.9	11.8	29.8	29.8	6.2	24.2	
Actuated g/C Ratio	0.09	0.22	0.22	0.15	0.26	0.26	0.15	0.38	0.38	0.08	0.31	
Clearance Time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Vehicle Extension (s)	2.0	4.0	4.0	2.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	
Lane Grp Cap (vph)	161	771	335	272	903	397	268	1352	590	141	1074	
v/s Ratio Prot	0.05	c0.10		c0.09	c0.11		c0.09	c0.25		0.04	0.10	
v/s Ratio Perm			0.03			0.04			0.09			
v/c Ratio	0.56	0.48	0.13	0.61	0.42	0.15	0.60	0.67	0.23	0.48	0.32	
Uniform Delay, d1	34.0	26.6	24.6	30.8	24.2	22.5	30.9	20.0	16.3	34.3	20.6	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	2.4	0.6	0.2	2.9	0.4	0.2	2.6	1.0	0.1	0.9	0.1	
Delay (s)	36.3	27.3	24.8	33.7	24.6	22.8	33.6	21.0	16.4	35.3	20.6	
Level of Service	D	C	C	C	C	C	C	C	B	D	C	
Approach Delay (s)		28.5			26.6			21.9			23.0	
Approach LOS		C			C			C			C	

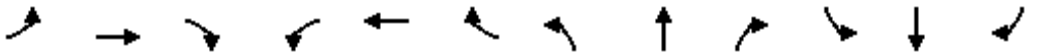
Intersection Summary			
HCM Average Control Delay	24.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	78.0	Sum of lost time (s)	14.0
Intersection Capacity Utilization	61.7%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	307	2	689	0	482	301	0	382	113
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0	4.0		4.0	4.0		4.0	
Lane Util. Factor				0.95	0.91	0.95		0.91	1.00		0.91	
Frt				1.00	0.86	0.85		1.00	0.85		0.97	
Flt Protected				0.95	1.00	1.00		1.00	1.00		1.00	
Satd. Flow (prot)				1698	1472	1519		5136	1599		4960	
Flt Permitted				0.95	1.00	1.00		1.00	1.00		1.00	
Satd. Flow (perm)				1698	1472	1519		5136	1599		4960	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	327	2	733	0	513	320	0	406	120
RTOR Reduction (vph)	0	0	0	0	100	100	0	0	0	0	85	0
Lane Group Flow (vph)	0	0	0	294	287	281	0	513	320	0	441	0
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Split		Perm			Free			
Protected Phases				8	8			2			6	
Permitted Phases						8			Free			
Actuated Green, G (s)				16.1	16.1	16.1		9.9	34.0		9.9	
Effective Green, g (s)				16.1	16.1	16.1		9.9	34.0		9.9	
Actuated g/C Ratio				0.47	0.47	0.47		0.29	1.00		0.29	
Clearance Time (s)				4.0	4.0	4.0		4.0			4.0	
Vehicle Extension (s)				3.0	3.0	3.0		3.0			3.0	
Lane Grp Cap (vph)				804	697	719		1495	1599		1444	
v/s Ratio Prot				0.17	c0.19			c0.10			0.09	
v/s Ratio Perm						0.18			0.20			
v/c Ratio				0.37	0.41	0.39		0.34	0.20		0.31	
Uniform Delay, d1				5.7	5.9	5.8		9.5	0.0		9.4	
Progression Factor				1.00	1.00	1.00		1.00	1.00		1.00	
Incremental Delay, d2				0.3	0.4	0.4		0.1	0.3		0.1	
Delay (s)				6.0	6.3	6.1		9.6	0.3		9.5	
Level of Service				A	A	A		A	A		A	
Approach Delay (s)		0.0			6.1			6.0			9.5	
Approach LOS		A			A			A			A	

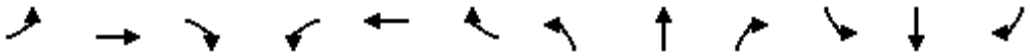
Intersection Summary			
HCM Average Control Delay	6.8	HCM Level of Service	A
HCM Volume to Capacity ratio	0.39		
Actuated Cycle Length (s)	34.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	44.4%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	213	0	161	0	0	0	0	569	364	0	458	232
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0					4.0			4.0	4.0
Lane Util. Factor	1.00		1.00					0.91			0.95	1.00
Frpb, ped/bikes	1.00		1.00					0.99			1.00	0.98
Flpb, ped/bikes	1.00		1.00					1.00			1.00	1.00
Frt	1.00		0.85					0.94			1.00	0.85
Flt Protected	0.95		1.00					1.00			1.00	1.00
Satd. Flow (prot)	1770		1583					4742			3539	1549
Flt Permitted	0.95		1.00					1.00			1.00	1.00
Satd. Flow (perm)	1770		1583					4742			3539	1549
Peak-hour factor, PHF	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Adj. Flow (vph)	248	0	187	0	0	0	0	662	423	0	533	270
RTOR Reduction (vph)	0	0	124	0	0	0	0	166	0	0	0	0
Lane Group Flow (vph)	248	0	63	0	0	0	0	919	0	0	533	270
Confl. Peds. (#/hr)							4		2	2		4
Confl. Bikes (#/hr)									3			
Turn Type	Split		Perm									Free
Protected Phases	8	8						2			6	
Permitted Phases			8									Free
Actuated Green, G (s)	12.8		12.8					17.4			17.4	38.2
Effective Green, g (s)	12.8		12.8					17.4			17.4	38.2
Actuated g/C Ratio	0.34		0.34					0.46			0.46	1.00
Clearance Time (s)	4.0		4.0					4.0			4.0	
Vehicle Extension (s)	3.0		3.0					3.0			3.0	
Lane Grp Cap (vph)	593		530					2160			1612	1549
v/s Ratio Prot	c0.14							c0.19			0.15	
v/s Ratio Perm			0.04									0.17
v/c Ratio	0.42		0.12					0.43			0.33	0.17
Uniform Delay, d1	9.8		8.8					7.0			6.7	0.0
Progression Factor	1.00		1.00					1.00			1.00	1.00
Incremental Delay, d2	0.5		0.1					0.1			0.1	0.2
Delay (s)	10.3		8.9					7.2			6.8	0.2
Level of Service	B		A					A			A	A
Approach Delay (s)		9.7			0.0			7.2			4.6	
Approach LOS		A			A			A			A	

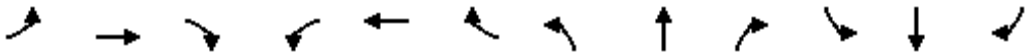
Intersection Summary			
HCM Average Control Delay	6.7	HCM Level of Service	A
HCM Volume to Capacity ratio	0.42		
Actuated Cycle Length (s)	38.2	Sum of lost time (s)	8.0
Intersection Capacity Utilization	37.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	146	1	59	9	8	216	21	571	0	11	516	91
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Lane Util. Factor		1.00		1.00	1.00			0.95		1.00	0.95	
Frpb, ped/bikes		0.99		1.00	0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00		1.00	1.00			1.00		0.95	1.00	
Frt		0.96		1.00	0.86			1.00		1.00	0.98	
Flt Protected		0.97		0.95	1.00			1.00		0.95	1.00	
Satd. Flow (prot)		1697		1751	1557			3499		1671	3415	
Flt Permitted		1.00		0.61	1.00			0.92		0.95	1.00	
Satd. Flow (perm)		1757		1122	1557			3224		1671	3415	
Peak-hour factor, PHF	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Adj. Flow (vph)	172	1	69	11	9	254	25	672	0	13	607	107
RTOR Reduction (vph)	0	14	0	0	199	0	0	0	0	0	12	0
Lane Group Flow (vph)	0	228	0	11	64	0	0	697	0	13	702	0
Confl. Peds. (#/hr)	1		3	3		1			5	5		
Confl. Bikes (#/hr)						1			2			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Perm			Prot		
Protected Phases		3			4			2		1	6	
Permitted Phases	3			4			2					
Actuated Green, G (s)		2.3		11.2	11.2			21.4		0.8	26.2	
Effective Green, g (s)		2.3		11.2	11.2			21.4		0.8	26.2	
Actuated g/C Ratio		0.04		0.22	0.22			0.41		0.02	0.51	
Clearance Time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		78		243	337			1334		26	1731	
v/s Ratio Prot					c0.04					0.01	c0.21	
v/s Ratio Perm		c0.13		0.01				c0.22				
v/c Ratio		2.92		0.05	0.19			0.52		0.50	0.41	
Uniform Delay, d1		24.7		16.0	16.5			11.3		25.3	7.9	
Progression Factor		1.00		1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		897.2		0.1	0.3			0.4		14.3	0.2	
Delay (s)		921.9		16.1	16.8			11.7		39.6	8.1	
Level of Service		F		B	B			B		D	A	
Approach Delay (s)		921.9			16.8			11.7			8.6	
Approach LOS		F			B			B			A	

Intersection Summary			
HCM Average Control Delay	124.8	HCM Level of Service	F
HCM Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	51.7	Sum of lost time (s)	16.0
Intersection Capacity Utilization	67.8%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



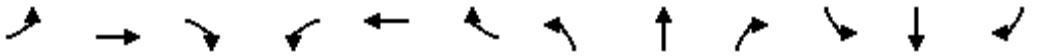
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	156	12	13	60	42	290	14	141	20	47	317	165
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00	1.00	1.00	0.99		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	0.87		1.00	0.98		1.00	0.95	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	3041		1763	3467		1770	3334	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	3041		1763	3467		1770	3334	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	164	13	14	63	44	305	15	148	21	49	334	174
RTOR Reduction (vph)	0	0	14	0	229	0	0	14	0	0	78	0
Lane Group Flow (vph)	164	13	0	63	120	0	15	155	0	49	430	0
Confl. Peds. (#/hr)							16		1	1		16
Confl. Bikes (#/hr)						1			1			
Turn Type	Prot		Perm	Prot			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4									
Actuated Green, G (s)	2.1	1.3	1.3	11.3	10.5		0.3	10.2		3.5	13.4	
Effective Green, g (s)	2.1	1.3	1.3	11.3	10.5		0.3	10.2		3.5	13.4	
Actuated g/C Ratio	0.05	0.03	0.03	0.27	0.25		0.01	0.24		0.08	0.32	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	88	109	49	473	755		13	836		146	1056	
v/s Ratio Prot	c0.09	0.00		0.04	c0.04		0.01	0.04		c0.03	c0.13	
v/s Ratio Perm			0.00									
v/c Ratio	1.86	0.12	0.01	0.13	0.16		1.15	0.18		0.34	0.41	
Uniform Delay, d1	20.1	19.9	19.9	11.8	12.4		21.0	12.7		18.3	11.3	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	428.7	0.5	0.1	0.1	0.1		305.0	0.1		1.4	0.3	
Delay (s)	448.8	20.4	19.9	11.9	12.5		326.0	12.9		19.7	11.6	
Level of Service	F	C	B	B	B		F	B		B	B	
Approach Delay (s)		388.2			12.4			38.4			12.3	
Approach LOS		F			B			D			B	

Intersection Summary			
HCM Average Control Delay	69.3	HCM Level of Service	E
HCM Volume to Capacity ratio	0.44		
Actuated Cycle Length (s)	42.3	Sum of lost time (s)	16.0
Intersection Capacity Utilization	52.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	91	40	284	294	131	56
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.91	0.91	0.91	0.91	0.91	0.91
Hourly flow rate (vph)	100	44	312	323	144	62
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				1133		
pX, platoon unblocked						
vC, conflicting volume			144		1047	100
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			144		1047	100
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			78		26	94
cM capacity (veh/h)			1426		196	950

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2
Volume Total	100	44	312	323	144	62
Volume Left	0	0	312	0	144	0
Volume Right	0	44	0	0	0	62
cSH	1700	1700	1426	1700	196	950
Volume to Capacity	0.06	0.03	0.22	0.19	0.74	0.06
Queue Length 95th (ft)	0	0	21	0	120	5
Control Delay (s)	0.0	0.0	8.2	0.0	62.1	9.1
Lane LOS			A		F	A
Approach Delay (s)	0.0		4.0		46.2	
Approach LOS					E	

Intersection Summary			
Average Delay	12.3		
Intersection Capacity Utilization	36.3%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	106	49	1	1	179	462	8	11	2	95	8	44
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	1.00		1.00	0.89		1.00	0.98			0.96	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.97	
Satd. Flow (prot)	1626	1707		1626	1527		1626	1675			1591	
Flt Permitted	0.95	1.00		0.95	1.00		0.69	1.00			0.80	
Satd. Flow (perm)	1626	1707		1626	1527		1188	1675			1308	
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	120	56	1	1	203	525	9	12	2	108	9	50
RTOR Reduction (vph)	0	0	0	0	130	0	0	2	0	0	29	0
Lane Group Flow (vph)	120	57	0	1	598	0	9	12	0	0	138	0
Heavy Vehicles (%)	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	4.8	30.3		0.9	26.4		8.3	8.3			8.3	
Effective Green, g (s)	4.8	30.3		0.9	26.4		8.3	8.3			8.3	
Actuated g/C Ratio	0.09	0.59		0.02	0.51		0.16	0.16			0.16	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	152	1004		28	783		191	270			211	
v/s Ratio Prot	c0.07	c0.03		0.00	c0.39			0.01				
v/s Ratio Perm							0.01				c0.11	
v/c Ratio	0.79	0.06		0.04	0.76		0.05	0.05			0.65	
Uniform Delay, d1	22.9	4.5		24.9	10.1		18.3	18.3			20.2	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	23.2	0.0		0.5	4.5		0.1	0.1			7.0	
Delay (s)	46.1	4.5		25.4	14.5		18.4	18.3			27.3	
Level of Service	D	A		C	B		B	B			C	
Approach Delay (s)		32.7			14.5			18.3			27.3	
Approach LOS		C			B			B			C	

Intersection Summary			
HCM Average Control Delay	19.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	51.5	Sum of lost time (s)	16.0
Intersection Capacity Utilization	68.7%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	96	51	53	518	125	40
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	104	55	58	563	136	43
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)	322					
pX, platoon unblocked						
vC, conflicting volume			104		810	132
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			104		810	132
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			96		60	95
cM capacity (veh/h)			1487		336	917

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	160	58	563	179
Volume Left	0	58	0	136
Volume Right	55	0	0	43
cSH	1700	1487	1700	397
Volume to Capacity	0.09	0.04	0.33	0.45
Queue Length 95th (ft)	0	3	0	57
Control Delay (s)	0.0	7.5	0.0	21.4
Lane LOS		A		C
Approach Delay (s)	0.0	0.7		21.4
Approach LOS				C

Intersection Summary			
Average Delay	4.4		
Intersection Capacity Utilization	43.3%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	315	54	83	86	349	545
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.78	0.78	0.78	0.78	0.78	0.78
Hourly flow rate (vph)	404	69	106	110	447	699
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			473		762	438
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			473		762	438
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			90		0	0
cM capacity (veh/h)			1089		337	618

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	473	106	110	1146
Volume Left	0	106	0	447
Volume Right	69	0	0	699
cSH	1700	1089	1700	466
Volume to Capacity	0.28	0.10	0.06	2.46
Queue Length 95th (ft)	0	8	0	2245
Control Delay (s)	0.0	8.7	0.0	682.1
Lane LOS		A		F
Approach Delay (s)	0.0	4.3		682.1
Approach LOS				F

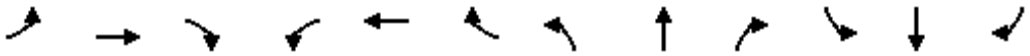
Intersection Summary			
Average Delay	426.3		
Intersection Capacity Utilization	87.3%	ICU Level of Service	E
Analysis Period (min)	15		

Intersection	
Intersection Delay (sec/veh)	49.4
Intersection LOS	E

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Volume (vph)	0	10	7	400	0	5	9	154	62	476	401	3
Peak Hour Factor	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Heavy Vehicles(%)	2	2	2	2	2	2	2	2	2	2	2	2
Movement Flow Rate	0	12	8	471	0	6	11	181	73	560	472	4
Number of Lanes	0	1	0	1	1	0	1	2	0	1	2	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	2	1	3	3
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	3	3	1	2
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	3	3	2	1
HCM Control Delay	12.9	73.3	15.1	47.8
HCM LOS	B	F	C	E

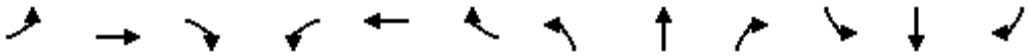
Lane	NBLn1	NBLn2	NBLn3	EBLn1	WBLn1	WBLn2	SBLn1	SBLn2	SBLn3
Volume Left (%)	100%	0%	0%	0%	100%	0%	100%	0%	0%
Volume Thru (%)	0%	100%	45%	59%	0%	0%	0%	100%	98%
Volume Right (%)	0%	0%	55%	41%	0%	100%	0%	0%	2%
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Traffic Volume by Lane	9	103	113	17	400	5	476	267	137
Left Turning Volume	0	103	51	10	0	0	0	267	134
Through Volume	0	0	62	7	0	5	0	0	3
Right Turning Volume	9	0	0	0	400	0	476	0	0
Lane Flow Rate	11	121	133	20	471	6	560	315	161
Geometry Group	8	8	8	8	8	8	8	8	8
Degree of Utilization, X	0.028	0.297	0.314	0.053	1	0.012	1	0.659	0.336
Departure Headway, Hd	9.365	8.867	8.485	9.601	8.684	7.496	8.036	7.539	7.523
Convergence(Y/N)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capacity	383	407	425	374	419	477	454	481	479
Service Time	7.094	6.596	6.214	7.343	6.43	5.241	5.756	5.258	5.243
HCM Lane V/C Ratio	0.029	0.297	0.313	0.053	1.124	0.013	1.233	0.655	0.336
HCM Control Delay	12.4	15.3	15.1	12.9	74.1	10.3	71	23.7	14
HCM Lane LOS	B	C	C	B	F	B	F	C	B
HCM 95th Percentile Queue	0.1	1.3	1.4	0.2	96.3	0	100.3	5.8	1.5



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	91	0	432	6	802	0	0	134	287
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor				1.00	1.00		1.00	0.95			0.95	
Frpb, ped/bikes				1.00	1.00		1.00	1.00			0.99	
Flpb, ped/bikes				1.00	1.00		1.00	1.00			1.00	
Frt				1.00	0.85		1.00	1.00			0.90	
Flt Protected				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)				1787	1599		1787	3574			3163	
Flt Permitted				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (perm)				1787	1599		1787	3574			3163	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	96	0	455	6	844	0	0	141	302
RTOR Reduction (vph)	0	0	0	0	231	0	0	0	0	0	170	0
Lane Group Flow (vph)	0	0	0	96	224	0	6	844	0	0	273	0
Confl. Peds. (#/hr)							1		2	2		1
Confl. Bikes (#/hr)			1						1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Split			Prot					
Protected Phases				8	8		5	2			6	
Permitted Phases												
Actuated Green, G (s)				2.2	2.2		2.2	18.9			12.7	
Effective Green, g (s)				2.2	2.2		2.2	18.9			12.7	
Actuated g/C Ratio				0.08	0.08		0.08	0.65			0.44	
Clearance Time (s)				4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)				3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)				135	121		135	2321			1380	
v/s Ratio Prot				0.05	c0.14		0.00	c0.24			0.09	
v/s Ratio Perm												
v/c Ratio				0.71	1.85		0.04	0.36			0.20	
Uniform Delay, d1				13.1	13.5		12.5	2.3			5.1	
Progression Factor				1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2				16.2	412.7		0.1	0.1			0.1	
Delay (s)				29.3	426.2		12.6	2.4			5.1	
Level of Service				C	F		B	A			A	
Approach Delay (s)		0.0			357.0			2.5			5.1	
Approach LOS		A			F			A			A	

Intersection Summary			
HCM Average Control Delay	109.1	HCM Level of Service	F
HCM Volume to Capacity ratio	0.52		
Actuated Cycle Length (s)	29.1	Sum of lost time (s)	8.0
Intersection Capacity Utilization	55.6%	ICU Level of Service	B
Analysis Period (min)	15		

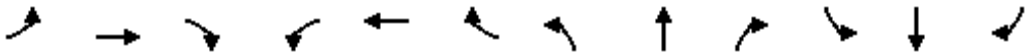
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	25	163	59	325	252	39	306	175	753	15	37	38
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		0.95	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	0.99		1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Frt	1.00	0.96		1.00	0.99		1.00	1.00	0.85		0.94	
Flt Protected	0.95	1.00		0.95	0.99		0.95	0.99	1.00		0.99	
Satd. Flow (prot)	1787	3431		1626	3326		1698	1762	1576		1759	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	0.99	1.00		0.99	
Satd. Flow (perm)	1787	3431		1626	3326		1698	1762	1576		1759	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	26	168	61	335	260	40	315	180	776	15	38	39
RTOR Reduction (vph)	0	40	0	0	8	0	0	0	536	0	31	0
Lane Group Flow (vph)	26	189	0	208	419	0	243	252	240	0	61	0
Confl. Peds. (#/hr)									2	2		
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Split			Split			Split		Perm	Split		
Protected Phases	4	4		8	8		2	2		6	6	
Permitted Phases									2			
Actuated Green, G (s)	9.6	9.6		14.8	14.8		21.0	21.0	21.0		6.4	
Effective Green, g (s)	9.6	9.6		14.8	14.8		21.0	21.0	21.0		6.4	
Actuated g/C Ratio	0.14	0.14		0.22	0.22		0.31	0.31	0.31		0.09	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	253	486		355	726		526	546	488		166	
v/s Ratio Prot	0.01	c0.05		c0.13	0.13		0.14	0.14			c0.03	
v/s Ratio Perm									c0.15			
v/c Ratio	0.10	0.39		0.59	0.58		0.46	0.46	0.49		0.37	
Uniform Delay, d1	25.3	26.4		23.8	23.7		18.8	18.8	19.1		28.8	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Incremental Delay, d2	0.2	0.5		2.5	1.1		0.6	0.6	0.8		1.4	
Delay (s)	25.5	26.9		26.2	24.8		19.5	19.5	19.8		30.2	
Level of Service	C	C		C	C		B	B	B		C	
Approach Delay (s)		26.8			25.3			19.7			30.2	
Approach LOS		C			C			B			C	

Intersection Summary			
HCM Average Control Delay	22.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.48		
Actuated Cycle Length (s)	67.8	Sum of lost time (s)	16.0
Intersection Capacity Utilization	68.3%	ICU Level of Service	C
Analysis Period (min)	15		

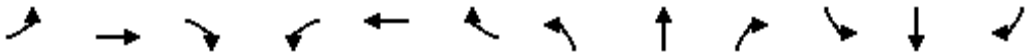
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	917	70	53	451	0	0	0	0	283	1	234
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		0.95			0.95						1.00	
Frpb, ped/bikes		1.00			1.00						1.00	
Flpb, ped/bikes		1.00			1.00						1.00	
Frt		0.99			1.00						0.94	
Flt Protected		1.00			0.99						0.97	
Satd. Flow (prot)		3528			3555						1719	
Flt Permitted		1.00			0.73						0.97	
Satd. Flow (perm)		3528			2623						1719	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	0	955	73	55	470	0	0	0	0	295	1	244
RTOR Reduction (vph)	0	13	0	0	0	0	0	0	0	0	27	0
Lane Group Flow (vph)	0	1015	0	0	525	0	0	0	0	0	513	0
Confl. Peds. (#/hr)	3		8	8		3						
Confl. Bikes (#/hr)						3						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Perm						Split		
Protected Phases		4			8					6	6	
Permitted Phases				8								
Actuated Green, G (s)		33.1			33.1						33.9	
Effective Green, g (s)		33.1			33.1						33.9	
Actuated g/C Ratio		0.44			0.44						0.45	
Clearance Time (s)		4.0			4.0						4.0	
Vehicle Extension (s)		3.0			3.0						3.0	
Lane Grp Cap (vph)		1557			1158						777	
v/s Ratio Prot		c0.29									c0.30	
v/s Ratio Perm					0.20							
v/c Ratio		0.65			0.45						0.66	
Uniform Delay, d1		16.4			14.6						16.0	
Progression Factor		1.00			0.88						1.00	
Incremental Delay, d2		1.0			0.3						4.4	
Delay (s)		17.4			13.1						20.4	
Level of Service		B			B						C	
Approach Delay (s)		17.4			13.1			0.0			20.4	
Approach LOS		B			B			A			C	

Intersection Summary			
HCM Average Control Delay	17.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.66		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	82.4%	ICU Level of Service	E
Analysis Period (min)	15		

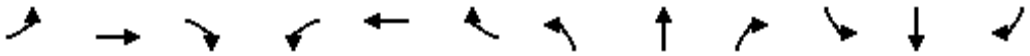
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	516	684	0	0	443	377	61	141	100	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor		0.95			0.95		0.95	0.95	1.00			
Frpb, ped/bikes		1.00			0.99		1.00	1.00	1.00			
Flpb, ped/bikes		1.00			1.00		1.00	1.00	1.00			
Frt		1.00			0.93		1.00	1.00	0.85			
Flt Protected		0.98			1.00		0.95	1.00	1.00			
Satd. Flow (prot)		3498			3292		1698	1784	1599			
Flt Permitted		0.55			1.00		0.95	1.00	1.00			
Satd. Flow (perm)		1963			3292		1698	1784	1599			
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	538	712	0	0	461	393	64	147	104	0	0	0
RTOR Reduction (vph)	0	0	0	0	122	0	0	0	83	0	0	0
Lane Group Flow (vph)	0	1250	0	0	732	0	58	153	21	0	0	0
Confl. Peds. (#/hr)	2		7	7		2						
Confl. Bikes (#/hr)						3						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm						Split		Prot			
Protected Phases		4			8		2	2	2			
Permitted Phases	4											
Actuated Green, G (s)		51.7			51.7		15.3	15.3	15.3			
Effective Green, g (s)		51.7			51.7		15.3	15.3	15.3			
Actuated g/C Ratio		0.69			0.69		0.20	0.20	0.20			
Clearance Time (s)		4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)		3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)		1353			2269		346	364	326			
v/s Ratio Prot					0.22		0.03	c0.09	0.01			
v/s Ratio Perm		c0.64										
v/c Ratio		1.35dl			0.32		0.17	0.42	0.07			
Uniform Delay, d1		10.0			4.7		24.6	26.0	24.1			
Progression Factor		0.75			1.00		1.00	1.00	1.00			
Incremental Delay, d2		9.7			0.1		1.0	3.5	0.4			
Delay (s)		17.3			4.7		25.6	29.5	24.5			
Level of Service		B			A		C	C	C			
Approach Delay (s)		17.3			4.7			27.1			0.0	
Approach LOS		B			A			C			A	

Intersection Summary			
HCM Average Control Delay	14.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.81		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	77.0%	ICU Level of Service	D
Analysis Period (min)	15		

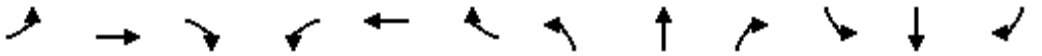
dl Defacto Left Lane. Recode with 1 though lane as a left lane.
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	146	1	59	9	8	216	21	571	0	11	516	91
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00			0.95		1.00	0.95	
Frpb, ped/bikes	1.00	0.99		1.00	0.99			1.00		1.00	1.00	
Flpb, ped/bikes	1.00	1.00		0.95	1.00			1.00		0.94	1.00	
Frt	1.00	0.85		1.00	0.86			1.00		1.00	0.98	
Flt Protected	0.95	1.00		0.95	1.00			1.00		0.95	1.00	
Satd. Flow (prot)	1752	1550		1664	1557			3499		1649	3415	
Flt Permitted	0.95	1.00		0.95	1.00			0.92		0.95	1.00	
Satd. Flow (perm)	1752	1550		1664	1557			3208		1649	3415	
Peak-hour factor, PHF	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Adj. Flow (vph)	172	1	69	11	9	254	25	672	0	13	607	107
RTOR Reduction (vph)	0	39	0	0	117	0	0	0	0	0	13	0
Lane Group Flow (vph)	172	31	0	11	146	0	0	697	0	13	701	0
Confl. Peds. (#/hr)	1		3	3		1			5	5		
Confl. Bikes (#/hr)						1			2			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Prot			Prot			Perm			Prot		
Protected Phases	3	8		7	4			2		1	6	
Permitted Phases							2					
Actuated Green, G (s)	11.3	28.7		0.2	17.6			20.3		0.2	24.5	
Effective Green, g (s)	11.3	28.7		0.2	17.6			20.3		0.2	24.5	
Actuated g/C Ratio	0.17	0.44		0.00	0.27			0.31		0.00	0.37	
Clearance Time (s)	4.0	4.0		4.0	4.0			4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)	303	680		5	419			996		5	1279	
v/s Ratio Prot	c0.10	0.02		0.01	c0.09					0.01	c0.21	
v/s Ratio Perm								c0.22				
v/c Ratio	0.57	0.05		2.20	0.35			0.70		2.60	0.55	
Uniform Delay, d1	24.8	10.5		32.6	19.3			19.9		32.6	16.1	
Progression Factor	1.00	1.00		1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2	2.4	0.0		925.2	0.5			2.2		1102.2	0.5	
Delay (s)	27.2	10.5		957.8	19.8			22.0		1134.8	16.6	
Level of Service	C	B		F	B			C		F	B	
Approach Delay (s)		22.4			57.4			22.0			36.6	
Approach LOS		C			E			C			D	

Intersection Summary			
HCM Average Control Delay	32.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.56		
Actuated Cycle Length (s)	65.4	Sum of lost time (s)	16.0
Intersection Capacity Utilization	63.9%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

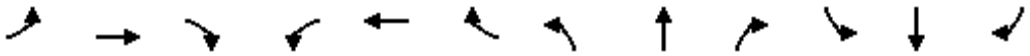


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	156	12	13	60	42	290	14	141	20	47	317	165
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00	1.00	1.00	0.99		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	0.87		1.00	0.98		1.00	0.95	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	3040		1762	3467		1770	3333	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	3040		1762	3467		1770	3333	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	164	13	14	63	44	305	15	148	21	49	334	174
RTOR Reduction (vph)	0	0	10	0	241	0	0	12	0	0	81	0
Lane Group Flow (vph)	164	13	4	63	108	0	15	157	0	49	427	0
Confl. Peds. (#/hr)							16		1	1		16
Confl. Bikes (#/hr)						1			1			
Turn Type	Prot		Perm	Prot			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4									
Actuated Green, G (s)	7.9	13.2	13.2	4.9	10.2		0.5	12.1		2.5	14.1	
Effective Green, g (s)	7.9	13.2	13.2	4.9	10.2		0.5	12.1		2.5	14.1	
Actuated g/C Ratio	0.16	0.27	0.27	0.10	0.21		0.01	0.25		0.05	0.29	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	287	959	429	178	637		18	861		91	965	
v/s Ratio Prot	c0.09	c0.00		0.04	c0.04		0.01	0.05		c0.03	c0.13	
v/s Ratio Perm			0.00									
v/c Ratio	0.57	0.01	0.01	0.35	0.17		0.83	0.18		0.54	0.44	
Uniform Delay, d1	18.8	13.0	13.0	20.4	15.8		24.1	14.4		22.5	14.1	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	2.7	0.0	0.0	1.2	0.1		131.9	0.1		6.0	0.3	
Delay (s)	21.6	13.0	13.0	21.6	15.9		156.0	14.5		28.5	14.4	
Level of Service	C	B	B	C	B		F	B		C	B	
Approach Delay (s)		20.4			16.8			26.0			15.7	
Approach LOS		C			B			C			B	

Intersection Summary			
HCM Average Control Delay	18.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.39		
Actuated Cycle Length (s)	48.7	Sum of lost time (s)	16.0
Intersection Capacity Utilization	52.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

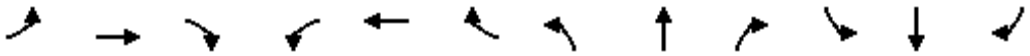
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	315	54	83	86	349	545
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0	4.0	4.0	4.0
Lane Util. Factor	1.00		1.00	1.00	1.00	1.00
Frt	0.98		1.00	1.00	1.00	0.85
Flt Protected	1.00		0.95	1.00	0.95	1.00
Satd. Flow (prot)	1826		1770	1863	1770	1583
Flt Permitted	1.00		0.20	1.00	0.95	1.00
Satd. Flow (perm)	1826		365	1863	1770	1583
Peak-hour factor, PHF	0.78	0.78	0.78	0.78	0.78	0.78
Adj. Flow (vph)	404	69	106	110	447	699
RTOR Reduction (vph)	10	0	0	0	0	216
Lane Group Flow (vph)	463	0	106	110	447	483
Turn Type			pm+pt			Perm
Protected Phases	4		3	8	2	
Permitted Phases			8			2
Actuated Green, G (s)	16.5		23.4	23.4	19.7	19.7
Effective Green, g (s)	16.5		23.4	23.4	19.7	19.7
Actuated g/C Ratio	0.32		0.46	0.46	0.39	0.39
Clearance Time (s)	4.0		4.0	4.0	4.0	4.0
Vehicle Extension (s)	3.0		3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	590		247	853	682	610
v/s Ratio Prot	c0.25		c0.02	0.06	0.25	
v/s Ratio Perm			0.17			c0.30
v/c Ratio	0.78		0.43	0.13	0.66	0.79
Uniform Delay, d1	15.7		9.7	8.0	12.9	13.9
Progression Factor	1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2	6.8		1.2	0.1	2.3	6.9
Delay (s)	22.5		10.9	8.0	15.2	20.8
Level of Service	C		B	A	B	C
Approach Delay (s)	22.5			9.4	18.6	
Approach LOS	C			A	B	

Intersection Summary			
HCM Average Control Delay	18.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.77		
Actuated Cycle Length (s)	51.1	Sum of lost time (s)	12.0
Intersection Capacity Utilization	60.3%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	10	7	400	0	5	9	154	62	476	401	3
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00		1.00	1.00		1.00	0.95		0.97	1.00	
Frpb, ped/bikes		0.99		1.00	1.00		1.00	1.00		1.00	1.00	
Flpb, ped/bikes		1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Frt		0.95		1.00	0.85		1.00	0.96		1.00	1.00	
Flt Protected		1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1751		1765	1583		1770	3387		3433	1860	
Flt Permitted		1.00		0.74	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)		1751		1383	1583		1770	3387		3433	1860	
Peak-hour factor, PHF	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Adj. Flow (vph)	0	12	8	471	0	6	11	181	73	560	472	4
RTOR Reduction (vph)	0	5	0	0	4	0	0	48	0	0	1	0
Lane Group Flow (vph)	0	15	0	471	2	0	11	206	0	560	475	0
Confl. Peds. (#/hr)			2	2								
Confl. Bikes (#/hr)			1									
Turn Type	Perm			Perm			Prot			Prot		
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8								
Actuated Green, G (s)		28.6		28.6	28.6		0.6	14.1		16.3	29.8	
Effective Green, g (s)		28.6		28.6	28.6		0.6	14.1		16.3	29.8	
Actuated g/C Ratio		0.40		0.40	0.40		0.01	0.20		0.23	0.42	
Clearance Time (s)		4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		705		557	638		15	673		788	781	
v/s Ratio Prot		0.01			0.00		0.01	0.06		c0.16	c0.26	
v/s Ratio Perm				c0.34								
v/c Ratio		0.02		0.85	0.00		0.73	0.31		0.71	0.61	
Uniform Delay, d1		12.8		19.2	12.7		35.1	24.3		25.2	16.1	
Progression Factor		1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.0		11.3	0.0		103.2	0.3		3.0	1.4	
Delay (s)		12.8		30.5	12.7		138.4	24.5		28.2	17.4	
Level of Service		B		C	B		F	C		C	B	
Approach Delay (s)		12.8			30.3			29.3			23.3	
Approach LOS		B			C			C			C	

Intersection Summary			
HCM Average Control Delay	25.9	HCM Level of Service	C
HCM Volume to Capacity ratio	0.73		
Actuated Cycle Length (s)	71.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	63.4%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	91	0	432	6	802	0	0	134	287
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor				1.00	1.00		1.00	0.95			0.95	
Frpb, ped/bikes				1.00	1.00		1.00	1.00			0.99	
Flpb, ped/bikes				1.00	1.00		1.00	1.00			1.00	
Frt				1.00	0.85		1.00	1.00			0.90	
Flt Protected				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)				1787	1599		1787	3574			3162	
Flt Permitted				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (perm)				1787	1599		1787	3574			3162	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	96	0	455	6	844	0	0	141	302
RTOR Reduction (vph)	0	0	0	0	123	0	0	0	0	0	194	0
Lane Group Flow (vph)	0	0	0	96	332	0	6	844	0	0	249	0
Confl. Peds. (#/hr)							1		2	2		1
Confl. Bikes (#/hr)			1						1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Split			Prot					
Protected Phases				8	8		5	2			6	
Permitted Phases												
Actuated Green, G (s)				13.8	13.8		2.6	22.4			15.8	
Effective Green, g (s)				13.8	13.8		2.6	22.4			15.8	
Actuated g/C Ratio				0.31	0.31		0.06	0.51			0.36	
Clearance Time (s)				4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)				3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)				558	499		105	1811			1130	
v/s Ratio Prot				0.05	c0.21		0.00	c0.24			0.08	
v/s Ratio Perm												
v/c Ratio				0.17	0.67		0.06	0.47			0.22	
Uniform Delay, d1				11.0	13.2		19.6	7.0			9.9	
Progression Factor				1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2				0.1	3.3		0.2	0.2			0.1	
Delay (s)				11.2	16.5		19.9	7.2			10.0	
Level of Service				B	B		B	A			B	
Approach Delay (s)		0.0			15.6			7.3			10.0	
Approach LOS		A			B			A			B	

Intersection Summary			
HCM Average Control Delay	10.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	44.2	Sum of lost time (s)	8.0
Intersection Capacity Utilization	55.6%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

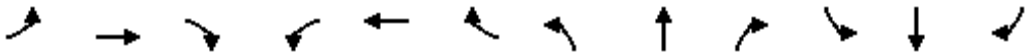
Near-Term (2018) No Project Conditions

FEHR PEERS

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	80	280	80	290	360	130	50	270	150	70	660	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frpb, ped/bikes	1.00	1.00	0.98	1.00	1.00	0.98	1.00	1.00	0.98	1.00	1.00	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1736	3471	1518	1736	3471	1516	1736	3471	1530	1736	3431	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1736	3471	1518	1736	3471	1516	1736	3471	1530	1736	3431	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	87	304	87	315	391	141	54	293	163	76	717	54
RTOR Reduction (vph)	0	0	59	0	0	92	0	0	120	0	7	0
Lane Group Flow (vph)	87	304	28	315	391	49	54	293	43	76	764	0
Confl. Peds. (#/hr)	14		13	13		14	4		4	4		4
Confl. Bikes (#/hr)						1						1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases			2			6			8			
Actuated Green, G (s)	6.1	15.2	15.2	14.5	21.6	21.6	2.1	16.9	16.9	4.2	19.0	
Effective Green, g (s)	6.1	15.2	15.2	14.5	21.6	21.6	2.1	16.9	16.9	4.2	19.0	
Actuated g/C Ratio	0.10	0.24	0.24	0.23	0.34	0.34	0.03	0.26	0.26	0.07	0.30	
Clearance Time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Vehicle Extension (s)	2.0	4.0	4.0	2.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	
Lane Grp Cap (vph)	166	827	362	395	1175	513	57	919	405	114	1022	
v/s Ratio Prot	0.05	0.09		c0.18	c0.11		c0.03	0.08		0.04	c0.22	
v/s Ratio Perm			0.02			0.03			0.03			
v/c Ratio	0.52	0.37	0.08	0.80	0.33	0.10	0.95	0.32	0.11	0.67	0.75	
Uniform Delay, d1	27.5	20.3	18.9	23.3	15.7	14.4	30.8	18.8	17.7	29.1	20.2	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	1.4	0.4	0.1	10.0	0.2	0.1	98.4	0.1	0.0	10.8	2.6	
Delay (s)	28.8	20.7	19.0	33.3	16.0	14.5	129.2	18.9	17.8	40.0	22.9	
Level of Service	C	C	B	C	B	B	F	B	B	D	C	
Approach Delay (s)		21.8			22.2			30.2			24.4	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	24.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.58		
Actuated Cycle Length (s)	63.8	Sum of lost time (s)	6.0
Intersection Capacity Utilization	65.2%	ICU Level of Service	C
Analysis Period (min)	15		

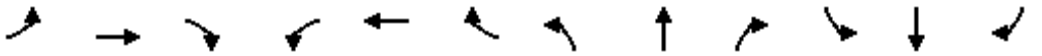
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	330	10	190	0	270	140	0	790	250
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0	4.0		4.0	4.0		4.0	
Lane Util. Factor				0.95	0.91	0.95		0.91	1.00		0.91	
Frpb, ped/bikes				1.00	1.00	0.99		1.00	0.98		0.99	
Flpb, ped/bikes				1.00	1.00	1.00		1.00	1.00		1.00	
Frt				1.00	0.98	0.85		1.00	0.85		0.96	
Flt Protected				0.95	0.96	1.00		1.00	1.00		1.00	
Satd. Flow (prot)				1665	1576	1471		5036	1535		4827	
Flt Permitted				0.95	0.96	1.00		1.00	1.00		1.00	
Satd. Flow (perm)				1665	1576	1471		5036	1535		4827	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	351	11	202	0	287	149	0	840	266
RTOR Reduction (vph)	0	0	0	0	13	116	0	0	0	0	77	0
Lane Group Flow (vph)	0	0	0	197	180	58	0	287	149	0	1029	0
Confl. Peds. (#/hr)	1					1	2		1	1		2
Confl. Bikes (#/hr)									2			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type				Split		Perm			Free			
Protected Phases				8	8			2			6	
Permitted Phases						8			Free			
Actuated Green, G (s)				12.9	12.9	12.9		17.6	38.5		17.6	
Effective Green, g (s)				12.9	12.9	12.9		17.6	38.5		17.6	
Actuated g/C Ratio				0.34	0.34	0.34		0.46	1.00		0.46	
Clearance Time (s)				4.0	4.0	4.0		4.0			4.0	
Vehicle Extension (s)				3.0	3.0	3.0		3.0			3.0	
Lane Grp Cap (vph)				558	528	493		2302	1535		2207	
v/s Ratio Prot				c0.12	0.11			0.06			c0.21	
v/s Ratio Perm						0.04			0.10			
v/c Ratio				0.35	0.34	0.12		0.12	0.10		0.47	
Uniform Delay, d1				9.7	9.6	8.9		6.0	0.0		7.2	
Progression Factor				1.00	1.00	1.00		1.00	1.00		1.00	
Incremental Delay, d2				0.4	0.4	0.1		0.0	0.1		0.2	
Delay (s)				10.0	10.0	9.0		6.0	0.1		7.4	
Level of Service				B	A	A		A	A		A	
Approach Delay (s)		0.0			9.7			4.0			7.4	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	7.3	HCM Level of Service	A
HCM Volume to Capacity ratio	0.42		
Actuated Cycle Length (s)	38.5	Sum of lost time (s)	8.0
Intersection Capacity Utilization	39.4%	ICU Level of Service	A
Analysis Period (min)	15		

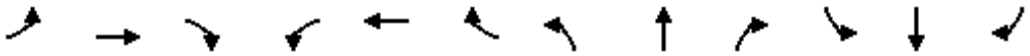
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	80	0	130	0	0	0	0	330	330	0	550	570
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0					4.0			4.0	4.0
Lane Util. Factor	1.00		1.00					0.91			0.95	1.00
Frpb, ped/bikes	1.00		1.00					0.99			1.00	0.98
Flpb, ped/bikes	1.00		1.00					1.00			1.00	1.00
Frt	1.00		0.85					0.93			1.00	0.85
Flt Protected	0.95		1.00					1.00			1.00	1.00
Satd. Flow (prot)	1752		1568					4602			3505	1536
Flt Permitted	0.95		1.00					1.00			1.00	1.00
Satd. Flow (perm)	1752		1568					4602			3505	1536
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	87	0	141	0	0	0	0	359	359	0	598	620
RTOR Reduction (vph)	0	0	92	0	0	0	0	198	0	0	0	0
Lane Group Flow (vph)	87	0	49	0	0	0	0	520	0	0	598	620
Confl. Peds. (#/hr)							1		3	3		1
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Split		Perm									Free
Protected Phases	8	8						2			6	
Permitted Phases			8									Free
Actuated Green, G (s)	7.7		7.7					12.8			12.8	28.5
Effective Green, g (s)	7.7		7.7					12.8			12.8	28.5
Actuated g/C Ratio	0.27		0.27					0.45			0.45	1.00
Clearance Time (s)	4.0		4.0					4.0			4.0	
Vehicle Extension (s)	3.0		3.0					3.0			3.0	
Lane Grp Cap (vph)	473		424					2067			1574	1536
v/s Ratio Prot	0.05							0.11			0.17	
v/s Ratio Perm			0.03									c0.40
v/c Ratio	0.18		0.12					0.25			0.38	0.40
Uniform Delay, d1	8.0		7.8					4.9			5.2	0.0
Progression Factor	1.00		1.00					1.00			1.00	1.00
Incremental Delay, d2	0.2		0.1					0.1			0.2	0.8
Delay (s)	8.2		8.0					4.9			5.4	0.8
Level of Service	A		A					A			A	A
Approach Delay (s)		8.0			0.0			4.9			3.0	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	4.2	HCM Level of Service	A
HCM Volume to Capacity ratio	0.40		
Actuated Cycle Length (s)	28.5	Sum of lost time (s)	0.0
Intersection Capacity Utilization	30.0%	ICU Level of Service	A
Analysis Period (min)	15		

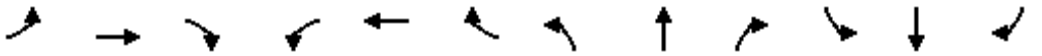
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	50	20	30	10	10	30	30	580	20	290	280	110
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Lane Util. Factor		1.00		1.00	1.00			0.95		1.00	0.95	
Frpb, ped/bikes		1.00		1.00	0.99			1.00		1.00	0.99	
Flpb, ped/bikes		1.00		1.00	1.00			1.00		1.00	1.00	
Frt		0.96		1.00	0.89			1.00		1.00	0.96	
Flt Protected		0.98		0.95	1.00			1.00		0.95	1.00	
Satd. Flow (prot)		1709		1736	1605			3446		1736	3302	
Flt Permitted		1.00		0.69	1.00			0.92		0.95	1.00	
Satd. Flow (perm)		1751		1255	1605			3181		1736	3302	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	54	22	33	11	11	33	33	630	22	315	304	120
RTOR Reduction (vph)	0	16	0	0	28	0	0	2	0	0	26	0
Lane Group Flow (vph)	0	93	0	11	16	0	0	683	0	315	398	0
Confl. Peds. (#/hr)	3					3	2					2
Confl. Bikes (#/hr)												1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm			Perm			Perm			Prot		
Protected Phases		3			4			2		1	6	
Permitted Phases	3			4			2					
Actuated Green, G (s)		2.2		8.4	8.4			21.7		11.9	37.6	
Effective Green, g (s)		2.2		8.4	8.4			21.7		11.9	37.6	
Actuated g/C Ratio		0.04		0.14	0.14			0.36		0.20	0.62	
Clearance Time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		64		175	224			1147		343	2062	
v/s Ratio Prot					c0.01					c0.18	0.12	
v/s Ratio Perm		c0.05		0.01				c0.21				
v/c Ratio		1.45		0.06	0.07			0.60		0.92	0.19	
Uniform Delay, d1		29.0		22.5	22.5			15.7		23.7	4.8	
Progression Factor		1.00		1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		269.3		0.2	0.1			0.8		28.5	0.0	
Delay (s)		298.3		22.6	22.6			16.5		52.1	4.9	
Level of Service		F		C	C			B		D	A	
Approach Delay (s)		298.3			22.6			16.5			25.0	
Approach LOS		F			C			B			C	

Intersection Summary			
HCM Average Control Delay	40.0	HCM Level of Service	D
HCM Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	60.2	Sum of lost time (s)	16.0
Intersection Capacity Utilization	56.2%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group



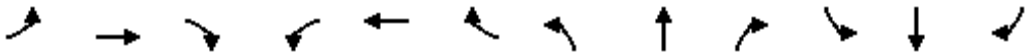
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	220	40	20	20	10	40	10	370	110	40	100	160
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00	1.00	1.00	0.96		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	0.88		1.00	0.97		1.00	0.91	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	2995		1767	3407		1770	3183	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	2995		1767	3407		1770	3183	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	239	43	22	22	11	43	11	402	120	43	109	174
RTOR Reduction (vph)	0	0	14	0	38	0	0	35	0	0	122	0
Lane Group Flow (vph)	239	43	8	22	16	0	11	487	0	43	161	0
Confl. Peds. (#/hr)	3					3	4					4
Confl. Bikes (#/hr)						20			1			1
Turn Type	Prot		Perm	Prot			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4									
Actuated Green, G (s)	13.1	19.0	19.0	0.6	6.5		0.5	14.2		1.7	15.4	
Effective Green, g (s)	13.1	19.0	19.0	0.6	6.5		0.5	14.2		1.7	15.4	
Actuated g/C Ratio	0.25	0.37	0.37	0.01	0.13		0.01	0.28		0.03	0.30	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	450	1306	584	21	378		17	939		58	952	
v/s Ratio Prot	c0.14	c0.01		0.01	0.01		0.01	c0.14		c0.02	0.05	
v/s Ratio Perm			0.01									
v/c Ratio	0.53	0.03	0.01	1.05	0.04		0.65	0.52		0.74	0.17	
Uniform Delay, d1	16.6	10.4	10.3	25.4	19.8		25.4	15.8		24.7	13.3	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	1.2	0.0	0.0	212.0	0.0		62.0	0.5		39.6	0.1	
Delay (s)	17.8	10.4	10.3	237.5	19.8		87.4	16.2		64.3	13.4	
Level of Service	B	B	B	F	B		F	B		E	B	
Approach Delay (s)		16.2			82.8			17.7			20.1	
Approach LOS		B			F			B			C	

Intersection Summary			
HCM Average Control Delay	22.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.40		
Actuated Cycle Length (s)	51.5	Sum of lost time (s)	12.0
Intersection Capacity Utilization	45.9%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	200	120	50	110	60	70
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	217	130	54	120	65	76
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				1133		
pX, platoon unblocked						
vC, conflicting volume			348		446	217
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			348		446	217
tC, single (s)			4.2		6.5	6.3
tC, 2 stage (s)						
tF (s)			2.3		3.6	3.4
p0 queue free %			95		88	91
cM capacity (veh/h)			1168		530	803

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2
Volume Total	217	130	54	120	65	76
Volume Left	0	0	54	0	65	0
Volume Right	0	130	0	0	0	76
cSH	1700	1700	1168	1700	530	803
Volume to Capacity	0.13	0.08	0.05	0.07	0.12	0.09
Queue Length 95th (ft)	0	0	4	0	10	8
Control Delay (s)	0.0	0.0	8.2	0.0	12.7	10.0
Lane LOS			A		B	A
Approach Delay (s)	0.0		2.6		11.2	
Approach LOS					B	

Intersection Summary			
Average Delay	3.1		
Intersection Capacity Utilization	27.2%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	60	40	20	20	50	70	10	20	20	80	30	160
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	0.99			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.95		1.00	0.91		1.00	0.93			0.92	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.99	
Satd. Flow (prot)	1556	1555		1556	1494		1556	1496			1484	
Flt Permitted	0.95	1.00		0.95	1.00		0.66	1.00			0.90	
Satd. Flow (perm)	1556	1555		1556	1494		1081	1496			1356	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	65	43	22	22	54	76	11	22	22	87	33	174
RTOR Reduction (vph)	0	18	0	0	64	0	0	14	0	0	74	0
Lane Group Flow (vph)	65	47	0	22	66	0	11	30	0	0	220	0
Confl. Peds. (#/hr)									2	2		
Confl. Bikes (#/hr)									2			
Heavy Vehicles (%)	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	1.9	5.6		0.9	4.6		11.1	11.1			11.1	
Effective Green, g (s)	1.9	5.6		0.9	4.6		11.1	11.1			11.1	
Actuated g/C Ratio	0.06	0.19		0.03	0.16		0.37	0.37			0.37	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	100	294		47	232		405	561			509	
v/s Ratio Prot	c0.04	0.03		0.01	c0.04			0.02				
v/s Ratio Perm							0.01				c0.16	
v/c Ratio	0.65	0.16		0.47	0.28		0.03	0.05			0.43	
Uniform Delay, d1	13.5	10.0		14.1	11.0		5.8	5.9			6.9	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	14.1	0.3		7.2	0.7		0.0	0.0			0.6	
Delay (s)	27.6	10.3		21.3	11.7		5.9	5.9			7.5	
Level of Service	C	B		C	B		A	A			A	
Approach Delay (s)		19.0			13.1			5.9			7.5	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	11.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.42		
Actuated Cycle Length (s)	29.6	Sum of lost time (s)	12.0
Intersection Capacity Utilization	39.2%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	50	100	30	40	100	150
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	54	109	33	43	109	163
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)	322					
pX, platoon unblocked						
vC, conflicting volume			54		217	109
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			54		217	109
tC, single (s)			4.3		6.6	6.4
tC, 2 stage (s)						
tF (s)			2.3		3.6	3.4
p0 queue free %			98		85	82
cM capacity (veh/h)			1466		724	908

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	163	33	43	272
Volume Left	0	33	0	109
Volume Right	109	0	0	163
cSH	1700	1466	1700	824
Volume to Capacity	0.10	0.02	0.03	0.33
Queue Length 95th (ft)	0	2	0	36
Control Delay (s)	0.0	7.5	0.0	11.5
Lane LOS		A		B
Approach Delay (s)	0.0	3.2		11.5
Approach LOS				B

Intersection Summary			
Average Delay	6.6		
Intersection Capacity Utilization	36.9%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	180	20	40	60	10	10
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	196	22	43	65	11	11
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			217		359	207
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			217		359	207
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			97		98	99
cM capacity (veh/h)			1335		613	826

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	217	43	65	22
Volume Left	0	43	0	11
Volume Right	22	0	0	11
cSH	1700	1335	1700	704
Volume to Capacity	0.13	0.03	0.04	0.03
Queue Length 95th (ft)	0	3	0	2
Control Delay (s)	0.0	7.8	0.0	10.3
Lane LOS		A		B
Approach Delay (s)	0.0	3.1		10.3
Approach LOS				B

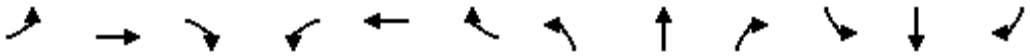
Intersection Summary			
Average Delay	1.6		
Intersection Capacity Utilization	27.4%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay (sec/veh)	27.2
Intersection LOS	D

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Volume (vph)	10	10	10	420	10	20	30	110	160	110	130	10
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles(%)	4	4	4	4	4	4	4	4	4	4	4	4
Movement Flow Rate	11	11	11	457	11	22	33	120	174	120	141	11
Number of Lanes	0	1	0	1	1	0	1	2	0	1	2	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	2	1	3	3
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	3	3	1	2
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	3	3	2	1
HCM Control Delay	11.5	45.3	13.6	12.8
HCM LOS	B	E	B	B

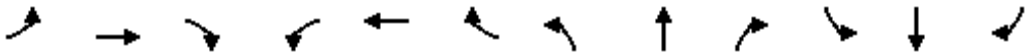
Lane	NBLn1	NBLn2	NBLn3	EBLn1	WBLn1	WBLn2	SBLn1	SBLn2	SBLn3
Volume Left (%)	100%	0%	0%	33%	100%	0%	100%	0%	0%
Volume Thru (%)	0%	100%	19%	33%	0%	33%	0%	100%	81%
Volume Right (%)	0%	0%	81%	33%	0%	67%	0%	0%	19%
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Traffic Volume by Lane	30	73	197	30	420	30	110	87	53
Left Turning Volume	0	73	37	10	0	10	0	87	43
Through Volume	0	0	160	10	0	20	0	0	10
Right Turning Volume	30	0	0	10	420	0	110	0	0
Lane Flow Rate	33	80	214	33	457	33	120	94	58
Geometry Group	8	8	8	8	8	8	8	8	8
Degree of Utilization, X	0.073	0.168	0.415	0.073	0.909	0.056	0.272	0.201	0.121
Departure Headway, Hd	8.085	7.57	6.984	8.112	7.298	6.33	8.181	7.666	7.53
Convergence(Y/N)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capacity	445	476	517	442	502	569	441	470	478
Service Time	5.801	5.286	4.7	5.849	4.998	4.03	5.899	5.384	5.248
HCM Lane V/C Ratio	0.074	0.168	0.414	0.075	0.91	0.058	0.272	0.2	0.121
HCM Control Delay	11.4	11.8	14.6	11.5	47.9	9.4	13.9	12.3	11.3
HCM Lane LOS	B	B	B	B	E	A	B	B	B
HCM 95th Percentile Queue	0.2	0.6	2.1	0.2	27.7	0.2	1.1	0.8	0.4



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	70	10	70	20	540	0	0	220	420
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor				1.00	1.00		1.00	0.95			0.95	
Frpb, ped/bikes				1.00	1.00		1.00	1.00			0.99	
Flpb, ped/bikes				1.00	1.00		1.00	1.00			1.00	
Frt				1.00	0.87		1.00	1.00			0.90	
Flt Protected				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)				1736	1588		1736	3471			3084	
Flt Permitted				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (perm)				1736	1588		1736	3471			3084	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	76	11	76	22	587	0	0	239	457
RTOR Reduction (vph)	0	0	0	0	67	0	0	0	0	0	260	0
Lane Group Flow (vph)	0	0	0	76	20	0	22	587	0	0	436	0
Confl. Peds. (#/hr)							1					1
Confl. Bikes (#/hr)									2			1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type				Split			Prot					
Protected Phases				8	8		5	2			6	
Permitted Phases												
Actuated Green, G (s)				3.8	3.8		1.8	19.1			13.3	
Effective Green, g (s)				3.8	3.8		1.8	19.1			13.3	
Actuated g/C Ratio				0.12	0.12		0.06	0.62			0.43	
Clearance Time (s)				4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)				3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)				213	195		101	2146			1327	
v/s Ratio Prot				c0.04	0.01		0.01	c0.17			c0.14	
v/s Ratio Perm												
v/c Ratio				0.36	0.10		0.22	0.27			0.33	
Uniform Delay, d1				12.4	12.0		13.9	2.7			5.8	
Progression Factor				1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2				1.0	0.2		1.1	0.1			0.1	
Delay (s)				13.5	12.3		15.0	2.8			6.0	
Level of Service				B	B		B	A			A	
Approach Delay (s)		0.0			12.8			3.2			6.0	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	5.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.35		
Actuated Cycle Length (s)	30.9	Sum of lost time (s)	12.0
Intersection Capacity Utilization	31.2%	ICU Level of Service	A
Analysis Period (min)	15		

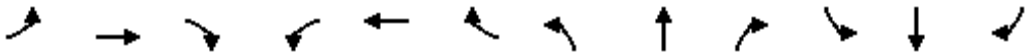
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	390	160	350	100	30	60	70	490	50	140	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		0.95	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	0.99		1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Frt	1.00	0.96		1.00	0.99		1.00	1.00	0.85		0.99	
Flt Protected	0.95	1.00		0.95	0.97		0.95	1.00	1.00		0.99	
Satd. Flow (prot)	1752	3339		1595	3208		1665	1745	1547		1797	
Flt Permitted	0.95	1.00		0.95	0.97		0.95	1.00	1.00		0.99	
Satd. Flow (perm)	1752	3339		1595	3208		1665	1745	1547		1797	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	424	174	380	109	33	65	76	533	54	152	22
RTOR Reduction (vph)	0	45	0	0	8	0	0	0	443	0	4	0
Lane Group Flow (vph)	11	553	0	190	324	0	58	83	90	0	224	0
Confl. Peds. (#/hr)	1					1			2	2		
Confl. Bikes (#/hr)			1			1						1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Split			Split			Split		Perm	Split		
Protected Phases	4	4		8	8		2	2		6	6	
Permitted Phases									2			
Actuated Green, G (s)	16.8	16.8		14.0	14.0		12.3	12.3	12.3		13.7	
Effective Green, g (s)	16.8	16.8		14.0	14.0		12.3	12.3	12.3		13.7	
Actuated g/C Ratio	0.23	0.23		0.19	0.19		0.17	0.17	0.17		0.19	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	404	771		307	617		281	295	261		338	
v/s Ratio Prot	0.01	c0.17		c0.12	0.10		0.03	0.05			c0.12	
v/s Ratio Perm									c0.06			
v/c Ratio	0.03	0.72		0.62	0.52		0.21	0.28	0.35		0.66	
Uniform Delay, d1	21.7	25.8		27.0	26.4		26.0	26.4	26.7		27.4	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Incremental Delay, d2	0.0	3.2		3.7	0.8		0.4	0.5	0.8		4.8	
Delay (s)	21.7	29.0		30.6	27.2		26.4	26.9	27.5		32.2	
Level of Service	C	C		C	C		C	C	C		C	
Approach Delay (s)		28.9			28.5			27.3			32.2	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	28.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	72.8	Sum of lost time (s)	16.0
Intersection Capacity Utilization	67.8%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

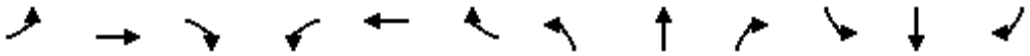


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	840	160	100	330	0	0	0	0	420	30	220
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		0.95			0.95						1.00	
Frpb, ped/bikes		1.00			1.00						1.00	
Flpb, ped/bikes		1.00			1.00						1.00	
Frt		0.98			1.00						0.96	
Flt Protected		1.00			0.99						0.97	
Satd. Flow (prot)		3437			3497						1726	
Flt Permitted		1.00			0.56						0.97	
Satd. Flow (perm)		3437			1980						1726	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	913	174	109	359	0	0	0	0	457	33	239
RTOR Reduction (vph)	0	27	0	0	0	0	0	0	0	0	28	0
Lane Group Flow (vph)	0	1060	0	0	468	0	0	0	0	0	701	0
Confl. Peds. (#/hr)	5		9	9		5						
Confl. Bikes (#/hr)						2						
Turn Type				Perm						Split		
Protected Phases		4			8					6	6	
Permitted Phases				8								
Actuated Green, G (s)		23.7			23.7						28.3	
Effective Green, g (s)		23.7			23.7						28.3	
Actuated g/C Ratio		0.39			0.39						0.47	
Clearance Time (s)		4.0			4.0						4.0	
Vehicle Extension (s)		3.0			3.0						3.0	
Lane Grp Cap (vph)		1358			782						814	
v/s Ratio Prot		c0.31									c0.41	
v/s Ratio Perm					0.24							
v/c Ratio		0.78			0.88dl						0.86	
Uniform Delay, d1		15.9			14.4						14.1	
Progression Factor		1.00			1.00						1.00	
Incremental Delay, d2		3.0			1.2						11.6	
Delay (s)		18.9			15.6						25.7	
Level of Service		B			B						C	
Approach Delay (s)		18.9			15.6			0.0			25.7	
Approach LOS		B			B			A			C	

Intersection Summary			
HCM Average Control Delay	20.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.82		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	90.1%	ICU Level of Service	E
Analysis Period (min)	15		

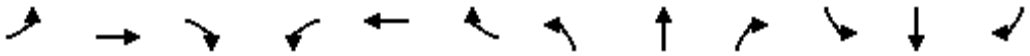
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

c Critical Lane Group



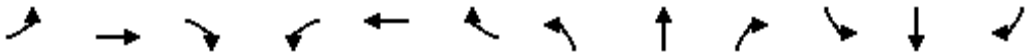
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	230	1030	0	0	390	410	40	10	80	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor		0.95			0.95		0.95	0.95	1.00			
Frpb, ped/bikes		1.00			0.99		1.00	1.00	1.00			
Flpb, ped/bikes		1.00			1.00		1.00	1.00	1.00			
Frt		1.00			0.92		1.00	1.00	0.85			
Flt Protected		0.99			1.00		0.95	0.97	1.00			
Satd. Flow (prot)		3507			3225		1681	1719	1583			
Flt Permitted		0.62			1.00		0.95	0.97	1.00			
Satd. Flow (perm)		2206			3225		1681	1719	1583			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	250	1120	0	0	424	446	43	11	87	0	0	0
RTOR Reduction (vph)	0	0	0	0	135	0	0	0	69	0	0	0
Lane Group Flow (vph)	0	1370	0	0	735	0	27	27	18	0	0	0
Confl. Peds. (#/hr)	5		7	7		5			1	1		
Confl. Bikes (#/hr)						3						
Turn Type	Perm						Split		Prot			
Protected Phases		4			8		2	2	2			
Permitted Phases	4											
Actuated Green, G (s)		55.7			55.7		16.3	16.3	16.3			
Effective Green, g (s)		55.7			55.7		16.3	16.3	16.3			
Actuated g/C Ratio		0.70			0.70		0.20	0.20	0.20			
Clearance Time (s)		4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)		3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)		1536			2245		343	350	323			
v/s Ratio Prot					0.23		c0.02	0.02	0.01			
v/s Ratio Perm		c0.62										
v/c Ratio		0.89			0.33		0.08	0.08	0.05			
Uniform Delay, d1		9.7			4.8		25.8	25.8	25.6			
Progression Factor		1.00			1.00		1.00	1.00	1.00			
Incremental Delay, d2		7.0			0.1		0.4	0.4	0.3			
Delay (s)		16.7			4.9		26.2	26.2	26.0			
Level of Service		B			A		C	C	C			
Approach Delay (s)		16.7			4.9			26.1			0.0	
Approach LOS		B			A			C			A	

Intersection Summary			
HCM Average Control Delay	12.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	80.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	85.6%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	100	410	60	180	360	140	100	800	210	100	320	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frpb, ped/bikes	1.00	1.00	0.97	1.00	1.00	0.98	1.00	1.00	0.91	1.00	1.00	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.98	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1770	3539	1539	1770	3539	1557	1770	3539	1437	1770	3461	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1770	3539	1539	1770	3539	1557	1770	3539	1437	1770	3461	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	109	446	65	196	391	152	109	870	228	109	348	54
RTOR Reduction (vph)	0	0	30	0	0	105	0	0	114	0	16	0
Lane Group Flow (vph)	109	446	35	196	391	47	109	870	114	109	386	0
Confl. Peds. (#/hr)	5		19	19		5	4		14	14		4
Confl. Bikes (#/hr)						1			100			
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases			2			6			8			
Actuated Green, G (s)	5.4	17.4	17.4	9.9	19.9	19.9	6.1	21.4	21.4	6.1	21.4	
Effective Green, g (s)	5.4	17.4	17.4	9.9	19.9	19.9	6.1	21.4	21.4	6.1	21.4	
Actuated g/C Ratio	0.08	0.26	0.26	0.15	0.29	0.29	0.09	0.32	0.32	0.09	0.32	
Clearance Time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Vehicle Extension (s)	2.0	4.0	4.0	2.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	
Lane Grp Cap (vph)	141	908	395	258	1039	457	159	1117	454	159	1092	
v/s Ratio Prot	0.06	c0.13		c0.11	0.11		c0.06	c0.25		0.06	0.11	
v/s Ratio Perm			0.02			0.03			0.08			
v/c Ratio	0.77	0.49	0.09	0.76	0.38	0.10	0.69	0.78	0.25	0.69	0.35	
Uniform Delay, d1	30.6	21.4	19.2	27.8	19.0	17.5	29.9	21.1	17.2	29.9	17.9	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	20.9	0.6	0.1	10.8	0.3	0.1	9.4	3.2	0.1	9.4	0.1	
Delay (s)	51.5	22.0	19.3	38.6	19.3	17.6	39.3	24.2	17.4	39.3	17.9	
Level of Service	D	C	B	D	B	B	D	C	B	D	B	
Approach Delay (s)		26.9			24.1			24.3			22.5	
Approach LOS		C			C			C			C	

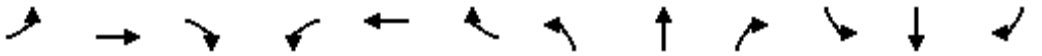
Intersection Summary			
HCM Average Control Delay	24.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	67.8	Sum of lost time (s)	13.0
Intersection Capacity Utilization	66.4%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	300	10	670	0	490	140	0	430	140
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0	4.0		4.0	4.0		4.0	
Lane Util. Factor				0.95	0.91	0.95		0.91	1.00		0.91	
Frt				1.00	0.87	0.85		1.00	0.85		0.96	
Flt Protected				0.95	1.00	1.00		1.00	1.00		1.00	
Satd. Flow (prot)				1698	1478	1519		5136	1599		4946	
Flt Permitted				0.95	1.00	1.00		1.00	1.00		1.00	
Satd. Flow (perm)				1698	1478	1519		5136	1599		4946	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	319	11	713	0	521	149	0	457	149
RTOR Reduction (vph)	0	0	0	0	99	99	0	0	0	0	103	0
Lane Group Flow (vph)	0	0	0	287	279	279	0	521	149	0	503	0
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Split		Perm			Free			
Protected Phases				8	8			2			6	
Permitted Phases						8			Free			
Actuated Green, G (s)				16.1	16.1	16.1		10.4	34.5		10.4	
Effective Green, g (s)				16.1	16.1	16.1		10.4	34.5		10.4	
Actuated g/C Ratio				0.47	0.47	0.47		0.30	1.00		0.30	
Clearance Time (s)				4.0	4.0	4.0		4.0			4.0	
Vehicle Extension (s)				3.0	3.0	3.0		3.0			3.0	
Lane Grp Cap (vph)				792	690	709		1548	1599		1491	
v/s Ratio Prot				0.17	c0.19			0.10			c0.10	
v/s Ratio Perm						0.18			0.09			
v/c Ratio				0.36	0.40	0.39		0.34	0.09		0.34	
Uniform Delay, d1				5.9	6.0	6.0		9.4	0.0		9.4	
Progression Factor				1.00	1.00	1.00		1.00	1.00		1.00	
Incremental Delay, d2				0.3	0.4	0.4		0.1	0.1		0.1	
Delay (s)				6.2	6.4	6.4		9.5	0.1		9.5	
Level of Service				A	A	A		A	A		A	
Approach Delay (s)		0.0			6.3			7.4			9.5	
Approach LOS		A			A			A			A	

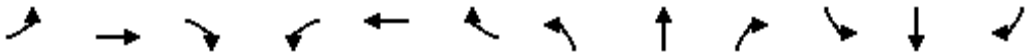
Intersection Summary			
HCM Average Control Delay	7.5	HCM Level of Service	A
HCM Volume to Capacity ratio	0.38		
Actuated Cycle Length (s)	34.5	Sum of lost time (s)	8.0
Intersection Capacity Utilization	43.8%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	260	0	170	0	0	0	0	370	370	0	480	260
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0					4.0			4.0	4.0
Lane Util. Factor	1.00		1.00					0.91			0.95	1.00
Frpb, ped/bikes	1.00		1.00					0.99			1.00	0.98
Flpb, ped/bikes	1.00		1.00					1.00			1.00	1.00
Frt	1.00		0.85					0.93			1.00	0.85
Flt Protected	0.95		1.00					1.00			1.00	1.00
Satd. Flow (prot)	1770		1583					4643			3539	1549
Flt Permitted	0.95		1.00					1.00			1.00	1.00
Satd. Flow (perm)	1770		1583					4643			3539	1549
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	283	0	185	0	0	0	0	402	402	0	522	283
RTOR Reduction (vph)	0	0	100	0	0	0	0	255	0	0	0	0
Lane Group Flow (vph)	283	0	85	0	0	0	0	549	0	0	522	283
Confl. Peds. (#/hr)							4		2	2		4
Confl. Bikes (#/hr)									3			
Turn Type	Split		Perm									Free
Protected Phases	8	8						2			6	
Permitted Phases			8									Free
Actuated Green, G (s)	12.4		12.4					11.7			11.7	32.1
Effective Green, g (s)	12.4		12.4					11.7			11.7	32.1
Actuated g/C Ratio	0.39		0.39					0.36			0.36	1.00
Clearance Time (s)	4.0		4.0					4.0			4.0	
Vehicle Extension (s)	3.0		3.0					3.0			3.0	
Lane Grp Cap (vph)	684		612					1692			1290	1549
v/s Ratio Prot	c0.16							0.12			c0.15	
v/s Ratio Perm			0.05									0.18
v/c Ratio	0.41		0.14					0.32			0.40	0.18
Uniform Delay, d1	7.2		6.4					7.4			7.6	0.0
Progression Factor	1.00		1.00					1.00			1.00	1.00
Incremental Delay, d2	0.4		0.1					0.1			0.2	0.3
Delay (s)	7.6		6.5					7.5			7.8	0.3
Level of Service	A		A					A			A	A
Approach Delay (s)		7.2			0.0			7.5			5.2	
Approach LOS		A			A			A			A	

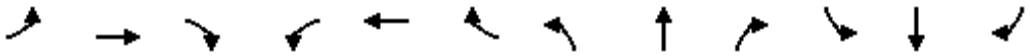
Intersection Summary			
HCM Average Control Delay	6.5	HCM Level of Service	A
HCM Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	32.1	Sum of lost time (s)	8.0
Intersection Capacity Utilization	36.6%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	170	10	70	20	20	230	30	340	10	20	530	110
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Lane Util. Factor		1.00		1.00	1.00			0.95		1.00	0.95	
Frpb, ped/bikes		0.99		1.00	0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00		1.00	1.00			1.00		0.94	1.00	
Frt		0.96		1.00	0.86			1.00		1.00	0.97	
Flt Protected		0.97		0.95	1.00			1.00		0.95	1.00	
Satd. Flow (prot)		1703		1751	1571			3474		1645	3402	
Flt Permitted		1.00		0.59	1.00			0.88		0.95	1.00	
Satd. Flow (perm)		1761		1091	1571			3058		1645	3402	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	185	11	76	22	22	250	33	370	11	22	576	120
RTOR Reduction (vph)	0	14	0	0	188	0	0	2	0	0	16	0
Lane Group Flow (vph)	0	258	0	22	84	0	0	412	0	22	680	0
Confl. Peds. (#/hr)	1		3	3		1			5	5		
Confl. Bikes (#/hr)						1			2			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Perm			Prot		
Protected Phases		3			4			2		1	6	
Permitted Phases	3			4			2					
Actuated Green, G (s)		2.4		11.4	11.4			15.4		0.8	20.2	
Effective Green, g (s)		2.4		11.4	11.4			15.4		0.8	20.2	
Actuated g/C Ratio		0.05		0.25	0.25			0.33		0.02	0.44	
Clearance Time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		92		270	389			1024		29	1494	
v/s Ratio Prot					c0.05					0.01	c0.20	
v/s Ratio Perm		c0.15		0.02				0.13				
v/c Ratio		2.80		0.08	0.22			0.40		0.76	0.45	
Uniform Delay, d1		21.8		13.3	13.7			11.8		22.5	9.0	
Progression Factor		1.00		1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		840.3		0.1	0.3			0.3		71.7	0.2	
Delay (s)		862.1		13.4	14.0			12.0		94.2	9.3	
Level of Service		F		B	B			B		F	A	
Approach Delay (s)		862.1			14.0			12.0			11.9	
Approach LOS		F			B			B			B	

Intersection Summary			
HCM Average Control Delay	148.5	HCM Level of Service	F
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	46.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	72.9%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



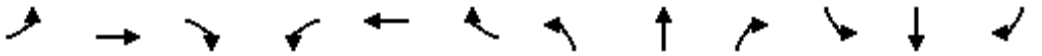
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	170	20	30	40	40	30	30	160	50	20	350	210
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00	1.00	1.00	0.99		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	0.94		1.00	0.96		1.00	0.94	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	3289		1770	3401		1770	3314	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	3289		1770	3401		1770	3314	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	179	21	32	42	42	32	32	168	53	21	368	221
RTOR Reduction (vph)	0	0	24	0	29	0	0	32	0	0	117	0
Lane Group Flow (vph)	179	21	8	42	45	0	32	189	0	21	472	0
Confl. Peds. (#/hr)							16		1	1		16
Confl. Bikes (#/hr)						1			1			
Turn Type	Prot		Perm	Prot			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4									
Actuated Green, G (s)	9.2	11.6	11.6	1.7	4.1		1.4	14.2		1.0	13.8	
Effective Green, g (s)	9.2	11.6	11.6	1.7	4.1		1.4	14.2		1.0	13.8	
Actuated g/C Ratio	0.21	0.26	0.26	0.04	0.09		0.03	0.32		0.02	0.31	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	366	923	413	68	303		56	1085		40	1028	
v/s Ratio Prot	c0.10	0.01		0.02	c0.01		c0.02	0.06		0.01	c0.14	
v/s Ratio Perm			0.01									
v/c Ratio	0.49	0.02	0.02	0.62	0.15		0.57	0.17		0.53	0.46	
Uniform Delay, d1	15.6	12.2	12.2	21.1	18.6		21.3	10.9		21.5	12.3	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	1.0	0.0	0.0	15.5	0.2		13.3	0.1		11.9	0.3	
Delay (s)	16.6	12.2	12.2	36.6	18.8		34.6	11.0		33.4	12.7	
Level of Service	B	B	B	D	B		C	B		C	B	
Approach Delay (s)		15.6			25.3			14.0			13.4	
Approach LOS		B			C			B			B	

Intersection Summary			
HCM Average Control Delay	15.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.43		
Actuated Cycle Length (s)	44.5	Sum of lost time (s)	16.0
Intersection Capacity Utilization	47.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	80	50	30	170	180	70
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	87	54	33	185	196	76
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				1133		
pX, platoon unblocked						
vC, conflicting volume			141		337	87
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			141		337	87
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			98		69	92
cM capacity (veh/h)			1429		640	966

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2
Volume Total	87	54	33	185	196	76
Volume Left	0	0	33	0	196	0
Volume Right	0	54	0	0	0	76
cSH	1700	1700	1429	1700	640	966
Volume to Capacity	0.05	0.03	0.02	0.11	0.31	0.08
Queue Length 95th (ft)	0	0	2	0	32	6
Control Delay (s)	0.0	0.0	7.6	0.0	13.1	9.0
Lane LOS			A		B	A
Approach Delay (s)	0.0		1.1		12.0	
Approach LOS					B	

Intersection Summary			
Average Delay	5.5		
Intersection Capacity Utilization	25.6%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	110	20	10	10	50	70	20	20	10	80	20	60
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.95		1.00	0.91		1.00	0.95			0.95	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.98	
Satd. Flow (prot)	1626	1626		1626	1562		1626	1626			1586	
Flt Permitted	0.95	1.00		0.95	1.00		0.79	1.00			0.82	
Satd. Flow (perm)	1626	1626		1626	1562		1353	1626			1341	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	120	22	11	11	54	76	22	22	11	87	22	65
RTOR Reduction (vph)	0	7	0	0	59	0	0	8	0	0	37	0
Lane Group Flow (vph)	120	26	0	11	71	0	22	25	0	0	137	0
Heavy Vehicles (%)	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	4.4	10.5		0.9	7.0		7.4	7.4			7.4	
Effective Green, g (s)	4.4	10.5		0.9	7.0		7.4	7.4			7.4	
Actuated g/C Ratio	0.14	0.34		0.03	0.23		0.24	0.24			0.24	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	232	554		48	355		325	391			322	
v/s Ratio Prot	c0.07	c0.02		0.01	c0.05			0.02				
v/s Ratio Perm							0.02				c0.10	
v/c Ratio	0.52	0.05		0.23	0.20		0.07	0.06			0.42	
Uniform Delay, d1	12.2	6.8		14.6	9.6		9.0	9.0			9.9	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	1.9	0.0		2.4	0.3		0.1	0.1			0.9	
Delay (s)	14.2	6.8		17.0	9.9		9.1	9.1			10.8	
Level of Service	B	A		B	A		A	A			B	
Approach Delay (s)		12.6			10.5			9.1			10.8	
Approach LOS		B			B			A			B	

Intersection Summary			
HCM Average Control Delay	11.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.39		
Actuated Cycle Length (s)	30.8	Sum of lost time (s)	16.0
Intersection Capacity Utilization	35.2%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	40	60	50	40	80	60
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	43	65	54	43	87	65
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)	322					
pX, platoon unblocked						
vC, conflicting volume			43		228	76
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			43		228	76
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			97		88	93
cM capacity (veh/h)			1565		734	985

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	109	54	43	152
Volume Left	0	54	0	87
Volume Right	65	0	0	65
cSH	1700	1565	1700	824
Volume to Capacity	0.06	0.03	0.03	0.18
Queue Length 95th (ft)	0	3	0	17
Control Delay (s)	0.0	7.4	0.0	10.4
Lane LOS		A		B
Approach Delay (s)	0.0	4.1		10.4
Approach LOS				B

Intersection Summary			
Average Delay	5.5		
Intersection Capacity Utilization	24.2%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	90	10	10	70	20	40
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	98	11	11	76	22	43
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			109		201	103
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			109		201	103
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			99		97	95
cM capacity (veh/h)			1482		782	952

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	109	11	76	65
Volume Left	0	11	0	22
Volume Right	11	0	0	43
cSH	1700	1482	1700	887
Volume to Capacity	0.06	0.01	0.04	0.07
Queue Length 95th (ft)	0	1	0	6
Control Delay (s)	0.0	7.4	0.0	9.4
Lane LOS		A		A
Approach Delay (s)	0.0	0.9		9.4
Approach LOS				A

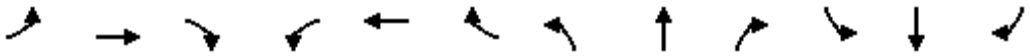
Intersection Summary			
Average Delay	2.7		
Intersection Capacity Utilization	17.5%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay (sec/veh)	20.8
Intersection LOS	C

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Volume (vph)	10	20	10	430	10	20	10	50	70	60	80	10
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles(%)	2	2	2	2	2	2	2	2	2	2	2	2
Movement Flow Rate	11	22	11	467	11	22	11	54	76	65	87	11
Number of Lanes	0	1	0	1	1	0	1	2	0	1	2	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	2	1	3	3
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	3	3	1	2
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	3	3	2	1
HCM Control Delay	10.1	28	10.3	10.6
HCM LOS	B	D	B	B

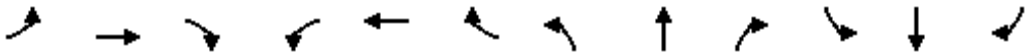
Lane	NBLn1	NBLn2	NBLn3	EBLn1	WBLn1	WBLn2	SBLn1	SBLn2	SBLn3
Volume Left (%)	100%	0%	0%	25%	100%	0%	100%	0%	0%
Volume Thru (%)	0%	100%	19%	50%	0%	33%	0%	100%	73%
Volume Right (%)	0%	0%	81%	25%	0%	67%	0%	0%	27%
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Traffic Volume by Lane	10	33	87	40	430	30	60	53	37
Left Turning Volume	0	33	17	20	0	10	0	53	27
Through Volume	0	0	70	10	0	20	0	0	10
Right Turning Volume	10	0	0	10	430	0	60	0	0
Lane Flow Rate	11	36	94	43	467	33	65	58	40
Geometry Group	8	8	8	8	8	8	8	8	8
Degree of Utilization, X	0.022	0.069	0.165	0.082	0.802	0.047	0.133	0.11	0.073
Departure Headway, Hd	7.411	6.9	6.322	6.761	6.18	5.215	7.332	6.82	6.625
Convergence(Y/N)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capacity	482	518	566	529	584	687	488	525	540
Service Time	5.169	4.657	4.078	4.518	3.913	2.947	5.087	4.575	4.38
HCM Lane V/C Ratio	0.023	0.069	0.166	0.081	0.8	0.048	0.133	0.11	0.074
HCM Control Delay	10.3	10.2	10.3	10.1	29.4	8.2	11.2	10.4	9.9
HCM Lane LOS	B	B	B	B	D	A	B	B	A
HCM 95th Percentile Queue	0.1	0.2	0.6	0.3	12	0.1	0.5	0.4	0.2



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	40	10	450	20	500	0	0	90	300
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor				1.00	1.00		1.00	0.95			0.95	
Frpb, ped/bikes				1.00	1.00		1.00	1.00			0.98	
Flpb, ped/bikes				1.00	1.00		1.00	1.00			1.00	
Frt				1.00	0.85		1.00	1.00			0.88	
Flt Protected				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)				1787	1605		1787	3574			3110	
Flt Permitted				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (perm)				1787	1605		1787	3574			3110	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	42	11	474	21	526	0	0	95	316
RTOR Reduction (vph)	0	0	0	0	255	0	0	0	0	0	218	0
Lane Group Flow (vph)	0	0	0	42	230	0	21	526	0	0	193	0
Confl. Peds. (#/hr)							1		2	2		1
Confl. Bikes (#/hr)			1						1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Split			Prot					
Protected Phases				8	8		5	2			6	
Permitted Phases												
Actuated Green, G (s)				10.1	10.1		2.1	16.9			10.8	
Effective Green, g (s)				10.1	10.1		2.1	16.9			10.8	
Actuated g/C Ratio				0.29	0.29		0.06	0.48			0.31	
Clearance Time (s)				4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)				3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)				516	463		107	1726			960	
v/s Ratio Prot				0.02	c0.14		0.01	c0.15			0.06	
v/s Ratio Perm												
v/c Ratio				0.08	0.50		0.20	0.30			0.20	
Uniform Delay, d1				9.1	10.3		15.6	5.5			8.9	
Progression Factor				1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2				0.1	0.8		0.9	0.1			0.1	
Delay (s)				9.1	11.2		16.5	5.6			9.0	
Level of Service				A	B		B	A			A	
Approach Delay (s)		0.0			11.0			6.0			9.0	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	8.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.38		
Actuated Cycle Length (s)	35.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	51.7%	ICU Level of Service	A
Analysis Period (min)	15		

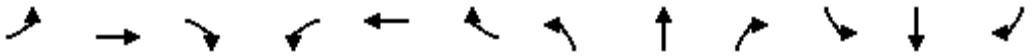
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	40	260	70	280	290	50	310	180	460	20	40	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		0.95	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	0.99		1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Frt	1.00	0.97		1.00	0.98		1.00	1.00	0.85		0.94	
Flt Protected	0.95	1.00		0.95	0.99		0.95	0.99	1.00		0.99	
Satd. Flow (prot)	1787	3461		1626	3331		1698	1763	1576		1749	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	0.99	1.00		0.99	
Satd. Flow (perm)	1787	3461		1626	3331		1698	1763	1576		1749	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	41	268	72	289	299	52	320	186	474	21	41	52
RTOR Reduction (vph)	0	26	0	0	11	0	0	0	346	0	34	0
Lane Group Flow (vph)	41	314	0	211	418	0	250	256	128	0	80	0
Confl. Peds. (#/hr)									2	2		
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Split			Split			Split		Perm	Split		
Protected Phases	4	4		8	8		2	2		6	6	
Permitted Phases									2			
Actuated Green, G (s)	12.3	12.3		15.9	15.9		19.0	19.0	19.0		7.2	
Effective Green, g (s)	12.3	12.3		15.9	15.9		19.0	19.0	19.0		7.2	
Actuated g/C Ratio	0.17	0.17		0.23	0.23		0.27	0.27	0.27		0.10	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	312	605		367	752		458	476	425		179	
v/s Ratio Prot	0.02	c0.09		c0.13	0.13		c0.15	0.15			c0.05	
v/s Ratio Perm									0.08			
v/c Ratio	0.13	0.52		0.57	0.56		0.55	0.54	0.30		0.45	
Uniform Delay, d1	24.5	26.4		24.2	24.1		22.0	21.9	20.4		29.7	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Incremental Delay, d2	0.2	0.8		2.2	0.9		1.3	1.2	0.4		1.8	
Delay (s)	24.7	27.1		26.4	25.0		23.3	23.1	20.8		31.5	
Level of Service	C	C		C	C		C	C	C		C	
Approach Delay (s)		26.9			25.5			22.1			31.5	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	24.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	70.4	Sum of lost time (s)	16.0
Intersection Capacity Utilization	54.7%	ICU Level of Service	A
Analysis Period (min)	15		

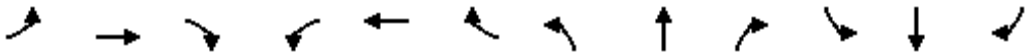
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	620	150	90	450	0	0	0	0	360	10	240
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		0.95			0.95						1.00	
Frpb, ped/bikes		0.99			1.00						1.00	
Flpb, ped/bikes		1.00			1.00						1.00	
Frt		0.97			1.00						0.95	
Flt Protected		1.00			0.99						0.97	
Satd. Flow (prot)		3451			3543						1730	
Flt Permitted		1.00			0.67						0.97	
Satd. Flow (perm)		3451			2378						1730	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	0	646	156	94	469	0	0	0	0	375	10	250
RTOR Reduction (vph)	0	45	0	0	0	0	0	0	0	0	35	0
Lane Group Flow (vph)	0	757	0	0	563	0	0	0	0	0	600	0
Confl. Peds. (#/hr)	3		8	8		3						
Confl. Bikes (#/hr)						3						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Perm						Split		
Protected Phases		4			8					6	6	
Permitted Phases				8								
Actuated Green, G (s)		19.3			19.3						27.7	
Effective Green, g (s)		19.3			19.3						27.7	
Actuated g/C Ratio		0.35			0.35						0.50	
Clearance Time (s)		4.0			4.0						4.0	
Vehicle Extension (s)		3.0			3.0						3.0	
Lane Grp Cap (vph)		1211			834						871	
v/s Ratio Prot		0.22									c0.35	
v/s Ratio Perm					c0.24							
v/c Ratio		0.62			0.68						0.69	
Uniform Delay, d1		14.8			15.2						10.4	
Progression Factor		1.00			1.00						1.00	
Incremental Delay, d2		1.0			2.2						4.4	
Delay (s)		15.9			17.4						14.8	
Level of Service		B			B						B	
Approach Delay (s)		15.9			17.4			0.0			14.8	
Approach LOS		B			B			A			B	

Intersection Summary			
HCM Average Control Delay	15.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	55.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	82.8%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group



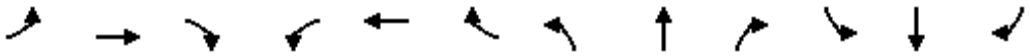
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	240	740	0	0	470	430	80	140	140	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor		0.95			0.95		0.95	0.95	1.00			
Frpb, ped/bikes		1.00			0.99		1.00	1.00	1.00			
Flpb, ped/bikes		1.00			1.00		1.00	1.00	1.00			
Frt		1.00			0.93		1.00	1.00	0.85			
Flt Protected		0.99			1.00		0.95	1.00	1.00			
Satd. Flow (prot)		3531			3281		1698	1782	1599			
Flt Permitted		0.57			1.00		0.95	1.00	1.00			
Satd. Flow (perm)		2045			3281		1698	1782	1599			
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	250	771	0	0	490	448	83	146	146	0	0	0
RTOR Reduction (vph)	0	0	0	0	149	0	0	0	109	0	0	0
Lane Group Flow (vph)	0	1021	0	0	789	0	75	154	37	0	0	0
Confl. Peds. (#/hr)	2		7	7		2						
Confl. Bikes (#/hr)						3						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm						Split		Prot			
Protected Phases		4			8		2	2	2			
Permitted Phases	4											
Actuated Green, G (s)		51.9			51.9		20.1	20.1	20.1			
Effective Green, g (s)		51.9			51.9		20.1	20.1	20.1			
Actuated g/C Ratio		0.65			0.65		0.25	0.25	0.25			
Clearance Time (s)		4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)		3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)		1327			2129		427	448	402			
v/s Ratio Prot					0.24		0.04	c0.09	0.02			
v/s Ratio Perm		c0.50										
v/c Ratio		0.77			0.37		0.18	0.34	0.09			
Uniform Delay, d1		9.9			6.5		23.5	24.5	23.0			
Progression Factor		1.00			1.00		1.00	1.00	1.00			
Incremental Delay, d2		2.8			0.1		0.9	2.1	0.4			
Delay (s)		12.6			6.6		24.4	26.6	23.4			
Level of Service		B			A		C	C	C			
Approach Delay (s)		12.6			6.6			24.9			0.0	
Approach LOS		B			A			C			A	

Intersection Summary			
HCM Average Control Delay	12.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	80.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	72.8%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Near-Term (2018) Plus Phase 1 Project Conditions

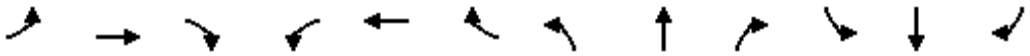
FEHR PEERS



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	80	282	84	290	360	131	51	271	150	74	667	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frpb, ped/bikes	1.00	1.00	0.98	1.00	1.00	0.98	1.00	1.00	0.98	1.00	1.00	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1736	3471	1518	1736	3471	1516	1736	3471	1530	1736	3431	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1736	3471	1518	1736	3471	1516	1736	3471	1530	1736	3431	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	87	307	91	315	391	142	55	295	163	80	725	54
RTOR Reduction (vph)	0	0	60	0	0	92	0	0	120	0	7	0
Lane Group Flow (vph)	87	307	31	315	391	50	55	295	43	80	772	0
Confl. Peds. (#/hr)	14		13	13		14	4		4	4		4
Confl. Bikes (#/hr)						1						1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases			2			6			8			
Actuated Green, G (s)	6.1	15.4	15.4	14.5	21.8	21.8	2.1	17.1	17.1	4.2	19.2	
Effective Green, g (s)	6.1	15.4	15.4	14.5	21.8	21.8	2.1	17.1	17.1	4.2	19.2	
Actuated g/C Ratio	0.10	0.24	0.24	0.23	0.34	0.34	0.03	0.27	0.27	0.07	0.30	
Clearance Time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Vehicle Extension (s)	2.0	4.0	4.0	2.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	
Lane Grp Cap (vph)	165	833	364	392	1179	515	57	925	408	114	1026	
v/s Ratio Prot	0.05	0.09		c0.18	c0.11		c0.03	0.08		0.05	c0.22	
v/s Ratio Perm			0.02			0.03			0.03			
v/c Ratio	0.53	0.37	0.09	0.80	0.33	0.10	0.96	0.32	0.11	0.70	0.75	
Uniform Delay, d1	27.7	20.3	18.9	23.5	15.8	14.5	31.0	18.9	17.8	29.4	20.4	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	1.4	0.4	0.1	10.7	0.2	0.1	105.2	0.1	0.0	14.7	2.8	
Delay (s)	29.1	20.7	19.1	34.2	16.0	14.6	136.2	19.0	17.8	44.1	23.2	
Level of Service	C	C	B	C	B	B	F	B	B	D	C	
Approach Delay (s)		21.9			22.5			31.2			25.1	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	24.9	HCM Level of Service	C
HCM Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	64.2	Sum of lost time (s)	6.0
Intersection Capacity Utilization	65.3%	ICU Level of Service	C
Analysis Period (min)	15		

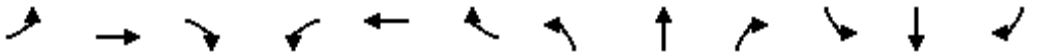
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	330	10	191	0	271	140	0	801	250
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0	4.0		4.0	4.0		4.0	
Lane Util. Factor				0.95	0.91	0.95		0.91	1.00		0.91	
Frpb, ped/bikes				1.00	1.00	0.99		1.00	0.98		0.99	
Flpb, ped/bikes				1.00	1.00	1.00		1.00	1.00		1.00	
Frt				1.00	0.98	0.85		1.00	0.85		0.96	
Flt Protected				0.95	0.96	1.00		1.00	1.00		1.00	
Satd. Flow (prot)				1665	1576	1471		5036	1535		4830	
Flt Permitted				0.95	0.96	1.00		1.00	1.00		1.00	
Satd. Flow (perm)				1665	1576	1471		5036	1535		4830	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	351	11	203	0	288	149	0	852	266
RTOR Reduction (vph)	0	0	0	0	13	117	0	0	0	0	76	0
Lane Group Flow (vph)	0	0	0	197	180	58	0	288	149	0	1042	0
Confl. Peds. (#/hr)	1					1	2		1	1		2
Confl. Bikes (#/hr)									2			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type				Split		Perm			Free			
Protected Phases				8	8			2			6	
Permitted Phases						8			Free			
Actuated Green, G (s)				12.9	12.9	12.9		17.9	38.8		17.9	
Effective Green, g (s)				12.9	12.9	12.9		17.9	38.8		17.9	
Actuated g/C Ratio				0.33	0.33	0.33		0.46	1.00		0.46	
Clearance Time (s)				4.0	4.0	4.0		4.0			4.0	
Vehicle Extension (s)				3.0	3.0	3.0		3.0			3.0	
Lane Grp Cap (vph)				554	524	489		2323	1535		2228	
v/s Ratio Prot				c0.12	0.11			0.06			c0.22	
v/s Ratio Perm						0.04			0.10			
v/c Ratio				0.36	0.34	0.12		0.12	0.10		0.47	
Uniform Delay, d1				9.8	9.8	9.0		6.0	0.0		7.2	
Progression Factor				1.00	1.00	1.00		1.00	1.00		1.00	
Incremental Delay, d2				0.4	0.4	0.1		0.0	0.1		0.2	
Delay (s)				10.2	10.2	9.1		6.0	0.1		7.3	
Level of Service				B	B	A		A	A		A	
Approach Delay (s)		0.0			9.8			4.0			7.3	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	7.3	HCM Level of Service	A
HCM Volume to Capacity ratio	0.42		
Actuated Cycle Length (s)	38.8	Sum of lost time (s)	8.0
Intersection Capacity Utilization	39.6%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	80	0	130	0	0	0	0	331	330	0	555	575
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0					4.0			4.0	4.0
Lane Util. Factor	1.00		1.00					0.91			0.95	1.00
Frpb, ped/bikes	1.00		1.00					0.99			1.00	0.98
Flpb, ped/bikes	1.00		1.00					1.00			1.00	1.00
Frt	1.00		0.85					0.93			1.00	0.85
Flt Protected	0.95		1.00					1.00			1.00	1.00
Satd. Flow (prot)	1752		1568					4603			3505	1536
Flt Permitted	0.95		1.00					1.00			1.00	1.00
Satd. Flow (perm)	1752		1568					4603			3505	1536
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	87	0	141	0	0	0	0	360	359	0	603	625
RTOR Reduction (vph)	0	0	90	0	0	0	0	197	0	0	0	0
Lane Group Flow (vph)	87	0	51	0	0	0	0	522	0	0	603	625
Confl. Peds. (#/hr)							1		3	3		1
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Split		Perm									Free
Protected Phases	8	8						2			6	
Permitted Phases			8									Free
Actuated Green, G (s)	7.7		7.7					12.9			12.9	28.6
Effective Green, g (s)	7.7		7.7					12.9			12.9	28.6
Actuated g/C Ratio	0.27		0.27					0.45			0.45	1.00
Clearance Time (s)	4.0		4.0					4.0			4.0	
Vehicle Extension (s)	3.0		3.0					3.0			3.0	
Lane Grp Cap (vph)	472		422					2076			1581	1536
v/s Ratio Prot	0.05							0.11			0.17	
v/s Ratio Perm			0.03									c0.41
v/c Ratio	0.18		0.12					0.25			0.38	0.41
Uniform Delay, d1	8.0		7.9					4.9			5.2	0.0
Progression Factor	1.00		1.00					1.00			1.00	1.00
Incremental Delay, d2	0.2		0.1					0.1			0.2	0.8
Delay (s)	8.2		8.0					4.9			5.4	0.8
Level of Service	A		A					A			A	A
Approach Delay (s)		8.1			0.0			4.9			3.0	
Approach LOS		A			A			A			A	

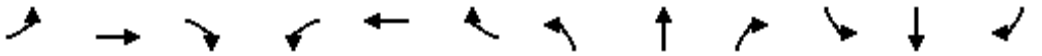
Intersection Summary			
HCM Average Control Delay	4.2	HCM Level of Service	A
HCM Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	28.6	Sum of lost time (s)	0.0
Intersection Capacity Utilization	30.1%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	50	20	30	10	10	30	30	581	20	290	285	110
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Lane Util. Factor		1.00		1.00	1.00			0.95		1.00	0.95	
Frpb, ped/bikes		1.00		1.00	0.99			1.00		1.00	0.99	
Flpb, ped/bikes		1.00		1.00	1.00			1.00		1.00	1.00	
Frt		0.96		1.00	0.89			1.00		1.00	0.96	
Flt Protected		0.98		0.95	1.00			1.00		0.95	1.00	
Satd. Flow (prot)		1709		1736	1605			3446		1736	3305	
Flt Permitted		1.00		0.69	1.00			0.92		0.95	1.00	
Satd. Flow (perm)		1751		1255	1605			3180		1736	3305	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	54	22	33	11	11	33	33	632	22	315	310	120
RTOR Reduction (vph)	0	16	0	0	28	0	0	2	0	0	26	0
Lane Group Flow (vph)	0	93	0	11	16	0	0	685	0	315	404	0
Confl. Peds. (#/hr)	3					3	2					2
Confl. Bikes (#/hr)												1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm			Perm			Perm			Prot		
Protected Phases		3			4			2		1	6	
Permitted Phases	3			4			2					
Actuated Green, G (s)		2.2		8.4	8.4			21.7		11.9	37.6	
Effective Green, g (s)		2.2		8.4	8.4			21.7		11.9	37.6	
Actuated g/C Ratio		0.04		0.14	0.14			0.36		0.20	0.62	
Clearance Time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		64		175	224			1146		343	2064	
v/s Ratio Prot					c0.01					c0.18	0.12	
v/s Ratio Perm		c0.05		0.01				c0.22				
v/c Ratio		1.45		0.06	0.07			0.60		0.92	0.20	
Uniform Delay, d1		29.0		22.5	22.5			15.7		23.7	4.8	
Progression Factor		1.00		1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		269.3		0.2	0.1			0.8		28.5	0.0	
Delay (s)		298.3		22.6	22.6			16.5		52.1	4.9	
Level of Service		F		C	C			B		D	A	
Approach Delay (s)		298.3			22.6			16.5			24.9	
Approach LOS		F			C			B			C	

Intersection Summary			
HCM Average Control Delay	39.9	HCM Level of Service	D
HCM Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	60.2	Sum of lost time (s)	16.0
Intersection Capacity Utilization	56.3%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	220	44	20	21	11	41	10	370	114	45	100	160
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00	1.00	1.00	0.96		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	0.88		1.00	0.96		1.00	0.91	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	2994		1767	3404		1770	3183	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	2994		1767	3404		1770	3183	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	239	48	22	23	12	45	11	402	124	49	109	174
RTOR Reduction (vph)	0	0	14	0	40	0	0	36	0	0	117	0
Lane Group Flow (vph)	239	48	8	23	17	0	11	490	0	49	166	0
Confl. Peds. (#/hr)	3					3	4					4
Confl. Bikes (#/hr)						20			1			1
Turn Type	Prot		Perm	Prot			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4									
Actuated Green, G (s)	13.2	19.0	19.0	0.6	6.4		0.5	15.0		2.9	17.4	
Effective Green, g (s)	13.2	19.0	19.0	0.6	6.4		0.5	15.0		2.9	17.4	
Actuated g/C Ratio	0.25	0.36	0.36	0.01	0.12		0.01	0.28		0.05	0.33	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	437	1257	562	20	358		17	954		96	1035	
v/s Ratio Prot	c0.14	c0.01		0.01	0.01		0.01	c0.14		c0.03	0.05	
v/s Ratio Perm			0.00									
v/c Ratio	0.55	0.04	0.01	1.15	0.05		0.65	0.51		0.51	0.16	
Uniform Delay, d1	17.5	11.3	11.2	26.4	20.9		26.4	16.2		24.6	12.8	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	1.4	0.0	0.0	252.2	0.1		62.0	0.5		4.5	0.1	
Delay (s)	18.9	11.3	11.2	278.6	20.9		88.4	16.7		29.1	12.9	
Level of Service	B	B	B	F	C		F	B		C	B	
Approach Delay (s)		17.2			95.0			18.1			15.3	
Approach LOS		B			F			B			B	

Intersection Summary			
HCM Average Control Delay	22.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.39		
Actuated Cycle Length (s)	53.5	Sum of lost time (s)	12.0
Intersection Capacity Utilization	46.1%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	222	120	58	113	60	70
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	241	130	63	123	65	76
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				1133		
pX, platoon unblocked						
vC, conflicting volume			372		490	241
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			372		490	241
tC, single (s)			4.2		6.5	6.3
tC, 2 stage (s)						
tF (s)			2.3		3.6	3.4
p0 queue free %			94		87	90
cM capacity (veh/h)			1144		494	778

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2
Volume Total	241	130	63	123	65	76
Volume Left	0	0	63	0	65	0
Volume Right	0	130	0	0	0	76
cSH	1700	1700	1144	1700	494	778
Volume to Capacity	0.14	0.08	0.06	0.07	0.13	0.10
Queue Length 95th (ft)	0	0	4	0	11	8
Control Delay (s)	0.0	0.0	8.3	0.0	13.4	10.1
Lane LOS			A		B	B
Approach Delay (s)	0.0		2.8		11.6	
Approach LOS					B	

Intersection Summary			
Average Delay	3.1		
Intersection Capacity Utilization	28.4%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	60	87	20	20	50	81	10	20	20	102	30	160
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	0.99			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.97		1.00	0.91		1.00	0.93			0.93	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.98	
Satd. Flow (prot)	1556	1592		1556	1486		1556	1497			1490	
Flt Permitted	0.95	1.00		0.95	1.00		0.63	1.00			0.88	
Satd. Flow (perm)	1556	1592		1556	1486		1029	1497			1338	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	65	95	22	22	54	88	11	22	22	111	33	174
RTOR Reduction (vph)	0	16	0	0	75	0	0	13	0	0	58	0
Lane Group Flow (vph)	65	101	0	22	67	0	11	31	0	0	260	0
Confl. Peds. (#/hr)									2	2		
Confl. Bikes (#/hr)									2			
Heavy Vehicles (%)	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	1.9	5.7		1.0	4.8		13.1	13.1			13.1	
Effective Green, g (s)	1.9	5.7		1.0	4.8		13.1	13.1			13.1	
Actuated g/C Ratio	0.06	0.18		0.03	0.15		0.41	0.41			0.41	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	93	285		49	224		424	617			551	
v/s Ratio Prot	c0.04	c0.06		0.01	0.05			0.02				
v/s Ratio Perm							0.01				c0.19	
v/c Ratio	0.70	0.36		0.45	0.30		0.03	0.05			0.47	
Uniform Delay, d1	14.7	11.4		15.1	12.0		5.6	5.6			6.8	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	20.5	0.8		6.4	0.8		0.0	0.0			0.6	
Delay (s)	35.1	12.2		21.5	12.8		5.6	5.6			7.5	
Level of Service	D	B		C	B		A	A			A	
Approach Delay (s)		20.4			13.9			5.6			7.5	
Approach LOS		C			B			A			A	

Intersection Summary			
HCM Average Control Delay	12.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.40		
Actuated Cycle Length (s)	31.8	Sum of lost time (s)	8.0
Intersection Capacity Utilization	44.6%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	119	100	32	51	100	163
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	129	109	35	55	109	177
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)	322					
pX, platoon unblocked						
vC, conflicting volume			129		309	184
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			129		309	184
tC, single (s)			4.3		6.6	6.4
tC, 2 stage (s)						
tF (s)			2.3		3.6	3.4
p0 queue free %			97		83	78
cM capacity (veh/h)			1374		639	824

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	238	35	55	286
Volume Left	0	35	0	109
Volume Right	109	0	0	177
cSH	1700	1374	1700	742
Volume to Capacity	0.14	0.03	0.03	0.39
Queue Length 95th (ft)	0	2	0	46
Control Delay (s)	0.0	7.7	0.0	12.9
Lane LOS		A		B
Approach Delay (s)	0.0	3.0		12.9
Approach LOS				B

Intersection Summary			
Average Delay	6.4		
Intersection Capacity Utilization	41.3%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	180	102	140	60	23	26
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	196	111	152	65	25	28
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			307		621	251
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			307		621	251
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			88		94	96
cM capacity (veh/h)			1237		391	780

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	307	152	65	53
Volume Left	0	152	0	25
Volume Right	111	0	0	28
cSH	1700	1237	1700	532
Volume to Capacity	0.18	0.12	0.04	0.10
Queue Length 95th (ft)	0	10	0	8
Control Delay (s)	0.0	8.3	0.0	12.5
Lane LOS		A		B
Approach Delay (s)	0.0	5.8		12.5
Approach LOS				B

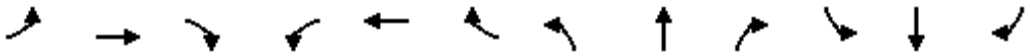
Intersection Summary			
Average Delay	3.3		
Intersection Capacity Utilization	36.8%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay (sec/veh)	32.6
Intersection LOS	D

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Volume (vph)	10	10	10	420	10	20	30	210	160	120	136	10
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles(%)	4	4	4	4	4	4	4	4	4	4	4	4
Movement Flow Rate	11	11	11	457	11	22	33	228	174	130	148	11
Number of Lanes	0	1	0	1	1	0	1	2	0	1	2	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	2	1	3	3
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	3	3	1	2
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	3	3	2	1
HCM Control Delay	12.2	60	15.8	13.8
HCM LOS	B	F	C	B

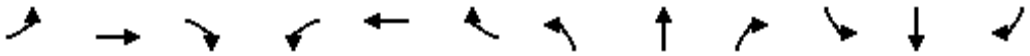
Lane	NBLn1	NBLn2	NBLn3	EBLn1	WBLn1	WBLn2	SBLn1	SBLn2	SBLn3
Volume Left (%)	100%	0%	0%	33%	100%	0%	100%	0%	0%
Volume Thru (%)	0%	100%	30%	33%	0%	33%	0%	100%	82%
Volume Right (%)	0%	0%	70%	33%	0%	67%	0%	0%	18%
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Traffic Volume by Lane	30	140	230	30	420	30	120	91	55
Left Turning Volume	0	140	70	10	0	10	0	91	45
Through Volume	0	0	160	10	0	20	0	0	10
Right Turning Volume	30	0	0	10	420	0	120	0	0
Lane Flow Rate	33	152	250	33	457	33	130	99	60
Geometry Group	8	8	8	8	8	8	8	8	8
Degree of Utilization, X	0.075	0.329	0.505	0.079	0.976	0.061	0.312	0.221	0.133
Departure Headway, Hd	8.295	7.779	7.276	8.673	7.7	6.73	8.603	8.085	7.955
Convergence(Y/N)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capacity	431	461	495	412	470	532	417	443	450
Service Time	6.052	5.536	5.033	6.452	5.45	4.479	6.365	5.847	5.716
HCM Lane V/C Ratio	0.077	0.33	0.505	0.08	0.972	0.062	0.312	0.223	0.133
HCM Control Delay	11.7	14.3	17.3	12.2	63.6	9.9	15.2	13.1	11.9
HCM Lane LOS	B	B	C	B	F	A	C	B	B
HCM 95th Percentile Queue	0.2	1.5	3.1	0.3	67.5	0.2	1.4	0.9	0.5



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	134	10	70	20	546	0	0	256	420
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor				1.00	1.00		1.00	0.95			0.95	
Frpb, ped/bikes				1.00	1.00		1.00	1.00			0.99	
Flpb, ped/bikes				1.00	1.00		1.00	1.00			1.00	
Frt				1.00	0.87		1.00	1.00			0.91	
Flt Protected				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)				1736	1588		1736	3471			3104	
Flt Permitted				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (perm)				1736	1588		1736	3471			3104	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	146	11	76	22	593	0	0	278	457
RTOR Reduction (vph)	0	0	0	0	61	0	0	0	0	0	280	0
Lane Group Flow (vph)	0	0	0	146	26	0	22	593	0	0	455	0
Confl. Peds. (#/hr)							1					1
Confl. Bikes (#/hr)									2			1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type				Split			Prot					
Protected Phases				8	8		5	2			6	
Permitted Phases												
Actuated Green, G (s)				6.8	6.8		1.9	19.0			13.1	
Effective Green, g (s)				6.8	6.8		1.9	19.0			13.1	
Actuated g/C Ratio				0.20	0.20		0.06	0.56			0.39	
Clearance Time (s)				4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)				3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)				349	319		98	1951			1203	
v/s Ratio Prot				c0.08	0.02		0.01	c0.17			c0.15	
v/s Ratio Perm												
v/c Ratio				0.42	0.08		0.22	0.30			0.38	
Uniform Delay, d1				11.8	11.0		15.2	3.9			7.4	
Progression Factor				1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2				0.8	0.1		1.2	0.1			0.2	
Delay (s)				12.6	11.1		16.4	4.0			7.6	
Level of Service				B	B		B	A			A	
Approach Delay (s)		0.0			12.0			4.4			7.6	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	7.0	HCM Level of Service	A
HCM Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	33.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	34.8%	ICU Level of Service	A
Analysis Period (min)	15		

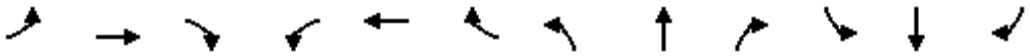
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	390	160	386	100	30	60	70	496	50	140	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		0.95	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	0.99		1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Frt	1.00	0.96		1.00	0.99		1.00	1.00	0.85		0.99	
Flt Protected	0.95	1.00		0.95	0.97		0.95	1.00	1.00		0.99	
Satd. Flow (prot)	1752	3339		1595	3207		1665	1745	1547		1797	
Flt Permitted	0.95	1.00		0.95	0.97		0.95	1.00	1.00		0.99	
Satd. Flow (perm)	1752	3339		1595	3207		1665	1745	1547		1797	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	424	174	420	109	33	65	76	539	54	152	22
RTOR Reduction (vph)	0	45	0	0	8	0	0	0	448	0	4	0
Lane Group Flow (vph)	11	553	0	210	344	0	58	83	91	0	224	0
Confl. Peds. (#/hr)	1					1			2	2		
Confl. Bikes (#/hr)			1			1						1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Split			Split			Split		Perm	Split		
Protected Phases	4	4		8	8		2	2		6	6	
Permitted Phases									2			
Actuated Green, G (s)	16.8	16.8		14.7	14.7		12.4	12.4	12.4		13.8	
Effective Green, g (s)	16.8	16.8		14.7	14.7		12.4	12.4	12.4		13.8	
Actuated g/C Ratio	0.23	0.23		0.20	0.20		0.17	0.17	0.17		0.19	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	399	761		318	640		280	294	260		336	
v/s Ratio Prot	0.01	c0.17		c0.13	0.11		0.03	0.05			c0.12	
v/s Ratio Perm									c0.06			
v/c Ratio	0.03	0.73		0.66	0.54		0.21	0.28	0.35		0.67	
Uniform Delay, d1	22.1	26.3		27.2	26.5		26.4	26.8	27.1		27.8	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Incremental Delay, d2	0.0	3.5		5.1	0.9		0.4	0.5	0.8		4.9	
Delay (s)	22.1	29.8		32.3	27.3		26.8	27.3	27.9		32.7	
Level of Service	C	C		C	C		C	C	C		C	
Approach Delay (s)		29.7			29.2			27.7			32.7	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	29.2	HCM Level of Service	C
HCM Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	73.7	Sum of lost time (s)	16.0
Intersection Capacity Utilization	68.2%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

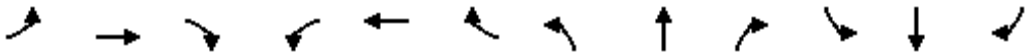


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	846	160	100	334	0	0	0	0	420	30	253
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		0.95			0.95						1.00	
Frpb, ped/bikes		1.00			1.00						1.00	
Flpb, ped/bikes		1.00			1.00						1.00	
Frt		0.98			1.00						0.95	
Flt Protected		1.00			0.99						0.97	
Satd. Flow (prot)		3438			3497						1721	
Flt Permitted		1.00			0.56						0.97	
Satd. Flow (perm)		3438			1976						1721	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	920	174	109	363	0	0	0	0	457	33	275
RTOR Reduction (vph)	0	27	0	0	0	0	0	0	0	0	32	0
Lane Group Flow (vph)	0	1067	0	0	472	0	0	0	0	0	733	0
Confl. Peds. (#/hr)	5		9	9		5						
Confl. Bikes (#/hr)						2						
Turn Type				Perm						Split		
Protected Phases		4			8					6	6	
Permitted Phases				8								
Actuated Green, G (s)		23.7			23.7						28.3	
Effective Green, g (s)		23.7			23.7						28.3	
Actuated g/C Ratio		0.39			0.39						0.47	
Clearance Time (s)		4.0			4.0						4.0	
Vehicle Extension (s)		3.0			3.0						3.0	
Lane Grp Cap (vph)		1358			781						812	
v/s Ratio Prot		c0.31									c0.43	
v/s Ratio Perm					0.24							
v/c Ratio		0.79			0.88dl						0.90	
Uniform Delay, d1		15.9			14.4						14.6	
Progression Factor		1.00			1.00						1.00	
Incremental Delay, d2		3.1			1.3						15.2	
Delay (s)		19.0			15.8						29.8	
Level of Service		B			B						C	
Approach Delay (s)		19.0			15.8			0.0			29.8	
Approach LOS		B			B			A			C	

Intersection Summary			
HCM Average Control Delay	21.9	HCM Level of Service	C
HCM Volume to Capacity ratio	0.85		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	92.4%	ICU Level of Service	F
Analysis Period (min)	15		

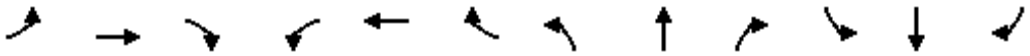
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

c Critical Lane Group



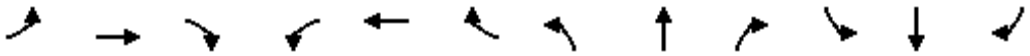
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	235	1031	0	0	394	410	40	10	80	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor		0.95			0.95		0.95	0.95	1.00			
Frpb, ped/bikes		1.00			0.99		1.00	1.00	1.00			
Flpb, ped/bikes		1.00			1.00		1.00	1.00	1.00			
Frt		1.00			0.92		1.00	1.00	0.85			
Flt Protected		0.99			1.00		0.95	0.97	1.00			
Satd. Flow (prot)		3506			3226		1681	1719	1583			
Flt Permitted		0.62			1.00		0.95	0.97	1.00			
Satd. Flow (perm)		2196			3226		1681	1719	1583			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	255	1121	0	0	428	446	43	11	87	0	0	0
RTOR Reduction (vph)	0	0	0	0	135	0	0	0	69	0	0	0
Lane Group Flow (vph)	0	1376	0	0	739	0	27	27	18	0	0	0
Confl. Peds. (#/hr)	5		7	7		5			1	1		
Confl. Bikes (#/hr)						3						
Turn Type	Perm						Split		Prot			
Protected Phases		4			8		2	2	2			
Permitted Phases	4											
Actuated Green, G (s)		55.7			55.7		16.3	16.3	16.3			
Effective Green, g (s)		55.7			55.7		16.3	16.3	16.3			
Actuated g/C Ratio		0.70			0.70		0.20	0.20	0.20			
Clearance Time (s)		4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)		3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)		1529			2246		343	350	323			
v/s Ratio Prot					0.23		c0.02	0.02	0.01			
v/s Ratio Perm		c0.63										
v/c Ratio		0.90			0.33		0.08	0.08	0.05			
Uniform Delay, d1		9.9			4.8		25.8	25.8	25.6			
Progression Factor		1.00			1.00		1.00	1.00	1.00			
Incremental Delay, d2		7.5			0.1		0.4	0.4	0.3			
Delay (s)		17.4			4.9		26.2	26.2	26.0			
Level of Service		B			A		C	C	C			
Approach Delay (s)		17.4			4.9			26.1			0.0	
Approach LOS		B			A			C			A	

Intersection Summary			
HCM Average Control Delay	13.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	80.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	85.9%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	100	410	61	180	362	143	103	807	210	101	321	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frpb, ped/bikes	1.00	1.00	0.97	1.00	1.00	0.98	1.00	1.00	0.91	1.00	1.00	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.98	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1770	3539	1539	1770	3539	1557	1770	3539	1438	1770	3461	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1770	3539	1539	1770	3539	1557	1770	3539	1438	1770	3461	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	109	446	66	196	393	155	112	877	228	110	349	54
RTOR Reduction (vph)	0	0	30	0	0	106	0	0	113	0	16	0
Lane Group Flow (vph)	109	446	36	196	393	49	112	877	115	110	387	0
Confl. Peds. (#/hr)	5		19	19		5	4		14	14		4
Confl. Bikes (#/hr)						1			100			
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases			2			6			8			
Actuated Green, G (s)	5.4	17.4	17.4	9.9	19.9	19.9	6.1	21.5	21.5	6.1	21.5	
Effective Green, g (s)	5.4	17.4	17.4	9.9	19.9	19.9	6.1	21.5	21.5	6.1	21.5	
Actuated g/C Ratio	0.08	0.26	0.26	0.15	0.29	0.29	0.09	0.32	0.32	0.09	0.32	
Clearance Time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Vehicle Extension (s)	2.0	4.0	4.0	2.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	
Lane Grp Cap (vph)	141	907	394	258	1037	456	159	1121	455	159	1096	
v/s Ratio Prot	0.06	c0.13		c0.11	0.11		c0.06	c0.25		0.06	0.11	
v/s Ratio Perm			0.02			0.03			0.08			
v/c Ratio	0.77	0.49	0.09	0.76	0.38	0.11	0.70	0.78	0.25	0.69	0.35	
Uniform Delay, d1	30.6	21.5	19.2	27.9	19.1	17.5	30.0	21.1	17.2	30.0	17.9	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	20.9	0.6	0.1	10.8	0.3	0.1	11.0	3.3	0.1	10.0	0.1	
Delay (s)	51.6	22.1	19.4	38.7	19.4	17.7	41.0	24.4	17.3	40.0	17.9	
Level of Service	D	C	B	D	B	B	D	C	B	D	B	
Approach Delay (s)		27.0			24.1			24.6			22.7	
Approach LOS		C			C			C			C	

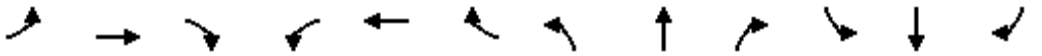
Intersection Summary			
HCM Average Control Delay	24.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	67.9	Sum of lost time (s)	13.0
Intersection Capacity Utilization	66.6%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	300	10	675	0	495	140	0	432	140
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0	4.0		4.0	4.0		4.0	
Lane Util. Factor				0.95	0.91	0.95		0.91	1.00		0.91	
Frt				1.00	0.87	0.85		1.00	0.85		0.96	
Flt Protected				0.95	1.00	1.00		1.00	1.00		1.00	
Satd. Flow (prot)				1698	1478	1519		5136	1599		4947	
Flt Permitted				0.95	1.00	1.00		1.00	1.00		1.00	
Satd. Flow (perm)				1698	1478	1519		5136	1599		4947	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	319	11	718	0	527	149	0	460	149
RTOR Reduction (vph)	0	0	0	0	97	97	0	0	0	0	102	0
Lane Group Flow (vph)	0	0	0	287	283	284	0	527	149	0	507	0
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Split		Perm			Free			
Protected Phases				8	8			2			6	
Permitted Phases						8			Free			
Actuated Green, G (s)				16.1	16.1	16.1		10.5	34.6		10.5	
Effective Green, g (s)				16.1	16.1	16.1		10.5	34.6		10.5	
Actuated g/C Ratio				0.47	0.47	0.47		0.30	1.00		0.30	
Clearance Time (s)				4.0	4.0	4.0		4.0			4.0	
Vehicle Extension (s)				3.0	3.0	3.0		3.0			3.0	
Lane Grp Cap (vph)				790	688	707		1559	1599		1501	
v/s Ratio Prot				0.17	c0.19			c0.10			0.10	
v/s Ratio Perm						0.19			0.09			
v/c Ratio				0.36	0.41	0.40		0.34	0.09		0.34	
Uniform Delay, d1				6.0	6.1	6.1		9.4	0.0		9.4	
Progression Factor				1.00	1.00	1.00		1.00	1.00		1.00	
Incremental Delay, d2				0.3	0.4	0.4		0.1	0.1		0.1	
Delay (s)				6.2	6.5	6.5		9.5	0.1		9.5	
Level of Service				A	A	A		A	A		A	
Approach Delay (s)		0.0			6.4			7.4			9.5	
Approach LOS		A			A			A			A	

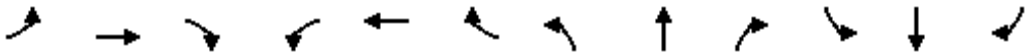
Intersection Summary			
HCM Average Control Delay	7.5	HCM Level of Service	A
HCM Volume to Capacity ratio	0.38		
Actuated Cycle Length (s)	34.6	Sum of lost time (s)	8.0
Intersection Capacity Utilization	44.1%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	260	0	170	0	0	0	0	375	370	0	481	261
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0					4.0			4.0	4.0
Lane Util. Factor	1.00		1.00					0.91			0.95	1.00
Frpb, ped/bikes	1.00		1.00					0.99			1.00	0.98
Flpb, ped/bikes	1.00		1.00					1.00			1.00	1.00
Frt	1.00		0.85					0.93			1.00	0.85
Flt Protected	0.95		1.00					1.00			1.00	1.00
Satd. Flow (prot)	1770		1583					4647			3539	1549
Flt Permitted	0.95		1.00					1.00			1.00	1.00
Satd. Flow (perm)	1770		1583					4647			3539	1549
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	283	0	185	0	0	0	0	408	402	0	523	284
RTOR Reduction (vph)	0	0	100	0	0	0	0	255	0	0	0	0
Lane Group Flow (vph)	283	0	85	0	0	0	0	555	0	0	523	284
Confl. Peds. (#/hr)							4		2	2		4
Confl. Bikes (#/hr)									3			
Turn Type	Split		Perm									Free
Protected Phases	8	8						2			6	
Permitted Phases			8									Free
Actuated Green, G (s)	12.4		12.4					11.8			11.8	32.2
Effective Green, g (s)	12.4		12.4					11.8			11.8	32.2
Actuated g/C Ratio	0.39		0.39					0.37			0.37	1.00
Clearance Time (s)	4.0		4.0					4.0			4.0	
Vehicle Extension (s)	3.0		3.0					3.0			3.0	
Lane Grp Cap (vph)	682		610					1703			1297	1549
v/s Ratio Prot	c0.16							0.12			c0.15	
v/s Ratio Perm			0.05									0.18
v/c Ratio	0.41		0.14					0.33			0.40	0.18
Uniform Delay, d1	7.2		6.4					7.3			7.6	0.0
Progression Factor	1.00		1.00					1.00			1.00	1.00
Incremental Delay, d2	0.4		0.1					0.1			0.2	0.3
Delay (s)	7.7		6.5					7.5			7.8	0.3
Level of Service	A		A					A			A	A
Approach Delay (s)		7.2			0.0			7.5			5.1	
Approach LOS		A			A			A			A	

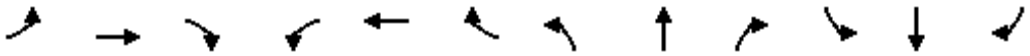
Intersection Summary			
HCM Average Control Delay	6.5	HCM Level of Service	A
HCM Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	32.2	Sum of lost time (s)	8.0
Intersection Capacity Utilization	36.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	170	10	70	20	20	230	30	345	10	20	531	110
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Lane Util. Factor		1.00		1.00	1.00			0.95		1.00	0.95	
Frpb, ped/bikes		0.99		1.00	0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00		1.00	1.00			1.00		0.94	1.00	
Frt		0.96		1.00	0.86			1.00		1.00	0.97	
Flt Protected		0.97		0.95	1.00			1.00		0.95	1.00	
Satd. Flow (prot)		1703		1751	1571			3475		1646	3402	
Flt Permitted		1.00		0.59	1.00			0.88		0.95	1.00	
Satd. Flow (perm)		1761		1091	1571			3060		1646	3402	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	185	11	76	22	22	250	33	375	11	22	577	120
RTOR Reduction (vph)	0	14	0	0	188	0	0	2	0	0	16	0
Lane Group Flow (vph)	0	258	0	22	84	0	0	417	0	22	681	0
Confl. Peds. (#/hr)	1		3	3		1			5	5		
Confl. Bikes (#/hr)						1			2			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Perm			Prot		
Protected Phases		3			4			2		1	6	
Permitted Phases	3			4			2					
Actuated Green, G (s)		2.4		11.4	11.4			15.4		0.8	20.2	
Effective Green, g (s)		2.4		11.4	11.4			15.4		0.8	20.2	
Actuated g/C Ratio		0.05		0.25	0.25			0.33		0.02	0.44	
Clearance Time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		92		270	389			1024		29	1494	
v/s Ratio Prot					c0.05					0.01	c0.20	
v/s Ratio Perm		c0.15		0.02				0.14				
v/c Ratio		2.80		0.08	0.22			0.41		0.76	0.46	
Uniform Delay, d1		21.8		13.3	13.7			11.8		22.5	9.0	
Progression Factor		1.00		1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		840.3		0.1	0.3			0.3		71.7	0.2	
Delay (s)		862.1		13.4	14.0			12.0		94.2	9.3	
Level of Service		F		B	B			B		F	A	
Approach Delay (s)		862.1			14.0			12.0			11.9	
Approach LOS		F			B			B			B	

Intersection Summary			
HCM Average Control Delay	148.0	HCM Level of Service	F
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	46.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	73.1%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group



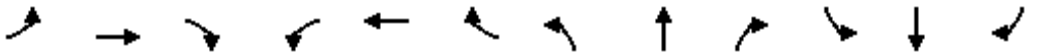
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	170	21	30	43	43	35	30	160	51	21	350	210
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00	1.00	1.00	0.99		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	0.93		1.00	0.96		1.00	0.94	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	3278		1770	3399		1770	3314	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	3278		1770	3399		1770	3314	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	179	22	32	45	45	37	32	168	54	22	368	221
RTOR Reduction (vph)	0	0	24	0	34	0	0	33	0	0	117	0
Lane Group Flow (vph)	179	22	8	45	48	0	32	189	0	22	472	0
Confl. Peds. (#/hr)							16		1	1		16
Confl. Bikes (#/hr)						1			1			
Turn Type	Prot		Perm	Prot			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4									
Actuated Green, G (s)	9.2	11.6	11.6	1.7	4.1		1.4	14.2		1.0	13.8	
Effective Green, g (s)	9.2	11.6	11.6	1.7	4.1		1.4	14.2		1.0	13.8	
Actuated g/C Ratio	0.21	0.26	0.26	0.04	0.09		0.03	0.32		0.02	0.31	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	366	923	413	68	302		56	1085		40	1028	
v/s Ratio Prot	c0.10	0.01		0.03	c0.01		c0.02	0.06		0.01	c0.14	
v/s Ratio Perm			0.01									
v/c Ratio	0.49	0.02	0.02	0.66	0.16		0.57	0.17		0.55	0.46	
Uniform Delay, d1	15.6	12.2	12.2	21.1	18.6		21.3	10.9		21.5	12.3	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	1.0	0.0	0.0	21.6	0.3		13.3	0.1		15.3	0.3	
Delay (s)	16.6	12.2	12.2	42.7	18.9		34.6	11.0		36.9	12.7	
Level of Service	B	B	B	D	B		C	B		D	B	
Approach Delay (s)		15.6			27.3			14.0			13.5	
Approach LOS		B			C			B			B	

Intersection Summary			
HCM Average Control Delay	15.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.43		
Actuated Cycle Length (s)	44.5	Sum of lost time (s)	16.0
Intersection Capacity Utilization	47.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	83	50	75	191	180	70
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	90	54	82	208	196	76
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				1133		
pX, platoon unblocked						
vC, conflicting volume			145		461	90
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			145		461	90
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			94		63	92
cM capacity (veh/h)			1426		523	962

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2
Volume Total	90	54	82	208	196	76
Volume Left	0	0	82	0	196	0
Volume Right	0	54	0	0	0	76
cSH	1700	1700	1426	1700	523	962
Volume to Capacity	0.05	0.03	0.06	0.12	0.37	0.08
Queue Length 95th (ft)	0	0	5	0	43	6
Control Delay (s)	0.0	0.0	7.7	0.0	15.9	9.1
Lane LOS			A		C	A
Approach Delay (s)	0.0		2.2		14.0	
Approach LOS					B	

Intersection Summary			
Average Delay	6.3		
Intersection Capacity Utilization	27.5%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	110	27	10	10	50	135	20	20	10	83	20	60
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.96		1.00	0.89		1.00	0.95			0.95	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.98	
Satd. Flow (prot)	1626	1641		1626	1524		1626	1626			1587	
Flt Permitted	0.95	1.00		0.95	1.00		0.78	1.00			0.82	
Satd. Flow (perm)	1626	1641		1626	1524		1332	1626			1338	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	120	29	11	11	54	147	22	22	11	90	22	65
RTOR Reduction (vph)	0	7	0	0	112	0	0	8	0	0	36	0
Lane Group Flow (vph)	120	33	0	11	89	0	22	25	0	0	141	0
Heavy Vehicles (%)	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	4.4	10.9		0.9	7.4		7.6	7.6			7.6	
Effective Green, g (s)	4.4	10.9		0.9	7.4		7.6	7.6			7.6	
Actuated g/C Ratio	0.14	0.35		0.03	0.24		0.24	0.24			0.24	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	228	570		47	359		322	394			324	
v/s Ratio Prot	c0.07	c0.02		0.01	c0.06			0.02				
v/s Ratio Perm							0.02				c0.11	
v/c Ratio	0.53	0.06		0.23	0.25		0.07	0.06			0.44	
Uniform Delay, d1	12.5	6.8		14.9	9.7		9.2	9.2			10.1	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	2.2	0.0		2.6	0.4		0.1	0.1			0.9	
Delay (s)	14.7	6.9		17.5	10.1		9.3	9.2			11.0	
Level of Service	B	A		B	B		A	A			B	
Approach Delay (s)		12.8			10.5			9.2			11.0	
Approach LOS		B			B			A			B	

Intersection Summary			
HCM Average Control Delay	11.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.42		
Actuated Cycle Length (s)	31.4	Sum of lost time (s)	16.0
Intersection Capacity Utilization	43.0%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	50	60	62	105	80	62
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	54	65	67	114	87	67
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)	322					
pX, platoon unblocked						
vC, conflicting volume			54		336	87
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			54		336	87
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			96		86	93
cM capacity (veh/h)			1551		631	972

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	120	67	114	154
Volume Left	0	67	0	87
Volume Right	65	0	0	67
cSH	1700	1551	1700	745
Volume to Capacity	0.07	0.04	0.07	0.21
Queue Length 95th (ft)	0	3	0	19
Control Delay (s)	0.0	7.4	0.0	11.1
Lane LOS		A		B
Approach Delay (s)	0.0	2.8		11.1
Approach LOS				B

Intersection Summary			
Average Delay	4.9		
Intersection Capacity Utilization	25.0%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	90	22	25	70	97	135
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	98	24	27	76	105	147
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			122		240	110
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			122		240	110
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			98		86	84
cM capacity (veh/h)			1466		734	944

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	122	27	76	252
Volume Left	0	27	0	105
Volume Right	24	0	0	147
cSH	1700	1466	1700	843
Volume to Capacity	0.07	0.02	0.04	0.30
Queue Length 95th (ft)	0	1	0	31
Control Delay (s)	0.0	7.5	0.0	11.1
Lane LOS		A		B
Approach Delay (s)	0.0	2.0		11.1
Approach LOS				B

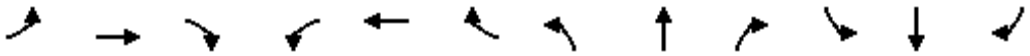
Intersection Summary			
Average Delay	6.3		
Intersection Capacity Utilization	28.4%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay (sec/veh)	23.8
Intersection LOS	C

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Volume (vph)	10	20	10	430	10	20	10	65	70	120	114	10
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles(%)	2	2	2	2	2	2	2	2	2	2	2	2
Movement Flow Rate	11	22	11	467	11	22	11	71	76	130	124	11
Number of Lanes	0	1	0	1	1	0	1	2	0	1	2	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	2	1	3	3
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	3	3	1	2
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	3	3	2	1
HCM Control Delay	10.8	35.2	11	11.9
HCM LOS	B	E	B	B

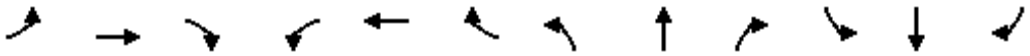
Lane	NBLn1	NBLn2	NBLn3	EBLn1	WBLn1	WBLn2	SBLn1	SBLn2	SBLn3
Volume Left (%)	100%	0%	0%	25%	100%	0%	100%	0%	0%
Volume Thru (%)	0%	100%	24%	50%	0%	33%	0%	100%	79%
Volume Right (%)	0%	0%	76%	25%	0%	67%	0%	0%	21%
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Traffic Volume by Lane	10	43	92	40	430	30	120	76	48
Left Turning Volume	0	43	22	20	0	10	0	76	38
Through Volume	0	0	70	10	0	20	0	0	10
Right Turning Volume	10	0	0	10	430	0	120	0	0
Lane Flow Rate	11	47	100	43	467	33	130	83	52
Geometry Group	8	8	8	8	8	8	8	8	8
Degree of Utilization, X	0.024	0.095	0.187	0.088	0.856	0.051	0.272	0.16	0.099
Departure Headway, Hd	7.804	7.29	6.741	7.257	6.596	5.63	7.505	6.993	6.843
Convergence(Y/N)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capacity	456	488	528	490	547	634	476	510	521
Service Time	5.598	5.084	4.534	5.053	4.354	3.387	5.289	4.776	4.627
HCM Lane V/C Ratio	0.024	0.096	0.189	0.088	0.854	0.052	0.273	0.163	0.1
HCM Control Delay	10.8	10.9	11.1	10.8	37.1	8.7	13.1	11.1	10.4
HCM Lane LOS	B	B	B	B	E	A	B	B	B
HCM 95th Percentile Queue	0.1	0.3	0.7	0.3	17.3	0.2	1.1	0.6	0.3



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	49	10	450	20	534	0	0	95	300
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor				1.00	1.00		1.00	0.95			0.95	
Frpb, ped/bikes				1.00	1.00		1.00	1.00			0.98	
Flpb, ped/bikes				1.00	1.00		1.00	1.00			1.00	
Frt				1.00	0.85		1.00	1.00			0.89	
Flt Protected				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)				1787	1605		1787	3574			3115	
Flt Permitted				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (perm)				1787	1605		1787	3574			3115	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	52	11	474	21	562	0	0	100	316
RTOR Reduction (vph)	0	0	0	0	235	0	0	0	0	0	216	0
Lane Group Flow (vph)	0	0	0	52	250	0	21	562	0	0	200	0
Confl. Peds. (#/hr)							1		2	2		1
Confl. Bikes (#/hr)			1						1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Split			Prot					
Protected Phases				8	8		5	2			6	
Permitted Phases												
Actuated Green, G (s)				10.7	10.7		2.2	17.8			11.6	
Effective Green, g (s)				10.7	10.7		2.2	17.8			11.6	
Actuated g/C Ratio				0.29	0.29		0.06	0.49			0.32	
Clearance Time (s)				4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)				3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)				524	471		108	1743			990	
v/s Ratio Prot				0.03	c0.16		0.01	c0.16			0.06	
v/s Ratio Perm												
v/c Ratio				0.10	0.53		0.19	0.32			0.20	
Uniform Delay, d1				9.4	10.8		16.3	5.7			9.1	
Progression Factor				1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2				0.1	1.2		0.9	0.1			0.1	
Delay (s)				9.5	12.0		17.2	5.8			9.2	
Level of Service				A	B		B	A			A	
Approach Delay (s)		0.0			11.7			6.2			9.2	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	8.9	HCM Level of Service	A
HCM Volume to Capacity ratio	0.40		
Actuated Cycle Length (s)	36.5	Sum of lost time (s)	8.0
Intersection Capacity Utilization	51.7%	ICU Level of Service	A
Analysis Period (min)	15		

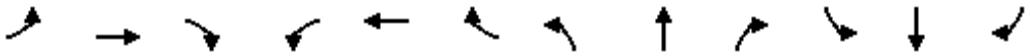
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	40	260	70	285	290	50	310	180	494	20	40	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		0.95	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	0.99		1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Frt	1.00	0.97		1.00	0.98		1.00	1.00	0.85		0.94	
Flt Protected	0.95	1.00		0.95	0.99		0.95	0.99	1.00		0.99	
Satd. Flow (prot)	1787	3461		1626	3331		1698	1763	1576		1749	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	0.99	1.00		0.99	
Satd. Flow (perm)	1787	3461		1626	3331		1698	1763	1576		1749	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	41	268	72	294	299	52	320	186	509	21	41	52
RTOR Reduction (vph)	0	26	0	0	11	0	0	0	371	0	34	0
Lane Group Flow (vph)	41	314	0	212	422	0	250	256	138	0	80	0
Confl. Peds. (#/hr)									2	2		
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Split			Split			Split		Perm	Split		
Protected Phases	4	4		8	8		2	2		6	6	
Permitted Phases									2			
Actuated Green, G (s)	12.3	12.3		16.1	16.1		19.2	19.2	19.2		7.2	
Effective Green, g (s)	12.3	12.3		16.1	16.1		19.2	19.2	19.2		7.2	
Actuated g/C Ratio	0.17	0.17		0.23	0.23		0.27	0.27	0.27		0.10	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	310	601		370	757		460	478	427		178	
v/s Ratio Prot	0.02	c0.09		c0.13	0.13		c0.15	0.15			c0.05	
v/s Ratio Perm									0.09			
v/c Ratio	0.13	0.52		0.57	0.56		0.54	0.54	0.32		0.45	
Uniform Delay, d1	24.7	26.6		24.3	24.2		22.1	22.0	20.6		29.9	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Incremental Delay, d2	0.2	0.8		2.1	0.9		1.3	1.2	0.4		1.8	
Delay (s)	24.9	27.4		26.4	25.1		23.4	23.2	21.1		31.7	
Level of Service	C	C		C	C		C	C	C		C	
Approach Delay (s)		27.1			25.5			22.2			31.7	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	24.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	70.8	Sum of lost time (s)	16.0
Intersection Capacity Utilization	56.5%	ICU Level of Service	B
Analysis Period (min)	15		

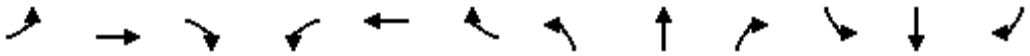
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	654	150	90	451	0	0	0	0	360	10	245
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		0.95			0.95						1.00	
Frpb, ped/bikes		0.99			1.00						1.00	
Flpb, ped/bikes		1.00			1.00						1.00	
Frt		0.97			1.00						0.95	
Flt Protected		1.00			0.99						0.97	
Satd. Flow (prot)		3456			3543						1729	
Flt Permitted		1.00			0.66						0.97	
Satd. Flow (perm)		3456			2357						1729	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	0	681	156	94	470	0	0	0	0	375	10	255
RTOR Reduction (vph)	0	42	0	0	0	0	0	0	0	0	36	0
Lane Group Flow (vph)	0	795	0	0	564	0	0	0	0	0	604	0
Confl. Peds. (#/hr)	3		8	8		3						
Confl. Bikes (#/hr)						3						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Perm						Split		
Protected Phases		4			8					6	6	
Permitted Phases				8								
Actuated Green, G (s)		19.8			19.8						27.2	
Effective Green, g (s)		19.8			19.8						27.2	
Actuated g/C Ratio		0.36			0.36						0.49	
Clearance Time (s)		4.0			4.0						4.0	
Vehicle Extension (s)		3.0			3.0						3.0	
Lane Grp Cap (vph)		1244			849						855	
v/s Ratio Prot		0.23									c0.35	
v/s Ratio Perm					c0.24							
v/c Ratio		0.64			0.66						0.71	
Uniform Delay, d1		14.6			14.8						10.8	
Progression Factor		1.00			1.00						1.00	
Incremental Delay, d2		1.1			2.0						4.9	
Delay (s)		15.7			16.8						15.7	
Level of Service		B			B						B	
Approach Delay (s)		15.7			16.8			0.0			15.7	
Approach LOS		B			B			A			B	

Intersection Summary			
HCM Average Control Delay	16.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.69		
Actuated Cycle Length (s)	55.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	84.1%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group



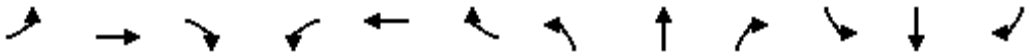
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	271	743	0	0	471	430	80	140	140	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor		0.95			0.95		0.95	0.95	1.00			
Frpb, ped/bikes		1.00			0.99		1.00	1.00	1.00			
Flpb, ped/bikes		1.00			1.00		1.00	1.00	1.00			
Frt		1.00			0.93		1.00	1.00	0.85			
Flt Protected		0.99			1.00		0.95	1.00	1.00			
Satd. Flow (prot)		3527			3282		1698	1782	1599			
Flt Permitted		0.57			1.00		0.95	1.00	1.00			
Satd. Flow (perm)		2023			3282		1698	1782	1599			
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	282	774	0	0	491	448	83	146	146	0	0	0
RTOR Reduction (vph)	0	0	0	0	144	0	0	0	111	0	0	0
Lane Group Flow (vph)	0	1056	0	0	795	0	75	154	35	0	0	0
Confl. Peds. (#/hr)	2		7	7		2						
Confl. Bikes (#/hr)						3						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm						Split		Prot			
Protected Phases		4			8		2	2	2			
Permitted Phases	4											
Actuated Green, G (s)		52.9			52.9		19.1	19.1	19.1			
Effective Green, g (s)		52.9			52.9		19.1	19.1	19.1			
Actuated g/C Ratio		0.66			0.66		0.24	0.24	0.24			
Clearance Time (s)		4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)		3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)		1338			2170		405	425	382			
v/s Ratio Prot					0.24		0.04	c0.09	0.02			
v/s Ratio Perm		c0.52										
v/c Ratio		0.79			0.37		0.19	0.36	0.09			
Uniform Delay, d1		9.6			6.1		24.3	25.4	23.7			
Progression Factor		1.00			1.00		1.00	1.00	1.00			
Incremental Delay, d2		3.2			0.1		1.0	2.4	0.5			
Delay (s)		12.8			6.2		25.3	27.8	24.2			
Level of Service		B			A		C	C	C			
Approach Delay (s)		12.8			6.2			25.9			0.0	
Approach LOS		B			A			C			A	

Intersection Summary			
HCM Average Control Delay	12.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	80.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	73.8%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Cumulative (2035) No Project Conditions

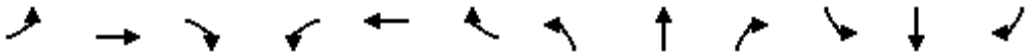
FEHR PEERS



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	110	300	100	400	470	220	60	370	170	70	830	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frpb, ped/bikes	1.00	1.00	0.97	1.00	1.00	0.97	1.00	1.00	0.98	1.00	1.00	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1736	3471	1514	1736	3471	1511	1736	3471	1528	1736	3439	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1736	3471	1514	1736	3471	1511	1736	3471	1528	1736	3439	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	120	326	109	435	511	239	65	402	185	76	902	54
RTOR Reduction (vph)	0	0	61	0	0	108	0	0	125	0	5	0
Lane Group Flow (vph)	120	326	48	435	511	131	65	402	60	76	951	0
Confl. Peds. (#/hr)	14		13	13		14	4		4	4		4
Confl. Bikes (#/hr)						1						1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases			2			6			8			
Actuated Green, G (s)	8.0	16.3	16.3	22.2	28.5	28.5	4.0	26.4	26.4	3.9	26.3	
Effective Green, g (s)	8.0	16.3	16.3	22.2	28.5	28.5	4.0	26.4	26.4	3.9	26.3	
Actuated g/C Ratio	0.10	0.20	0.20	0.27	0.35	0.35	0.05	0.32	0.32	0.05	0.32	
Clearance Time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Vehicle Extension (s)	2.0	4.0	4.0	2.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	
Lane Grp Cap (vph)	170	692	302	471	1209	526	85	1120	493	83	1106	
v/s Ratio Prot	0.07	0.09		c0.25	c0.15		0.04	0.12		c0.04	c0.28	
v/s Ratio Perm			0.03			0.09			0.04			
v/c Ratio	0.71	0.47	0.16	0.92	0.42	0.25	0.76	0.36	0.12	0.92	0.86	
Uniform Delay, d1	35.8	28.9	27.1	29.0	20.4	19.0	38.4	21.2	19.5	38.8	26.0	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	10.4	0.7	0.3	23.5	0.3	0.3	30.0	0.1	0.0	69.6	6.8	
Delay (s)	46.1	29.6	27.4	52.5	20.7	19.4	68.5	21.3	19.6	108.4	32.8	
Level of Service	D	C	C	D	C	B	E	C	B	F	C	
Approach Delay (s)		32.8			32.1			25.5			38.4	
Approach LOS		C			C			C			D	

Intersection Summary			
HCM Average Control Delay	32.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	81.8	Sum of lost time (s)	9.0
Intersection Capacity Utilization	75.8%	ICU Level of Service	D
Analysis Period (min)	15		

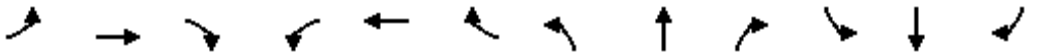
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	380	10	230	0	350	150	0	1060	290
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0	4.0		4.0	4.0		4.0	
Lane Util. Factor				0.95	0.91	0.95		0.91	1.00		0.91	
Frpb, ped/bikes				1.00	1.00	0.99		1.00	0.98		1.00	
Flpb, ped/bikes				1.00	1.00	1.00		1.00	1.00		1.00	
Frt				1.00	0.97	0.85		1.00	0.85		0.97	
Flt Protected				0.95	0.96	1.00		1.00	1.00		1.00	
Satd. Flow (prot)				1665	1571	1471		5036	1535		4850	
Flt Permitted				0.95	0.96	1.00		1.00	1.00		1.00	
Satd. Flow (perm)				1665	1571	1471		5036	1535		4850	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	404	11	245	0	372	160	0	1128	309
RTOR Reduction (vph)	0	0	0	0	15	140	0	0	0	0	63	0
Lane Group Flow (vph)	0	0	0	226	213	66	0	372	160	0	1374	0
Confl. Peds. (#/hr)	1					1	2		1	1		2
Confl. Bikes (#/hr)									2			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type				Split		Perm			Free			
Protected Phases				8	8			2			6	
Permitted Phases						8			Free			
Actuated Green, G (s)				14.5	14.5	14.5		22.9	45.4		22.9	
Effective Green, g (s)				14.5	14.5	14.5		22.9	45.4		22.9	
Actuated g/C Ratio				0.32	0.32	0.32		0.50	1.00		0.50	
Clearance Time (s)				4.0	4.0	4.0		4.0			4.0	
Vehicle Extension (s)				3.0	3.0	3.0		3.0			3.0	
Lane Grp Cap (vph)				532	502	470		2540	1535		2446	
v/s Ratio Prot				c0.14	0.14			0.07			c0.28	
v/s Ratio Perm						0.04			0.10			
v/c Ratio				0.42	0.42	0.14		0.15	0.10		0.56	
Uniform Delay, d1				12.2	12.2	11.0		6.0	0.0		7.8	
Progression Factor				1.00	1.00	1.00		1.00	1.00		1.00	
Incremental Delay, d2				0.5	0.6	0.1		0.0	0.1		0.3	
Delay (s)				12.7	12.7	11.1		6.0	0.1		8.1	
Level of Service				B	B	B		A	A		A	
Approach Delay (s)		0.0			12.2			4.3			8.1	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	8.4	HCM Level of Service	A
HCM Volume to Capacity ratio	0.51		
Actuated Cycle Length (s)	45.4	Sum of lost time (s)	8.0
Intersection Capacity Utilization	47.2%	ICU Level of Service	A
Analysis Period (min)	15		

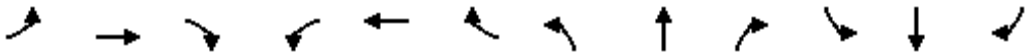
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	100	0	230	0	0	0	0	400	360	0	630	820
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0					4.0			4.0	4.0
Lane Util. Factor	1.00		1.00					0.91			0.95	1.00
Frpb, ped/bikes	1.00		1.00					0.99			1.00	0.98
Flpb, ped/bikes	1.00		1.00					1.00			1.00	1.00
Frt	1.00		0.85					0.93			1.00	0.85
Flt Protected	0.95		1.00					1.00			1.00	1.00
Satd. Flow (prot)	1752		1568					4625			3505	1536
Flt Permitted	0.95		1.00					1.00			1.00	1.00
Satd. Flow (perm)	1752		1568					4625			3505	1536
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	109	0	250	0	0	0	0	435	391	0	685	891
RTOR Reduction (vph)	0	0	65	0	0	0	0	210	0	0	0	0
Lane Group Flow (vph)	109	0	185	0	0	0	0	616	0	0	685	891
Confl. Peds. (#/hr)							1		3	3		1
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Split		Perm									Free
Protected Phases	8	8						2			6	
Permitted Phases			8									Free
Actuated Green, G (s)	9.0		9.0					14.6			14.6	31.6
Effective Green, g (s)	9.0		9.0					14.6			14.6	31.6
Actuated g/C Ratio	0.28		0.28					0.46			0.46	1.00
Clearance Time (s)	4.0		4.0					4.0			4.0	
Vehicle Extension (s)	3.0		3.0					3.0			3.0	
Lane Grp Cap (vph)	499		447					2137			1619	1536
v/s Ratio Prot	0.06							0.13			0.20	
v/s Ratio Perm			0.12									c0.58
v/c Ratio	0.22		0.41					0.29			0.42	0.58
Uniform Delay, d1	8.6		9.2					5.3			5.7	0.0
Progression Factor	1.00		1.00					1.00			1.00	1.00
Incremental Delay, d2	0.2		0.6					0.1			0.2	1.6
Delay (s)	8.8		9.8					5.3			5.9	1.6
Level of Service	A		A					A			A	A
Approach Delay (s)		9.5			0.0			5.3			3.5	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	4.8	HCM Level of Service	A
HCM Volume to Capacity ratio	0.58		
Actuated Cycle Length (s)	31.6	Sum of lost time (s)	0.0
Intersection Capacity Utilization	38.3%	ICU Level of Service	A
Analysis Period (min)	15		

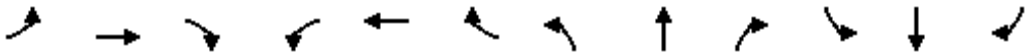
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	70	20	40	10	10	40	40	650	30	320	390	130
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Lane Util. Factor		1.00		1.00	1.00			0.95		1.00	0.95	
Frpb, ped/bikes		1.00		1.00	0.99			1.00		1.00	0.99	
Flpb, ped/bikes		1.00		1.00	1.00			1.00		1.00	1.00	
Frt		0.96		1.00	0.88			0.99		1.00	0.96	
Flt Protected		0.97		0.95	1.00			1.00		0.95	1.00	
Satd. Flow (prot)		1705		1736	1592			3440		1736	3322	
Flt Permitted		1.00		0.67	1.00			0.90		0.95	1.00	
Satd. Flow (perm)		1751		1219	1592			3104		1736	3322	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	76	22	43	11	11	43	43	707	33	348	424	141
RTOR Reduction (vph)	0	16	0	0	37	0	0	3	0	0	20	0
Lane Group Flow (vph)	0	125	0	11	17	0	0	780	0	348	545	0
Confl. Peds. (#/hr)	3					3	2					2
Confl. Bikes (#/hr)												1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm			Perm			Perm			Prot		
Protected Phases		3			4			2		1	6	
Permitted Phases	3			4			2					
Actuated Green, G (s)		2.2		8.4	8.4			21.8		11.9	37.7	
Effective Green, g (s)		2.2		8.4	8.4			21.8		11.9	37.7	
Actuated g/C Ratio		0.04		0.14	0.14			0.36		0.20	0.63	
Clearance Time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		64		170	222			1122		343	2077	
v/s Ratio Prot					c0.01					c0.20	0.16	
v/s Ratio Perm		c0.07		0.01				c0.25				
v/c Ratio		1.95		0.06	0.08			0.70		1.01	0.26	
Uniform Delay, d1		29.0		22.5	22.6			16.4		24.2	5.1	
Progression Factor		1.00		1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		477.8		0.2	0.1			1.9		52.3	0.1	
Delay (s)		506.9		22.7	22.7			18.3		76.5	5.1	
Level of Service		F		C	C			B		E	A	
Approach Delay (s)		506.9			22.7			18.3			32.4	
Approach LOS		F			C			B			C	

Intersection Summary			
HCM Average Control Delay	61.4	HCM Level of Service	E
HCM Volume to Capacity ratio	0.73		
Actuated Cycle Length (s)	60.3	Sum of lost time (s)	16.0
Intersection Capacity Utilization	62.1%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group



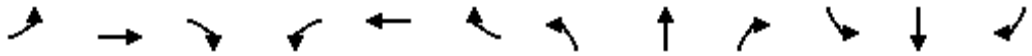
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	300	70	20	20	20	50	20	400	140	40	150	230
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00	1.00	1.00	0.96		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	0.89		1.00	0.96		1.00	0.91	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	3044		1767	3390		1770	3187	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	3044		1767	3390		1770	3187	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	326	76	22	22	22	54	22	435	152	43	163	250
RTOR Reduction (vph)	0	0	13	0	48	0	0	33	0	0	172	0
Lane Group Flow (vph)	326	76	9	22	28	0	22	554	0	43	241	0
Confl. Peds. (#/hr)	3					3	4					4
Confl. Bikes (#/hr)						20			1			1
Turn Type	Prot		Perm	Prot			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4									
Actuated Green, G (s)	18.1	24.5	24.5	0.6	7.0		0.6	17.0		2.6	19.0	
Effective Green, g (s)	18.1	24.5	24.5	0.6	7.0		0.6	17.0		2.6	19.0	
Actuated g/C Ratio	0.30	0.40	0.40	0.01	0.12		0.01	0.28		0.04	0.31	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	528	1428	639	17	351		17	949		76	998	
v/s Ratio Prot	c0.18	0.02		0.01	c0.01		0.01	c0.16		c0.02	0.08	
v/s Ratio Perm			0.01									
v/c Ratio	0.62	0.05	0.01	1.29	0.08		1.29	0.58		0.57	0.24	
Uniform Delay, d1	18.3	11.0	10.9	30.1	24.0		30.1	18.8		28.5	15.5	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	2.2	0.0	0.0	323.2	0.1		323.2	0.9		9.3	0.1	
Delay (s)	20.5	11.0	10.9	353.2	24.1		353.2	19.7		37.8	15.6	
Level of Service	C	B	B	F	C		F	B		D	B	
Approach Delay (s)		18.3			98.0			31.8			17.7	
Approach LOS		B			F			C			B	

Intersection Summary			
HCM Average Control Delay	28.2	HCM Level of Service	C
HCM Volume to Capacity ratio	0.51		
Actuated Cycle Length (s)	60.7	Sum of lost time (s)	16.0
Intersection Capacity Utilization	52.2%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	360	140	100	160	100	100
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	391	152	109	174	109	109
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				1133		
pX, platoon unblocked						
vC, conflicting volume			543		783	391
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			543		783	391
tC, single (s)			4.2		6.5	6.3
tC, 2 stage (s)						
tF (s)			2.3		3.6	3.4
p0 queue free %			89		66	83
cM capacity (veh/h)			996		316	644

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2
Volume Total	391	152	109	174	109	109
Volume Left	0	0	109	0	109	0
Volume Right	0	152	0	0	0	109
cSH	1700	1700	996	1700	316	644
Volume to Capacity	0.23	0.09	0.11	0.10	0.34	0.17
Queue Length 95th (ft)	0	0	9	0	37	15
Control Delay (s)	0.0	0.0	9.1	0.0	22.3	11.7
Lane LOS			A		C	B
Approach Delay (s)	0.0		3.5		17.0	
Approach LOS					C	

Intersection Summary			
Average Delay	4.5		
Intersection Capacity Utilization	40.0%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	80	50	30	20	70	100	20	30	30	120	40	300
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	0.99			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.94		1.00	0.91		1.00	0.93			0.91	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.99	
Satd. Flow (prot)	1671	1659		1671	1604		1671	1608			1583	
Flt Permitted	0.95	1.00		0.95	1.00		0.43	1.00			0.90	
Satd. Flow (perm)	1671	1659		1671	1604		751	1608			1442	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	87	54	33	22	76	109	22	33	33	130	43	326
RTOR Reduction (vph)	0	15	0	0	44	0	0	19	0	0	75	0
Lane Group Flow (vph)	87	72	0	22	141	0	22	47	0	0	424	0
Confl. Peds. (#/hr)									2	2		
Confl. Bikes (#/hr)									2			
Heavy Vehicles (%)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	6.6	18.9		1.1	13.4		22.4	22.4			22.4	
Effective Green, g (s)	6.6	18.9		1.1	13.4		22.4	22.4			22.4	
Actuated g/C Ratio	0.12	0.35		0.02	0.25		0.41	0.41			0.41	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	203	576		34	395		309	662			594	
v/s Ratio Prot	c0.05	0.04		0.01	c0.09			0.03				
v/s Ratio Perm							0.03				c0.29	
v/c Ratio	0.43	0.12		0.65	0.36		0.07	0.07			0.71	
Uniform Delay, d1	22.2	12.1		26.5	16.9		9.7	9.7			13.3	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	1.5	0.1		35.3	0.6		0.1	0.0			4.0	
Delay (s)	23.6	12.2		61.7	17.5		9.8	9.7			17.4	
Level of Service	C	B		E	B		A	A			B	
Approach Delay (s)		17.9			22.2			9.8			17.4	
Approach LOS		B			C			A			B	

Intersection Summary			
HCM Average Control Delay	17.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.56		
Actuated Cycle Length (s)	54.4	Sum of lost time (s)	12.0
Intersection Capacity Utilization	58.1%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	70	130	40	60	130	200
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	76	141	43	65	141	217
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)	322					
pX, platoon unblocked						
vC, conflicting volume			76		299	147
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			76		299	147
tC, single (s)			4.2		6.5	6.3
tC, 2 stage (s)						
tF (s)			2.3		3.6	3.4
p0 queue free %			97		79	75
cM capacity (veh/h)			1486		660	885

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	217	43	65	359
Volume Left	0	43	0	141
Volume Right	141	0	0	217
cSH	1700	1486	1700	780
Volume to Capacity	0.13	0.03	0.04	0.46
Queue Length 95th (ft)	0	2	0	61
Control Delay (s)	0.0	7.5	0.0	13.5
Lane LOS		A		B
Approach Delay (s)	0.0	3.0		13.5
Approach LOS				B

Intersection Summary			
Average Delay	7.5		
Intersection Capacity Utilization	44.5%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	250	20	50	90	10	10
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	272	22	54	98	11	11
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			293		489	283
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			293		489	283
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			96		98	99
cM capacity (veh/h)			1251		510	749

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	293	54	98	22
Volume Left	0	54	0	11
Volume Right	22	0	0	11
cSH	1700	1251	1700	607
Volume to Capacity	0.17	0.04	0.06	0.04
Queue Length 95th (ft)	0	3	0	3
Control Delay (s)	0.0	8.0	0.0	11.2
Lane LOS		A		B
Approach Delay (s)	0.0	2.9		11.2
Approach LOS				B

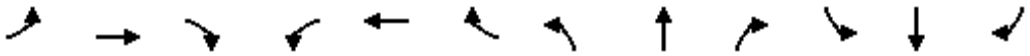
Intersection Summary			
Average Delay	1.5		
Intersection Capacity Utilization	31.0%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay (sec/veh)	30.9
Intersection LOS	D

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Volume (vph)	10	10	10	420	10	30	30	130	170	130	150	10
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles(%)	4	4	4	4	4	4	4	4	4	4	4	4
Movement Flow Rate	11	11	11	457	11	33	33	141	185	141	163	11
Number of Lanes	0	1	0	1	1	0	1	2	0	1	2	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	2	1	3	3
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	3	3	1	2
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	3	3	2	1
HCM Control Delay	12	54.4	14.9	13.8
HCM LOS	B	F	B	B

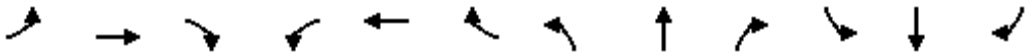
Lane	NBLn1	NBLn2	NBLn3	EBLn1	WBLn1	WBLn2	SBLn1	SBLn2	SBLn3
Volume Left (%)	100%	0%	0%	33%	100%	0%	100%	0%	0%
Volume Thru (%)	0%	100%	20%	33%	0%	25%	0%	100%	83%
Volume Right (%)	0%	0%	80%	33%	0%	75%	0%	0%	17%
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Traffic Volume by Lane	30	87	213	30	420	40	130	100	60
Left Turning Volume	0	87	43	10	0	10	0	100	50
Through Volume	0	0	170	10	0	30	0	0	10
Right Turning Volume	30	0	0	10	420	0	130	0	0
Lane Flow Rate	33	94	232	33	457	43	141	109	65
Geometry Group	8	8	8	8	8	8	8	8	8
Degree of Utilization, X	0.075	0.204	0.466	0.077	0.957	0.079	0.329	0.238	0.14
Departure Headway, Hd	8.319	7.803	7.227	8.492	7.547	6.518	8.385	7.869	7.748
Convergence(Y/N)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capacity	430	460	499	421	479	549	428	455	462
Service Time	6.074	5.557	4.981	6.264	5.291	4.262	6.142	5.625	5.505
HCM Lane V/C Ratio	0.077	0.204	0.465	0.078	0.954	0.078	0.329	0.24	0.141
HCM Control Delay	11.8	12.6	16.2	12	58.6	9.8	15.2	13.1	11.8
HCM Lane LOS	B	B	C	B	F	A	C	B	B
HCM 95th Percentile Queue	0.2	0.8	2.6	0.3	50.3	0.3	1.5	0.9	0.5



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	80	10	80	20	560	0	0	250	530
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor				1.00	1.00		1.00	0.95			0.95	
Frpb, ped/bikes				1.00	1.00		1.00	1.00			0.99	
Flpb, ped/bikes				1.00	1.00		1.00	1.00			1.00	
Frt				1.00	0.87		1.00	1.00			0.90	
Flt Protected				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)				1736	1584		1736	3471			3071	
Flt Permitted				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (perm)				1736	1584		1736	3471			3071	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	87	11	87	22	609	0	0	272	576
RTOR Reduction (vph)	0	0	0	0	72	0	0	0	0	0	291	0
Lane Group Flow (vph)	0	0	0	87	26	0	22	609	0	0	557	0
Confl. Peds. (#/hr)							1					1
Confl. Bikes (#/hr)									2			1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type				Split			Prot					
Protected Phases				8	8		5	2			6	
Permitted Phases												
Actuated Green, G (s)				6.3	6.3		1.9	21.2			15.3	
Effective Green, g (s)				6.3	6.3		1.9	21.2			15.3	
Actuated g/C Ratio				0.18	0.18		0.05	0.60			0.43	
Clearance Time (s)				4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)				3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)				308	281		93	2073			1324	
v/s Ratio Prot				c0.05	0.02		0.01	c0.18			c0.18	
v/s Ratio Perm												
v/c Ratio				0.28	0.09		0.24	0.29			0.42	
Uniform Delay, d1				12.6	12.2		16.1	3.5			7.0	
Progression Factor				1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2				0.5	0.1		1.3	0.1			0.2	
Delay (s)				13.1	12.4		17.4	3.6			7.2	
Level of Service				B	B		B	A			A	
Approach Delay (s)		0.0			12.7			4.1			7.2	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	6.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.39		
Actuated Cycle Length (s)	35.5	Sum of lost time (s)	12.0
Intersection Capacity Utilization	36.2%	ICU Level of Service	A
Analysis Period (min)	15		

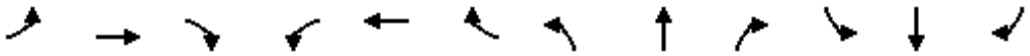
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	450	160	480	150	30	60	70	510	60	140	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		0.95	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	0.99		1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Frt	1.00	0.96		1.00	0.99		1.00	1.00	0.85		0.99	
Flt Protected	0.95	1.00		0.95	0.97		0.95	1.00	1.00		0.99	
Satd. Flow (prot)	1752	3355		1595	3223		1665	1745	1546		1795	
Flt Permitted	0.95	1.00		0.95	0.97		0.95	1.00	1.00		0.99	
Satd. Flow (perm)	1752	3355		1595	3223		1665	1745	1546		1795	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	489	174	522	163	33	65	76	554	65	152	22
RTOR Reduction (vph)	0	32	0	0	5	0	0	0	469	0	3	0
Lane Group Flow (vph)	11	631	0	261	452	0	58	83	85	0	236	0
Confl. Peds. (#/hr)	1					1			2	2		
Confl. Bikes (#/hr)			1			1						1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Split			Split			Split		Perm	Split		
Protected Phases	4	4		8	8		2	2		6	6	
Permitted Phases									2			
Actuated Green, G (s)	18.6	18.6		19.6	19.6		12.6	12.6	12.6		15.0	
Effective Green, g (s)	18.6	18.6		19.6	19.6		12.6	12.6	12.6		15.0	
Actuated g/C Ratio	0.23	0.23		0.24	0.24		0.15	0.15	0.15		0.18	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	398	763		382	772		256	269	238		329	
v/s Ratio Prot	0.01	c0.19		c0.16	0.14		0.03	0.05			c0.13	
v/s Ratio Perm									c0.06			
v/c Ratio	0.03	0.83		0.68	0.59		0.23	0.31	0.36		0.72	
Uniform Delay, d1	24.6	30.1		28.3	27.5		30.3	30.7	31.0		31.4	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Incremental Delay, d2	0.0	7.4		5.0	1.1		0.5	0.7	0.9		7.2	
Delay (s)	24.6	37.4		33.3	28.6		30.8	31.4	31.9		38.7	
Level of Service	C	D		C	C		C	C	C		D	
Approach Delay (s)		37.2			30.3			31.8			38.7	
Approach LOS		D			C			C			D	

Intersection Summary			
HCM Average Control Delay	33.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	81.8	Sum of lost time (s)	16.0
Intersection Capacity Utilization	71.3%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

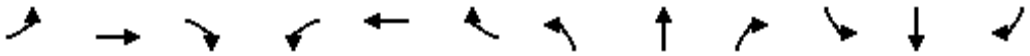


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	850	250	160	350	0	0	0	0	510	40	300
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		0.95			0.95						1.00	
Frpb, ped/bikes		0.99			1.00						1.00	
Flpb, ped/bikes		1.00			1.00						1.00	
Frt		0.97			1.00						0.95	
Flt Protected		1.00			0.98						0.97	
Satd. Flow (prot)		3391			3484						1722	
Flt Permitted		1.00			0.56						0.97	
Satd. Flow (perm)		3391			1986						1722	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	924	272	174	380	0	0	0	0	554	43	326
RTOR Reduction (vph)	0	30	0	0	0	0	0	0	0	0	22	0
Lane Group Flow (vph)	0	1166	0	0	554	0	0	0	0	0	901	0
Confl. Peds. (#/hr)	5		9	9		5						
Confl. Bikes (#/hr)						2						
Turn Type				Perm						Split		
Protected Phases		4			8					6	6	
Permitted Phases				8								
Actuated Green, G (s)		31.0			31.0						51.0	
Effective Green, g (s)		31.0			31.0						51.0	
Actuated g/C Ratio		0.34			0.34						0.57	
Clearance Time (s)		4.0			4.0						4.0	
Vehicle Extension (s)		3.0			3.0						3.0	
Lane Grp Cap (vph)		1168			684						976	
v/s Ratio Prot		c0.34									c0.52	
v/s Ratio Perm					0.28							
v/c Ratio		1.00			2.10dl						0.92	
Uniform Delay, d1		29.5			26.8						17.7	
Progression Factor		1.00			0.98						1.00	
Incremental Delay, d2		25.9			9.6						15.4	
Delay (s)		55.4			35.8						33.1	
Level of Service		E			D						C	
Approach Delay (s)		55.4			35.8			0.0			33.1	
Approach LOS		E			D			A			C	

Intersection Summary			
HCM Average Control Delay	43.6	HCM Level of Service	D
HCM Volume to Capacity ratio	0.95		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	111.2%	ICU Level of Service	H
Analysis Period (min)	15		

dl Defacto Left Lane. Recode with 1 though lane as a left lane.

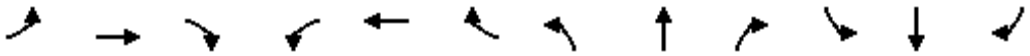
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	280	1080	0	0	430	480	80	10	120	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor		0.95			0.95		0.95	0.95	1.00			
Frpb, ped/bikes		1.00			0.99		1.00	1.00	1.00			
Flpb, ped/bikes		1.00			1.00		1.00	1.00	1.00			
Frt		1.00			0.92		1.00	1.00	0.85			
Flt Protected		0.99			1.00		0.95	0.96	1.00			
Satd. Flow (prot)		3502			3215		1681	1704	1583			
Flt Permitted		0.58			1.00		0.95	0.96	1.00			
Satd. Flow (perm)		2062			3215		1681	1704	1583			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	304	1174	0	0	467	522	87	11	130	0	0	0
RTOR Reduction (vph)	0	0	0	0	139	0	0	0	105	0	0	0
Lane Group Flow (vph)	0	1478	0	0	850	0	49	49	25	0	0	0
Confl. Peds. (#/hr)	5		7	7		5			1	1		
Confl. Bikes (#/hr)						3						
Turn Type	Perm						Split		Prot			
Protected Phases		4			8		2	2	2			
Permitted Phases	4											
Actuated Green, G (s)		66.0			66.0		16.0	16.0	16.0			
Effective Green, g (s)		66.0			66.0		16.0	16.0	16.0			
Actuated g/C Ratio		0.73			0.73		0.18	0.18	0.18			
Clearance Time (s)		4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)		3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)		1512			2358		299	303	281			
v/s Ratio Prot					0.26		c0.03	0.03	0.02			
v/s Ratio Perm		c0.72										
v/c Ratio		0.98			0.36		0.16	0.16	0.09			
Uniform Delay, d1		11.3			4.3		31.3	31.3	30.9			
Progression Factor		0.71			1.00		1.00	1.00	1.00			
Incremental Delay, d2		8.1			0.4		1.2	1.1	0.6			
Delay (s)		16.1			4.8		32.5	32.5	31.5			
Level of Service		B			A		C	C	C			
Approach Delay (s)		16.1			4.8			31.9			0.0	
Approach LOS		B			A			C			A	

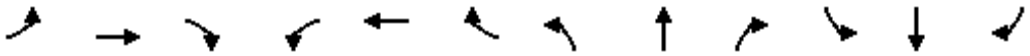
Intersection Summary			
HCM Average Control Delay	13.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.82		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	104.7%	ICU Level of Service	G
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	120	620	60	240	420	220	100	1030	320	210	490	70
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frpb, ped/bikes	1.00	1.00	0.96	1.00	1.00	0.98	1.00	1.00	0.91	1.00	1.00	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.98	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1770	3539	1526	1770	3539	1553	1770	3539	1447	1770	3466	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1770	3539	1526	1770	3539	1553	1770	3539	1447	1770	3466	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	130	674	65	261	457	239	109	1120	348	228	533	76
RTOR Reduction (vph)	0	0	13	0	0	96	0	0	102	0	10	0
Lane Group Flow (vph)	130	674	52	261	457	143	109	1120	246	228	599	0
Confl. Peds. (#/hr)	5		19	19		5	4		14	14		4
Confl. Bikes (#/hr)						1			100			
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases			2			6			8			
Actuated Green, G (s)	10.1	23.2	23.2	15.1	26.2	26.2	10.8	39.5	39.5	13.1	41.8	
Effective Green, g (s)	10.1	23.2	23.2	15.1	26.2	26.2	10.8	39.5	39.5	13.1	41.8	
Actuated g/C Ratio	0.10	0.22	0.22	0.15	0.25	0.25	0.10	0.38	0.38	0.13	0.40	
Clearance Time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Vehicle Extension (s)	2.0	4.0	4.0	2.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	
Lane Grp Cap (vph)	172	790	341	257	892	392	184	1345	550	223	1394	
v/s Ratio Prot	0.07	c0.19		c0.15	c0.13		0.06	c0.32		c0.13	0.17	
v/s Ratio Perm			0.03			0.09			0.17			
v/c Ratio	0.76	0.85	0.15	1.02	0.51	0.37	0.59	0.83	0.45	1.02	0.43	
Uniform Delay, d1	45.7	38.7	32.4	44.4	33.4	32.0	44.4	29.2	24.1	45.4	22.4	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	15.3	9.2	0.3	60.2	0.7	0.8	3.4	4.4	0.2	66.2	0.1	
Delay (s)	61.0	47.9	32.7	104.6	34.0	32.8	47.8	33.6	24.3	111.6	22.5	
Level of Service	E	D	C	F	C	C	D	C	C	F	C	
Approach Delay (s)		48.7			53.0			32.5			46.8	
Approach LOS		D			D			C			D	

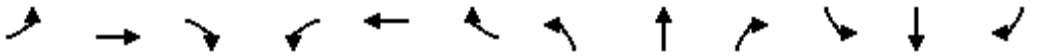
Intersection Summary			
HCM Average Control Delay	43.3	HCM Level of Service	D
HCM Volume to Capacity ratio	0.89		
Actuated Cycle Length (s)	103.9	Sum of lost time (s)	17.0
Intersection Capacity Utilization	85.2%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	280	10	800	0	690	230	0	610	190
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0	4.0		4.0	4.0		4.0	
Lane Util. Factor				0.95	0.91	0.95		0.91	1.00		0.91	
Frt				1.00	0.86	0.85		1.00	0.85		0.96	
Flt Protected				0.95	1.00	1.00		1.00	1.00		1.00	
Satd. Flow (prot)				1698	1474	1519		5136	1599		4953	
Flt Permitted				0.95	1.00	1.00		1.00	1.00		1.00	
Satd. Flow (perm)				1698	1474	1519		5136	1599		4953	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	298	11	851	0	734	245	0	649	202
RTOR Reduction (vph)	0	0	0	0	45	45	0	0	0	0	92	0
Lane Group Flow (vph)	0	0	0	268	404	398	0	734	245	0	759	0
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Split		Perm			Free			
Protected Phases				8	8			2			6	
Permitted Phases						8			Free			
Actuated Green, G (s)				20.6	20.6	20.6		15.0	43.6		15.0	
Effective Green, g (s)				20.6	20.6	20.6		15.0	43.6		15.0	
Actuated g/C Ratio				0.47	0.47	0.47		0.34	1.00		0.34	
Clearance Time (s)				4.0	4.0	4.0		4.0			4.0	
Vehicle Extension (s)				3.0	3.0	3.0		3.0			3.0	
Lane Grp Cap (vph)				802	696	718		1767	1599		1704	
v/s Ratio Prot				0.16	c0.27			0.14			c0.15	
v/s Ratio Perm						0.26			0.15			
v/c Ratio				0.33	0.58	0.55		0.42	0.15		0.45	
Uniform Delay, d1				7.2	8.4	8.2		10.9	0.0		11.1	
Progression Factor				1.00	1.00	1.00		1.00	1.00		1.00	
Incremental Delay, d2				0.2	1.2	0.9		0.2	0.2		0.2	
Delay (s)				7.5	9.5	9.1		11.1	0.2		11.3	
Level of Service				A	A	A		B	A		B	
Approach Delay (s)		0.0			8.9			8.4			11.3	
Approach LOS		A			A			A			B	

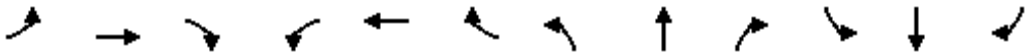
Intersection Summary			
HCM Average Control Delay	9.4	HCM Level of Service	A
HCM Volume to Capacity ratio	0.52		
Actuated Cycle Length (s)	43.6	Sum of lost time (s)	8.0
Intersection Capacity Utilization	53.0%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	390	0	250	0	0	0	0	530	370	0	550	340
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0					4.0			4.0	4.0
Lane Util. Factor	1.00		1.00					0.91			0.95	1.00
Frpb, ped/bikes	1.00		1.00					0.99			1.00	0.98
Flpb, ped/bikes	1.00		1.00					1.00			1.00	1.00
Frt	1.00		0.85					0.94			1.00	0.85
Flt Protected	0.95		1.00					1.00			1.00	1.00
Satd. Flow (prot)	1770		1583					4722			3539	1549
Flt Permitted	0.95		1.00					1.00			1.00	1.00
Satd. Flow (perm)	1770		1583					4722			3539	1549
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	424	0	272	0	0	0	0	576	402	0	598	370
RTOR Reduction (vph)	0	0	73	0	0	0	0	204	0	0	0	0
Lane Group Flow (vph)	424	0	199	0	0	0	0	774	0	0	598	370
Confl. Peds. (#/hr)							4		2	2		4
Confl. Bikes (#/hr)									3			
Turn Type	Split		Perm									Free
Protected Phases	8	8						2			6	
Permitted Phases			8									Free
Actuated Green, G (s)	15.8		15.8					14.9			14.9	38.7
Effective Green, g (s)	15.8		15.8					14.9			14.9	38.7
Actuated g/C Ratio	0.41		0.41					0.39			0.39	1.00
Clearance Time (s)	4.0		4.0					4.0			4.0	
Vehicle Extension (s)	3.0		3.0					3.0			3.0	
Lane Grp Cap (vph)	723		646					1818			1363	1549
v/s Ratio Prot	c0.24							0.16			c0.17	
v/s Ratio Perm			0.13									0.24
v/c Ratio	0.59		0.31					0.43			0.44	0.24
Uniform Delay, d1	8.9		7.8					8.8			8.8	0.0
Progression Factor	1.00		1.00					1.00			1.00	1.00
Incremental Delay, d2	1.2		0.3					0.2			0.2	0.4
Delay (s)	10.1		8.0					8.9			9.0	0.4
Level of Service	B		A					A			A	A
Approach Delay (s)		9.3			0.0			8.9			5.7	
Approach LOS		A			A			A			A	

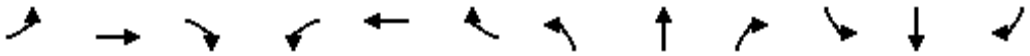
Intersection Summary			
HCM Average Control Delay	7.8	HCM Level of Service	A
HCM Volume to Capacity ratio	0.51		
Actuated Cycle Length (s)	38.7	Sum of lost time (s)	8.0
Intersection Capacity Utilization	46.9%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	200	20	100	20	20	260	30	440	10	20	650	130
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Lane Util. Factor		1.00		1.00	1.00			0.95		1.00	0.95	
Frpb, ped/bikes		0.99		1.00	0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00		1.00	1.00			1.00		0.94	1.00	
Frt		0.96		1.00	0.86			1.00		1.00	0.98	
Flt Protected		0.97		0.95	1.00			1.00		0.95	1.00	
Satd. Flow (prot)		1697		1751	1568			3481		1654	3406	
Flt Permitted		1.00		0.55	1.00			0.88		0.95	1.00	
Satd. Flow (perm)		1750		1018	1568			3066		1654	3406	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	217	22	109	22	22	283	33	478	11	22	707	141
RTOR Reduction (vph)	0	17	0	0	216	0	0	1	0	0	15	0
Lane Group Flow (vph)	0	331	0	22	89	0	0	521	0	22	833	0
Confl. Peds. (#/hr)	1		3	3		1			5	5		
Confl. Bikes (#/hr)						1			2			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Perm			Prot		
Protected Phases		3			4			2		1	6	
Permitted Phases	3			4			2					
Actuated Green, G (s)		2.4		11.5	11.5			18.0		0.9	22.9	
Effective Green, g (s)		2.4		11.5	11.5			18.0		0.9	22.9	
Actuated g/C Ratio		0.05		0.24	0.24			0.37		0.02	0.47	
Clearance Time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		86		240	370			1131		31	1598	
v/s Ratio Prot					c0.06					0.01	c0.24	
v/s Ratio Perm		c0.19		0.02				0.17				
v/c Ratio		3.85		0.09	0.24			0.46		0.71	0.52	
Uniform Delay, d1		23.2		14.6	15.1			11.7		23.8	9.1	
Progression Factor		1.00		1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		1309.1		0.2	0.3			0.3		54.2	0.3	
Delay (s)		1332.3		14.7	15.4			12.0		78.0	9.4	
Level of Service		F		B	B			B		E	A	
Approach Delay (s)		1332.3			15.4			12.0			11.1	
Approach LOS		F			B			B			B	

Intersection Summary			
HCM Average Control Delay	234.5	HCM Level of Service	F
HCM Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	48.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	81.4%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group



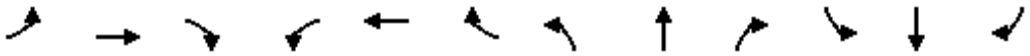
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	190	50	50	50	120	50	50	190	130	40	440	300
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	0.99		1.00	0.99	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	0.96		1.00	0.94		1.00	0.94	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	3368		1770	3305		1770	3294	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	3368		1770	3305		1770	3294	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	200	53	53	53	126	53	53	200	137	42	463	316
RTOR Reduction (vph)	0	0	41	0	46	0	0	90	0	0	149	0
Lane Group Flow (vph)	200	53	12	53	133	0	53	247	0	42	630	0
Confl. Peds. (#/hr)							16		1	1		16
Confl. Bikes (#/hr)						1			1			
Turn Type	Prot		Perm	Prot			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4									
Actuated Green, G (s)	9.0	11.9	11.9	4.0	6.9		3.0	18.0		2.6	17.6	
Effective Green, g (s)	9.0	11.9	11.9	4.0	6.9		3.0	18.0		2.6	17.6	
Actuated g/C Ratio	0.17	0.23	0.23	0.08	0.13		0.06	0.34		0.05	0.34	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	303	802	359	135	443		101	1133		88	1104	
v/s Ratio Prot	c0.11	0.01		0.03	c0.04		c0.03	0.07		0.02	c0.19	
v/s Ratio Perm			0.01									
v/c Ratio	0.66	0.07	0.03	0.39	0.30		0.52	0.22		0.48	0.57	
Uniform Delay, d1	20.3	15.9	15.8	23.1	20.6		24.1	12.3		24.3	14.3	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	5.3	0.0	0.0	1.9	0.4		4.8	0.1		4.0	0.7	
Delay (s)	25.6	16.0	15.9	25.0	21.0		28.9	12.3		28.3	15.1	
Level of Service	C	B	B	C	C		C	B		C	B	
Approach Delay (s)		22.3			21.9			14.6			15.7	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	17.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	52.5	Sum of lost time (s)	16.0
Intersection Capacity Utilization	54.5%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	110	60	60	210	290	150
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	120	65	65	228	315	163
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				1133		
pX, platoon unblocked						
vC, conflicting volume			185		478	120
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			185		478	120
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			95		39	82
cM capacity (veh/h)			1378		517	927

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2
Volume Total	120	65	65	228	315	163
Volume Left	0	0	65	0	315	0
Volume Right	0	65	0	0	0	163
cSH	1700	1700	1378	1700	517	927
Volume to Capacity	0.07	0.04	0.05	0.13	0.61	0.18
Queue Length 95th (ft)	0	0	4	0	101	16
Control Delay (s)	0.0	0.0	7.7	0.0	22.3	9.7
Lane LOS			A		C	A
Approach Delay (s)	0.0		1.7		18.0	
Approach LOS					C	

Intersection Summary			
Average Delay	9.5		
Intersection Capacity Utilization	33.8%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	120	20	10	10	80	130	20	20	10	170	20	70
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.95		1.00	0.91		1.00	0.95			0.96	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.97	
Satd. Flow (prot)	1671	1671		1671	1596		1671	1671			1642	
Flt Permitted	0.95	1.00		0.95	1.00		0.64	1.00			0.78	
Satd. Flow (perm)	1671	1671		1671	1596		1121	1671			1327	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	130	22	11	11	87	141	22	22	11	185	22	76
RTOR Reduction (vph)	0	7	0	0	109	0	0	7	0	0	20	0
Lane Group Flow (vph)	130	26	0	11	119	0	22	26	0	0	263	0
Heavy Vehicles (%)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	5.4	13.1		1.1	8.8		12.7	12.7			12.7	
Effective Green, g (s)	5.4	13.1		1.1	8.8		12.7	12.7			12.7	
Actuated g/C Ratio	0.14	0.34		0.03	0.23		0.33	0.33			0.33	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	232	563		47	361		366	546			433	
v/s Ratio Prot	c0.08	0.02		0.01	c0.07			0.02				
v/s Ratio Perm							0.02				c0.20	
v/c Ratio	0.56	0.05		0.23	0.33		0.06	0.05			0.61	
Uniform Delay, d1	15.6	8.7		18.5	12.6		9.0	9.0			11.0	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	3.1	0.0		2.6	0.5		0.1	0.0			2.4	
Delay (s)	18.7	8.7		21.0	13.1		9.1	9.0			13.4	
Level of Service	B	A		C	B		A	A			B	
Approach Delay (s)		16.7			13.5			9.0			13.4	
Approach LOS		B			B			A			B	

Intersection Summary			
HCM Average Control Delay	13.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.51		
Actuated Cycle Length (s)	38.9	Sum of lost time (s)	12.0
Intersection Capacity Utilization	50.2%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	90	110	70	60	160	100
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	98	120	76	65	174	109
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)	322					
pX, platoon unblocked						
vC, conflicting volume			98		375	158
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			98		375	158
tC, single (s)			4.2		6.5	6.3
tC, 2 stage (s)						
tF (s)			2.3		3.6	3.4
p0 queue free %			95		70	88
cM capacity (veh/h)			1458		582	872

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	217	76	65	283
Volume Left	0	76	0	174
Volume Right	120	0	0	109
cSH	1700	1458	1700	668
Volume to Capacity	0.13	0.05	0.04	0.42
Queue Length 95th (ft)	0	4	0	53
Control Delay (s)	0.0	7.6	0.0	14.3
Lane LOS		A		B
Approach Delay (s)	0.0	4.1		14.3
Approach LOS				B

Intersection Summary			
Average Delay	7.2		
Intersection Capacity Utilization	40.3%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	180	10	10	110	20	50
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	196	11	11	120	22	54
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			207		342	201
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			207		342	201
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			99		97	94
cM capacity (veh/h)			1365		649	840

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	207	11	120	76
Volume Left	0	11	0	22
Volume Right	11	0	0	54
cSH	1700	1365	1700	775
Volume to Capacity	0.12	0.01	0.07	0.10
Queue Length 95th (ft)	0	1	0	8
Control Delay (s)	0.0	7.7	0.0	10.2
Lane LOS		A		B
Approach Delay (s)	0.0	0.6		10.2
Approach LOS				B

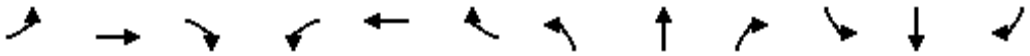
Intersection Summary			
Average Delay	2.1		
Intersection Capacity Utilization	20.9%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay (sec/veh)	39.3
Intersection LOS	E

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Volume (vph)	10	20	10	510	10	30	10	90	70	90	100	10
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles(%)	2	2	2	2	2	2	2	2	2	2	2	2
Movement Flow Rate	11	22	11	554	11	33	11	98	76	98	109	11
Number of Lanes	0	1	0	1	1	0	1	2	0	1	2	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	2	1	3	3
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	3	3	1	2
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	3	3	2	1
HCM Control Delay	11	60	11.4	11.7
HCM LOS	B	F	B	B

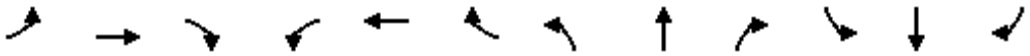
Lane	NBLn1	NBLn2	NBLn3	EBLn1	WBLn1	WBLn2	SBLn1	SBLn2	SBLn3
Volume Left (%)	100%	0%	0%	25%	100%	0%	100%	0%	0%
Volume Thru (%)	0%	100%	30%	50%	0%	25%	0%	100%	77%
Volume Right (%)	0%	0%	70%	25%	0%	75%	0%	0%	23%
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Traffic Volume by Lane	10	60	100	40	510	40	90	67	43
Left Turning Volume	0	60	30	20	0	10	0	67	33
Through Volume	0	0	70	10	0	30	0	0	10
Right Turning Volume	10	0	0	10	510	0	90	0	0
Lane Flow Rate	11	65	109	43	554	43	98	72	47
Geometry Group	8	8	8	8	8	8	8	8	8
Degree of Utilization, X	0.024	0.136	0.212	0.09	1	0.067	0.212	0.149	0.095
Departure Headway, Hd	7.925	7.423	7.021	7.492	6.592	5.567	7.815	7.414	7.248
Convergence(Y/N)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capacity	455	486	521	478	549	641	462	493	504
Service Time	5.621	5.123	4.635	5.24	4.346	3.321	5.515	5.017	4.857
HCM Lane V/C Ratio	0.024	0.134	0.209	0.09	1.009	0.067	0.212	0.146	0.093
HCM Control Delay	10.8	11.3	11.5	11	64	8.7	12.6	11.3	10.6
HCM Lane LOS	B	B	B	B	F	A	B	B	B
HCM 95th Percentile Queue	0.1	0.5	0.8	0.3	110.4	0.2	0.8	0.5	0.3



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	70	10	480	30	590	0	0	90	330
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor				1.00	1.00		1.00	0.95			0.95	
Frpb, ped/bikes				1.00	1.00		1.00	1.00			0.98	
Flpb, ped/bikes				1.00	1.00		1.00	1.00			1.00	
Frt				1.00	0.85		1.00	1.00			0.88	
Flt Protected				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)				1787	1605		1787	3574			3100	
Flt Permitted				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (perm)				1787	1605		1787	3574			3100	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	74	11	505	32	621	0	0	95	347
RTOR Reduction (vph)	0	0	0	0	173	0	0	0	0	0	247	0
Lane Group Flow (vph)	0	0	0	74	343	0	32	621	0	0	195	0
Confl. Peds. (#/hr)							1		2	2		1
Confl. Bikes (#/hr)			1						1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Split			Prot					
Protected Phases				8	8		5	2			6	
Permitted Phases												
Actuated Green, G (s)				14.1	14.1		3.5	19.5			12.0	
Effective Green, g (s)				14.1	14.1		3.5	19.5			12.0	
Actuated g/C Ratio				0.34	0.34		0.08	0.47			0.29	
Clearance Time (s)				4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)				3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)				606	544		150	1675			894	
v/s Ratio Prot				0.04	c0.21		0.02	c0.17			0.06	
v/s Ratio Perm												
v/c Ratio				0.12	0.63		0.21	0.37			0.22	
Uniform Delay, d1				9.5	11.6		17.8	7.1			11.2	
Progression Factor				1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2				0.1	2.4		0.7	0.1			0.1	
Delay (s)				9.6	13.9		18.5	7.2			11.4	
Level of Service				A	B		B	A			B	
Approach Delay (s)		0.0			13.4			7.8			11.4	
Approach LOS		A			B			A			B	

Intersection Summary			
HCM Average Control Delay	10.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.48		
Actuated Cycle Length (s)	41.6	Sum of lost time (s)	8.0
Intersection Capacity Utilization	56.8%	ICU Level of Service	B
Analysis Period (min)	15		

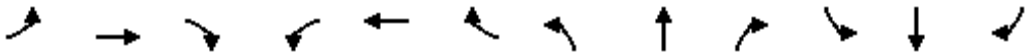
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	50	530	90	290	370	60	310	180	580	30	40	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		0.95	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	0.99		1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Frt	1.00	0.98		1.00	0.98		1.00	1.00	0.85		0.94	
Flt Protected	0.95	1.00		0.95	0.99		0.95	0.99	1.00		0.99	
Satd. Flow (prot)	1787	3496		1626	3342		1698	1763	1576		1753	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	0.99	1.00		0.99	
Satd. Flow (perm)	1787	3496		1626	3342		1698	1763	1576		1753	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	52	546	93	299	381	62	320	186	598	31	41	52
RTOR Reduction (vph)	0	13	0	0	11	0	0	0	437	0	30	0
Lane Group Flow (vph)	52	626	0	245	486	0	250	256	161	0	94	0
Confl. Peds. (#/hr)									2	2		
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Split			Split			Split		Perm	Split		
Protected Phases	4	4		8	8		2	2		6	6	
Permitted Phases									2			
Actuated Green, G (s)	16.8	16.8		16.3	16.3		21.1	21.1	21.1		8.0	
Effective Green, g (s)	16.8	16.8		16.3	16.3		21.1	21.1	21.1		8.0	
Actuated g/C Ratio	0.21	0.21		0.21	0.21		0.27	0.27	0.27		0.10	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	384	751		339	697		458	476	425		179	
v/s Ratio Prot	0.03	c0.18		c0.15	0.15		c0.15	0.15			c0.05	
v/s Ratio Perm									0.10			
v/c Ratio	0.14	0.83		0.72	0.70		0.55	0.54	0.38		0.53	
Uniform Delay, d1	24.8	29.4		28.8	28.7		24.4	24.4	23.2		33.3	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Incremental Delay, d2	0.2	7.9		7.4	3.0		1.3	1.2	0.6		2.8	
Delay (s)	25.0	37.2		36.3	31.7		25.8	25.6	23.8		36.1	
Level of Service	C	D		D	C		C	C	C		D	
Approach Delay (s)		36.3			33.2			24.7			36.1	
Approach LOS		D			C			C			D	

Intersection Summary			
HCM Average Control Delay	30.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	78.2	Sum of lost time (s)	16.0
Intersection Capacity Utilization	70.5%	ICU Level of Service	C
Analysis Period (min)	15		

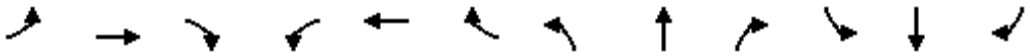
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	720	370	170	460	0	0	0	0	570	20	390
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		0.95			0.95						1.00	
Frpb, ped/bikes		0.99			1.00						1.00	
Flpb, ped/bikes		1.00			1.00						1.00	
Frt		0.95			1.00						0.95	
Flt Protected		1.00			0.99						0.97	
Satd. Flow (prot)		3348			3527						1730	
Flt Permitted		1.00			0.51						0.97	
Satd. Flow (perm)		3348			1837						1730	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	0	750	385	177	479	0	0	0	0	594	21	406
RTOR Reduction (vph)	0	54	0	0	0	0	0	0	0	0	20	0
Lane Group Flow (vph)	0	1081	0	0	656	0	0	0	0	0	1001	0
Confl. Peds. (#/hr)	3		8	8		3						
Confl. Bikes (#/hr)						3						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Perm						Split		
Protected Phases		4			8					6	6	
Permitted Phases				8								
Actuated Green, G (s)		49.0			49.0						63.0	
Effective Green, g (s)		49.0			49.0						63.0	
Actuated g/C Ratio		0.41			0.41						0.52	
Clearance Time (s)		4.0			4.0						4.0	
Vehicle Extension (s)		3.0			3.0						3.0	
Lane Grp Cap (vph)		1367			750						908	
v/s Ratio Prot		0.32									c0.58	
v/s Ratio Perm					c0.36							
v/c Ratio		0.79			2.53dl						1.10	
Uniform Delay, d1		31.0			32.7						28.5	
Progression Factor		1.00			1.04						1.00	
Incremental Delay, d2		4.7			12.6						62.0	
Delay (s)		35.7			46.5						90.5	
Level of Service		D			D						F	
Approach Delay (s)		35.7			46.5			0.0			90.5	
Approach LOS		D			D			A			F	

Intersection Summary			
HCM Average Control Delay	58.1	HCM Level of Service	E
HCM Volume to Capacity ratio	1.00		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	119.4%	ICU Level of Service	H
Analysis Period (min)	15		

dl Defacto Left Lane. Recode with 1 though lane as a left lane.
c Critical Lane Group



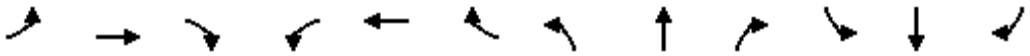
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	310	980	0	0	530	550	100	140	220	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor		0.95			0.95		0.95	0.95	1.00			
Frpb, ped/bikes		1.00			0.99		1.00	1.00	1.00			
Flpb, ped/bikes		1.00			1.00		1.00	1.00	1.00			
Frt		1.00			0.92		1.00	1.00	0.85			
Flt Protected		0.99			1.00		0.95	1.00	1.00			
Satd. Flow (prot)		3531			3261		1698	1781	1599			
Flt Permitted		0.54			1.00		0.95	1.00	1.00			
Satd. Flow (perm)		1946			3261		1698	1781	1599			
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	323	1021	0	0	552	573	104	146	229	0	0	0
RTOR Reduction (vph)	0	0	0	0	53	0	0	0	173	0	0	0
Lane Group Flow (vph)	0	1344	0	0	1072	0	94	156	56	0	0	0
Confl. Peds. (#/hr)	2		7	7		2						
Confl. Bikes (#/hr)						3						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm						Split		Prot			
Protected Phases		4			8		2	2	2			
Permitted Phases	4											
Actuated Green, G (s)		96.0			96.0		16.0	16.0	16.0			
Effective Green, g (s)		96.0			96.0		16.0	16.0	16.0			
Actuated g/C Ratio		0.80			0.80		0.13	0.13	0.13			
Clearance Time (s)		4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)		3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)		1557			2609		226	237	213			
v/s Ratio Prot					0.33		0.06	c0.09	0.03			
v/s Ratio Perm		c0.69										
v/c Ratio		0.92dl			0.41		0.42	0.66	0.26			
Uniform Delay, d1		7.8			3.6		47.7	49.4	46.7			
Progression Factor		0.84			1.00		1.00	1.00	1.00			
Incremental Delay, d2		2.5			0.5		5.6	13.5	3.0			
Delay (s)		9.0			4.1		53.3	62.9	49.7			
Level of Service		A			A		D	E	D			
Approach Delay (s)		9.0			4.1			54.7			0.0	
Approach LOS		A			A			D			A	

Intersection Summary			
HCM Average Control Delay	14.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.83		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	96.8%	ICU Level of Service	F
Analysis Period (min)	15		

dl Defacto Left Lane. Recode with 1 though lane as a left lane.
c Critical Lane Group

Cumulative (2035) Plus Project Buildout Conditions

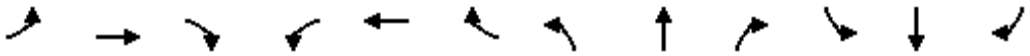
FEHR PEERS



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	110	300	153	400	470	220	68	387	170	70	936	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frpb, ped/bikes	1.00	1.00	0.97	1.00	1.00	0.97	1.00	1.00	0.98	1.00	1.00	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1736	3471	1514	1736	3471	1511	1736	3471	1528	1736	3442	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1736	3471	1514	1736	3471	1511	1736	3471	1528	1736	3442	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	120	326	166	435	511	239	74	421	185	76	1017	54
RTOR Reduction (vph)	0	0	93	0	0	109	0	0	123	0	4	0
Lane Group Flow (vph)	120	326	73	435	511	130	74	421	62	76	1067	0
Confl. Peds. (#/hr)	14		13	13		14	4		4	4		4
Confl. Bikes (#/hr)						1						1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases			2			6			8			
Actuated Green, G (s)	8.2	16.4	16.4	22.1	28.3	28.3	4.0	27.8	27.8	3.9	27.7	
Effective Green, g (s)	8.2	16.4	16.4	22.1	28.3	28.3	4.0	27.8	27.8	3.9	27.7	
Actuated g/C Ratio	0.10	0.20	0.20	0.27	0.34	0.34	0.05	0.33	0.33	0.05	0.33	
Clearance Time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Vehicle Extension (s)	2.0	4.0	4.0	2.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	
Lane Grp Cap (vph)	171	684	298	461	1181	514	83	1160	511	81	1146	
v/s Ratio Prot	0.07	0.09		c0.25	c0.15		0.04	0.12		c0.04	c0.31	
v/s Ratio Perm			0.05			0.09			0.04			
v/c Ratio	0.70	0.48	0.24	0.94	0.43	0.25	0.89	0.36	0.12	0.94	0.93	
Uniform Delay, d1	36.3	29.6	28.2	29.9	21.2	19.8	39.4	21.0	19.2	39.5	26.8	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	10.1	0.7	0.6	27.8	0.3	0.4	62.6	0.1	0.0	77.7	13.1	
Delay (s)	46.4	30.3	28.8	57.7	21.6	20.2	102.0	21.1	19.3	117.3	39.9	
Level of Service	D	C	C	E	C	C	F	C	B	F	D	
Approach Delay (s)		33.1			34.6			29.4			45.0	
Approach LOS		C			C			C			D	

Intersection Summary			
HCM Average Control Delay	36.6	HCM Level of Service	D
HCM Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	83.2	Sum of lost time (s)	9.0
Intersection Capacity Utilization	79.2%	ICU Level of Service	D
Analysis Period (min)	15		

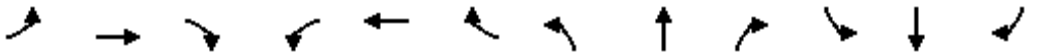
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	380	10	243	0	363	183	0	1219	290
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0	4.0		4.0	4.0		4.0	
Lane Util. Factor				0.95	0.91	0.95		0.91	1.00		0.91	
Frpb, ped/bikes				1.00	1.00	0.99		1.00	0.98		1.00	
Flpb, ped/bikes				1.00	1.00	1.00		1.00	1.00		1.00	
Frt				1.00	0.97	0.85		1.00	0.85		0.97	
Flt Protected				0.95	0.96	1.00		1.00	1.00		1.00	
Satd. Flow (prot)				1665	1563	1471		5036	1535		4869	
Flt Permitted				0.95	0.96	1.00		1.00	1.00		1.00	
Satd. Flow (perm)				1665	1563	1471		5036	1535		4869	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	404	11	259	0	386	195	0	1297	309
RTOR Reduction (vph)	0	0	0	0	20	145	0	0	0	0	49	0
Lane Group Flow (vph)	0	0	0	234	210	65	0	386	195	0	1557	0
Confl. Peds. (#/hr)	1					1	2		1	1		2
Confl. Bikes (#/hr)									2			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type				Split		Perm			Free			
Protected Phases				8	8			2			6	
Permitted Phases						8			Free			
Actuated Green, G (s)				14.7	14.7	14.7		24.6	47.3		24.6	
Effective Green, g (s)				14.7	14.7	14.7		24.6	47.3		24.6	
Actuated g/C Ratio				0.31	0.31	0.31		0.52	1.00		0.52	
Clearance Time (s)				4.0	4.0	4.0		4.0			4.0	
Vehicle Extension (s)				3.0	3.0	3.0		3.0			3.0	
Lane Grp Cap (vph)				517	486	457		2619	1535		2532	
v/s Ratio Prot				c0.14	0.13			0.08			c0.32	
v/s Ratio Perm						0.04			0.13			
v/c Ratio				0.45	0.43	0.14		0.15	0.13		0.61	
Uniform Delay, d1				13.1	13.0	11.8		5.9	0.0		8.0	
Progression Factor				1.00	1.00	1.00		1.00	1.00		1.00	
Incremental Delay, d2				0.6	0.6	0.1		0.0	0.2		0.4	
Delay (s)				13.7	13.6	11.9		5.9	0.2		8.5	
Level of Service				B	B	B		A	A		A	
Approach Delay (s)		0.0			13.1			4.0			8.5	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	8.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	47.3	Sum of lost time (s)	8.0
Intersection Capacity Utilization	50.4%	ICU Level of Service	A
Analysis Period (min)	15		

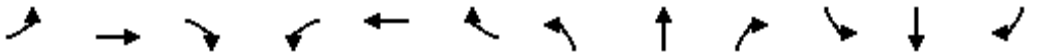
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	100	0	434	0	0	0	0	445	360	0	710	900
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0					4.0			4.0	4.0
Lane Util. Factor	1.00		1.00					0.91			0.95	1.00
Frpb, ped/bikes	1.00		1.00					0.99			1.00	0.98
Flpb, ped/bikes	1.00		1.00					1.00			1.00	1.00
Frt	1.00		0.85					0.93			1.00	0.85
Flt Protected	0.95		1.00					1.00			1.00	1.00
Satd. Flow (prot)	1752		1568					4646			3505	1536
Flt Permitted	0.95		1.00					1.00			1.00	1.00
Satd. Flow (perm)	1752		1568					4646			3505	1536
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	109	0	472	0	0	0	0	484	391	0	772	978
RTOR Reduction (vph)	0	0	38	0	0	0	0	237	0	0	0	0
Lane Group Flow (vph)	109	0	434	0	0	0	0	638	0	0	772	978
Confl. Peds. (#/hr)							1		3	3		1
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Split		Perm									Free
Protected Phases	8	8						2			6	
Permitted Phases			8									Free
Actuated Green, G (s)	17.4		17.4					16.0			16.0	41.4
Effective Green, g (s)	17.4		17.4					16.0			16.0	41.4
Actuated g/C Ratio	0.42		0.42					0.39			0.39	1.00
Clearance Time (s)	4.0		4.0					4.0			4.0	
Vehicle Extension (s)	3.0		3.0					3.0			3.0	
Lane Grp Cap (vph)	736		659					1796			1355	1536
v/s Ratio Prot	0.06							0.14			0.22	
v/s Ratio Perm			0.28									c0.64
v/c Ratio	0.15		0.66					0.36			0.57	0.64
Uniform Delay, d1	7.4		9.6					9.0			10.0	0.0
Progression Factor	1.00		1.00					1.00			1.00	1.00
Incremental Delay, d2	0.1		2.4					0.1			0.6	2.0
Delay (s)	7.5		12.0					9.2			10.5	2.0
Level of Service	A		B					A			B	A
Approach Delay (s)		11.2			0.0			9.2			5.8	
Approach LOS		B			A			A			A	

Intersection Summary			
HCM Average Control Delay	7.7	HCM Level of Service	A
HCM Volume to Capacity ratio	0.64		
Actuated Cycle Length (s)	41.4	Sum of lost time (s)	0.0
Intersection Capacity Utilization	53.2%	ICU Level of Service	A
Analysis Period (min)	15		

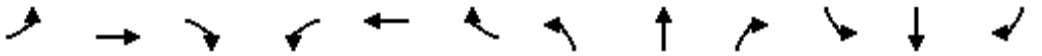
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	70	20	40	10	10	40	40	695	30	320	673	130
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Lane Util. Factor		1.00		1.00	1.00			0.95		1.00	0.95	
Frpb, ped/bikes		1.00		1.00	0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00		1.00	1.00			1.00		1.00	1.00	
Frt		0.96		1.00	0.88			0.99		1.00	0.98	
Flt Protected		0.97		0.95	1.00			1.00		0.95	1.00	
Satd. Flow (prot)		1705		1736	1592			3441		1736	3375	
Flt Permitted		1.00		0.67	1.00			0.87		0.95	1.00	
Satd. Flow (perm)		1751		1219	1592			3018		1736	3375	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	76	22	43	11	11	43	43	755	33	348	732	141
RTOR Reduction (vph)	0	16	0	0	37	0	0	3	0	0	10	0
Lane Group Flow (vph)	0	125	0	11	17	0	0	828	0	348	863	0
Confl. Peds. (#/hr)	3					3	2					2
Confl. Bikes (#/hr)												1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm			Perm			Perm			Prot		
Protected Phases		3			4			2		1	6	
Permitted Phases	3			4			2					
Actuated Green, G (s)		2.2		8.4	8.4			21.8		11.9	37.7	
Effective Green, g (s)		2.2		8.4	8.4			21.8		11.9	37.7	
Actuated g/C Ratio		0.04		0.14	0.14			0.36		0.20	0.63	
Clearance Time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		64		170	222			1091		343	2110	
v/s Ratio Prot					c0.01					c0.20	0.26	
v/s Ratio Perm		c0.07		0.01				c0.27				
v/c Ratio		1.95		0.06	0.08			0.76		1.01	0.41	
Uniform Delay, d1		29.0		22.5	22.6			16.9		24.2	5.7	
Progression Factor		1.00		1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		477.8		0.2	0.1			3.1		52.3	0.1	
Delay (s)		506.9		22.7	22.7			20.0		76.5	5.8	
Level of Service		F		C	C			C		E	A	
Approach Delay (s)		506.9			22.7			20.0			26.0	
Approach LOS		F			C			C			C	

Intersection Summary			
HCM Average Control Delay	53.7	HCM Level of Service	D
HCM Volume to Capacity ratio	0.76		
Actuated Cycle Length (s)	60.3	Sum of lost time (s)	16.0
Intersection Capacity Utilization	68.2%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	300	105	20	26	26	95	20	400	175	323	150	230
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00	1.00	1.00	0.96		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	0.88		1.00	0.95		1.00	0.91	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	3010		1770	3364		1770	3186	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	3010		1770	3364		1770	3186	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	326	114	22	28	28	103	22	435	190	351	163	250
RTOR Reduction (vph)	0	0	15	0	88	0	0	52	0	0	145	0
Lane Group Flow (vph)	326	114	7	28	43	0	22	573	0	351	268	0
Confl. Peds. (#/hr)	3					3	4					4
Confl. Bikes (#/hr)						20			1			1
Turn Type	Prot		Perm	Prot			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4									
Actuated Green, G (s)	17.1	26.9	26.9	1.9	11.7		1.9	17.7		18.1	33.9	
Effective Green, g (s)	17.1	26.9	26.9	1.9	11.7		1.9	17.7		18.1	33.9	
Actuated g/C Ratio	0.21	0.33	0.33	0.02	0.15		0.02	0.22		0.22	0.42	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	376	1181	528	42	437		42	739		397	1340	
v/s Ratio Prot	c0.18	c0.03		0.02	0.01		0.01	c0.17		c0.20	0.08	
v/s Ratio Perm			0.00									
v/c Ratio	0.87	0.10	0.01	0.67	0.10		0.52	0.78		0.88	0.20	
Uniform Delay, d1	30.7	18.5	18.0	39.0	29.9		38.9	29.6		30.2	14.8	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	18.5	0.0	0.0	33.4	0.1		11.3	5.1		20.2	0.1	
Delay (s)	49.2	18.5	18.0	72.4	30.0		50.2	34.7		50.4	14.8	
Level of Service	D	B	B	E	C		D	C		D	B	
Approach Delay (s)		40.1			37.4			35.2			31.2	
Approach LOS		D			D			D			C	

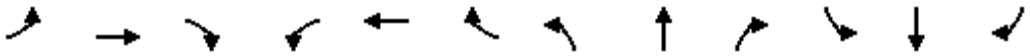
Intersection Summary			
HCM Average Control Delay	35.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	80.6	Sum of lost time (s)	12.0
Intersection Capacity Utilization	70.1%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	519	140	145	185	100	261
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	564	152	158	201	109	284
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				1133		
pX, platoon unblocked						
vC, conflicting volume			716		1080	564
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			716		1080	564
tC, single (s)			4.1		6.5	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.6	3.3
p0 queue free %			82		44	45
cM capacity (veh/h)			871		192	519

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2
Volume Total	564	152	158	201	109	284
Volume Left	0	0	158	0	109	0
Volume Right	0	152	0	0	0	284
cSH	1700	1700	871	1700	192	519
Volume to Capacity	0.33	0.09	0.18	0.12	0.56	0.55
Queue Length 95th (ft)	0	0	16	0	76	81
Control Delay (s)	0.0	0.0	10.0	0.0	45.6	20.0
Lane LOS			B		E	C
Approach Delay (s)	0.0		4.4		27.1	
Approach LOS					D	

Intersection Summary			
Average Delay	8.3		
Intersection Capacity Utilization	50.9%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	80	333	30	20	96	171	20	30	30	440	40	300
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	0.99			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.99		1.00	0.90		1.00	0.93			0.95	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.97	
Satd. Flow (prot)	1671	1783		1671	1635		1671	1609			1647	
Flt Permitted	0.95	1.00		0.95	1.00		0.41	1.00			0.79	
Satd. Flow (perm)	1671	1783		1671	1635		717	1609			1335	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	87	362	33	22	104	186	22	33	33	478	43	326
RTOR Reduction (vph)	0	2	0	0	56	0	0	13	0	0	17	0
Lane Group Flow (vph)	87	393	0	22	234	0	22	53	0	0	830	0
Confl. Peds. (#/hr)									2	2		
Confl. Bikes (#/hr)									2			
Heavy Vehicles (%)	8%	5%	8%	8%	5%	5%	8%	8%	8%	5%	8%	8%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	7.7	29.4		3.2	24.9		67.3	67.3			67.3	
Effective Green, g (s)	7.7	29.4		3.2	24.9		67.3	67.3			67.3	
Actuated g/C Ratio	0.07	0.26		0.03	0.22		0.60	0.60			0.60	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	115	468		48	364		431	968			803	
v/s Ratio Prot	c0.05	c0.22		0.01	0.14			0.03				
v/s Ratio Perm							0.03				c0.62	
v/c Ratio	0.76	0.84		0.46	0.64		0.05	0.05			1.03	
Uniform Delay, d1	51.2	39.0		53.5	39.5		9.2	9.2			22.3	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	24.3	12.5		6.8	3.9		0.0	0.0			40.7	
Delay (s)	75.5	51.5		60.3	43.3		9.2	9.2			63.0	
Level of Service	E	D		E	D		A	A			E	
Approach Delay (s)		55.8			44.5			9.2			63.0	
Approach LOS		E			D			A			E	

Intersection Summary			
HCM Average Control Delay	54.9	HCM Level of Service	D
HCM Volume to Capacity ratio	0.95		
Actuated Cycle Length (s)	111.9	Sum of lost time (s)	8.0
Intersection Capacity Utilization	84.2%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	594	210	43	144	143	218
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	646	228	47	157	155	237
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)	322					
pX, platoon unblocked			0.80		0.80	0.80
vC, conflicting volume			646		1010	760
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			428		885	571
tC, single (s)			4.2		6.5	6.3
tC, 2 stage (s)						
tF (s)			2.3		3.6	3.4
p0 queue free %			95		33	42
cM capacity (veh/h)			877		232	406

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	874	47	157	392
Volume Left	0	47	0	155
Volume Right	228	0	0	237
cSH	1700	877	1700	313
Volume to Capacity	0.51	0.05	0.09	1.25
Queue Length 95th (ft)	0	4	0	451
Control Delay (s)	0.0	9.3	0.0	172.1
Lane LOS		A		F
Approach Delay (s)	0.0	2.1		172.1
Approach LOS				F

Intersection Summary			
Average Delay	46.3		
Intersection Capacity Utilization	72.0%	ICU Level of Service	C
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	294	377	587	365	67	96
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	320	410	638	397	73	104
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			729		2197	524
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			729		2197	524
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			26		0	81
cM capacity (veh/h)			861		13	547

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	729	638	397	177
Volume Left	0	638	0	73
Volume Right	410	0	0	104
cSH	1700	861	1700	30
Volume to Capacity	0.43	0.74	0.23	6.00
Queue Length 95th (ft)	0	172	0	Err
Control Delay (s)	0.0	20.1	0.0	Err
Lane LOS		C		F
Approach Delay (s)	0.0	12.4		Err
Approach LOS				F

Intersection Summary			
Average Delay	919.2		
Intersection Capacity Utilization	90.7%	ICU Level of Service	E
Analysis Period (min)	15		

Intersection	
Intersection Delay (sec/veh)	59.8
Intersection LOS	F

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Volume (vph)	10	10	10	420	10	30	30	942	170	203	207	10
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles(%)	4	4	4	4	4	4	4	4	4	4	4	4
Movement Flow Rate	11	11	11	457	11	33	33	1024	185	221	225	11
Number of Lanes	0	1	0	1	1	0	1	2	0	1	2	0

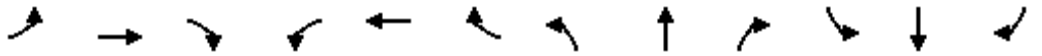
Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	2	1	3	3
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	3	3	1	2
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	3	3	2	1
HCM Control Delay	14.8	72.6	70.3	20.6
HCM LOS	B	F	F	C

Lane	NBLn1	NBLn2	NBLn3	EBLn1	WBLn1	WBLn2	SBLn1	SBLn2	SBLn3
Volume Left (%)	100%	0%	0%	33%	100%	0%	100%	0%	0%
Volume Thru (%)	0%	100%	65%	33%	0%	25%	0%	100%	87%
Volume Right (%)	0%	0%	35%	33%	0%	75%	0%	0%	13%
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Traffic Volume by Lane	30	628	484	30	420	40	203	138	79
Left Turning Volume	0	628	314	10	0	10	0	138	69
Through Volume	0	0	170	10	0	30	0	0	10
Right Turning Volume	30	0	0	10	420	0	203	0	0
Lane Flow Rate	33	683	526	33	457	43	221	150	86
Geometry Group	8	8	8	8	8	8	8	8	8
Degree of Utilization, X	0.08	1	1	0.098	1	0.104	0.59	0.381	0.216
Departure Headway, Hd	8.799	8.301	8.056	10.852	9.612	8.591	9.633	9.134	9.046
Convergence(Y/N)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capacity	408	444	452	331	379	417	375	396	398
Service Time	6.546	6.049	5.804	8.599	7.365	6.345	7.356	6.857	6.768
HCM Lane V/C Ratio	0.081	1.538	1.164	0.1	1.206	0.103	0.589	0.379	0.216
HCM Control Delay	12.3	72.3	71.2	14.8	78.3	12.3	25.3	17.4	14.2
HCM Lane LOS	B	F	F	B	F	B	D	C	B
HCM 95th Percentile Queue	0.3	98.5	100	0.3	91.5	0.3	4.3	1.8	0.8

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	538	10	80	20	617	0	0	604	530
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor				1.00	1.00		1.00	0.95			0.95	
Frpb, ped/bikes				1.00	1.00		1.00	1.00			0.99	
Flpb, ped/bikes				1.00	1.00		1.00	1.00			1.00	
Frt				1.00	0.87		1.00	1.00			0.93	
Flt Protected				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)				1736	1584		1736	3471			3195	
Flt Permitted				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (perm)				1736	1584		1736	3471			3195	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	585	11	87	22	671	0	0	657	576
RTOR Reduction (vph)	0	0	0	0	52	0	0	0	0	0	121	0
Lane Group Flow (vph)	0	0	0	585	46	0	22	671	0	0	1112	0
Confl. Peds. (#/hr)							1					1
Confl. Bikes (#/hr)									2			1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type				Split			Prot					
Protected Phases				8	8		5	2			6	
Permitted Phases												
Actuated Green, G (s)				38.6	38.6		4.4	49.0			40.6	
Effective Green, g (s)				38.6	38.6		4.4	49.0			40.6	
Actuated g/C Ratio				0.40	0.40		0.05	0.51			0.42	
Clearance Time (s)				4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)				3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)				701	640		80	1779			1357	
v/s Ratio Prot				c0.34	0.03		0.01	c0.19			c0.35	
v/s Ratio Perm												
v/c Ratio				0.83	0.07		0.28	0.38			0.82	
Uniform Delay, d1				25.6	17.5		44.1	14.1			24.3	
Progression Factor				1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2				8.5	0.0		1.9	0.1			4.0	
Delay (s)				34.1	17.6		45.9	14.2			28.2	
Level of Service				C	B		D	B			C	
Approach Delay (s)		0.0			31.7			15.2			28.2	
Approach LOS		A			C			B			C	

Intersection Summary			
HCM Average Control Delay	25.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.81		
Actuated Cycle Length (s)	95.6	Sum of lost time (s)	12.0
Intersection Capacity Utilization	70.2%	ICU Level of Service	C
Analysis Period (min)	15		

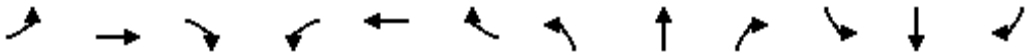
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	450	160	834	150	30	60	70	567	60	140	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		0.95	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	0.99		1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Frt	1.00	0.96		1.00	0.99		1.00	1.00	0.85		0.99	
Flt Protected	0.95	1.00		0.95	0.97		0.95	1.00	1.00		0.99	
Satd. Flow (prot)	1752	3355		1595	3215		1665	1745	1546		1795	
Flt Permitted	0.95	1.00		0.95	0.97		0.95	1.00	1.00		0.99	
Satd. Flow (perm)	1752	3355		1595	3215		1665	1745	1546		1795	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	489	174	907	163	33	65	76	616	65	152	22
RTOR Reduction (vph)	0	33	0	0	3	0	0	0	527	0	3	0
Lane Group Flow (vph)	11	630	0	453	647	0	58	83	89	0	236	0
Confl. Peds. (#/hr)	1					1			2	2		
Confl. Bikes (#/hr)			1			1						1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Split			Split			Split		Perm	Split		
Protected Phases	4	4		8	8		2	2		6	6	
Permitted Phases									2			
Actuated Green, G (s)	18.1	18.1		29.2	29.2		13.2	13.2	13.2		15.3	
Effective Green, g (s)	18.1	18.1		29.2	29.2		13.2	13.2	13.2		15.3	
Actuated g/C Ratio	0.20	0.20		0.32	0.32		0.14	0.14	0.14		0.17	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	345	661		507	1023		239	251	222		299	
v/s Ratio Prot	0.01	c0.19		c0.28	0.20		0.03	0.05			c0.13	
v/s Ratio Perm									c0.06			
v/c Ratio	0.03	0.95		0.89	0.85dl		0.24	0.33	0.40		0.79	
Uniform Delay, d1	29.8	36.4		29.8	26.7		34.9	35.3	35.7		36.7	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Incremental Delay, d2	0.0	23.9		17.9	1.3		0.5	0.8	1.2		12.9	
Delay (s)	29.8	60.3		47.7	28.0		35.4	36.1	36.9		49.6	
Level of Service	C	E		D	C		D	D	D		D	
Approach Delay (s)		59.8			36.1			36.7			49.6	
Approach LOS		E			D			D			D	

Intersection Summary			
HCM Average Control Delay	43.2	HCM Level of Service	D
HCM Volume to Capacity ratio	0.80		
Actuated Cycle Length (s)	91.8	Sum of lost time (s)	16.0
Intersection Capacity Utilization	74.8%	ICU Level of Service	D
Analysis Period (min)	15		

dl Defacto Left Lane. Recode with 1 though lane as a left lane.
c Critical Lane Group

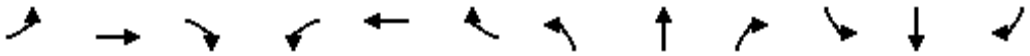


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	907	250	160	385	0	0	0	0	510	40	619
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		0.95			0.95						1.00	
Frpb, ped/bikes		0.99			1.00						1.00	
Flpb, ped/bikes		1.00			1.00						1.00	
Frt		0.97			1.00						0.93	
Flt Protected		1.00			0.99						0.98	
Satd. Flow (prot)		3398			3488						1693	
Flt Permitted		1.00			0.56						0.98	
Satd. Flow (perm)		3398			1996						1693	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	986	272	174	418	0	0	0	0	554	43	673
RTOR Reduction (vph)	0	28	0	0	0	0	0	0	0	0	45	0
Lane Group Flow (vph)	0	1230	0	0	592	0	0	0	0	0	1225	0
Confl. Peds. (#/hr)	5		9	9		5						
Confl. Bikes (#/hr)						2						
Turn Type				Perm						Split		
Protected Phases		4			8					6	6	
Permitted Phases				8								
Actuated Green, G (s)		31.0			31.0						51.0	
Effective Green, g (s)		31.0			31.0						51.0	
Actuated g/C Ratio		0.34			0.34						0.57	
Clearance Time (s)		4.0			4.0						4.0	
Vehicle Extension (s)		3.0			3.0						3.0	
Lane Grp Cap (vph)		1170			688						959	
v/s Ratio Prot		c0.36									c0.72	
v/s Ratio Perm					0.30							
v/c Ratio		1.05			2.10dl						1.28	
Uniform Delay, d1		29.5			27.5						19.5	
Progression Factor		1.00			0.97						1.00	
Incremental Delay, d2		40.8			12.7						132.9	
Delay (s)		70.3			39.4						152.4	
Level of Service		E			D						F	
Approach Delay (s)		70.3			39.4			0.0			152.4	
Approach LOS		E			D			A			F	

Intersection Summary			
HCM Average Control Delay	97.9	HCM Level of Service	F
HCM Volume to Capacity ratio	1.19		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	132.4%	ICU Level of Service	H
Analysis Period (min)	15		

dl Defacto Left Lane. Recode with 1 though lane as a left lane.

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	331	1086	0	0	465	480	80	10	120	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor		0.95			0.95		0.95	0.95	1.00			
Frpb, ped/bikes		1.00			0.99		1.00	1.00	1.00			
Flpb, ped/bikes		1.00			1.00		1.00	1.00	1.00			
Frt		1.00			0.92		1.00	1.00	0.85			
Flt Protected		0.99			1.00		0.95	0.96	1.00			
Satd. Flow (prot)		3498			3227		1681	1704	1583			
Flt Permitted		0.56			1.00		0.95	0.96	1.00			
Satd. Flow (perm)		1994			3227		1681	1704	1583			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	360	1180	0	0	505	522	87	11	130	0	0	0
RTOR Reduction (vph)	0	0	0	0	139	0	0	0	104	0	0	0
Lane Group Flow (vph)	0	1540	0	0	888	0	49	49	26	0	0	0
Confl. Peds. (#/hr)	5		7	7		5			1	1		
Confl. Bikes (#/hr)						3						
Turn Type	Perm						Split		Prot			
Protected Phases		4			8		2	2	2			
Permitted Phases	4											
Actuated Green, G (s)		66.0			66.0		16.0	16.0	16.0			
Effective Green, g (s)		66.0			66.0		16.0	16.0	16.0			
Actuated g/C Ratio		0.73			0.73		0.18	0.18	0.18			
Clearance Time (s)		4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)		3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)		1462			2366		299	303	281			
v/s Ratio Prot					0.28		c0.03	0.03	0.02			
v/s Ratio Perm		c0.77										
v/c Ratio		1.05			0.38		0.16	0.16	0.09			
Uniform Delay, d1		12.0			4.4		31.3	31.3	30.9			
Progression Factor		0.75			1.00		1.00	1.00	1.00			
Incremental Delay, d2		26.0			0.5		1.2	1.1	0.6			
Delay (s)		35.0			4.9		32.5	32.5	31.6			
Level of Service		C			A		C	C	C			
Approach Delay (s)		35.0			4.9			32.0			0.0	
Approach LOS		C			A			C			A	

Intersection Summary			
HCM Average Control Delay	23.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.88		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	106.3%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	519	140	145	185	100	261
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frpb, ped/bikes	1.00	0.98	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	1.00	1.00	0.95	1.00	0.95	1.00
Satd. Flow (prot)	1810	1464	1719	1810	1671	1538
Flt Permitted	1.00	1.00	0.35	1.00	0.95	1.00
Satd. Flow (perm)	1810	1464	637	1810	1671	1538
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	564	152	158	201	109	284
RTOR Reduction (vph)	0	78	0	0	0	166
Lane Group Flow (vph)	564	74	158	201	109	118
Confl. Bikes (#/hr)		1				
Heavy Vehicles (%)	5%	8%	5%	5%	8%	5%
Turn Type		Perm	Perm			Perm
Protected Phases	4			8	2	
Permitted Phases		4	8			2
Actuated Green, G (s)	15.3	15.3	15.3	15.3	8.2	8.2
Effective Green, g (s)	15.3	15.3	15.3	15.3	8.2	8.2
Actuated g/C Ratio	0.49	0.49	0.49	0.49	0.26	0.26
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	879	711	309	879	435	400
v/s Ratio Prot	c0.31			0.11	0.07	
v/s Ratio Perm		0.05	0.25			c0.08
v/c Ratio	0.64	0.10	0.51	0.23	0.25	0.29
Uniform Delay, d1	6.1	4.4	5.5	4.7	9.2	9.3
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.6	0.1	1.4	0.1	0.3	0.4
Delay (s)	7.7	4.5	7.0	4.8	9.5	9.7
Level of Service	A	A	A	A	A	A
Approach Delay (s)	7.0			5.8	9.7	
Approach LOS	A			A	A	

Intersection Summary			
HCM Average Control Delay	7.4	HCM Level of Service	A
HCM Volume to Capacity ratio	0.52		
Actuated Cycle Length (s)	31.5	Sum of lost time (s)	8.0
Intersection Capacity Utilization	50.9%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	594	210	43	144	143	218
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0	4.0	4.0	
Lane Util. Factor	1.00		1.00	1.00	1.00	
Frt	0.96		1.00	1.00	0.92	
Flt Protected	1.00		0.95	1.00	0.98	
Satd. Flow (prot)	1733		1671	1810	1611	
Flt Permitted	1.00		0.20	1.00	0.98	
Satd. Flow (perm)	1733		356	1810	1611	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	646	228	47	157	155	237
RTOR Reduction (vph)	12	0	0	0	65	0
Lane Group Flow (vph)	862	0	47	157	327	0
Heavy Vehicles (%)	5%	8%	8%	5%	8%	5%
Turn Type			Perm			
Protected Phases	4			8	2	
Permitted Phases			8			
Actuated Green, G (s)	60.1		60.1	60.1	21.9	
Effective Green, g (s)	60.1		60.1	60.1	21.9	
Actuated g/C Ratio	0.67		0.67	0.67	0.24	
Clearance Time (s)	4.0		4.0	4.0	4.0	
Vehicle Extension (s)	3.0		3.0	3.0	3.0	
Lane Grp Cap (vph)	1157		238	1209	392	
v/s Ratio Prot	c0.50			0.09	c0.20	
v/s Ratio Perm			0.13			
v/c Ratio	0.74		0.20	0.13	0.83	
Uniform Delay, d1	9.9		5.7	5.4	32.3	
Progression Factor	0.87		1.00	1.00	1.00	
Incremental Delay, d2	1.9		1.9	0.2	14.1	
Delay (s)	10.5		7.6	5.7	46.4	
Level of Service	B		A	A	D	
Approach Delay (s)	10.5			6.1	46.4	
Approach LOS	B			A	D	

Intersection Summary			
HCM Average Control Delay	19.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.77		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	72.0%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

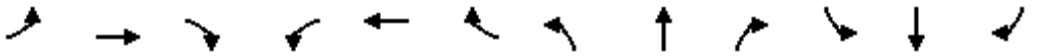
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	294	377	587	365	67	96
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0	4.0	4.0	4.0
Lane Util. Factor	1.00		1.00	1.00	1.00	1.00
Frt	0.92		1.00	1.00	1.00	0.85
Flt Protected	1.00		0.95	1.00	0.95	1.00
Satd. Flow (prot)	1672		1719	1810	1719	1538
Flt Permitted	1.00		0.10	1.00	0.95	1.00
Satd. Flow (perm)	1672		190	1810	1719	1538
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	320	410	638	397	73	104
RTOR Reduction (vph)	48	0	0	0	0	93
Lane Group Flow (vph)	682	0	638	397	73	11
Heavy Vehicles (%)	5%	5%	5%	5%	5%	5%
Turn Type			pm+pt			Perm
Protected Phases	4		3	8	2	
Permitted Phases			8			2
Actuated Green, G (s)	34.1		66.1	66.1	8.8	8.8
Effective Green, g (s)	34.1		66.1	66.1	8.8	8.8
Actuated g/C Ratio	0.41		0.80	0.80	0.11	0.11
Clearance Time (s)	4.0		4.0	4.0	4.0	4.0
Vehicle Extension (s)	3.0		3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	688		668	1443	182	163
v/s Ratio Prot	0.41		c0.32	0.22	c0.04	
v/s Ratio Perm			c0.44			0.01
v/c Ratio	0.99		0.96	0.28	0.40	0.07
Uniform Delay, d1	24.2		22.3	2.2	34.6	33.4
Progression Factor	1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2	31.9		24.1	0.1	1.4	0.2
Delay (s)	56.1		46.4	2.3	36.0	33.5
Level of Service	E		D	A	D	C
Approach Delay (s)	56.1			29.5	34.6	
Approach LOS	E			C	C	

Intersection Summary			
HCM Average Control Delay	40.0	HCM Level of Service	D
HCM Volume to Capacity ratio	0.87		
Actuated Cycle Length (s)	82.9	Sum of lost time (s)	8.0
Intersection Capacity Utilization	84.8%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	10	10	420	10	30	30	942	170	203	207	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00		1.00	1.00		1.00	0.95		0.97	1.00	
Frpb, ped/bikes		1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Flpb, ped/bikes		1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Frt		0.95		1.00	0.89		1.00	0.98		1.00	0.99	
Flt Protected		0.98		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1709		1736	1621		1736	3391		3367	1812	
Flt Permitted		0.94		0.74	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)		1640		1344	1621		1736	3391		3367	1812	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	11	11	457	11	33	33	1024	185	221	225	11
RTOR Reduction (vph)	0	7	0	0	21	0	0	16	0	0	2	0
Lane Group Flow (vph)	0	26	0	457	23	0	33	1193	0	221	234	0
Confl. Bikes (#/hr)			1									1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm			Perm			Prot			Prot		
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8								
Actuated Green, G (s)		31.8		31.8	31.8		3.4	35.9		7.1	39.6	
Effective Green, g (s)		31.8		31.8	31.8		3.4	35.9		7.1	39.6	
Actuated g/C Ratio		0.37		0.37	0.37		0.04	0.41		0.08	0.46	
Clearance Time (s)		4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		601		492	594		68	1402		275	827	
v/s Ratio Prot					0.01		0.02	c0.35		c0.07	c0.13	
v/s Ratio Perm		0.02		c0.34								
v/c Ratio		0.04		0.93	0.04		0.49	0.85		0.80	0.28	
Uniform Delay, d1		17.7		26.4	17.7		40.8	23.0		39.2	14.7	
Progression Factor		1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.0		23.9	0.0		5.4	5.2		15.5	0.2	
Delay (s)		17.7		50.3	17.7		46.2	28.2		54.7	14.9	
Level of Service		B		D	B		D	C		D	B	
Approach Delay (s)		17.7			47.4			28.7			34.1	
Approach LOS		B			D			C			C	

Intersection Summary			
HCM Average Control Delay	33.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.91		
Actuated Cycle Length (s)	86.8	Sum of lost time (s)	16.0
Intersection Capacity Utilization	77.2%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

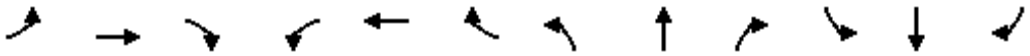


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	907	250	160	385	0	0	0	0	510	40	619
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	4.0
Lane Util. Factor		0.95			0.95						1.00	1.00
Frpb, ped/bikes		0.99			1.00						1.00	1.00
Flpb, ped/bikes		1.00			1.00						1.00	1.00
Frt		0.97			1.00						1.00	0.85
Flt Protected		1.00			0.99						0.96	1.00
Satd. Flow (prot)		3398			3486						1780	1583
Flt Permitted		1.00			0.52						0.96	1.00
Satd. Flow (perm)		3398			1837						1780	1583
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	986	272	174	418	0	0	0	0	554	43	673
RTOR Reduction (vph)	0	28	0	0	0	0	0	0	0	0	0	203
Lane Group Flow (vph)	0	1230	0	0	592	0	0	0	0	0	597	470
Confl. Peds. (#/hr)	5		9	9		5						
Confl. Bikes (#/hr)						2						
Turn Type				Perm						Split		Perm
Protected Phases		4			8					6	6	
Permitted Phases				8								6
Actuated Green, G (s)		44.0			44.0						38.0	38.0
Effective Green, g (s)		44.0			44.0						38.0	38.0
Actuated g/C Ratio		0.49			0.49						0.42	0.42
Clearance Time (s)		4.0			4.0						4.0	4.0
Vehicle Extension (s)		3.0			3.0						3.0	3.0
Lane Grp Cap (vph)		1661			898						752	668
v/s Ratio Prot		c0.36									c0.34	
v/s Ratio Perm					0.32							0.30
v/c Ratio		0.74			1.79dl						0.79	0.70
Uniform Delay, d1		18.4			17.3						22.6	21.4
Progression Factor		1.00			1.07						1.00	1.00
Incremental Delay, d2		3.0			3.6						8.4	6.1
Delay (s)		21.4			22.1						31.0	27.5
Level of Service		C			C						C	C
Approach Delay (s)		21.4			22.1			0.0			29.2	
Approach LOS		C			C			A			C	

Intersection Summary			
HCM Average Control Delay	24.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.77		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	94.4%	ICU Level of Service	F
Analysis Period (min)	15		

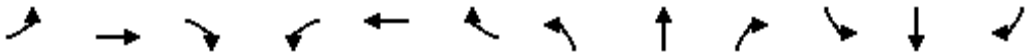
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	120	620	68	240	420	220	150	1131	320	210	506	70
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frpb, ped/bikes	1.00	1.00	0.96	1.00	1.00	0.98	1.00	1.00	0.92	1.00	1.00	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.98	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1770	3539	1525	1770	3539	1553	1770	3539	1450	1770	3468	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1770	3539	1525	1770	3539	1553	1770	3539	1450	1770	3468	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	130	674	74	261	457	239	163	1229	348	228	550	76
RTOR Reduction (vph)	0	0	15	0	0	97	0	0	90	0	9	0
Lane Group Flow (vph)	130	674	59	261	457	142	163	1229	258	228	617	0
Confl. Peds. (#/hr)	5		19	19		5	4		14	14		4
Confl. Bikes (#/hr)						1			100			
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases			2			6			8			
Actuated Green, G (s)	10.2	23.4	23.4	15.0	26.2	26.2	13.7	42.1	42.1	13.0	41.4	
Effective Green, g (s)	10.2	23.4	23.4	15.0	26.2	26.2	13.7	42.1	42.1	13.0	41.4	
Actuated g/C Ratio	0.10	0.22	0.22	0.14	0.25	0.25	0.13	0.40	0.40	0.12	0.39	
Clearance Time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Vehicle Extension (s)	2.0	4.0	4.0	2.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	
Lane Grp Cap (vph)	170	778	335	249	871	382	228	1399	573	216	1348	
v/s Ratio Prot	0.07	c0.19		c0.15	c0.13		0.09	c0.35		c0.13	0.18	
v/s Ratio Perm			0.04			0.09			0.18			
v/c Ratio	0.76	0.87	0.18	1.05	0.52	0.37	0.71	0.88	0.45	1.06	0.46	
Uniform Delay, d1	47.0	40.0	33.7	45.8	34.8	33.3	44.5	29.8	23.7	46.8	24.2	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	16.7	10.3	0.3	70.2	0.7	0.8	8.5	6.4	0.2	76.6	0.1	
Delay (s)	63.6	50.3	34.1	116.0	35.5	34.2	53.1	36.2	23.9	123.4	24.3	
Level of Service	E	D	C	F	D	C	D	D	C	F	C	
Approach Delay (s)		50.9			57.1			35.3			50.8	
Approach LOS		D			E			D			D	

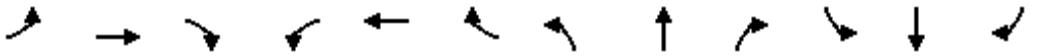
Intersection Summary			
HCM Average Control Delay	46.1	HCM Level of Service	D
HCM Volume to Capacity ratio	0.91		
Actuated Cycle Length (s)	106.5	Sum of lost time (s)	14.0
Intersection Capacity Utilization	88.0%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	280	10	876	0	766	423	0	633	190
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0	4.0		4.0	4.0		4.0	
Lane Util. Factor				0.95	0.91	0.95		0.91	1.00		0.91	
Frt				1.00	0.86	0.85		1.00	0.85		0.97	
Flt Protected				0.95	1.00	1.00		1.00	1.00		1.00	
Satd. Flow (prot)				1698	1472	1519		5136	1599		4958	
Flt Permitted				0.95	1.00	1.00		1.00	1.00		1.00	
Satd. Flow (perm)				1698	1472	1519		5136	1599		4958	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	298	11	932	0	815	450	0	673	202
RTOR Reduction (vph)	0	0	0	0	32	32	0	0	0	0	90	0
Lane Group Flow (vph)	0	0	0	268	456	453	0	815	450	0	785	0
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Split		Perm			Free			
Protected Phases				8	8			2			6	
Permitted Phases						8			Free			
Actuated Green, G (s)				23.0	23.0	23.0		15.7	46.7		15.7	
Effective Green, g (s)				23.0	23.0	23.0		15.7	46.7		15.7	
Actuated g/C Ratio				0.49	0.49	0.49		0.34	1.00		0.34	
Clearance Time (s)				4.0	4.0	4.0		4.0			4.0	
Vehicle Extension (s)				3.0	3.0	3.0		3.0			3.0	
Lane Grp Cap (vph)				836	725	748		1727	1599		1667	
v/s Ratio Prot				0.16	c0.31			c0.16			0.16	
v/s Ratio Perm						0.30			0.28			
v/c Ratio				0.32	0.63	0.60		0.47	0.28		0.47	
Uniform Delay, d1				7.1	8.7	8.6		12.2	0.0		12.2	
Progression Factor				1.00	1.00	1.00		1.00	1.00		1.00	
Incremental Delay, d2				0.2	1.7	1.4		0.2	0.4		0.2	
Delay (s)				7.4	10.4	10.0		12.4	0.4		12.4	
Level of Service				A	B	A		B	A		B	
Approach Delay (s)		0.0			9.6			8.2			12.4	
Approach LOS		A			A			A			B	

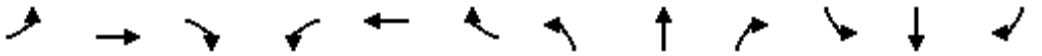
Intersection Summary			
HCM Average Control Delay	9.8	HCM Level of Service	A
HCM Volume to Capacity ratio	0.56		
Actuated Cycle Length (s)	46.7	Sum of lost time (s)	8.0
Intersection Capacity Utilization	57.6%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	390	0	280	0	0	0	0	798	370	0	562	352
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0					4.0			4.0	4.0
Lane Util. Factor	1.00		1.00					0.91			0.95	1.00
Frpb, ped/bikes	1.00		1.00					0.99			1.00	0.98
Flpb, ped/bikes	1.00		1.00					1.00			1.00	1.00
Frt	1.00		0.85					0.95			1.00	0.85
Flt Protected	0.95		1.00					1.00			1.00	1.00
Satd. Flow (prot)	1770		1583					4806			3539	1549
Flt Permitted	0.95		1.00					1.00			1.00	1.00
Satd. Flow (perm)	1770		1583					4806			3539	1549
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	424	0	304	0	0	0	0	867	402	0	611	383
RTOR Reduction (vph)	0	0	72	0	0	0	0	124	0	0	0	0
Lane Group Flow (vph)	424	0	232	0	0	0	0	1145	0	0	611	383
Confl. Peds. (#/hr)							4		2	2		4
Confl. Bikes (#/hr)									3			
Turn Type	Split		Perm									Free
Protected Phases	8	8						2			6	
Permitted Phases			8									Free
Actuated Green, G (s)	17.1		17.1					19.4			19.4	44.5
Effective Green, g (s)	17.1		17.1					19.4			19.4	44.5
Actuated g/C Ratio	0.38		0.38					0.44			0.44	1.00
Clearance Time (s)	4.0		4.0					4.0			4.0	
Vehicle Extension (s)	3.0		3.0					3.0			3.0	
Lane Grp Cap (vph)	680		608					2095			1543	1549
v/s Ratio Prot	c0.24							c0.24			0.17	
v/s Ratio Perm			0.15									0.25
v/c Ratio	0.62		0.38					0.55			0.40	0.25
Uniform Delay, d1	11.1		9.9					9.3			8.6	0.0
Progression Factor	1.00		1.00					1.00			1.00	1.00
Incremental Delay, d2	1.8		0.4					0.3			0.2	0.4
Delay (s)	12.9		10.3					9.6			8.7	0.4
Level of Service	B		B					A			A	A
Approach Delay (s)		11.8			0.0			9.6			5.5	
Approach LOS		B			A			A			A	

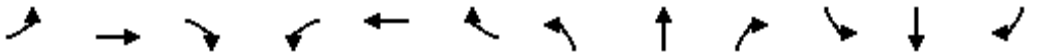
Intersection Summary			
HCM Average Control Delay	8.8	HCM Level of Service	A
HCM Volume to Capacity ratio	0.58		
Actuated Cycle Length (s)	44.5	Sum of lost time (s)	8.0
Intersection Capacity Utilization	52.0%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	200	20	100	20	20	260	30	708	10	20	691	130
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Lane Util. Factor		1.00		1.00	1.00			0.95		1.00	0.95	
Frpb, ped/bikes		0.99		1.00	0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00		1.00	1.00			1.00		0.96	1.00	
Frt		0.96		1.00	0.86			1.00		1.00	0.98	
Flt Protected		0.97		0.95	1.00			1.00		0.95	1.00	
Satd. Flow (prot)		1695		1751	1568			3489		1681	3411	
Flt Permitted		1.00		0.55	1.00			0.90		0.95	1.00	
Satd. Flow (perm)		1748		1018	1568			3143		1681	3411	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	217	22	109	22	22	283	33	770	11	22	751	141
RTOR Reduction (vph)	0	17	0	0	221	0	0	1	0	0	13	0
Lane Group Flow (vph)	0	331	0	22	84	0	0	813	0	22	879	0
Confl. Peds. (#/hr)	1		3	3		1			5	5		
Confl. Bikes (#/hr)						1			2			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Perm			Prot		
Protected Phases		3			4			2		1	6	
Permitted Phases	3			4			2					
Actuated Green, G (s)		2.2		11.7	11.7			22.7		0.9	27.6	
Effective Green, g (s)		2.2		11.7	11.7			22.7		0.9	27.6	
Actuated g/C Ratio		0.04		0.22	0.22			0.42		0.02	0.52	
Clearance Time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		72		223	343			1334		28	1760	
v/s Ratio Prot					c0.05					0.01	c0.26	
v/s Ratio Perm		c0.19		0.02				c0.26				
v/c Ratio		4.59		0.10	0.24			0.61		0.79	0.50	
Uniform Delay, d1		25.6		16.7	17.3			12.0		26.2	8.4	
Progression Factor		1.00		1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		1648.5		0.2	0.4			0.8		82.7	0.2	
Delay (s)		1674.1		16.9	17.6			12.8		108.9	8.7	
Level of Service		F		B	B			B		F	A	
Approach Delay (s)		1674.1			17.6			12.8			11.1	
Approach LOS		F			B			B			B	

Intersection Summary			
HCM Average Control Delay	253.4	HCM Level of Service	F
HCM Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	53.5	Sum of lost time (s)	16.0
Intersection Capacity Utilization	88.2%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group



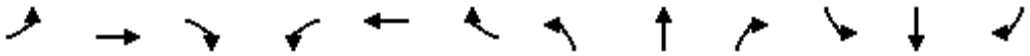
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	190	55	50	84	154	318	50	190	135	81	440	300
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00	1.00	1.00	0.99		1.00	0.99		1.00	0.99	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	0.90		1.00	0.94		1.00	0.94	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	3153		1770	3300		1770	3293	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	3153		1770	3300		1770	3293	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	200	58	53	88	162	335	53	200	142	85	463	316
RTOR Reduction (vph)	0	0	38	0	265	0	0	104	0	0	156	0
Lane Group Flow (vph)	200	58	15	88	232	0	53	238	0	85	623	0
Confl. Peds. (#/hr)							16		1	1		16
Confl. Bikes (#/hr)						1			1			
Turn Type	Prot		Perm	Prot			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4									
Actuated Green, G (s)	8.6	16.1	16.1	4.4	11.9		3.0	15.2		4.9	17.1	
Effective Green, g (s)	8.6	16.1	16.1	4.4	11.9		3.0	15.2		4.9	17.1	
Actuated g/C Ratio	0.15	0.28	0.28	0.08	0.21		0.05	0.27		0.09	0.30	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	269	1007	450	138	663		94	886		153	995	
v/s Ratio Prot	c0.11	0.02		0.05	c0.07		0.03	0.07		c0.05	c0.19	
v/s Ratio Perm			0.01									
v/c Ratio	0.74	0.06	0.03	0.64	0.35		0.56	0.27		0.56	0.63	
Uniform Delay, d1	22.9	14.7	14.6	25.3	19.1		26.2	16.3		24.8	17.0	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	10.6	0.0	0.0	9.3	0.3		7.5	0.2		4.3	1.2	
Delay (s)	33.5	14.8	14.7	34.6	19.4		33.7	16.5		29.1	18.2	
Level of Service	C	B	B	C	B		C	B		C	B	
Approach Delay (s)		26.8			21.7			18.8			19.3	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	20.9	HCM Level of Service	C
HCM Volume to Capacity ratio	0.53		
Actuated Cycle Length (s)	56.6	Sum of lost time (s)	12.0
Intersection Capacity Utilization	64.1%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	133	60	328	361	290	174
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	145	65	357	392	315	189
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				1133		
pX, platoon unblocked						
vC, conflicting volume			210		1250	145
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			210		1250	145
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			74		0	79
cM capacity (veh/h)			1349		139	897

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2
Volume Total	145	65	357	392	315	189
Volume Left	0	0	357	0	315	0
Volume Right	0	65	0	0	0	189
cSH	1700	1700	1349	1700	139	897
Volume to Capacity	0.09	0.04	0.26	0.23	2.27	0.21
Queue Length 95th (ft)	0	0	27	0	662	20
Control Delay (s)	0.0	0.0	8.6	0.0	644.4	10.1
Lane LOS			A		F	B
Approach Delay (s)	0.0		4.1		406.5	
Approach LOS					F	

Intersection Summary			
Average Delay	142.2		
Intersection Capacity Utilization	51.2%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	120	61	10	10	232	550	20	20	10	217	20	70
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.98		1.00	0.89		1.00	0.95			0.97	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.97	
Satd. Flow (prot)	1671	1764		1671	1619		1671	1671			1680	
Flt Permitted	0.95	1.00		0.95	1.00		0.65	1.00			0.77	
Satd. Flow (perm)	1671	1764		1671	1619		1152	1671			1338	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	130	66	11	11	252	598	22	22	11	236	22	76
RTOR Reduction (vph)	0	5	0	0	134	0	0	8	0	0	18	0
Lane Group Flow (vph)	130	72	0	11	716	0	22	25	0	0	316	0
Heavy Vehicles (%)	8%	5%	8%	8%	5%	5%	8%	8%	8%	5%	8%	8%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	5.0	33.8		1.4	30.2		15.6	15.6			15.6	
Effective Green, g (s)	5.0	33.8		1.4	30.2		15.6	15.6			15.6	
Actuated g/C Ratio	0.08	0.54		0.02	0.48		0.25	0.25			0.25	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	133	949		37	779		286	415			332	
v/s Ratio Prot	c0.08	c0.04		0.01	c0.44			0.01				
v/s Ratio Perm							0.02				c0.24	
v/c Ratio	0.98	0.08		0.30	0.92		0.08	0.06			0.95	
Uniform Delay, d1	28.8	7.0		30.2	15.2		18.1	18.0			23.2	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	70.4	0.0		4.5	15.6		0.1	0.1			36.6	
Delay (s)	99.2	7.0		34.7	30.8		18.2	18.1			59.8	
Level of Service	F	A		C	C		B	B			E	
Approach Delay (s)		64.9			30.8			18.1			59.8	
Approach LOS		E			C			B			E	

Intersection Summary			
HCM Average Control Delay	41.9	HCM Level of Service	D
HCM Volume to Capacity ratio	0.97		
Actuated Cycle Length (s)	62.8	Sum of lost time (s)	16.0
Intersection Capacity Utilization	86.7%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	167	122	87	557	236	103
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	182	133	95	605	257	112
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)	322					
pX, platoon unblocked						
vC, conflicting volume			182		1042	248
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			182		1042	248
tC, single (s)			4.2		6.5	6.3
tC, 2 stage (s)						
tF (s)			2.3		3.6	3.4
p0 queue free %			93		0	86
cM capacity (veh/h)			1358		230	776

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	314	95	605	368
Volume Left	0	95	0	257
Volume Right	133	0	0	112
cSH	1700	1358	1700	293
Volume to Capacity	0.18	0.07	0.36	1.26
Queue Length 95th (ft)	0	6	0	434
Control Delay (s)	0.0	7.8	0.0	176.7
Lane LOS		A		F
Approach Delay (s)	0.0	1.1		176.7
Approach LOS				F

Intersection Summary			
Average Delay	47.6		
Intersection Capacity Utilization	55.4%	ICU Level of Service	B
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	441	62	89	150	358	559
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	479	67	97	163	389	608
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			547		870	513
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			547		870	513
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			91		0	0
cM capacity (veh/h)			1023		292	561

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	547	97	163	997
Volume Left	0	97	0	389
Volume Right	67	0	0	608
cSH	1700	1023	1700	412
Volume to Capacity	0.32	0.09	0.10	2.42
Queue Length 95th (ft)	0	8	0	1946
Control Delay (s)	0.0	8.9	0.0	665.9
Lane LOS		A		F
Approach Delay (s)	0.0	3.3		665.9
Approach LOS				F

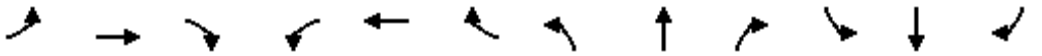
Intersection Summary			
Average Delay	368.5		
Intersection Capacity Utilization	96.1%	ICU Level of Service	F
Analysis Period (min)	15		

Intersection	
Intersection Delay (sec/veh)	50.2
Intersection LOS	F

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Volume (vph)	10	20	10	510	10	30	10	209	70	525	436	10
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles(%)	2	2	2	2	2	2	2	2	2	2	2	2
Movement Flow Rate	11	22	11	554	11	33	11	227	76	571	474	11
Number of Lanes	0	1	0	1	1	0	1	2	0	1	2	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	2	1	3	3
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	3	3	1	2
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	3	3	2	1
HCM Control Delay	14.4	71.2	16.9	49.7
HCM LOS	B	F	C	E

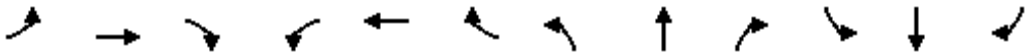
Lane	NBLn1	NBLn2	NBLn3	EBLn1	WBLn1	WBLn2	SBLn1	SBLn2	SBLn3
Volume Left (%)	100%	0%	0%	25%	100%	0%	100%	0%	0%
Volume Thru (%)	0%	100%	50%	50%	0%	25%	0%	100%	94%
Volume Right (%)	0%	0%	50%	25%	0%	75%	0%	0%	6%
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Traffic Volume by Lane	10	139	140	40	510	40	525	291	155
Left Turning Volume	0	139	70	20	0	10	0	291	145
Through Volume	0	0	70	10	0	30	0	0	10
Right Turning Volume	10	0	0	10	510	0	525	0	0
Lane Flow Rate	11	151	152	43	554	43	571	316	169
Geometry Group	8	8	8	8	8	8	8	8	8
Degree of Utilization, X	0.029	0.385	0.371	0.123	1	0.097	1	0.692	0.368
Departure Headway, Hd	9.653	9.155	8.805	10.183	9.052	8.036	8.381	7.883	7.838
Convergence(Y/N)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capacity	371	394	408	352	405	445	434	458	459
Service Time	7.4	6.902	6.552	7.951	6.822	5.806	6.119	5.621	5.576
HCM Lane V/C Ratio	0.03	0.383	0.373	0.122	1.368	0.097	1.316	0.69	0.368
HCM Control Delay	12.7	17.5	16.7	14.4	75.9	11.7	72.7	26.6	15.1
HCM Lane LOS	B	C	C	B	F	B	F	D	C
HCM 95th Percentile Queue	0.1	1.9	1.8	0.4	94.2	0.3	98.1	6.7	1.7



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	137	10	480	30	926	0	0	142	330
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor				1.00	1.00		1.00	0.95			0.95	
Frpb, ped/bikes				1.00	1.00		1.00	1.00			0.98	
Flpb, ped/bikes				1.00	1.00		1.00	1.00			1.00	
Frt				1.00	0.85		1.00	1.00			0.90	
Flt Protected				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)				1787	1605		1787	3574			3151	
Flt Permitted				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (perm)				1787	1605		1787	3574			3151	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	144	11	505	32	975	0	0	149	347
RTOR Reduction (vph)	0	0	0	0	72	0	0	0	0	0	232	0
Lane Group Flow (vph)	0	0	0	144	444	0	32	975	0	0	264	0
Confl. Peds. (#/hr)							1		2	2		1
Confl. Bikes (#/hr)			1						1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Split			Prot					
Protected Phases				8	8		5	2			6	
Permitted Phases												
Actuated Green, G (s)				19.3	19.3		4.2	25.9			17.7	
Effective Green, g (s)				19.3	19.3		4.2	25.9			17.7	
Actuated g/C Ratio				0.36	0.36		0.08	0.49			0.33	
Clearance Time (s)				4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)				3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)				648	582		141	1740			1048	
v/s Ratio Prot				0.08	c0.28		0.02	c0.27			0.08	
v/s Ratio Perm												
v/c Ratio				0.22	0.76		0.23	0.56			0.25	
Uniform Delay, d1				11.7	14.9		23.0	9.6			12.9	
Progression Factor				1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2				0.2	5.9		0.8	0.4			0.1	
Delay (s)				11.9	20.8		23.8	10.0			13.1	
Level of Service				B	C		C	B			B	
Approach Delay (s)		0.0			18.9			10.5			13.1	
Approach LOS		A			B			B			B	

Intersection Summary			
HCM Average Control Delay	13.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	53.2	Sum of lost time (s)	8.0
Intersection Capacity Utilization	62.5%	ICU Level of Service	B
Analysis Period (min)	15		

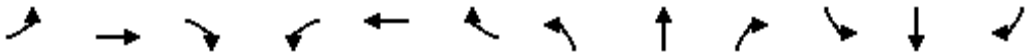
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	50	530	90	342	370	60	310	180	916	30	40	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		0.95	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	0.99		1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Frt	1.00	0.98		1.00	0.98		1.00	1.00	0.85		0.94	
Flt Protected	0.95	1.00		0.95	0.99		0.95	0.99	1.00		0.99	
Satd. Flow (prot)	1787	3496		1626	3336		1698	1763	1576		1753	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	0.99	1.00		0.99	
Satd. Flow (perm)	1787	3496		1626	3336		1698	1763	1576		1753	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	52	546	93	353	381	62	320	186	944	31	41	52
RTOR Reduction (vph)	0	14	0	0	10	0	0	0	452	0	29	0
Lane Group Flow (vph)	52	625	0	261	525	0	250	256	492	0	95	0
Confl. Peds. (#/hr)									2	2		
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Split			Split			Split		Perm	Split		
Protected Phases	4	4		8	8		2	2		6	6	
Permitted Phases									2			
Actuated Green, G (s)	16.0	16.0		17.4	17.4		29.1	29.1	29.1		10.0	
Effective Green, g (s)	16.0	16.0		17.4	17.4		29.1	29.1	29.1		10.0	
Actuated g/C Ratio	0.18	0.18		0.20	0.20		0.33	0.33	0.33		0.11	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	323	632		320	656		558	580	518		198	
v/s Ratio Prot	0.03	c0.18		c0.16	0.16		0.15	0.15			c0.05	
v/s Ratio Perm									c0.31			
v/c Ratio	0.16	0.99		0.82	0.80		0.45	0.44	0.95		0.48	
Uniform Delay, d1	30.6	36.2		34.0	33.9		23.4	23.3	29.0		36.8	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Incremental Delay, d2	0.2	32.6		14.7	7.0		0.6	0.5	27.5		1.8	
Delay (s)	30.8	68.8		48.7	40.9		24.0	23.9	56.5		38.6	
Level of Service	C	E		D	D		C	C	E		D	
Approach Delay (s)		66.0			43.4			45.1			38.6	
Approach LOS		E			D			D			D	

Intersection Summary			
HCM Average Control Delay	49.1	HCM Level of Service	D
HCM Volume to Capacity ratio	0.86		
Actuated Cycle Length (s)	88.5	Sum of lost time (s)	16.0
Intersection Capacity Utilization	91.3%	ICU Level of Service	F
Analysis Period (min)	15		

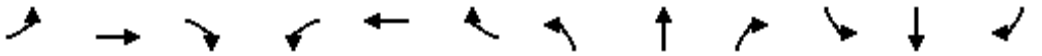
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	1056	370	170	465	0	0	0	0	570	20	437
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		0.95			0.95						1.00	
Frpb, ped/bikes		0.99			1.00						1.00	
Flpb, ped/bikes		1.00			1.00						1.00	
Frt		0.96			1.00						0.94	
Flt Protected		1.00			0.99						0.97	
Satd. Flow (prot)		3401			3527						1725	
Flt Permitted		1.00			0.54						0.97	
Satd. Flow (perm)		3401			1944						1725	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	0	1100	385	177	484	0	0	0	0	594	21	455
RTOR Reduction (vph)	0	29	0	0	0	0	0	0	0	0	22	0
Lane Group Flow (vph)	0	1456	0	0	661	0	0	0	0	0	1048	0
Confl. Peds. (#/hr)	3		8	8		3						
Confl. Bikes (#/hr)						3						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Perm						Split		
Protected Phases		4			8					6	6	
Permitted Phases				8								
Actuated Green, G (s)		49.0			49.0						63.0	
Effective Green, g (s)		49.0			49.0						63.0	
Actuated g/C Ratio		0.41			0.41						0.52	
Clearance Time (s)		4.0			4.0						4.0	
Vehicle Extension (s)		3.0			3.0						3.0	
Lane Grp Cap (vph)		1389			794						906	
v/s Ratio Prot		c0.43									c0.61	
v/s Ratio Perm					0.34							
v/c Ratio		1.05			2.81dl						1.16	
Uniform Delay, d1		35.5			31.8						28.5	
Progression Factor		1.00			1.01						1.00	
Incremental Delay, d2		37.9			9.2						82.8	
Delay (s)		73.4			41.3						111.3	
Level of Service		E			D						F	
Approach Delay (s)		73.4			41.3			0.0			111.3	
Approach LOS		E			D			A			F	

Intersection Summary			
HCM Average Control Delay	79.4	HCM Level of Service	E
HCM Volume to Capacity ratio	1.11		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	131.5%	ICU Level of Service	H
Analysis Period (min)	15		

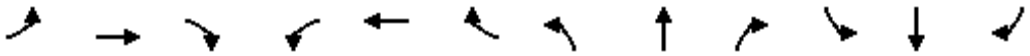
dl Defacto Left Lane. Recode with 1 though lane as a left lane.
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	612	1014	0	0	535	550	100	140	220	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor		0.95			0.95		0.95	0.95	1.00			
Frpb, ped/bikes		1.00			0.99		1.00	1.00	1.00			
Flpb, ped/bikes		1.00			1.00		1.00	1.00	1.00			
Frt		1.00			0.92		1.00	1.00	0.85			
Flt Protected		0.98			1.00		0.95	1.00	1.00			
Satd. Flow (prot)		3508			3263		1698	1781	1599			
Flt Permitted		0.52			1.00		0.95	1.00	1.00			
Satd. Flow (perm)		1844			3263		1698	1781	1599			
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	638	1056	0	0	557	573	104	146	229	0	0	0
RTOR Reduction (vph)	0	0	0	0	53	0	0	0	164	0	0	0
Lane Group Flow (vph)	0	1694	0	0	1077	0	94	156	65	0	0	0
Confl. Peds. (#/hr)	2		7	7		2						
Confl. Bikes (#/hr)						3						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm						Split		Prot			
Protected Phases		4			8		2	2	2			
Permitted Phases	4											
Actuated Green, G (s)		96.0			96.0		16.0	16.0	16.0			
Effective Green, g (s)		96.0			96.0		16.0	16.0	16.0			
Actuated g/C Ratio		0.80			0.80		0.13	0.13	0.13			
Clearance Time (s)		4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)		3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)		1475			2610		226	237	213			
v/s Ratio Prot					0.33		0.06	c0.09	0.04			
v/s Ratio Perm		c0.92										
v/c Ratio		1.84dl			0.41		0.42	0.66	0.31			
Uniform Delay, d1		12.0			3.6		47.7	49.4	47.0			
Progression Factor		0.80			1.00		1.00	1.00	1.00			
Incremental Delay, d2		67.7			0.5		5.6	13.5	3.7			
Delay (s)		77.3			4.1		53.3	62.9	50.7			
Level of Service		E			A		D	E	D			
Approach Delay (s)		77.3			4.1			55.1			0.0	
Approach LOS		E			A			E			A	

Intersection Summary			
HCM Average Control Delay	49.0	HCM Level of Service	D
HCM Volume to Capacity ratio	1.08		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	106.5%	ICU Level of Service	G
Analysis Period (min)	15		

dl Defacto Left Lane. Recode with 1 though lane as a left lane.
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	200	20	100	20	20	260	30	708	10	20	691	130
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00			0.95		1.00	0.95	
Frpb, ped/bikes	1.00	0.99		1.00	0.99			1.00		1.00	1.00	
Flpb, ped/bikes	1.00	1.00		0.96	1.00			1.00		0.95	1.00	
Frt	1.00	0.88		1.00	0.86			1.00		1.00	0.98	
Flt Protected	0.95	1.00		0.95	1.00			1.00		0.95	1.00	
Satd. Flow (prot)	1752	1595		1675	1569			3489		1669	3410	
Flt Permitted	0.95	1.00		0.95	1.00			0.89		0.95	1.00	
Satd. Flow (perm)	1752	1595		1675	1569			3124		1669	3410	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	217	22	109	22	22	283	33	770	11	22	751	141
RTOR Reduction (vph)	0	67	0	0	103	0	0	1	0	0	14	0
Lane Group Flow (vph)	217	64	0	22	202	0	0	813	0	22	878	0
Confl. Peds. (#/hr)	1		3	3		1			5	5		
Confl. Bikes (#/hr)						1			2			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Prot			Prot			Perm			Prot		
Protected Phases	3	8		7	4			2		1	6	
Permitted Phases							2					
Actuated Green, G (s)	5.5	24.2		0.6	19.3			20.9		0.5	25.4	
Effective Green, g (s)	5.5	24.2		0.6	19.3			20.9		0.5	25.4	
Actuated g/C Ratio	0.09	0.39		0.01	0.31			0.34		0.01	0.41	
Clearance Time (s)	4.0	4.0		4.0	4.0			4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)	155	621		16	487			1050		13	1393	
v/s Ratio Prot	c0.12	0.04		0.01	c0.13					0.01	c0.26	
v/s Ratio Perm								c0.26				
v/c Ratio	1.40	0.10		1.38	0.42			0.77		1.69	0.63	
Uniform Delay, d1	28.4	12.1		30.8	17.0			18.5		30.9	14.7	
Progression Factor	1.00	1.00		1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2	214.2	0.1		361.4	0.6			3.6		515.9	0.9	
Delay (s)	242.5	12.2		392.2	17.6			22.2		546.8	15.6	
Level of Service	F	B		F	B			C		F	B	
Approach Delay (s)		155.8			42.8			22.2			28.4	
Approach LOS		F			D			C			C	

Intersection Summary				
HCM Average Control Delay	46.7	HCM Level of Service	D	
HCM Volume to Capacity ratio	0.72			
Actuated Cycle Length (s)	62.2	Sum of lost time (s)	16.0	
Intersection Capacity Utilization	81.0%	ICU Level of Service	D	
Analysis Period (min)	15			

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	133	60	328	361	290	174
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frpb, ped/bikes	1.00	0.98	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	1.00	1.00	0.95	1.00	0.95	1.00
Satd. Flow (prot)	1827	1521	1736	1827	1736	1553
Flt Permitted	1.00	1.00	0.66	1.00	0.95	1.00
Satd. Flow (perm)	1827	1521	1214	1827	1736	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	145	65	357	392	315	189
RTOR Reduction (vph)	0	36	0	0	0	127
Lane Group Flow (vph)	145	29	357	392	315	62
Confl. Bikes (#/hr)		1				
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%
Turn Type		Perm	Perm			Perm
Protected Phases	4			8	2	
Permitted Phases		4	8			2
Actuated Green, G (s)	15.5	15.5	15.5	15.5	11.6	11.6
Effective Green, g (s)	15.5	15.5	15.5	15.5	11.6	11.6
Actuated g/C Ratio	0.44	0.44	0.44	0.44	0.33	0.33
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	807	672	536	807	574	513
v/s Ratio Prot	0.08			0.21	c0.18	
v/s Ratio Perm		0.02	c0.29			0.04
v/c Ratio	0.18	0.04	0.67	0.49	0.55	0.12
Uniform Delay, d1	5.9	5.6	7.8	7.0	9.6	8.2
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.1	0.0	3.1	0.5	1.1	0.1
Delay (s)	6.1	5.6	10.9	7.4	10.7	8.3
Level of Service	A	A	B	A	B	A
Approach Delay (s)	5.9			9.1	9.8	
Approach LOS	A			A	A	

Intersection Summary			
HCM Average Control Delay	8.9	HCM Level of Service	A
HCM Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	35.1	Sum of lost time (s)	8.0
Intersection Capacity Utilization	51.2%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

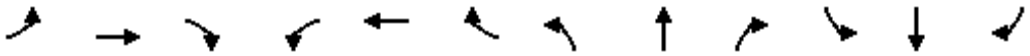
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	167	122	87	557	236	103
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0	4.0	4.0	
Lane Util. Factor	1.00		1.00	1.00	1.00	
Frt	0.94		1.00	1.00	0.96	
Flt Protected	1.00		0.95	1.00	0.97	
Satd. Flow (prot)	1686		1671	1810	1630	
Flt Permitted	1.00		0.55	1.00	0.97	
Satd. Flow (perm)	1686		964	1810	1630	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	182	133	95	605	257	112
RTOR Reduction (vph)	37	0	0	0	29	0
Lane Group Flow (vph)	278	0	95	605	340	0
Heavy Vehicles (%)	5%	8%	8%	5%	8%	8%
Turn Type			Perm			
Protected Phases	4			8	2	
Permitted Phases			8			
Actuated Green, G (s)	35.0		35.0	35.0	17.0	
Effective Green, g (s)	35.0		35.0	35.0	17.0	
Actuated g/C Ratio	0.58		0.58	0.58	0.28	
Clearance Time (s)	4.0		4.0	4.0	4.0	
Vehicle Extension (s)	3.0		3.0	3.0	3.0	
Lane Grp Cap (vph)	984		562	1056	462	
v/s Ratio Prot	0.17			c0.33	c0.21	
v/s Ratio Perm			0.10			
v/c Ratio	0.28		0.17	0.57	0.74	
Uniform Delay, d1	6.2		5.8	7.8	19.5	
Progression Factor	1.37		1.00	1.00	1.00	
Incremental Delay, d2	0.5		0.7	2.3	6.0	
Delay (s)	9.1		6.4	10.1	25.5	
Level of Service	A		A	B	C	
Approach Delay (s)	9.1			9.6	25.5	
Approach LOS	A			A	C	

Intersection Summary			
HCM Average Control Delay	13.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	55.4%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

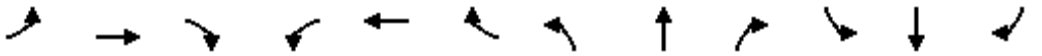
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	441	62	89	150	358	559
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0	4.0	4.0	4.0
Lane Util. Factor	1.00		1.00	1.00	1.00	1.00
Frt	0.98		1.00	1.00	1.00	0.85
Flt Protected	1.00		0.95	1.00	0.95	1.00
Satd. Flow (prot)	1832		1770	1863	1770	1583
Flt Permitted	1.00		0.18	1.00	0.95	1.00
Satd. Flow (perm)	1832		330	1863	1770	1583
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	479	67	97	163	389	608
RTOR Reduction (vph)	8	0	0	0	0	215
Lane Group Flow (vph)	538	0	97	163	389	393
Turn Type			pm+pt			Perm
Protected Phases	4		3	8	2	
Permitted Phases			8			2
Actuated Green, G (s)	18.6		25.5	25.5	17.4	17.4
Effective Green, g (s)	18.6		25.5	25.5	17.4	17.4
Actuated g/C Ratio	0.37		0.50	0.50	0.34	0.34
Clearance Time (s)	4.0		4.0	4.0	4.0	4.0
Vehicle Extension (s)	3.0		3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	669		247	933	605	541
v/s Ratio Prot	c0.29		c0.02	0.09	0.22	
v/s Ratio Perm			0.17			c0.25
v/c Ratio	0.80		0.39	0.17	0.64	0.73
Uniform Delay, d1	14.5		8.9	6.9	14.1	14.7
Progression Factor	1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2	6.9		1.0	0.1	2.3	4.8
Delay (s)	21.5		9.9	7.0	16.5	19.5
Level of Service	C		A	A	B	B
Approach Delay (s)	21.5			8.1	18.3	
Approach LOS	C			A	B	

Intersection Summary			
HCM Average Control Delay	17.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.74		
Actuated Cycle Length (s)	50.9	Sum of lost time (s)	12.0
Intersection Capacity Utilization	68.3%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	20	10	510	10	30	10	209	70	525	436	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00		1.00	1.00		1.00	0.95		0.97	1.00	
Frpb, ped/bikes		1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Flpb, ped/bikes		1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Frt		0.97		1.00	0.89		1.00	0.96		1.00	1.00	
Flt Protected		0.99		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1771		1765	1653		1770	3406		3433	1856	
Flt Permitted		0.96		0.73	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)		1720		1353	1653		1770	3406		3433	1856	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	22	11	554	11	33	11	227	76	571	474	11
RTOR Reduction (vph)	0	6	0	0	18	0	0	36	0	0	1	0
Lane Group Flow (vph)	0	38	0	554	26	0	11	267	0	571	484	0
Confl. Peds. (#/hr)			2	2								
Confl. Bikes (#/hr)			1									
Turn Type	Perm			Perm			Prot			Prot		
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8								
Actuated Green, G (s)		35.8		35.8	35.8		0.7	15.2		16.6	31.1	
Effective Green, g (s)		35.8		35.8	35.8		0.7	15.2		16.6	31.1	
Actuated g/C Ratio		0.45		0.45	0.45		0.01	0.19		0.21	0.39	
Clearance Time (s)		4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		774		609	743		16	650		716	725	
v/s Ratio Prot					0.02		0.01	0.08		c0.17	c0.26	
v/s Ratio Perm		0.02		c0.41								
v/c Ratio		0.05		0.91	0.03		0.69	0.41		0.80	0.67	
Uniform Delay, d1		12.3		20.4	12.2		39.3	28.3		29.9	20.0	
Progression Factor		1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.0		17.5	0.0		80.1	0.4		6.2	2.3	
Delay (s)		12.3		37.9	12.3		119.4	28.7		36.1	22.3	
Level of Service		B		D	B		F	C		D	C	
Approach Delay (s)		12.3			36.0			31.9			29.8	
Approach LOS		B			D			C			C	

Intersection Summary			
HCM Average Control Delay	31.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.81		
Actuated Cycle Length (s)	79.6	Sum of lost time (s)	8.0
Intersection Capacity Utilization	71.8%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	1056	370	170	465	0	0	0	0	570	20	437
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	4.0
Lane Util. Factor		0.95			0.95						1.00	1.00
Frpb, ped/bikes		0.99			1.00						1.00	1.00
Flpb, ped/bikes		1.00			1.00						1.00	1.00
Frt		0.96			1.00						1.00	0.85
Flt Protected		1.00			0.99						0.95	1.00
Satd. Flow (prot)		3401			3527						1795	1599
Flt Permitted		1.00			0.51						0.95	1.00
Satd. Flow (perm)		3401			1819						1795	1599
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	0	1100	385	177	484	0	0	0	0	594	21	455
RTOR Reduction (vph)	0	29	0	0	0	0	0	0	0	0	0	111
Lane Group Flow (vph)	0	1456	0	0	661	0	0	0	0	0	615	344
Confl. Peds. (#/hr)	3		8	8		3						
Confl. Bikes (#/hr)						3						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Perm						Split		Perm
Protected Phases		4			8					6	6	
Permitted Phases				8								6
Actuated Green, G (s)		63.0			63.0						49.0	49.0
Effective Green, g (s)		63.0			63.0						49.0	49.0
Actuated g/C Ratio		0.52			0.52						0.41	0.41
Clearance Time (s)		4.0			4.0						4.0	4.0
Vehicle Extension (s)		3.0			3.0						3.0	3.0
Lane Grp Cap (vph)		1786			955						733	653
v/s Ratio Prot		c0.43									c0.34	
v/s Ratio Perm					0.36							0.21
v/c Ratio		0.82			2.77dl						0.84	0.53
Uniform Delay, d1		23.7			21.3						32.0	26.8
Progression Factor		1.00			0.96						1.00	1.00
Incremental Delay, d2		4.2			3.8						11.1	3.0
Delay (s)		27.9			24.1						43.0	29.8
Level of Service		C			C						D	C
Approach Delay (s)		27.9			24.1			0.0			37.4	
Approach LOS		C			C			A			D	

Intersection Summary			
HCM Average Control Delay	30.3	HCM Level of Service	C
HCM Volume to Capacity ratio	0.83		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	104.7%	ICU Level of Service	G
Analysis Period (min)	15		

dl Defacto Left Lane. Recode with 1 though lane as a left lane.
c Critical Lane Group

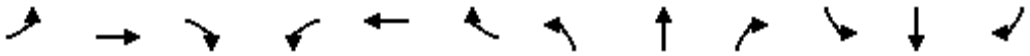
Near-Term (2018) Plus Additional Employment Alternative Conditions

FEHR PEERS

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	80	283	86	290	360	131	51	272	150	76	672	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frpb, ped/bikes	1.00	1.00	0.98	1.00	1.00	0.98	1.00	1.00	0.98	1.00	1.00	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1736	3471	1518	1736	3471	1516	1736	3471	1530	1736	3432	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1736	3471	1518	1736	3471	1516	1736	3471	1530	1736	3432	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	87	308	93	315	391	142	55	296	163	83	730	54
RTOR Reduction (vph)	0	0	62	0	0	92	0	0	119	0	7	0
Lane Group Flow (vph)	87	308	31	315	391	50	55	296	44	83	777	0
Confl. Peds. (#/hr)	14		13	13		14	4		4	4		4
Confl. Bikes (#/hr)						1						1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases			2			6			8			
Actuated Green, G (s)	6.0	15.4	15.4	14.5	21.9	21.9	2.1	17.2	17.2	4.2	19.3	
Effective Green, g (s)	6.0	15.4	15.4	14.5	21.9	21.9	2.1	17.2	17.2	4.2	19.3	
Actuated g/C Ratio	0.09	0.24	0.24	0.23	0.34	0.34	0.03	0.27	0.27	0.07	0.30	
Clearance Time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Vehicle Extension (s)	2.0	4.0	4.0	2.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	
Lane Grp Cap (vph)	162	831	364	391	1182	516	57	928	409	113	1030	
v/s Ratio Prot	0.05	0.09		c0.18	c0.11		c0.03	0.09		0.05	c0.23	
v/s Ratio Perm			0.02			0.03			0.03			
v/c Ratio	0.54	0.37	0.09	0.81	0.33	0.10	0.96	0.32	0.11	0.73	0.75	
Uniform Delay, d1	27.8	20.4	19.0	23.6	15.8	14.5	31.1	18.9	17.8	29.5	20.4	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	1.7	0.4	0.1	10.9	0.2	0.1	105.2	0.1	0.0	19.0	2.8	
Delay (s)	29.5	20.8	19.1	34.4	16.0	14.6	136.2	18.9	17.8	48.5	23.2	
Level of Service	C	C	B	C	B	B	F	B	B	D	C	
Approach Delay (s)		22.0			22.6			31.1			25.6	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	25.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	64.3	Sum of lost time (s)	6.0
Intersection Capacity Utilization	65.4%	ICU Level of Service	C
Analysis Period (min)	15		

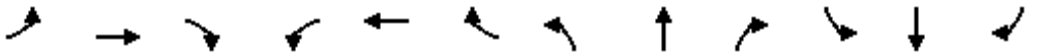
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	330	10	191	0	271	140	0	809	250
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0	4.0		4.0	4.0		4.0	
Lane Util. Factor				0.95	0.91	0.95		0.91	1.00		0.91	
Frpb, ped/bikes				1.00	1.00	0.99		1.00	0.98		0.99	
Flpb, ped/bikes				1.00	1.00	1.00		1.00	1.00		1.00	
Frt				1.00	0.98	0.85		1.00	0.85		0.96	
Flt Protected				0.95	0.96	1.00		1.00	1.00		1.00	
Satd. Flow (prot)				1665	1576	1471		5036	1535		4831	
Flt Permitted				0.95	0.96	1.00		1.00	1.00		1.00	
Satd. Flow (perm)				1665	1576	1471		5036	1535		4831	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	351	11	203	0	288	149	0	861	266
RTOR Reduction (vph)	0	0	0	0	13	117	0	0	0	0	75	0
Lane Group Flow (vph)	0	0	0	197	180	58	0	288	149	0	1052	0
Confl. Peds. (#/hr)	1					1	2		1	1		2
Confl. Bikes (#/hr)									2			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type				Split		Perm			Free			
Protected Phases				8	8			2			6	
Permitted Phases						8			Free			
Actuated Green, G (s)				12.9	12.9	12.9		17.9	38.8		17.9	
Effective Green, g (s)				12.9	12.9	12.9		17.9	38.8		17.9	
Actuated g/C Ratio				0.33	0.33	0.33		0.46	1.00		0.46	
Clearance Time (s)				4.0	4.0	4.0		4.0			4.0	
Vehicle Extension (s)				3.0	3.0	3.0		3.0			3.0	
Lane Grp Cap (vph)				554	524	489		2323	1535		2229	
v/s Ratio Prot				c0.12	0.11			0.06			c0.22	
v/s Ratio Perm						0.04			0.10			
v/c Ratio				0.36	0.34	0.12		0.12	0.10		0.47	
Uniform Delay, d1				9.8	9.8	9.0		6.0	0.0		7.2	
Progression Factor				1.00	1.00	1.00		1.00	1.00		1.00	
Incremental Delay, d2				0.4	0.4	0.1		0.0	0.1		0.2	
Delay (s)				10.2	10.2	9.1		6.0	0.1		7.4	
Level of Service				B	B	A		A	A		A	
Approach Delay (s)		0.0			9.8			4.0			7.4	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	7.3	HCM Level of Service	A
HCM Volume to Capacity ratio	0.42		
Actuated Cycle Length (s)	38.8	Sum of lost time (s)	8.0
Intersection Capacity Utilization	39.7%	ICU Level of Service	A
Analysis Period (min)	15		

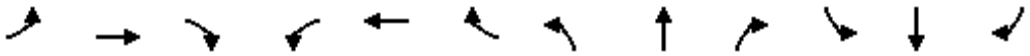
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	80	0	130	0	0	0	0	331	330	0	559	579
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0					4.0			4.0	4.0
Lane Util. Factor	1.00		1.00					0.91			0.95	1.00
Frpb, ped/bikes	1.00		1.00					0.99			1.00	0.98
Flpb, ped/bikes	1.00		1.00					1.00			1.00	1.00
Frt	1.00		0.85					0.93			1.00	0.85
Flt Protected	0.95		1.00					1.00			1.00	1.00
Satd. Flow (prot)	1752		1568					4603			3505	1536
Flt Permitted	0.95		1.00					1.00			1.00	1.00
Satd. Flow (perm)	1752		1568					4603			3505	1536
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	87	0	141	0	0	0	0	360	359	0	608	629
RTOR Reduction (vph)	0	0	88	0	0	0	0	197	0	0	0	0
Lane Group Flow (vph)	87	0	53	0	0	0	0	522	0	0	608	629
Confl. Peds. (#/hr)							1		3	3		1
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Split		Perm									Free
Protected Phases	8	8						2			6	
Permitted Phases			8									Free
Actuated Green, G (s)	7.7		7.7					12.9			12.9	28.6
Effective Green, g (s)	7.7		7.7					12.9			12.9	28.6
Actuated g/C Ratio	0.27		0.27					0.45			0.45	1.00
Clearance Time (s)	4.0		4.0					4.0			4.0	
Vehicle Extension (s)	3.0		3.0					3.0			3.0	
Lane Grp Cap (vph)	472		422					2076			1581	1536
v/s Ratio Prot	0.05							0.11			0.17	
v/s Ratio Perm			0.03									c0.41
v/c Ratio	0.18		0.12					0.25			0.38	0.41
Uniform Delay, d1	8.0		7.9					4.9			5.2	0.0
Progression Factor	1.00		1.00					1.00			1.00	1.00
Incremental Delay, d2	0.2		0.1					0.1			0.2	0.8
Delay (s)	8.2		8.0					4.9			5.4	0.8
Level of Service	A		A					A			A	A
Approach Delay (s)		8.1			0.0			4.9			3.1	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	4.2	HCM Level of Service	A
HCM Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	28.6	Sum of lost time (s)	0.0
Intersection Capacity Utilization	30.2%	ICU Level of Service	A
Analysis Period (min)	15		

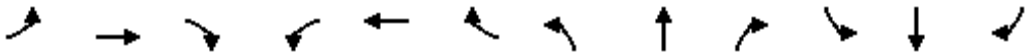
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	50	20	30	10	10	30	30	581	20	290	289	110
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Lane Util. Factor		1.00		1.00	1.00			0.95		1.00	0.95	
Frpb, ped/bikes		1.00		1.00	0.99			1.00		1.00	0.99	
Flpb, ped/bikes		1.00		1.00	1.00			1.00		1.00	1.00	
Frt		0.96		1.00	0.89			1.00		1.00	0.96	
Flt Protected		0.98		0.95	1.00			1.00		0.95	1.00	
Satd. Flow (prot)		1709		1736	1605			3446		1736	3306	
Flt Permitted		1.00		0.69	1.00			0.92		0.95	1.00	
Satd. Flow (perm)		1751		1255	1605			3179		1736	3306	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	54	22	33	11	11	33	33	632	22	315	314	120
RTOR Reduction (vph)	0	16	0	0	28	0	0	2	0	0	25	0
Lane Group Flow (vph)	0	93	0	11	16	0	0	685	0	315	409	0
Confl. Peds. (#/hr)	3					3	2					2
Confl. Bikes (#/hr)												1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm			Perm			Perm			Prot		
Protected Phases		3			4			2		1	6	
Permitted Phases	3			4			2					
Actuated Green, G (s)		2.2		8.4	8.4			21.7		11.9	37.6	
Effective Green, g (s)		2.2		8.4	8.4			21.7		11.9	37.6	
Actuated g/C Ratio		0.04		0.14	0.14			0.36		0.20	0.62	
Clearance Time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		64		175	224			1146		343	2065	
v/s Ratio Prot					c0.01					c0.18	0.12	
v/s Ratio Perm		c0.05		0.01				c0.22				
v/c Ratio		1.45		0.06	0.07			0.60		0.92	0.20	
Uniform Delay, d1		29.0		22.5	22.5			15.7		23.7	4.8	
Progression Factor		1.00		1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		269.3		0.2	0.1			0.8		28.5	0.0	
Delay (s)		298.3		22.6	22.6			16.5		52.1	4.9	
Level of Service		F		C	C			B		D	A	
Approach Delay (s)		298.3			22.6			16.5			24.8	
Approach LOS		F			C			B			C	

Intersection Summary			
HCM Average Control Delay	39.8	HCM Level of Service	D
HCM Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	60.2	Sum of lost time (s)	16.0
Intersection Capacity Utilization	56.3%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group



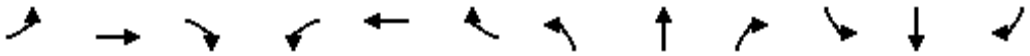
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	220	46	20	21	11	41	10	370	116	49	100	160
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00	1.00	1.00	0.96		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	0.88		1.00	0.96		1.00	0.91	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	2994		1767	3402		1770	3183	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	2994		1767	3402		1770	3183	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	239	50	22	23	12	45	11	402	126	53	109	174
RTOR Reduction (vph)	0	0	14	0	40	0	0	37	0	0	117	0
Lane Group Flow (vph)	239	50	8	23	17	0	11	491	0	53	166	0
Confl. Peds. (#/hr)	3					3	4					4
Confl. Bikes (#/hr)						20			1			1
Turn Type	Prot		Perm	Prot			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4									
Actuated Green, G (s)	13.2	19.0	19.0	0.6	6.4		0.5	15.0		2.9	17.4	
Effective Green, g (s)	13.2	19.0	19.0	0.6	6.4		0.5	15.0		2.9	17.4	
Actuated g/C Ratio	0.25	0.36	0.36	0.01	0.12		0.01	0.28		0.05	0.33	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	437	1257	562	20	358		17	954		96	1035	
v/s Ratio Prot	c0.14	c0.01		0.01	0.01		0.01	c0.14		c0.03	0.05	
v/s Ratio Perm			0.00									
v/c Ratio	0.55	0.04	0.01	1.15	0.05		0.65	0.51		0.55	0.16	
Uniform Delay, d1	17.5	11.3	11.2	26.4	20.9		26.4	16.2		24.7	12.8	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	1.4	0.0	0.0	252.2	0.1		62.0	0.5		6.7	0.1	
Delay (s)	18.9	11.3	11.2	278.6	20.9		88.4	16.7		31.4	12.9	
Level of Service	B	B	B	F	C		F	B		C	B	
Approach Delay (s)		17.2			95.0			18.1			15.8	
Approach LOS		B			F			B			B	

Intersection Summary			
HCM Average Control Delay	22.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.40		
Actuated Cycle Length (s)	53.5	Sum of lost time (s)	12.0
Intersection Capacity Utilization	46.1%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	237	120	63	116	60	70
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	258	130	68	126	65	76
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				1133		
pX, platoon unblocked						
vC, conflicting volume			388		521	258
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			388		521	258
tC, single (s)			4.2		6.5	6.3
tC, 2 stage (s)						
tF (s)			2.3		3.6	3.4
p0 queue free %			94		86	90
cM capacity (veh/h)			1128		472	762

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2
Volume Total	258	130	68	126	65	76
Volume Left	0	0	68	0	65	0
Volume Right	0	130	0	0	0	76
cSH	1700	1700	1128	1700	472	762
Volume to Capacity	0.15	0.08	0.06	0.07	0.14	0.10
Queue Length 95th (ft)	0	0	5	0	12	8
Control Delay (s)	0.0	0.0	8.4	0.0	13.9	10.2
Lane LOS			A		B	B
Approach Delay (s)	0.0		3.0		11.9	
Approach LOS					B	

Intersection Summary			
Average Delay	3.1		
Intersection Capacity Utilization	29.3%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	60	120	20	20	50	89	10	20	20	117	30	160
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	0.99			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.98		1.00	0.90		1.00	0.93			0.93	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.98	
Satd. Flow (prot)	1556	1602		1556	1480		1556	1497			1493	
Flt Permitted	0.95	1.00		0.95	1.00		0.60	1.00			0.87	
Satd. Flow (perm)	1556	1602		1556	1480		976	1497			1320	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	65	130	22	22	54	97	11	22	22	127	33	174
RTOR Reduction (vph)	0	11	0	0	77	0	0	14	0	0	55	0
Lane Group Flow (vph)	65	141	0	22	74	0	11	30	0	0	279	0
Confl. Peds. (#/hr)									2	2		
Confl. Bikes (#/hr)									2			
Heavy Vehicles (%)	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	2.0	8.3		1.0	7.3		13.4	13.4			13.4	
Effective Green, g (s)	2.0	8.3		1.0	7.3		13.4	13.4			13.4	
Actuated g/C Ratio	0.06	0.24		0.03	0.21		0.39	0.39			0.39	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	90	383		45	311		377	578			510	
v/s Ratio Prot	c0.04	c0.09		0.01	0.05			0.02				
v/s Ratio Perm							0.01				c0.21	
v/c Ratio	0.72	0.37		0.49	0.24		0.03	0.05			0.55	
Uniform Delay, d1	16.1	11.0		16.6	11.4		6.6	6.7			8.3	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	24.7	0.6		8.1	0.4		0.0	0.0			1.2	
Delay (s)	40.7	11.6		24.7	11.8		6.6	6.7			9.5	
Level of Service	D	B		C	B		A	A			A	
Approach Delay (s)		20.3			13.4			6.7			9.5	
Approach LOS		C			B			A			A	

Intersection Summary			
HCM Average Control Delay	13.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.44		
Actuated Cycle Length (s)	34.7	Sum of lost time (s)	8.0
Intersection Capacity Utilization	46.0%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	167	100	33	59	100	172
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	182	109	36	64	109	187
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)	322					
pX, platoon unblocked						
vC, conflicting volume			182		372	236
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			182		372	236
tC, single (s)			4.3		6.6	6.4
tC, 2 stage (s)						
tF (s)			2.3		3.6	3.4
p0 queue free %			97		81	76
cM capacity (veh/h)			1314		586	770

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	290	36	64	296
Volume Left	0	36	0	109
Volume Right	109	0	0	187
cSH	1700	1314	1700	690
Volume to Capacity	0.17	0.03	0.04	0.43
Queue Length 95th (ft)	0	2	0	54
Control Delay (s)	0.0	7.8	0.0	14.1
Lane LOS		A		B
Approach Delay (s)	0.0	2.8		14.1
Approach LOS				B

Intersection Summary			
Average Delay	6.5		
Intersection Capacity Utilization	44.3%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	180	159	210	60	32	37
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	196	173	228	65	35	40
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			368		804	282
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			368		804	282
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			81		88	95
cM capacity (veh/h)			1174		280	750

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	368	228	65	75
Volume Left	0	228	0	35
Volume Right	173	0	0	40
cSH	1700	1174	1700	422
Volume to Capacity	0.22	0.19	0.04	0.18
Queue Length 95th (ft)	0	18	0	16
Control Delay (s)	0.0	8.8	0.0	15.4
Lane LOS		A		C
Approach Delay (s)	0.0	6.8		15.4
Approach LOS				C

Intersection Summary			
Average Delay	4.3		
Intersection Capacity Utilization	44.9%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay, s/veh	34.6
Intersection LOS	D

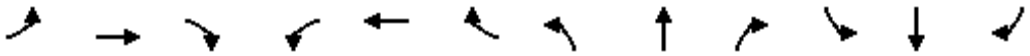
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	10	10	10	420	10	20	30	280	160	127	140	10
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles, %	4	4	4	4	4	4	4	4	4	4	4	4
Mvmt Flow	11	11	11	457	11	22	33	304	174	138	152	11
Number of Lanes	0	1	0	1	1	0	1	2	0	1	2	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	2	1	3	3
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	3	3	1	2
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	3	3	2	1
HCM Control Delay	12.5	66.7	17.4	14.1
HCM LOS	B	F	C	B

Lane	NBLn1	NBLn2	NBLn3	EBLn1	WBLn1	WBLn2	SBLn1	SBLn2	SBLn3
Vol Left, %	100%	0%	0%	33%	100%	0%	100%	0%	0%
Vol Thru, %	0%	100%	37%	33%	0%	33%	0%	100%	82%
Vol Right, %	0%	0%	63%	33%	0%	67%	0%	0%	18%
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Traffic Vol by Lane	30	187	253	30	420	30	127	93	57
LT Vol	0	187	93	10	0	10	0	93	47
Through Vol	0	0	160	10	0	20	0	0	10
RT Vol	30	0	0	10	420	0	127	0	0
Lane Flow Rate	33	203	275	33	457	33	138	101	62
Geometry Grp	8	8	8	8	8	8	8	8	8
Degree of Util (X)	0.075	0.438	0.56	0.082	1	0.064	0.333	0.231	0.138
Departure Headway (Hd)	8.263	7.765	7.325	9.057	7.996	7.024	8.694	8.196	8.073
Convergence, Y/N	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cap	437	469	496	401	457	512	417	442	448
Service Time	5.944	5.446	5.006	6.684	5.708	4.736	6.373	5.875	5.752
HCM Lane V/C Ratio	0.076	0.433	0.554	0.082	1	0.064	0.331	0.229	0.138
HCM Control Delay	11.6	16.3	18.9	12.5	70.7	10.2	15.6	13.3	12
HCM Lane LOS	B	C	C	B	F	B	C	B	B
HCM 95th-tile Q	0.2	2.2	3.4	0.3	13	0.2	1.4	0.9	0.5

Notes

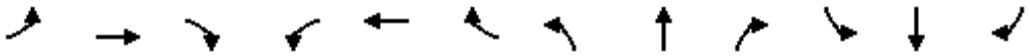
~ : Volume Exceeds Capacity; $: Delay Exceeds 300 Seconds; Error : Computation Not Defined



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	178	10	70	20	550	0	0	282	420
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor				1.00	1.00		1.00	0.95			0.95	
Frpb, ped/bikes				1.00	1.00		1.00	1.00			0.99	
Flpb, ped/bikes				1.00	1.00		1.00	1.00			1.00	
Frt				1.00	0.87		1.00	1.00			0.91	
Flt Protected				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)				1736	1588		1736	3471			3118	
Flt Permitted				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (perm)				1736	1588		1736	3471			3118	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	193	11	76	22	598	0	0	307	457
RTOR Reduction (vph)	0	0	0	0	60	0	0	0	0	0	278	0
Lane Group Flow (vph)	0	0	0	193	27	0	22	598	0	0	486	0
Confl. Peds. (#/hr)							1					1
Confl. Bikes (#/hr)									2			1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type				Split			Prot					
Protected Phases				8	8		5	2			6	
Permitted Phases												
Actuated Green, G (s)				7.5	7.5		2.0	19.8			13.8	
Effective Green, g (s)				7.5	7.5		2.0	19.8			13.8	
Actuated g/C Ratio				0.21	0.21		0.06	0.56			0.39	
Clearance Time (s)				4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)				3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)				369	337		98	1947			1219	
v/s Ratio Prot				c0.11	0.02		0.01	c0.17			c0.16	
v/s Ratio Perm												
v/c Ratio				0.52	0.08		0.22	0.31			0.40	
Uniform Delay, d1				12.3	11.1		15.9	4.1			7.8	
Progression Factor				1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2				1.3	0.1		1.2	0.1			0.2	
Delay (s)				13.7	11.2		17.1	4.2			8.0	
Level of Service				B	B		B	A			A	
Approach Delay (s)		0.0			12.9			4.7			8.0	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	7.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.45		
Actuated Cycle Length (s)	35.3	Sum of lost time (s)	12.0
Intersection Capacity Utilization	37.9%	ICU Level of Service	A
Analysis Period (min)	15		

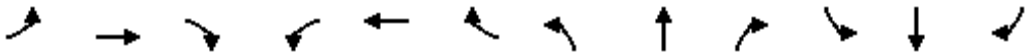
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	390	160	412	100	30	60	70	500	50	140	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		0.95	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	0.99		1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Frt	1.00	0.96		1.00	0.99		1.00	1.00	0.85		0.99	
Flt Protected	0.95	1.00		0.95	0.97		0.95	1.00	1.00		0.99	
Satd. Flow (prot)	1752	3339		1595	3207		1665	1745	1547		1797	
Flt Permitted	0.95	1.00		0.95	0.97		0.95	1.00	1.00		0.99	
Satd. Flow (perm)	1752	3339		1595	3207		1665	1745	1547		1797	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	424	174	448	109	33	65	76	543	54	152	22
RTOR Reduction (vph)	0	45	0	0	7	0	0	0	453	0	4	0
Lane Group Flow (vph)	11	553	0	224	359	0	58	83	90	0	224	0
Confl. Peds. (#/hr)	1					1			2	2		
Confl. Bikes (#/hr)			1			1						1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Split			Split			Split		Perm	Split		
Protected Phases	4	4		8	8		2	2		6	6	
Permitted Phases									2			
Actuated Green, G (s)	16.9	16.9		15.5	15.5		12.4	12.4	12.4		13.8	
Effective Green, g (s)	16.9	16.9		15.5	15.5		12.4	12.4	12.4		13.8	
Actuated g/C Ratio	0.23	0.23		0.21	0.21		0.17	0.17	0.17		0.18	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	397	756		331	666		277	290	257		332	
v/s Ratio Prot	0.01	c0.17		c0.14	0.11		0.03	0.05			c0.12	
v/s Ratio Perm									c0.06			
v/c Ratio	0.03	0.73		0.68	0.54		0.21	0.29	0.35		0.67	
Uniform Delay, d1	22.5	26.7		27.2	26.4		26.9	27.2	27.5		28.3	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Incremental Delay, d2	0.0	3.7		5.4	0.8		0.4	0.5	0.8		5.3	
Delay (s)	22.5	30.4		32.6	27.2		27.2	27.8	28.4		33.6	
Level of Service	C	C		C	C		C	C	C		C	
Approach Delay (s)		30.3			29.3			28.2			33.6	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	29.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	74.6	Sum of lost time (s)	16.0
Intersection Capacity Utilization	68.4%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

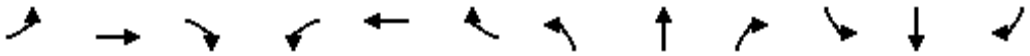


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	850	160	100	336	0	0	0	0	420	30	276
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		0.95			0.95						1.00	
Frpb, ped/bikes		1.00			1.00						1.00	
Flpb, ped/bikes		1.00			1.00						1.00	
Frt		0.98			1.00						0.95	
Flt Protected		1.00			0.99						0.97	
Satd. Flow (prot)		3438			3498						1718	
Flt Permitted		1.00			0.56						0.97	
Satd. Flow (perm)		3438			1974						1718	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	924	174	109	365	0	0	0	0	457	33	300
RTOR Reduction (vph)	0	27	0	0	0	0	0	0	0	0	35	0
Lane Group Flow (vph)	0	1071	0	0	474	0	0	0	0	0	755	0
Confl. Peds. (#/hr)	5		9	9		5						
Confl. Bikes (#/hr)						2						
Turn Type				Perm						Split		
Protected Phases		4			8					6	6	
Permitted Phases				8								
Actuated Green, G (s)		23.7			23.7						28.3	
Effective Green, g (s)		23.7			23.7						28.3	
Actuated g/C Ratio		0.39			0.39						0.47	
Clearance Time (s)		4.0			4.0						4.0	
Vehicle Extension (s)		3.0			3.0						3.0	
Lane Grp Cap (vph)		1358			780						810	
v/s Ratio Prot		c0.31									c0.44	
v/s Ratio Perm					0.24							
v/c Ratio		0.79			0.88dl						0.93	
Uniform Delay, d1		16.0			14.4						14.9	
Progression Factor		1.00			1.00						1.00	
Incremental Delay, d2		3.1			1.3						18.8	
Delay (s)		19.1			15.8						33.7	
Level of Service		B			B						C	
Approach Delay (s)		19.1			15.8			0.0			33.7	
Approach LOS		B			B			A			C	

Intersection Summary			
HCM Average Control Delay	23.3	HCM Level of Service	C
HCM Volume to Capacity ratio	0.87		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	94.0%	ICU Level of Service	F
Analysis Period (min)	15		

dl Defacto Left Lane. Recode with 1 though lane as a left lane.

c Critical Lane Group

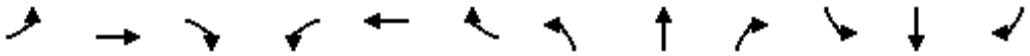


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	239	1031	0	0	396	410	40	10	80	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor		0.95			0.95		0.95	0.95	1.00			
Frpb, ped/bikes		1.00			0.99		1.00	1.00	1.00			
Flpb, ped/bikes		1.00			1.00		1.00	1.00	1.00			
Frt		1.00			0.92		1.00	1.00	0.85			
Flt Protected		0.99			1.00		0.95	0.97	1.00			
Satd. Flow (prot)		3505			3227		1681	1719	1583			
Flt Permitted		0.62			1.00		0.95	0.97	1.00			
Satd. Flow (perm)		2189			3227		1681	1719	1583			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	260	1121	0	0	430	446	43	11	87	0	0	0
RTOR Reduction (vph)	0	0	0	0	135	0	0	0	69	0	0	0
Lane Group Flow (vph)	0	1381	0	0	741	0	27	27	18	0	0	0
Confl. Peds. (#/hr)	5		7	7		5			1	1		
Confl. Bikes (#/hr)						3						
Turn Type	Perm						Split		Prot			
Protected Phases		4			8		2	2	2			
Permitted Phases	4											
Actuated Green, G (s)		55.8			55.8		16.2	16.2	16.2			
Effective Green, g (s)		55.8			55.8		16.2	16.2	16.2			
Actuated g/C Ratio		0.70			0.70		0.20	0.20	0.20			
Clearance Time (s)		4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)		3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)		1527			2251		340	348	321			
v/s Ratio Prot					0.23		c0.02	0.02	0.01			
v/s Ratio Perm		c0.63										
v/c Ratio		0.90			0.33		0.08	0.08	0.05			
Uniform Delay, d1		9.9			4.8		25.9	25.8	25.7			
Progression Factor		1.00			1.00		1.00	1.00	1.00			
Incremental Delay, d2		7.9			0.1		0.5	0.4	0.3			
Delay (s)		17.8			4.8		26.3	26.3	26.1			
Level of Service		B			A		C	C	C			
Approach Delay (s)		17.8			4.8			26.1			0.0	
Approach LOS		B			A			C			A	

Intersection Summary			
HCM Average Control Delay	13.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	80.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	86.1%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	100	410	61	180	363	146	106	812	210	101	322	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frpb, ped/bikes	1.00	1.00	0.97	1.00	1.00	0.98	1.00	1.00	0.91	1.00	1.00	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.98	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1770	3539	1539	1770	3539	1557	1770	3539	1438	1770	3461	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1770	3539	1539	1770	3539	1557	1770	3539	1438	1770	3461	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	109	446	66	196	395	159	115	883	228	110	350	54
RTOR Reduction (vph)	0	0	30	0	0	108	0	0	111	0	16	0
Lane Group Flow (vph)	109	446	36	196	395	51	115	883	117	110	388	0
Confl. Peds. (#/hr)	5		19	19		5	4		14	14		4
Confl. Bikes (#/hr)						1			100			
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases			2			6			8			
Actuated Green, G (s)	5.4	17.4	17.4	9.9	19.9	19.9	6.1	21.6	21.6	6.1	21.6	
Effective Green, g (s)	5.4	17.4	17.4	9.9	19.9	19.9	6.1	21.6	21.6	6.1	21.6	
Actuated g/C Ratio	0.08	0.26	0.26	0.15	0.29	0.29	0.09	0.32	0.32	0.09	0.32	
Clearance Time (s)	5.0	4.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	
Vehicle Extension (s)	2.0	4.0	4.0	2.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	
Lane Grp Cap (vph)	141	906	394	258	1036	456	159	1124	457	159	1099	
v/s Ratio Prot	0.06	c0.13		c0.11	0.11		c0.06	c0.25		0.06	0.11	
v/s Ratio Perm			0.02			0.03			0.08			
v/c Ratio	0.77	0.49	0.09	0.76	0.38	0.11	0.72	0.79	0.26	0.69	0.35	
Uniform Delay, d1	30.7	21.5	19.3	27.9	19.1	17.6	30.1	21.1	17.2	30.0	17.8	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	20.9	0.6	0.1	10.8	0.3	0.1	12.9	3.4	0.1	10.0	0.1	
Delay (s)	51.6	22.1	19.4	38.7	19.5	17.7	43.0	24.5	17.3	40.0	17.9	
Level of Service	D	C	B	D	B	B	D	C	B	D	B	
Approach Delay (s)		27.0			24.1			24.9			22.6	
Approach LOS		C			C			C			C	

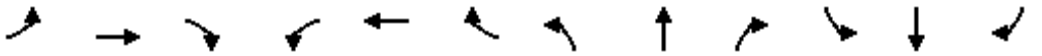
Intersection Summary			
HCM Average Control Delay	24.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	68.0	Sum of lost time (s)	13.0
Intersection Capacity Utilization	66.7%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	300	10	679	0	499	140	0	433	140
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0	4.0		4.0	4.0		4.0	
Lane Util. Factor				0.95	0.91	0.95		0.91	1.00		0.91	
Frt				1.00	0.87	0.85		1.00	0.85		0.96	
Flt Protected				0.95	1.00	1.00		1.00	1.00		1.00	
Satd. Flow (prot)				1698	1478	1519		5136	1599		4947	
Flt Permitted				0.95	1.00	1.00		1.00	1.00		1.00	
Satd. Flow (perm)				1698	1478	1519		5136	1599		4947	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	319	11	722	0	531	149	0	461	149
RTOR Reduction (vph)	0	0	0	0	95	95	0	0	0	0	102	0
Lane Group Flow (vph)	0	0	0	287	287	288	0	531	149	0	508	0
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Split		Perm			Free			
Protected Phases				8	8			2			6	
Permitted Phases						8			Free			
Actuated Green, G (s)				16.2	16.2	16.2		10.5	34.7		10.5	
Effective Green, g (s)				16.2	16.2	16.2		10.5	34.7		10.5	
Actuated g/C Ratio				0.47	0.47	0.47		0.30	1.00		0.30	
Clearance Time (s)				4.0	4.0	4.0		4.0			4.0	
Vehicle Extension (s)				3.0	3.0	3.0		3.0			3.0	
Lane Grp Cap (vph)				793	690	709		1554	1599		1497	
v/s Ratio Prot				0.17	c0.19			c0.10			0.10	
v/s Ratio Perm						0.19			0.09			
v/c Ratio				0.36	0.42	0.41		0.34	0.09		0.34	
Uniform Delay, d1				5.9	6.1	6.1		9.4	0.0		9.4	
Progression Factor				1.00	1.00	1.00		1.00	1.00		1.00	
Incremental Delay, d2				0.3	0.4	0.4		0.1	0.1		0.1	
Delay (s)				6.2	6.5	6.5		9.5	0.1		9.5	
Level of Service				A	A	A		A	A		A	
Approach Delay (s)		0.0			6.4			7.5			9.5	
Approach LOS		A			A			A			A	

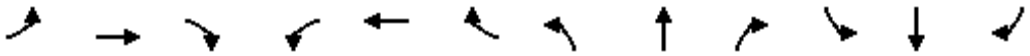
Intersection Summary			
HCM Average Control Delay	7.5	HCM Level of Service	A
HCM Volume to Capacity ratio	0.39		
Actuated Cycle Length (s)	34.7	Sum of lost time (s)	8.0
Intersection Capacity Utilization	44.3%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	260	0	170	0	0	0	0	379	370	0	481	261
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0					4.0			4.0	4.0
Lane Util. Factor	1.00		1.00					0.91			0.95	1.00
Frpb, ped/bikes	1.00		1.00					0.99			1.00	0.98
Flpb, ped/bikes	1.00		1.00					1.00			1.00	1.00
Frt	1.00		0.85					0.93			1.00	0.85
Flt Protected	0.95		1.00					1.00			1.00	1.00
Satd. Flow (prot)	1770		1583					4649			3539	1549
Flt Permitted	0.95		1.00					1.00			1.00	1.00
Satd. Flow (perm)	1770		1583					4649			3539	1549
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	283	0	185	0	0	0	0	412	402	0	523	284
RTOR Reduction (vph)	0	0	100	0	0	0	0	254	0	0	0	0
Lane Group Flow (vph)	283	0	85	0	0	0	0	560	0	0	523	284
Confl. Peds. (#/hr)							4		2	2		4
Confl. Bikes (#/hr)									3			
Turn Type	Split		Perm									Free
Protected Phases	8	8						2			6	
Permitted Phases			8									Free
Actuated Green, G (s)	12.4		12.4					11.9			11.9	32.3
Effective Green, g (s)	12.4		12.4					11.9			11.9	32.3
Actuated g/C Ratio	0.38		0.38					0.37			0.37	1.00
Clearance Time (s)	4.0		4.0					4.0			4.0	
Vehicle Extension (s)	3.0		3.0					3.0			3.0	
Lane Grp Cap (vph)	680		608					1713			1304	1549
v/s Ratio Prot	c0.16							0.12			c0.15	
v/s Ratio Perm			0.05									0.18
v/c Ratio	0.42		0.14					0.33			0.40	0.18
Uniform Delay, d1	7.3		6.5					7.3			7.6	0.0
Progression Factor	1.00		1.00					1.00			1.00	1.00
Incremental Delay, d2	0.4		0.1					0.1			0.2	0.3
Delay (s)	7.7		6.6					7.4			7.8	0.3
Level of Service	A		A					A			A	A
Approach Delay (s)		7.3			0.0			7.4			5.1	
Approach LOS		A			A			A			A	

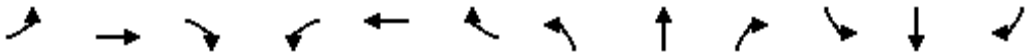
Intersection Summary			
HCM Average Control Delay	6.5	HCM Level of Service	A
HCM Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	32.3	Sum of lost time (s)	8.0
Intersection Capacity Utilization	36.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	170	10	70	20	20	230	30	349	10	20	531	110
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Lane Util. Factor		1.00		1.00	1.00			0.95		1.00	0.95	
Frpb, ped/bikes		0.99		1.00	0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00		1.00	1.00			1.00		0.94	1.00	
Frt		0.96		1.00	0.86			1.00		1.00	0.97	
Flt Protected		0.97		0.95	1.00			1.00		0.95	1.00	
Satd. Flow (prot)		1703		1751	1571			3475		1646	3402	
Flt Permitted		1.00		0.59	1.00			0.88		0.95	1.00	
Satd. Flow (perm)		1761		1091	1571			3062		1646	3402	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	185	11	76	22	22	250	33	379	11	22	577	120
RTOR Reduction (vph)	0	14	0	0	188	0	0	1	0	0	16	0
Lane Group Flow (vph)	0	258	0	22	84	0	0	422	0	22	681	0
Confl. Peds. (#/hr)	1		3	3		1			5	5		
Confl. Bikes (#/hr)						1			2			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Perm			Prot		
Protected Phases		3			4			2		1	6	
Permitted Phases	3			4			2					
Actuated Green, G (s)		2.4		11.4	11.4			15.4		0.8	20.2	
Effective Green, g (s)		2.4		11.4	11.4			15.4		0.8	20.2	
Actuated g/C Ratio		0.05		0.25	0.25			0.33		0.02	0.44	
Clearance Time (s)		4.0		4.0	4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		92		270	389			1025		29	1494	
v/s Ratio Prot					c0.05					0.01	c0.20	
v/s Ratio Perm		c0.15		0.02				0.14				
v/c Ratio		2.80		0.08	0.22			0.41		0.76	0.46	
Uniform Delay, d1		21.8		13.3	13.7			11.8		22.5	9.0	
Progression Factor		1.00		1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		840.3		0.1	0.3			0.3		71.7	0.2	
Delay (s)		862.1		13.4	14.0			12.1		94.2	9.3	
Level of Service		F		B	B			B		F	A	
Approach Delay (s)		862.1			14.0			12.1			11.9	
Approach LOS		F			B			B			B	

Intersection Summary			
HCM Average Control Delay	147.7	HCM Level of Service	F
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	46.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	73.2%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group



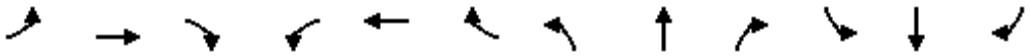
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	170	21	30	46	46	39	30	160	51	21	350	210
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes	1.00	1.00	1.00	1.00	0.99		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	0.93		1.00	0.96		1.00	0.94	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	3273		1770	3399		1770	3314	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	3273		1770	3399		1770	3314	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	179	22	32	48	48	41	32	168	54	22	368	221
RTOR Reduction (vph)	0	0	24	0	37	0	0	33	0	0	117	0
Lane Group Flow (vph)	179	22	8	48	52	0	32	189	0	22	472	0
Confl. Peds. (#/hr)							16		1	1		16
Confl. Bikes (#/hr)						1			1			
Turn Type	Prot		Perm	Prot			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4									
Actuated Green, G (s)	9.2	11.7	11.7	1.7	4.2		1.4	14.2		1.0	13.8	
Effective Green, g (s)	9.2	11.7	11.7	1.7	4.2		1.4	14.2		1.0	13.8	
Actuated g/C Ratio	0.21	0.26	0.26	0.04	0.09		0.03	0.32		0.02	0.31	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	365	928	415	67	308		56	1082		40	1025	
v/s Ratio Prot	c0.10	0.01		0.03	c0.02		c0.02	0.06		0.01	c0.14	
v/s Ratio Perm			0.01									
v/c Ratio	0.49	0.02	0.02	0.72	0.17		0.57	0.17		0.55	0.46	
Uniform Delay, d1	15.6	12.2	12.2	21.2	18.6		21.3	11.0		21.6	12.4	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	1.0	0.0	0.0	30.4	0.3		13.3	0.1		15.3	0.3	
Delay (s)	16.7	12.2	12.2	51.6	18.9		34.6	11.0		36.9	12.7	
Level of Service	B	B	B	D	B		C	B		D	B	
Approach Delay (s)		15.6			30.3			14.0			13.6	
Approach LOS		B			C			B			B	

Intersection Summary			
HCM Average Control Delay	15.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.43		
Actuated Cycle Length (s)	44.6	Sum of lost time (s)	16.0
Intersection Capacity Utilization	47.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	85	50	106	205	180	70
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	92	54	115	223	196	76
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				1133		
pX, platoon unblocked						
vC, conflicting volume			147		546	92
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			147		546	92
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			92		57	92
cM capacity (veh/h)			1423		455	959

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2
Volume Total	92	54	115	223	196	76
Volume Left	0	0	115	0	196	0
Volume Right	0	54	0	0	0	76
cSH	1700	1700	1423	1700	455	959
Volume to Capacity	0.05	0.03	0.08	0.13	0.43	0.08
Queue Length 95th (ft)	0	0	7	0	53	6
Control Delay (s)	0.0	0.0	7.8	0.0	18.7	9.1
Lane LOS			A		C	A
Approach Delay (s)	0.0		2.6		16.0	
Approach LOS					C	

Intersection Summary			
Average Delay	6.9		
Intersection Capacity Utilization	29.2%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	110	32	10	10	50	181	20	20	10	85	20	60
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.96		1.00	0.88		1.00	0.95			0.95	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.97	
Satd. Flow (prot)	1626	1650		1626	1510		1626	1626			1587	
Flt Permitted	0.95	1.00		0.95	1.00		0.77	1.00			0.82	
Satd. Flow (perm)	1626	1650		1626	1510		1322	1626			1336	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	120	35	11	11	54	197	22	22	11	92	22	65
RTOR Reduction (vph)	0	7	0	0	150	0	0	8	0	0	36	0
Lane Group Flow (vph)	120	39	0	11	101	0	22	25	0	0	143	0
Heavy Vehicles (%)	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	4.3	11.0		0.9	7.6		7.7	7.7			7.7	
Effective Green, g (s)	4.3	11.0		0.9	7.6		7.7	7.7			7.7	
Actuated g/C Ratio	0.14	0.35		0.03	0.24		0.24	0.24			0.24	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	221	574		46	363		322	396			326	
v/s Ratio Prot	c0.07	c0.02		0.01	c0.07			0.02				
v/s Ratio Perm							0.02				c0.11	
v/c Ratio	0.54	0.07		0.24	0.28		0.07	0.06			0.44	
Uniform Delay, d1	12.7	6.9		15.0	9.8		9.2	9.2			10.1	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	2.7	0.1		2.7	0.4		0.1	0.1			1.0	
Delay (s)	15.4	6.9		17.7	10.2		9.3	9.2			11.1	
Level of Service	B	A		B	B		A	A			B	
Approach Delay (s)		13.1			10.5			9.3			11.1	
Approach LOS		B			B			A			B	

Intersection Summary			
HCM Average Control Delay	11.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.44		
Actuated Cycle Length (s)	31.6	Sum of lost time (s)	16.0
Intersection Capacity Utilization	46.0%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	57	60	71	151	80	63
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	62	65	77	164	87	68
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)	322					
pX, platoon unblocked						
vC, conflicting volume			62		413	95
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			62		413	95
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			95		85	93
cM capacity (veh/h)			1541		566	962

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	127	77	164	155
Volume Left	0	77	0	87
Volume Right	65	0	0	68
cSH	1700	1541	1700	691
Volume to Capacity	0.07	0.05	0.10	0.22
Queue Length 95th (ft)	0	4	0	21
Control Delay (s)	0.0	7.5	0.0	11.7
Lane LOS		A		B
Approach Delay (s)	0.0	2.4		11.7
Approach LOS				B

Intersection Summary			
Average Delay	4.6		
Intersection Capacity Utilization	25.6%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	90	30	35	70	152	201
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	98	33	38	76	165	218
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			130		266	114
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			130		266	114
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			97		77	77
cM capacity (veh/h)			1455		704	938

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	130	38	76	384
Volume Left	0	38	0	165
Volume Right	33	0	0	218
cSH	1700	1455	1700	821
Volume to Capacity	0.08	0.03	0.04	0.47
Queue Length 95th (ft)	0	2	0	63
Control Delay (s)	0.0	7.5	0.0	13.2
Lane LOS		A		B
Approach Delay (s)	0.0	2.5		13.2
Approach LOS				B

Intersection Summary			
Average Delay	8.5		
Intersection Capacity Utilization	36.0%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay, s/veh	26.5
Intersection LOS	D

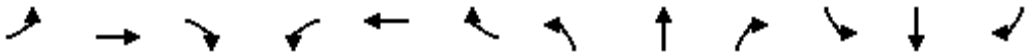
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	10	20	10	430	10	20	10	75	70	163	139	10
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	11	22	11	467	11	22	11	82	76	177	151	11
Number of Lanes	0	1	0	1	1	0	1	2	0	1	2	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	2	1	3	3
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	3	3	1	2
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	3	3	2	1
HCM Control Delay	11.2	41.7	11.6	13.3
HCM LOS	B	E	B	B

Lane	NBLn1	NBLn2	NBLn3	EBLn1	WBLn1	WBLn2	SBLn1	SBLn2	SBLn3
Vol Left, %	100%	0%	0%	25%	100%	0%	100%	0%	0%
Vol Thru, %	0%	100%	26%	50%	0%	33%	0%	100%	82%
Vol Right, %	0%	0%	74%	25%	0%	67%	0%	0%	18%
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop
Traffic Vol by Lane	10	50	95	40	430	30	163	93	56
LT Vol	0	50	25	20	0	10	0	93	46
Through Vol	0	0	70	10	0	20	0	0	10
RT Vol	10	0	0	10	430	0	163	0	0
Lane Flow Rate	11	54	103	43	467	33	177	101	61
Geometry Grp	8	8	8	8	8	8	8	8	8
Degree of Util (X)	0.025	0.116	0.205	0.093	0.894	0.054	0.38	0.202	0.121
Departure Headway (Hd)	8.203	7.687	7.155	7.731	6.985	6.017	7.728	7.215	7.087
Convergence, Y/N	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cap	438	468	504	465	523	599	468	500	508
Service Time	5.917	5.402	4.87	5.456	4.685	3.717	5.439	4.925	4.798
HCM Lane V/C Ratio	0.025	0.115	0.204	0.092	0.893	0.055	0.378	0.202	0.12
HCM Control Delay	11.1	11.4	11.7	11.2	44	9.1	15.1	11.7	10.8
HCM Lane LOS	B	B	B	B	E	A	C	B	B
HCM 95th-tile Q	0.1	0.4	0.8	0.3	10.2	0.2	1.8	0.7	0.4

Notes

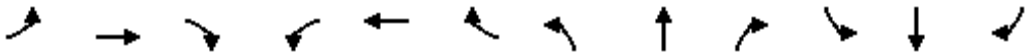
~ : Volume Exceeds Capacity; $: Delay Exceeds 300 Seconds; Error : Computation Not Defined



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	56	10	450	20	559	0	0	99	300
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor				1.00	1.00		1.00	0.95			0.95	
Frpb, ped/bikes				1.00	1.00		1.00	1.00			0.98	
Flpb, ped/bikes				1.00	1.00		1.00	1.00			1.00	
Frt				1.00	0.85		1.00	1.00			0.89	
Flt Protected				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)				1787	1605		1787	3574			3119	
Flt Permitted				0.95	1.00		0.95	1.00			1.00	
Satd. Flow (perm)				1787	1605		1787	3574			3119	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	59	11	474	21	588	0	0	104	316
RTOR Reduction (vph)	0	0	0	0	219	0	0	0	0	0	216	0
Lane Group Flow (vph)	0	0	0	59	266	0	21	588	0	0	204	0
Confl. Peds. (#/hr)							1		2	2		1
Confl. Bikes (#/hr)			1						1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Split			Prot					
Protected Phases				8	8		5	2			6	
Permitted Phases												
Actuated Green, G (s)				11.2	11.2		2.3	18.1			11.8	
Effective Green, g (s)				11.2	11.2		2.3	18.1			11.8	
Actuated g/C Ratio				0.30	0.30		0.06	0.49			0.32	
Clearance Time (s)				4.0	4.0		4.0	4.0			4.0	
Vehicle Extension (s)				3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)				537	482		110	1734			987	
v/s Ratio Prot				0.03	c0.17		0.01	c0.16			0.07	
v/s Ratio Perm												
v/c Ratio				0.11	0.55		0.19	0.34			0.21	
Uniform Delay, d1				9.4	10.9		16.6	5.9			9.3	
Progression Factor				1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2				0.1	1.4		0.8	0.1			0.1	
Delay (s)				9.5	12.3		17.5	6.0			9.4	
Level of Service				A	B		B	A			A	
Approach Delay (s)		0.0			12.0			6.4			9.4	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	9.2	HCM Level of Service	A
HCM Volume to Capacity ratio	0.42		
Actuated Cycle Length (s)	37.3	Sum of lost time (s)	8.0
Intersection Capacity Utilization	51.7%	ICU Level of Service	A
Analysis Period (min)	15		

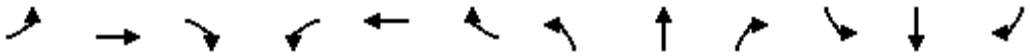
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	40	260	70	289	290	50	310	180	519	20	40	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		0.95	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	0.99		1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Frt	1.00	0.97		1.00	0.98		1.00	1.00	0.85		0.94	
Flt Protected	0.95	1.00		0.95	0.99		0.95	0.99	1.00		0.99	
Satd. Flow (prot)	1787	3461		1626	3330		1698	1763	1576		1749	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	0.99	1.00		0.99	
Satd. Flow (perm)	1787	3461		1626	3330		1698	1763	1576		1749	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	41	268	72	298	299	52	320	186	535	21	41	52
RTOR Reduction (vph)	0	26	0	0	11	0	0	0	390	0	34	0
Lane Group Flow (vph)	41	314	0	215	423	0	250	256	145	0	80	0
Confl. Peds. (#/hr)									2	2		
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Split			Split			Split		Perm	Split		
Protected Phases	4	4		8	8		2	2		6	6	
Permitted Phases									2			
Actuated Green, G (s)	12.3	12.3		16.1	16.1		19.2	19.2	19.2		7.2	
Effective Green, g (s)	12.3	12.3		16.1	16.1		19.2	19.2	19.2		7.2	
Actuated g/C Ratio	0.17	0.17		0.23	0.23		0.27	0.27	0.27		0.10	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	310	601		370	757		460	478	427		178	
v/s Ratio Prot	0.02	c0.09		c0.13	0.13		c0.15	0.15			c0.05	
v/s Ratio Perm									0.09			
v/c Ratio	0.13	0.52		0.58	0.56		0.54	0.54	0.34		0.45	
Uniform Delay, d1	24.7	26.6		24.3	24.2		22.1	22.0	20.7		29.9	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Incremental Delay, d2	0.2	0.8		2.3	0.9		1.3	1.2	0.5		1.8	
Delay (s)	24.9	27.4		26.7	25.1		23.4	23.2	21.2		31.7	
Level of Service	C	C		C	C		C	C	C		C	
Approach Delay (s)		27.1			25.6			22.2			31.7	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	24.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	70.8	Sum of lost time (s)	16.0
Intersection Capacity Utilization	58.0%	ICU Level of Service	B
Analysis Period (min)	15		

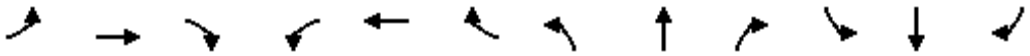
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	679	150	90	451	0	0	0	0	360	10	248
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		0.95			0.95						1.00	
Frpb, ped/bikes		0.99			1.00						1.00	
Flpb, ped/bikes		1.00			1.00						1.00	
Frt		0.97			1.00						0.95	
Flt Protected		1.00			0.99						0.97	
Satd. Flow (prot)		3459			3543						1729	
Flt Permitted		1.00			0.65						0.97	
Satd. Flow (perm)		3459			2339						1729	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	0	707	156	94	470	0	0	0	0	375	10	258
RTOR Reduction (vph)	0	40	0	0	0	0	0	0	0	0	37	0
Lane Group Flow (vph)	0	823	0	0	564	0	0	0	0	0	606	0
Confl. Peds. (#/hr)	3		8	8		3						
Confl. Bikes (#/hr)						3						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type				Perm						Split		
Protected Phases		4			8					6	6	
Permitted Phases				8								
Actuated Green, G (s)		20.1			20.1						26.9	
Effective Green, g (s)		20.1			20.1						26.9	
Actuated g/C Ratio		0.37			0.37						0.49	
Clearance Time (s)		4.0			4.0						4.0	
Vehicle Extension (s)		3.0			3.0						3.0	
Lane Grp Cap (vph)		1264			855						846	
v/s Ratio Prot		0.24									c0.35	
v/s Ratio Perm					c0.24							
v/c Ratio		0.65			0.66						0.72	
Uniform Delay, d1		14.5			14.6						11.0	
Progression Factor		1.00			1.00						1.00	
Incremental Delay, d2		1.2			1.9						5.2	
Delay (s)		15.7			16.4						16.2	
Level of Service		B			B						B	
Approach Delay (s)		15.7			16.4			0.0			16.2	
Approach LOS		B			B			A			B	

Intersection Summary			
HCM Average Control Delay	16.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.69		
Actuated Cycle Length (s)	55.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	85.0%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	293	746	0	0	471	430	80	180	140	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor		0.95			0.95		0.95	0.95	1.00			
Frpb, ped/bikes		1.00			0.99		1.00	1.00	1.00			
Flpb, ped/bikes		1.00			1.00		1.00	1.00	1.00			
Frt		1.00			0.93		1.00	1.00	0.85			
Flt Protected		0.99			1.00		0.95	1.00	1.00			
Satd. Flow (prot)		3524			3282		1698	1783	1599			
Flt Permitted		0.56			1.00		0.95	1.00	1.00			
Satd. Flow (perm)		2010			3282		1698	1783	1599			
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	305	777	0	0	491	448	83	188	146	0	0	0
RTOR Reduction (vph)	0	0	0	0	107	0	0	0	112	0	0	0
Lane Group Flow (vph)	0	1082	0	0	832	0	75	196	34	0	0	0
Confl. Peds. (#/hr)	2		7	7		2						
Confl. Bikes (#/hr)						3						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm						Split		Prot			
Protected Phases		4			8		2	2	2			
Permitted Phases	4											
Actuated Green, G (s)		53.5			53.5		18.5	18.5	18.5			
Effective Green, g (s)		53.5			53.5		18.5	18.5	18.5			
Actuated g/C Ratio		0.67			0.67		0.23	0.23	0.23			
Clearance Time (s)		4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)		3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)		1344			2195		393	412	370			
v/s Ratio Prot					0.25		0.04	c0.11	0.02			
v/s Ratio Perm		c0.54										
v/c Ratio		0.90dl			0.38		0.19	0.48	0.09			
Uniform Delay, d1		9.5			5.9		24.7	26.6	24.1			
Progression Factor		1.00			1.00		1.00	1.00	1.00			
Incremental Delay, d2		3.6			0.1		1.1	3.9	0.5			
Delay (s)		13.1			6.0		25.8	30.5	24.6			
Level of Service		B			A		C	C	C			
Approach Delay (s)		13.1			6.0			27.6			0.0	
Approach LOS		B			A			C			A	

Intersection Summary			
HCM Average Control Delay	12.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	80.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	76.6%	ICU Level of Service	D
Analysis Period (min)	15		

dl Defacto Left Lane. Recode with 1 though lane as a left lane.
c Critical Lane Group

Appendix C: Freeway LOS Calculations
Richmond Bay Campus

FEHR PEERS

Existing Conditions

FEHR PEERS

HCM 2000
Basic Freeway Segments
Capacity Analysis

Jurisdiction
Analysis Year Existing
Analyst EK

Agency or Company
Date
Project Description

General Information | *Flow Rate Calculation* | *Speed Calculation* | *Results*

	Freeway/ Direction	From/To	Analysis Time Period	Volume (vph)	PHF	Lanes	HOV Lane?	HOV Lane Volume	Terrain	Truck/ Bus %	RV %	E_T	E_R	f_{HV}	f_P	Flow Rate v_p (pcphpl)	Measured FFS (mph)	S (mph)	Density, D (pcplpm)	Level of Service
R-5	I-580 EB	I-580 between Bayview Avenue and Central Avenue	AM	2,680	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,000	65.0	65.0	**15.4**	**B**
R-6	I-580 EB	I-580 between Central Avenue and I-80	AM	2,730	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,528	65.0	65.0	**23.5**	**C**
R-7	I-80 EB	I-80 between Carlson Boulevard and Potrero Avenue	AM	4,040	0.92	4	Yes	290	Level	4%	0%	1.5	1.2	0.980	1.00	1,386	65.0	65.0	**21.3**	**C**
R-8	I-80 EB	I-80 @ Gilman Overpass	AM	5,840	0.92	5	Yes	780	Level	5%	0%	1.5	1.2	0.976	1.00	1,409	65.0	65.0	**21.7**	**C**
R-5	I-580 WB	I-580 between Bayview Avenue and Central Avenue	AM	2,490	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	929	65.0	65.0	**14.3**	**B**
R-6	I-580 WB	I-580 between Central Avenue and I-80	AM	2,890	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,618	65.0	64.8	**25.0**	**C**
R-7	I-80 WB	I-80 between Carlson Boulevard and Potrero Avenue	AM	6,010	0.92	4	Yes	960	Level	4%	0%	1.5	1.2	0.980	1.00	1,866	65.0	63.3	**29.5**	**D**
R-8	I-80 WB	I-80 @ Gilman Overpass	AM	8,350	0.92	5	Yes	1410	Level	5%	0%	1.5	1.2	0.976	1.00	1,933	65.0	62.5	**30.9**	**D**
R-5	I-580 EB	I-580 between Bayview Avenue and Central Avenue	PM	2,440	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	911	65.0	65.0	**14.0**	**B**
R-6	I-580 EB	I-580 between Central Avenue and I-80	PM	3,260	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,825	65.0	63.7	**28.7**	**D**
R-7	I-80 EB	I-80 between Carlson Boulevard and Potrero Avenue	PM	6,000	0.92	4	Yes	1260	Level	4%	0%	1.5	1.2	0.980	1.00	1,752	65.0	64.3	**27.3**	**D**
R-8	I-80 EB	I-80 @ Gilman Overpass	PM	7,310	0.92	5	Yes	1020	Level	5%	0%	1.5	1.2	0.976	1.00	1,752	65.0	64.3	**27.3**	**D**
R-5	I-580 WB	I-580 between Bayview Avenue and Central Avenue	PM	2,940	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,097	65.0	65.0	**16.9**	**B**
R-6	I-580 WB	I-580 between Central Avenue and I-80	PM	2,620	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,467	65.0	65.0	**22.6**	**C**
R-7	I-80 WB	I-80 between Carlson Boulevard and Potrero Avenue	PM	4,550	0.92	4	Yes	330	Level	4%	0%	1.5	1.2	0.980	1.00	1,560	65.0	64.9	**24.0**	**C**
R-8	I-80 WB	I-80 @ Gilman Overpass	PM	6,580	0.92	5	Yes	630	Level	5%	0%	1.5	1.2	0.976	1.00	1,657	65.0	64.7	**25.6**	**C**

Leisch Method for Weaving Analysis

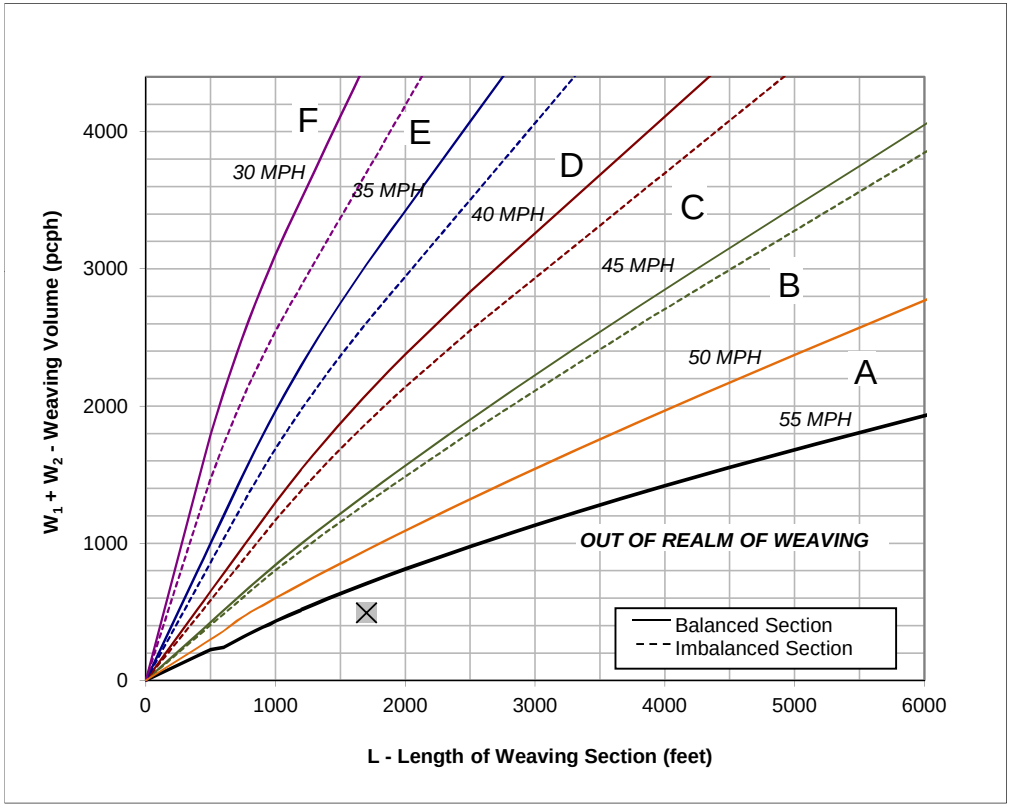
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,700

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,220	Volume (vph)*	320	Volume (vph)*	160
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,287	Volume (pcph)	330	Volume (pcph)	165

Project Information

Project	LBNL
Scenario	Existing AM
Freeway	EB I-580
On-ramp	Harbour Way
Off-ramp	Marina Bay Pkwy



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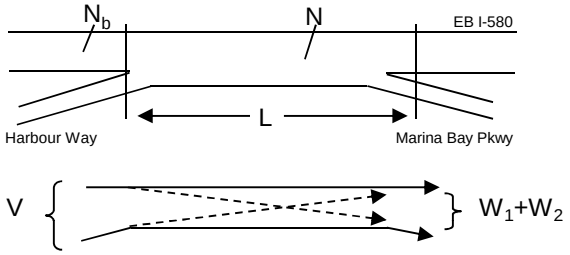


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **59.4**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **572**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

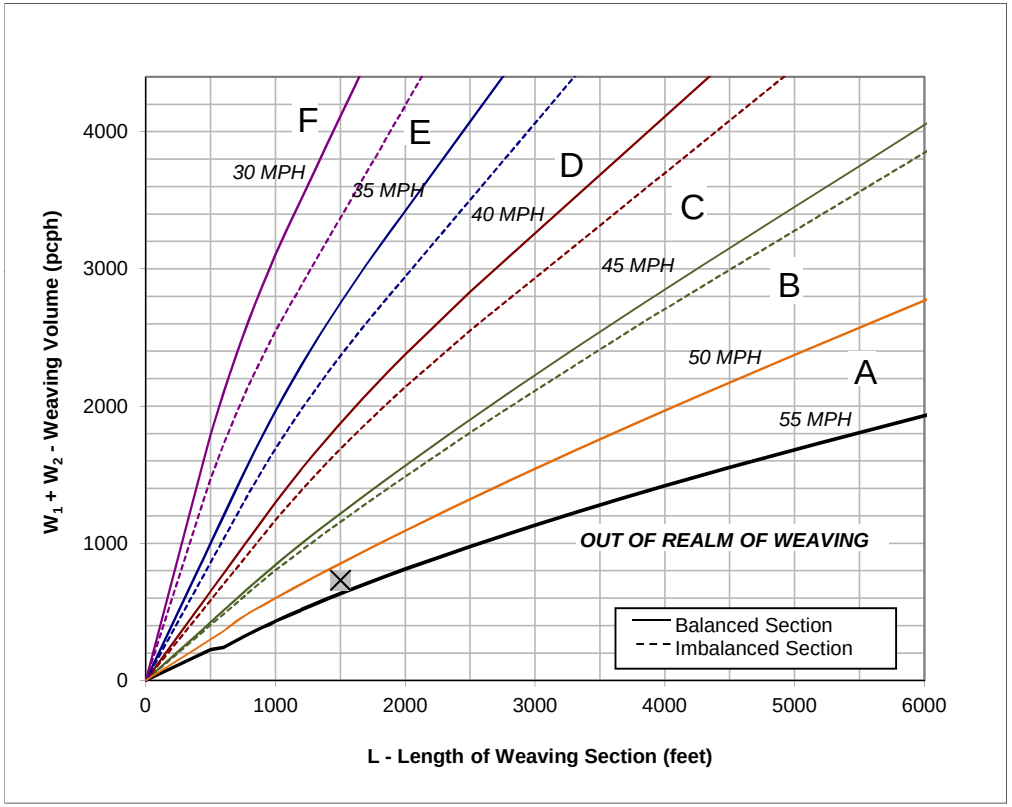
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,500

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,220	Volume (vph)*	320	Volume (vph)*	390
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,287	Volume (pcph)	330	Volume (pcph)	402

Project Information

Project	LBNL
Scenario	Existing AM
Freeway	WB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Harbour Way



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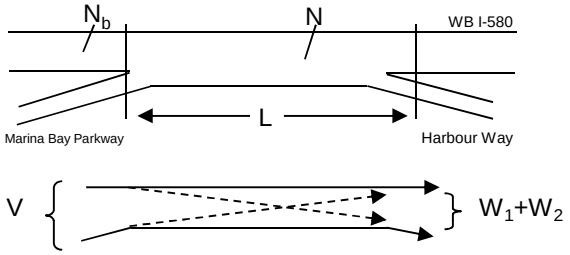


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **52.8**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **572**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

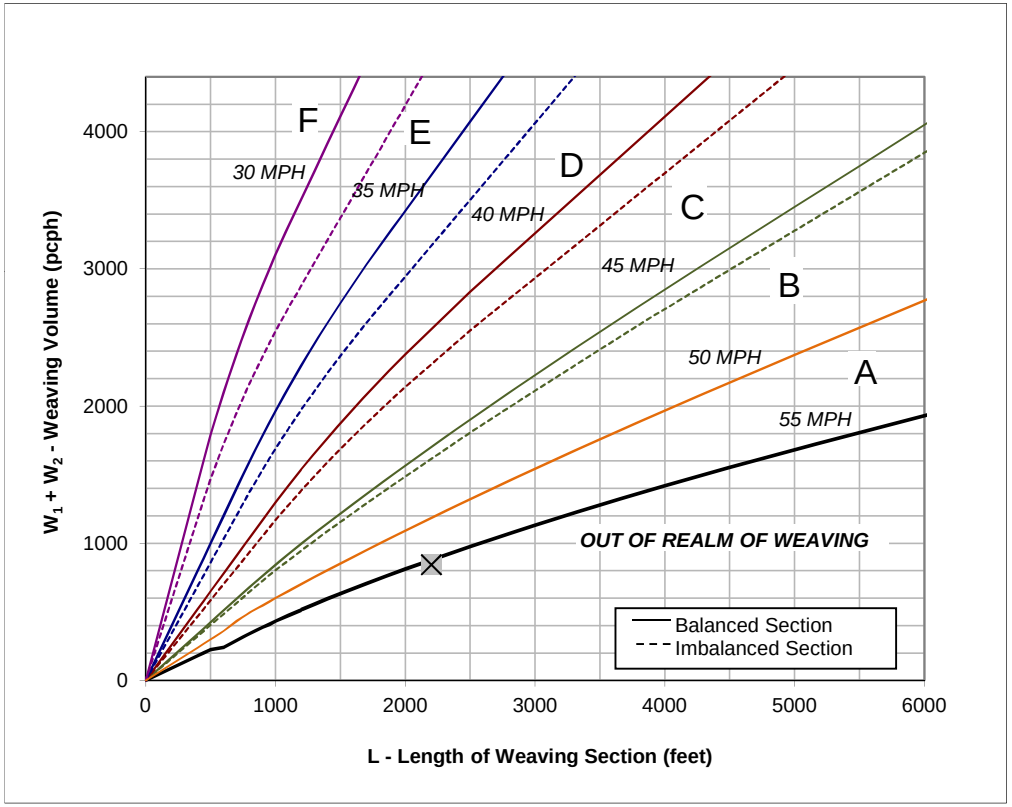
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,800	Volume (vph)*	740	Volume (vph)*	80
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,884	Volume (pcph)	762	Volume (pcph)	82

Project Information

Project	LBNL
Scenario	Existing AM
Freeway	EB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Regatta Blvd



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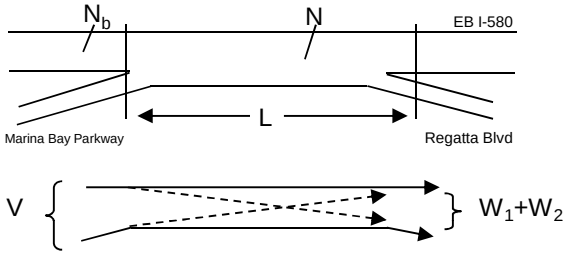


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **55.6**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **721**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

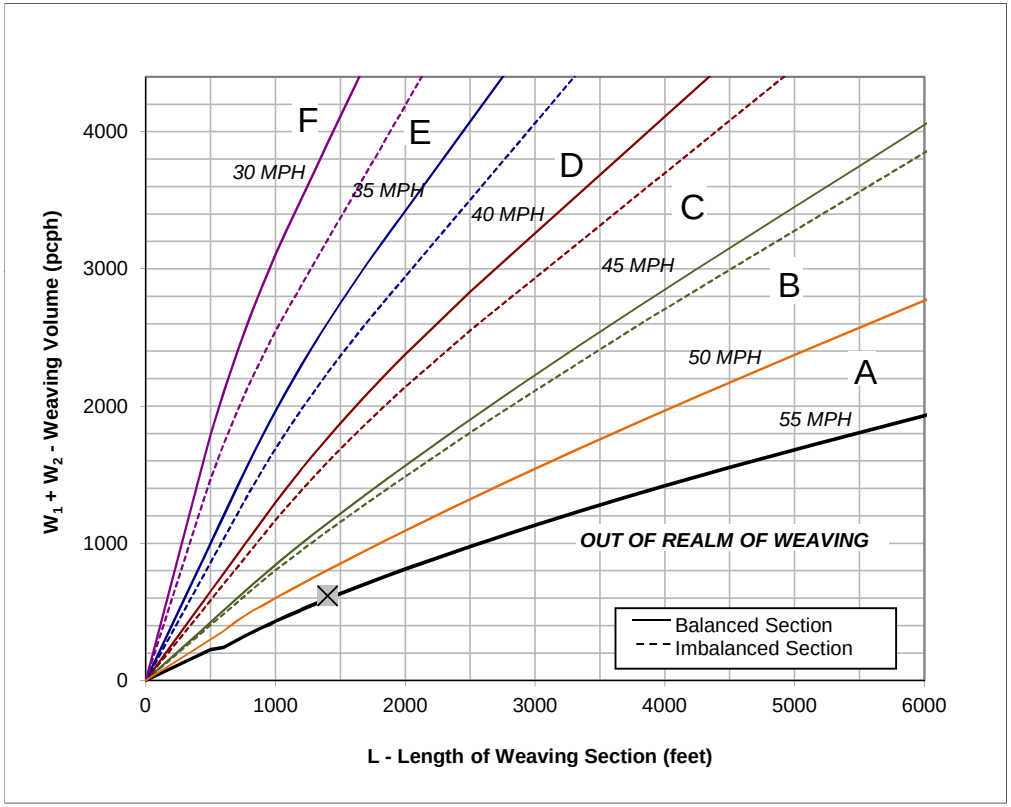
Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,400

Project Information	
Project	LBNL
Scenario	Existing AM
Freeway	WB I-580
On-ramp	Regatta Blvd
Off-ramp	Marina Bay Parkway

	Total Weaving Section (V)	On-ramp to Mainline (W_1)	Mainline to Off-ramp (W_2)
Volume (vph)*	2,790	130	470
Truck Percentage	6%	6%	6%
PCE for Trucks	1.5	1.5	1.5
Volume (pcph)	2,874	134	484



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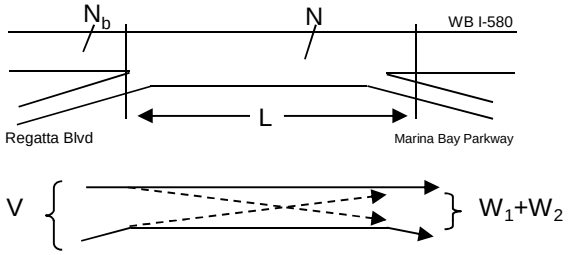


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **54.4**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **718**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

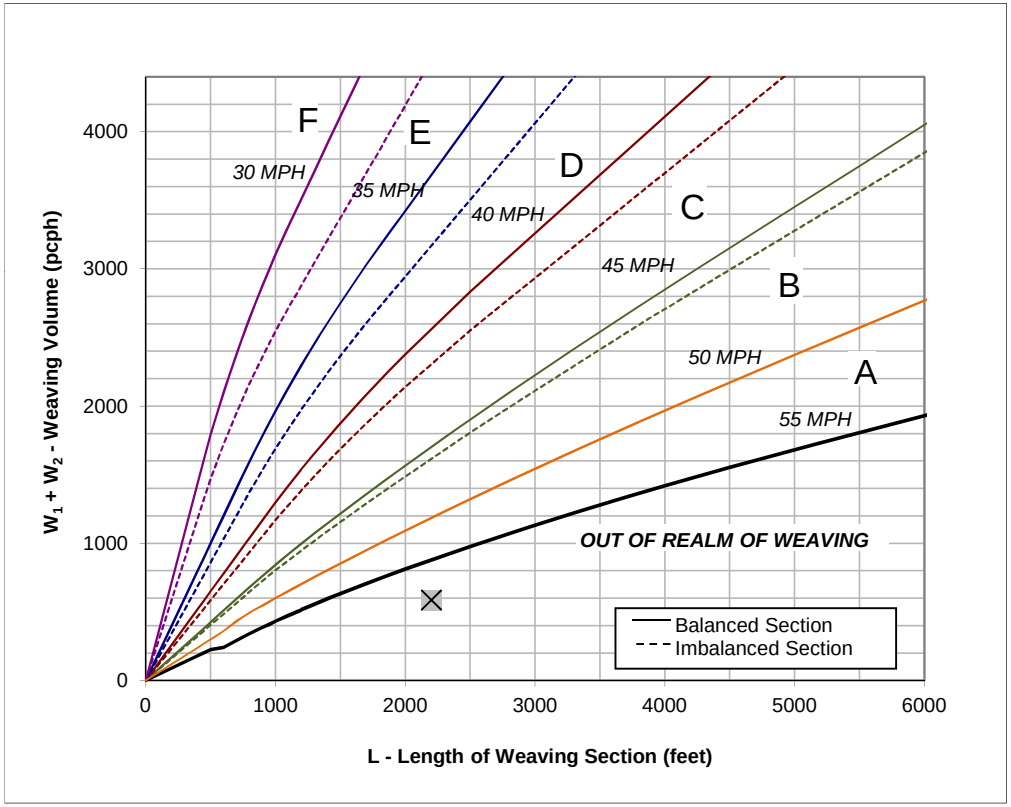
Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Project Information	
Project	LBNL
Scenario	Existing AM
Freeway	EB I-580
On-ramp	Regatta Blvd
Off-ramp	Bayview Ave

	Total Weaving Section (V)	On-ramp to Mainline (W_1)	Mainline to Off-ramp (W_2)
Volume (vph)*	2,870	140	430
Truck Percentage	6%	6%	6%
PCE for Trucks	1.5	1.5	1.5
Volume (pcph)	2,956	144	443



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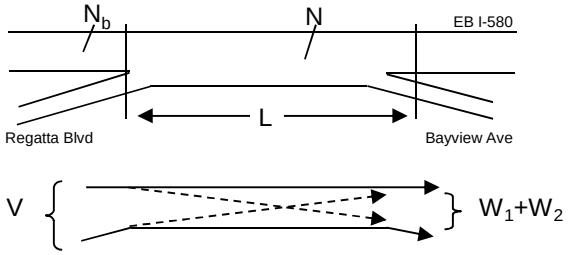


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **59.8**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **739**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

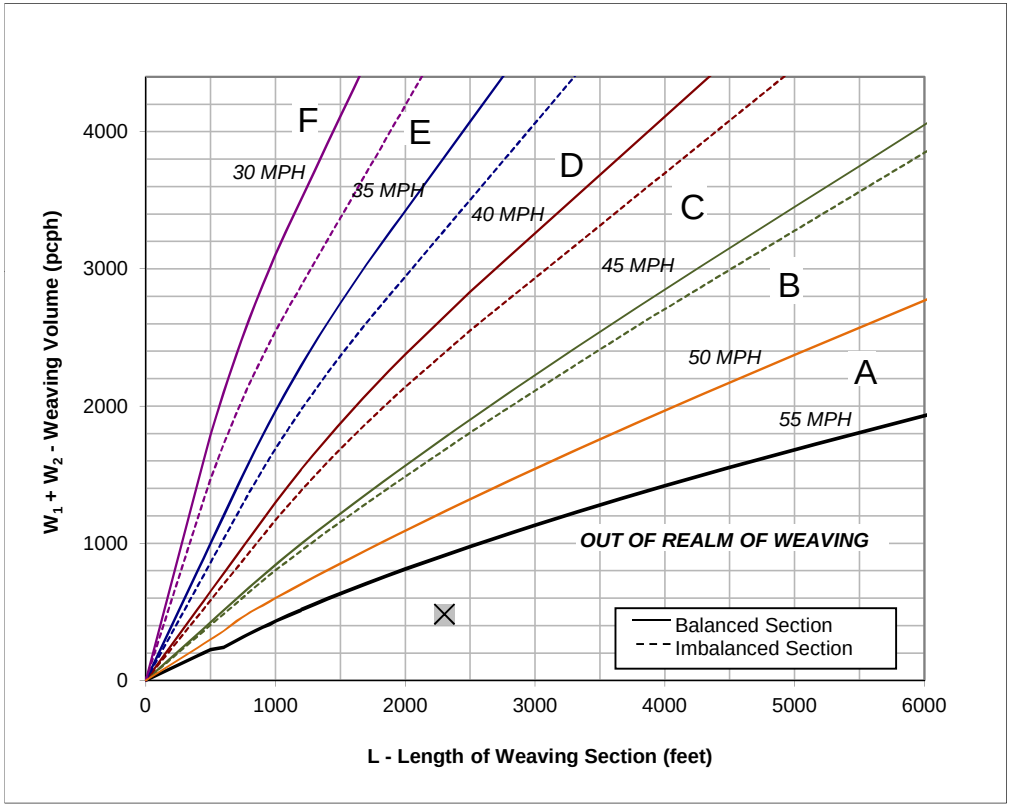
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,300

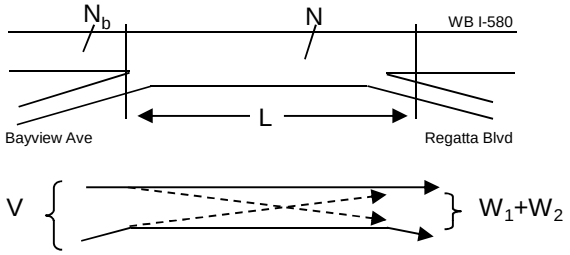
Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,750	Volume (vph)*	380	Volume (vph)*	90
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,833	Volume (pcph)	391	Volume (pcph)	93

Project Information

Project	LBNL
Scenario	Existing AM
Freeway	WB I-580
On-ramp	Bayview Ave
Off-ramp	Regatta Blvd



Figure



Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **61.7**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **708**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

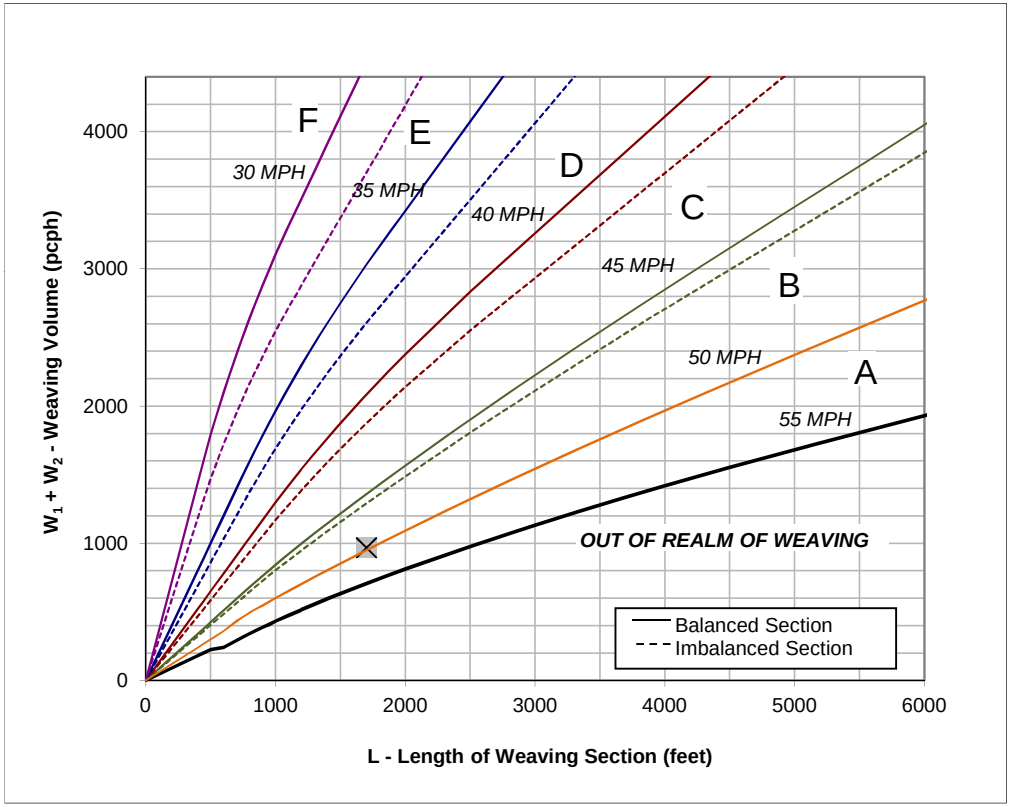
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,700

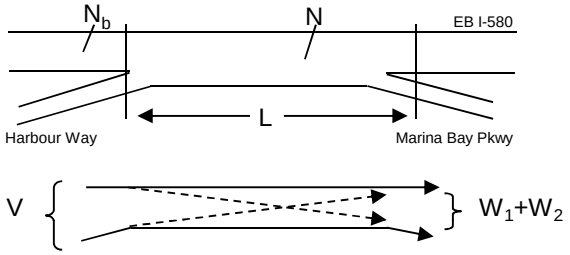
Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,530	Volume (vph)*	600	Volume (vph)*	340
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,606	Volume (pcph)	618	Volume (pcph)	350

Project Information

Project	LBNL
Scenario	Existing PM
Freeway	EB I-580
On-ramp	Harbour Way
Off-ramp	Marina Bay Pkwy



Figure



Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **49.6**
4. Weaving Intensity Factor (k) **1.25**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **673**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

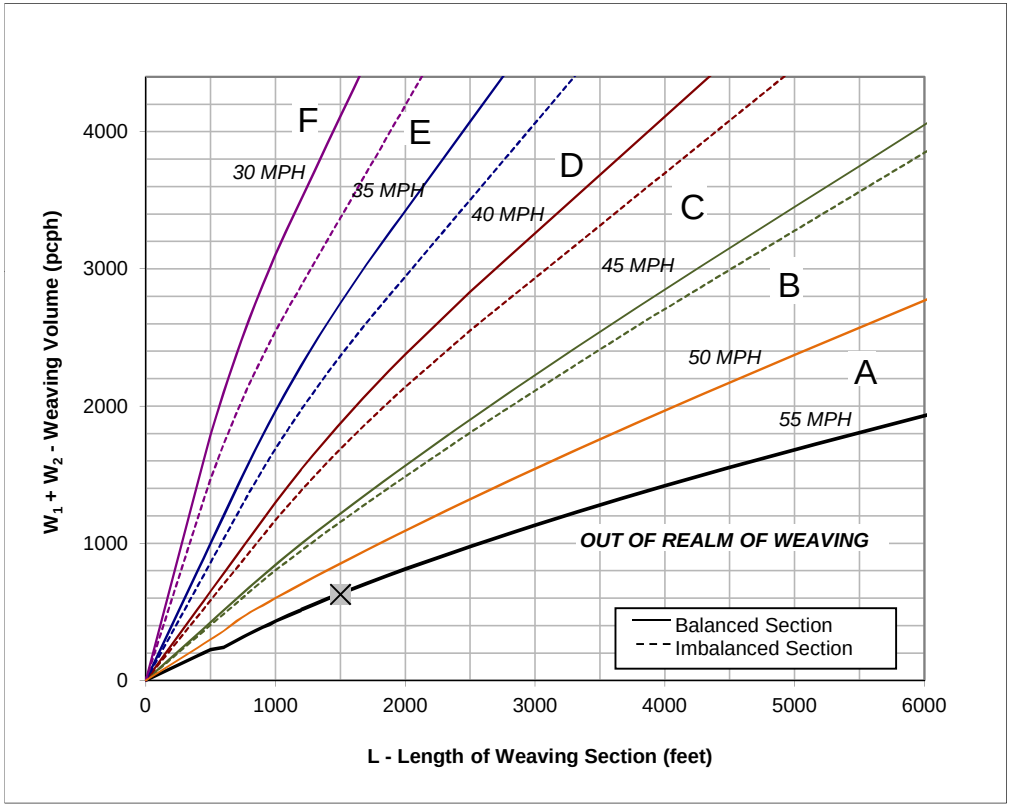
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,500

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	1,970	Volume (vph)*	220	Volume (vph)*	390
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,029	Volume (pcph)	227	Volume (pcph)	402

Project Information

Project	LBNL
Scenario	Existing PM
Freeway	WB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Harbour Way



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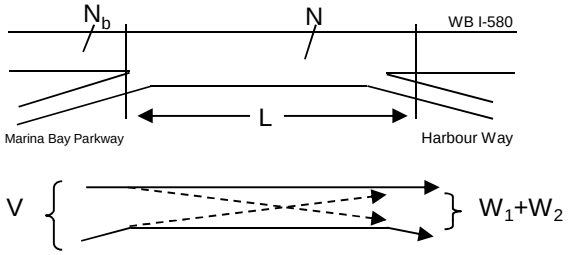


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **55.1**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **507**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

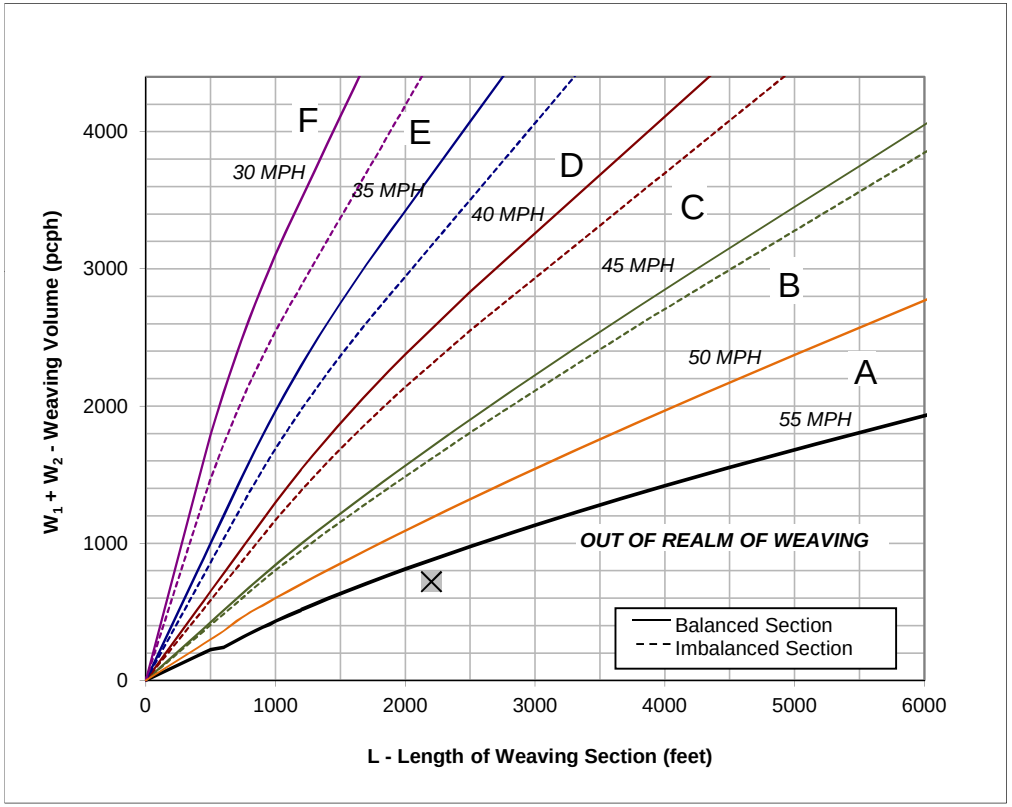
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,770	Volume (vph)*	580	Volume (vph)*	120
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,853	Volume (pcph)	597	Volume (pcph)	124

Project Information

Project	LBNL
Scenario	Existing PM
Freeway	EB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Regatta Blvd



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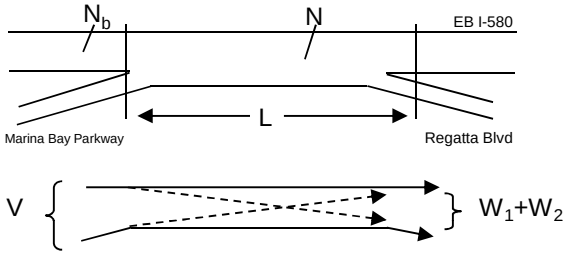


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **57.6**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **713**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

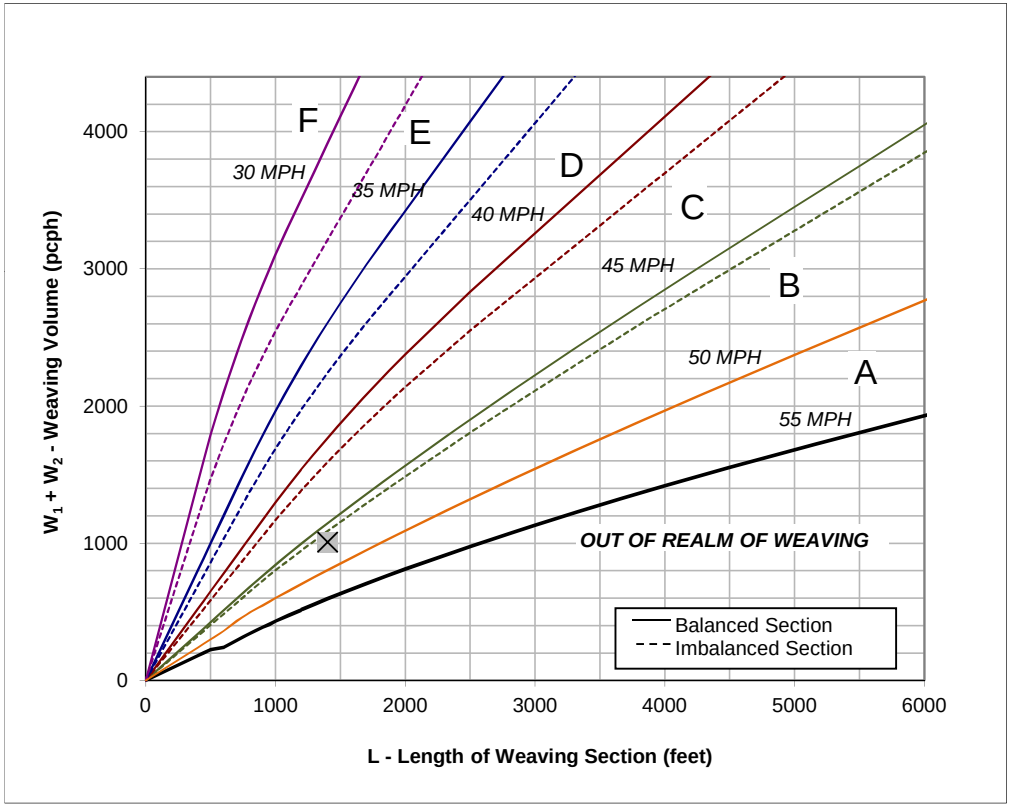
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,400

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,670	Volume (vph)*	60	Volume (vph)*	920
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,750	Volume (pcph)	62	Volume (pcph)	948

Project Information

Project	LBNL
Scenario	Existing PM
Freeway	WB I-580
On-ramp	Regatta Blvd
Off-ramp	Marina Bay Parkway



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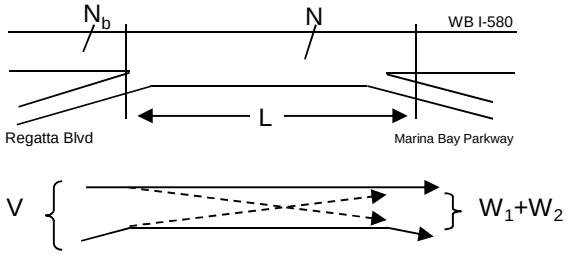


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   45 MPH and **50 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **46.4**
4. Weaving Intensity Factor (k) **2.30**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **708**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

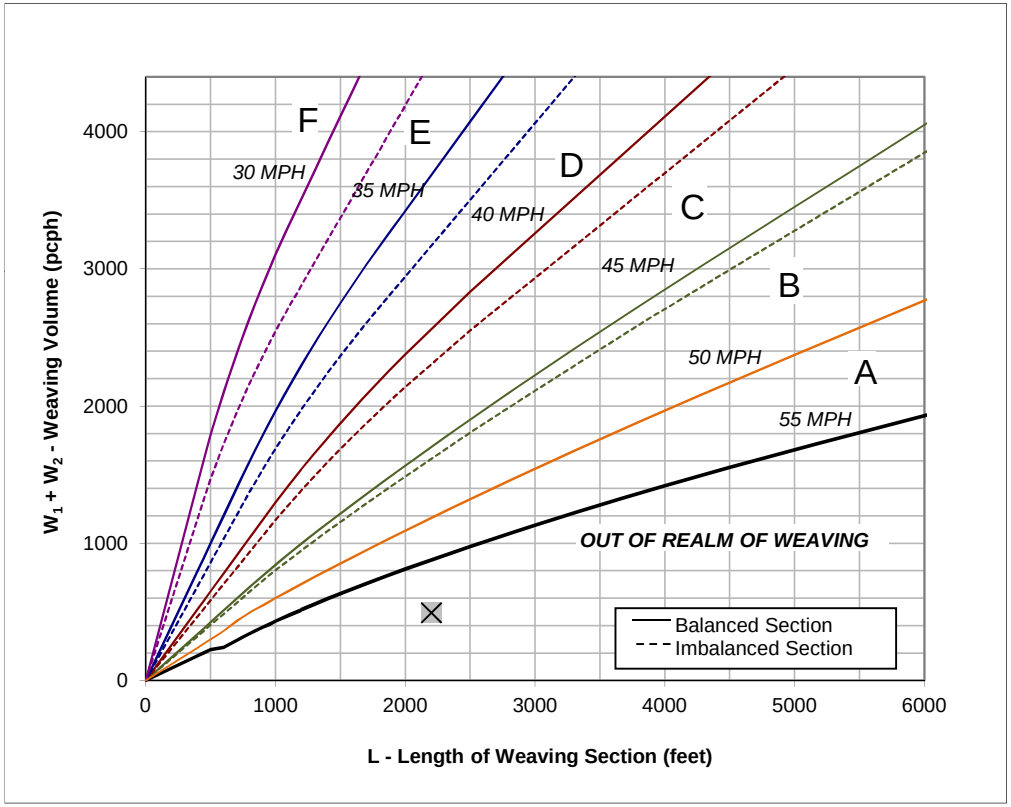
Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Project Information	
Project	LBNL
Scenario	Existing PM
Freeway	EB I-580
On-ramp	Regatta Blvd
Off-ramp	Bayview Ave

	Total Weaving Section (V)	On-ramp to Mainline (W_1)	Mainline to Off-ramp (W_2)
Volume (vph)*	2,730	400	80
Truck Percentage	6%	6%	6%
PCE for Trucks	1.5	1.5	1.5
Volume (pcph)	2,812	412	82



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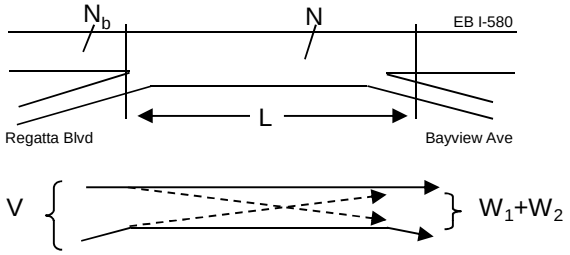


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **61.3**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **703**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

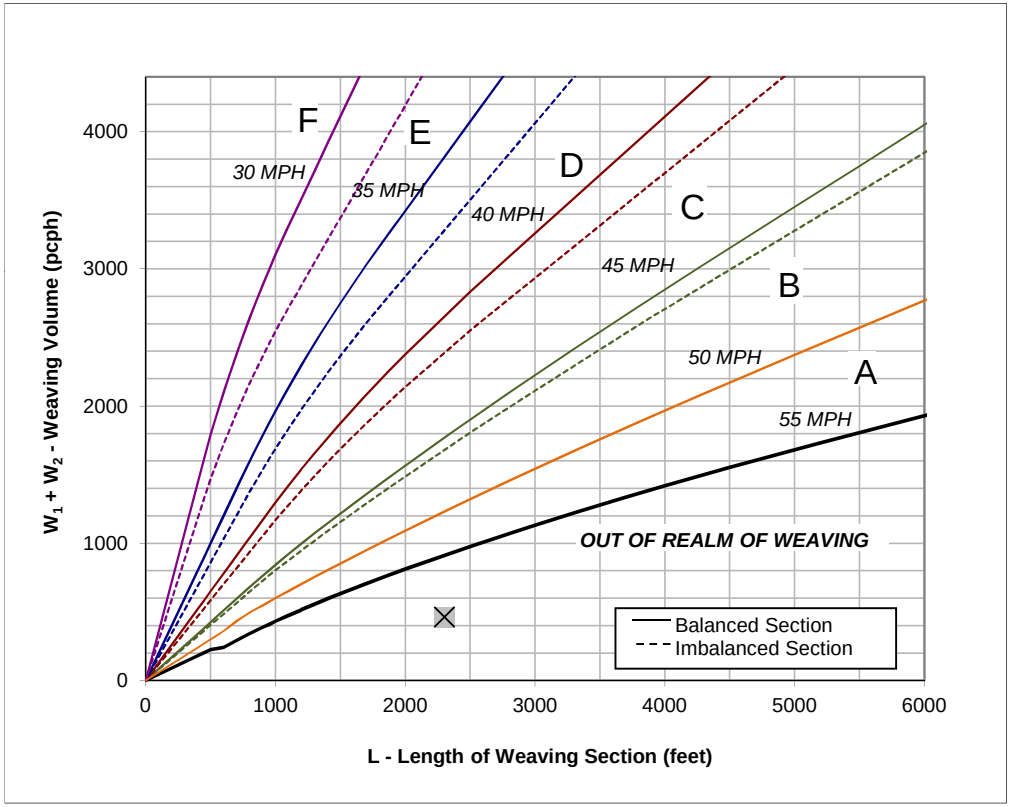
Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,300

Project Information	
Project	LBNL
Scenario	Existing PM
Freeway	WB I-580
On-ramp	Bayview Ave
Off-ramp	Regatta Blvd

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,780	Volume (vph)*	290	Volume (vph)*	160
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,863	Volume (pcph)	299	Volume (pcph)	165



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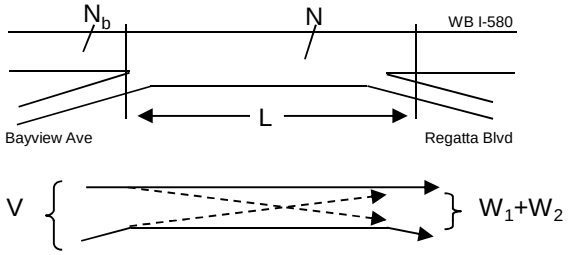


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **62.1**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **716**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Existing Plus Phase 1 Project Conditions

FEHR PEERS

HCM 2000
Basic Freeway Segments
Capacity Analysis

Jurisdiction
Analysis Year Existing + Project (Phase 1)
Analyst EK

Agency or Company
Date
Project Description

General Information | *Flow Rate Calculation* | *Speed Calculation* | *Results*

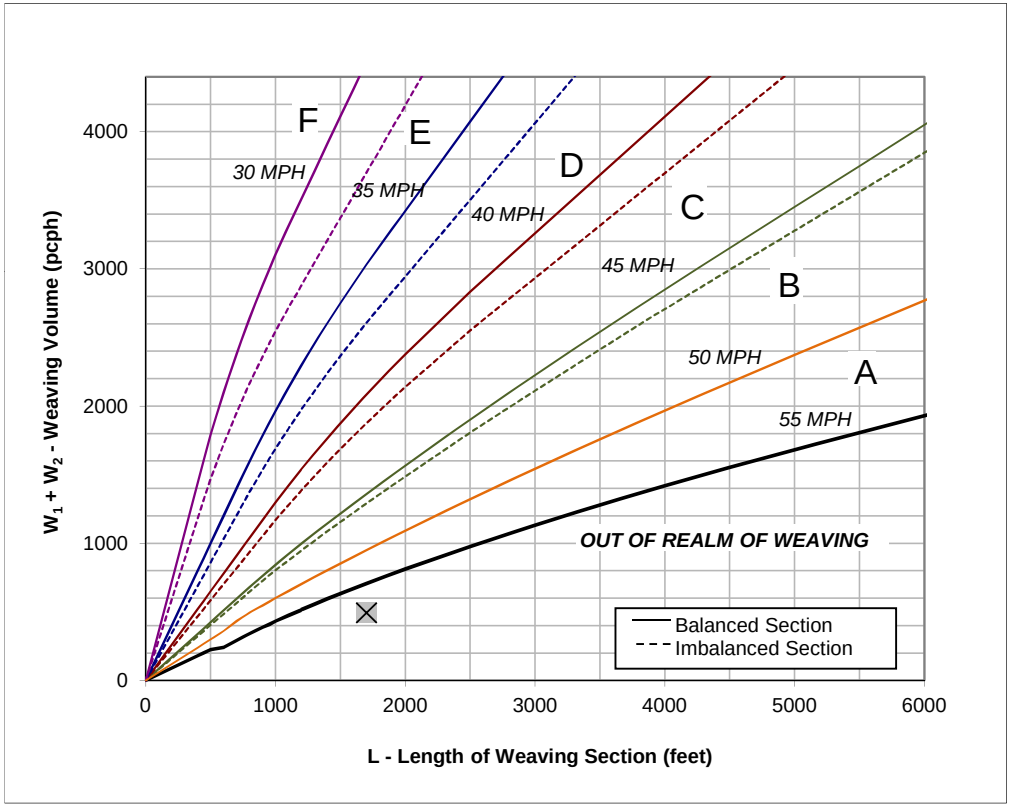
	Freeway/ Direction	From/To	Analysis Time Period	Volume (vph)	PHF	Lanes	HOV Lane?	HOV Lane Volume	Terrain	Truck/ Bus %	RV %	E_T	E_R	f_{HV}	f_P	Flow Rate v_p (pcphpl)	Measured FFS (mph)	S (mph)	Density, D (pcplpm)	Level of Service
R-5	I-580 EB	I-580 between Bayview Avenue and Central Avenue	AM	2,690	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,004	65.0	65.0	**15.4**	**B**
R-6	I-580 EB	I-580 between Central Avenue and I-80	AM	2,740	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,534	65.0	65.0	**23.6**	**C**
R-7	I-80 EB	I-80 between Carlson Boulevard and Potrero Avenue	AM	4,045	0.92	4	Yes	290	Level	4%	0%	1.5	1.2	0.980	1.00	1,388	65.0	65.0	**21.3**	**C**
R-8	I-80 EB	I-80 @ Gilman Overpass	AM	5,904	0.92	5	Yes	780	Level	5%	0%	1.5	1.2	0.976	1.00	1,427	65.0	65.0	**22.0**	**C**
R-5	I-580 WB	I-580 between Bayview Avenue and Central Avenue	AM	2,554	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	953	65.0	65.0	**14.7**	**B**
R-6	I-580 WB	I-580 between Central Avenue and I-80	AM	2,954	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,654	65.0	64.7	**25.5**	**C**
R-7	I-80 WB	I-80 between Carlson Boulevard and Potrero Avenue	AM	6,043	0.92	4	Yes	960	Level	4%	0%	1.5	1.2	0.980	1.00	1,879	65.0	63.1	**29.7**	**D**
R-8	I-80 WB	I-80 @ Gilman Overpass	AM	8,360	0.92	5	Yes	1410	Level	5%	0%	1.5	1.2	0.976	1.00	1,936	65.0	62.4	**31.0**	**D**
R-5	I-580 EB	I-580 between Bayview Avenue and Central Avenue	PM	2,500	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	933	65.0	65.0	**14.4**	**B**
R-6	I-580 EB	I-580 between Central Avenue and I-80	PM	3,320	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,858	65.0	63.4	**29.3**	**D**
R-7	I-80 EB	I-80 between Carlson Boulevard and Potrero Avenue	PM	6,031	0.92	4	Yes	1260	Level	4%	0%	1.5	1.2	0.980	1.00	1,763	65.0	64.2	**27.5**	**D**
R-8	I-80 EB	I-80 @ Gilman Overpass	PM	7,319	0.92	5	Yes	1020	Level	5%	0%	1.5	1.2	0.976	1.00	1,754	65.0	64.2	**27.3**	**D**
R-5	I-580 WB	I-580 between Bayview Avenue and Central Avenue	PM	2,949	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,101	65.0	65.0	**16.9**	**B**
R-6	I-580 WB	I-580 between Central Avenue and I-80	PM	2,629	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,472	65.0	65.0	**22.6**	**C**
R-7	I-80 WB	I-80 between Carlson Boulevard and Potrero Avenue	PM	4,555	0.92	4	Yes	330	Level	4%	0%	1.5	1.2	0.980	1.00	1,561	65.0	64.9	**24.0**	**C**
R-8	I-80 WB	I-80 @ Gilman Overpass	PM	6,640	0.92	5	Yes	630	Level	5%	0%	1.5	1.2	0.976	1.00	1,674	65.0	64.7	**25.9**	**C**

Leisch Method for Weaving Analysis

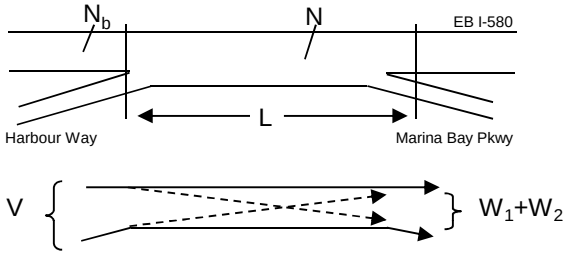
Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,700

Project Information	
Project	LBNL
Scenario	Existing + Project (Phase 1) AM
Freeway	EB I-580
On-ramp	Harbour Way
Off-ramp	Marina Bay Pkwy

	Total Weaving Section (V)	On-ramp to Mainline (W_1)	Mainline to Off-ramp (W_2)
Volume (vph)*	2,262	320	160
Truck Percentage	6%	6%	6%
PCE for Trucks	1.5	1.5	1.5
Volume (pcph)	2,330	330	165



Figure



Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **59.4**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **582**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

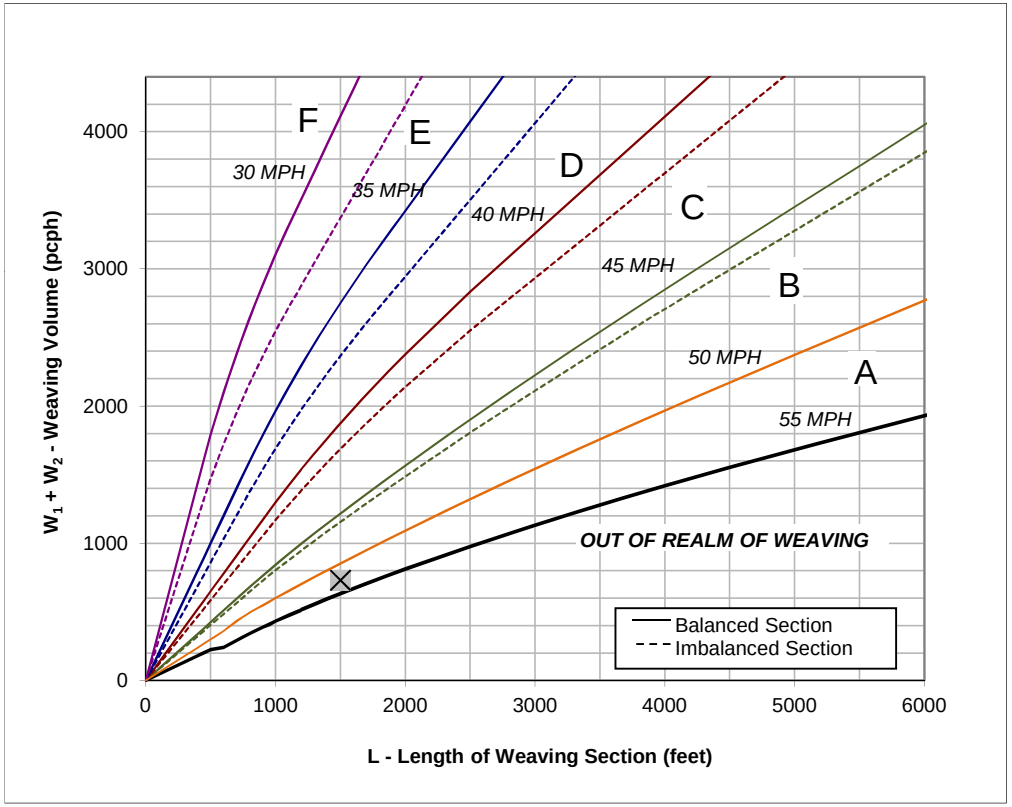
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,500

	Total Weaving Section (V)	On-ramp to Mainline (W_1)	Mainline to Off-ramp (W_2)
Volume (vph)*	2,227	320	390
Truck Percentage	6%	6%	6%
PCE for Trucks	1.5	1.5	1.5
Volume (pcph)	2,294	330	402

Project Information

Project	LBNL
Scenario	Existing + Project (Phase 1) AM
Freeway	WB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Harbour Way



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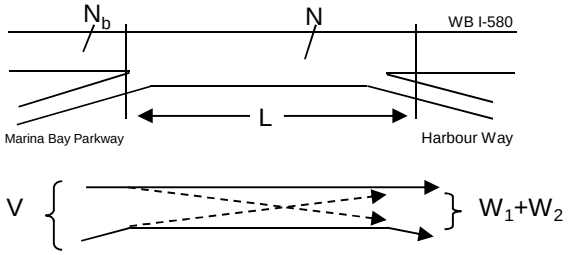


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **52.8**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **573**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

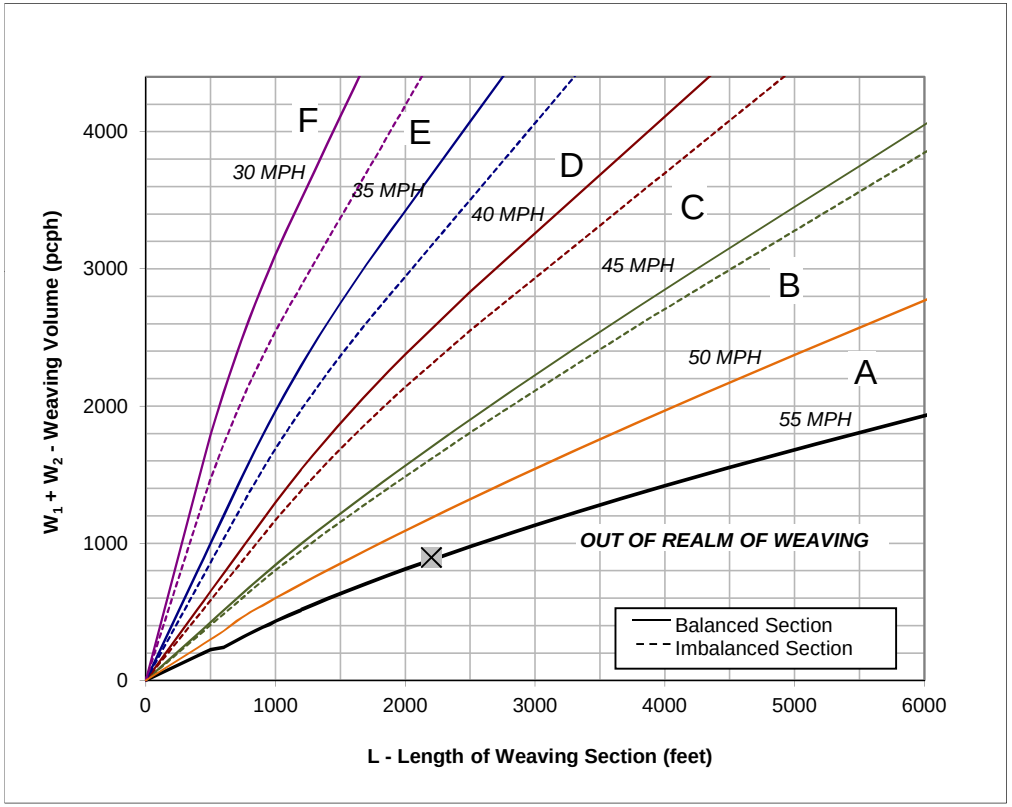
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,847	Volume (vph)*	745	Volume (vph)*	127
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,932	Volume (pcph)	767	Volume (pcph)	131

Project Information

Project	LBNL
Scenario	Existing + Project (Phase 1) AM
Freeway	EB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Regatta Blvd



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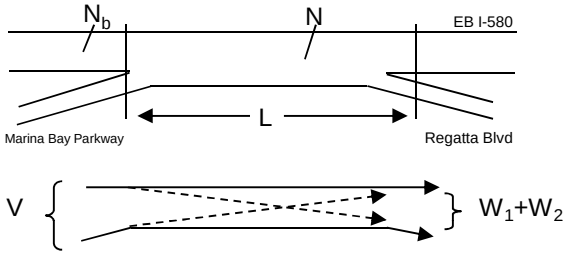


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **54.7**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **733**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

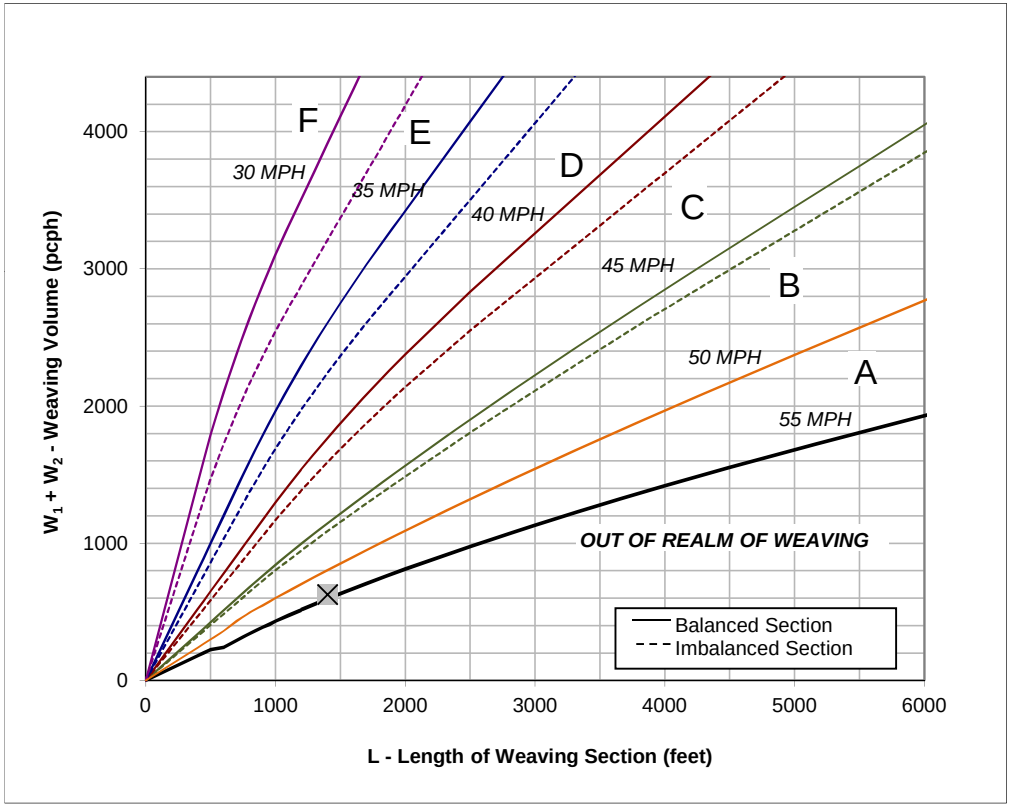
Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,400

Project Information	
Project	LBNL
Scenario	Existing + Project (Phase 1) AM
Freeway	WB I-580
On-ramp	Regatta Blvd
Off-ramp	Marina Bay Parkway

	Total Weaving Section (V)	On-ramp to Mainline (W_1)	Mainline to Off-ramp (W_2)
Volume (vph)*	2,798	138	471
Truck Percentage	6%	6%	6%
PCE for Trucks	1.5	1.5	1.5
Volume (pcph)	2,882	142	485



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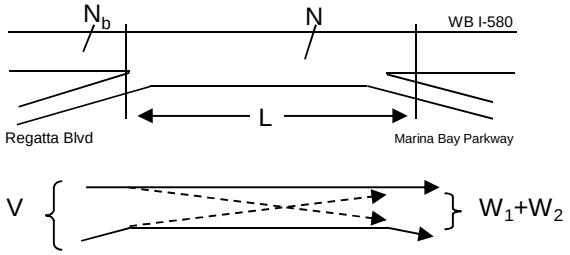


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **54.2**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **720**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

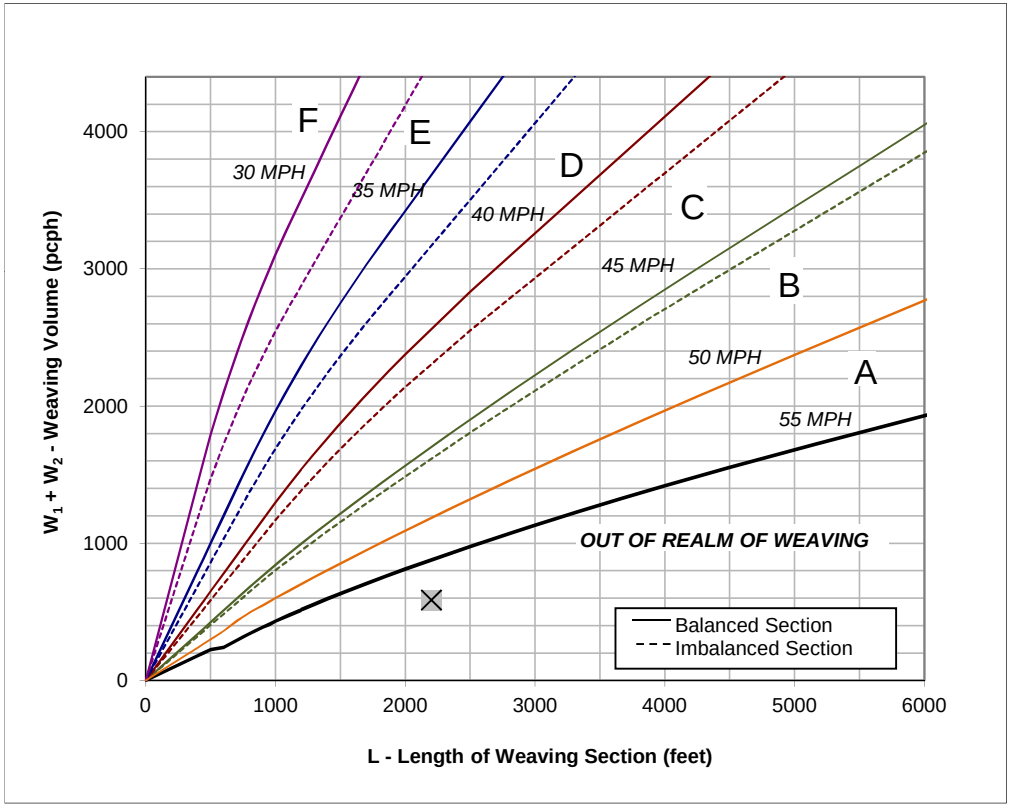
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,870	Volume (vph)*	140	Volume (vph)*	430
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,956	Volume (pcph)	144	Volume (pcph)	443

Project Information

Project	LBNL
Scenario	Existing + Project (Phase 1) AM
Freeway	EB I-580
On-ramp	Regatta Blvd
Off-ramp	Bayview Ave



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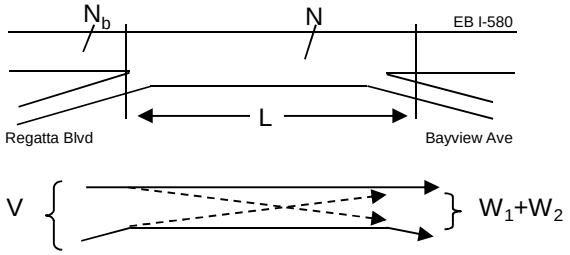


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **59.8**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **739**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

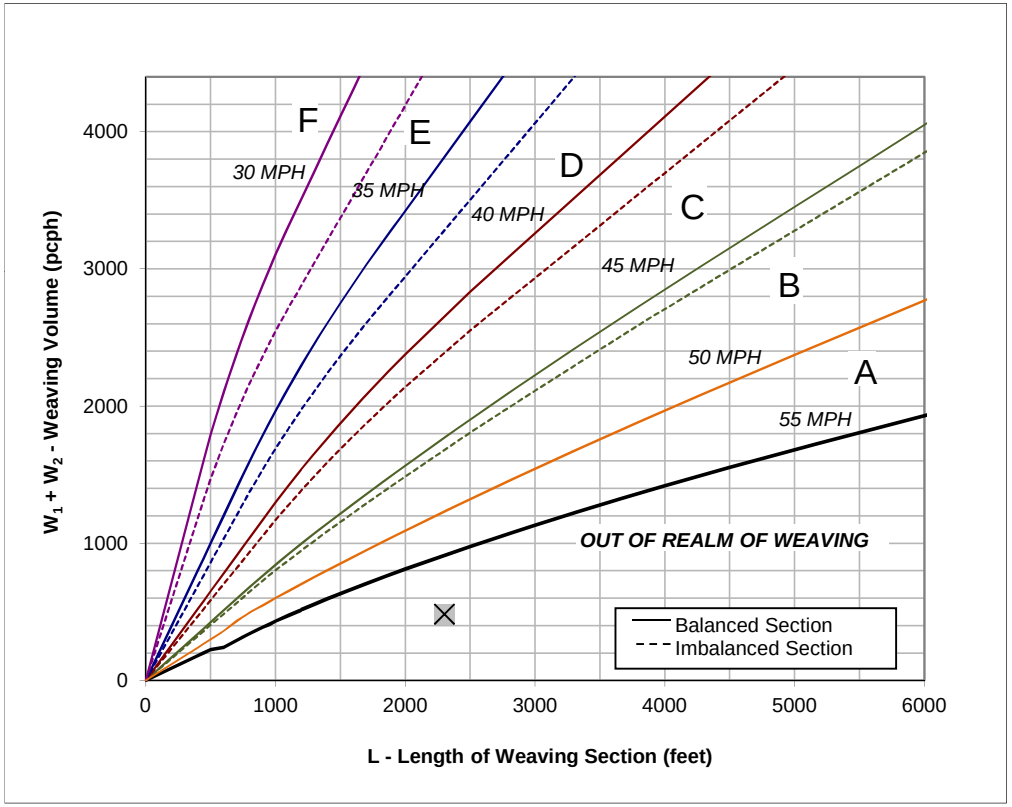
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,300

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,750	Volume (vph)*	380	Volume (vph)*	90
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,833	Volume (pcph)	391	Volume (pcph)	93

Project Information

Project	LBNL
Scenario	Existing + Project (Phase 1) AM
Freeway	WB I-580
On-ramp	Bayview Ave
Off-ramp	Regatta Blvd



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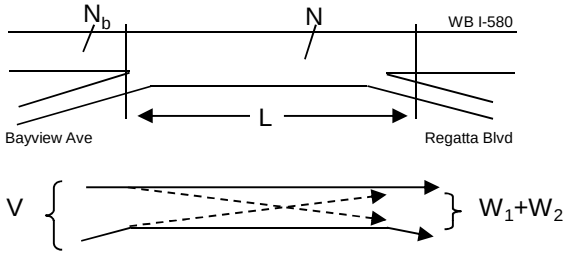


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **61.7**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **708**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

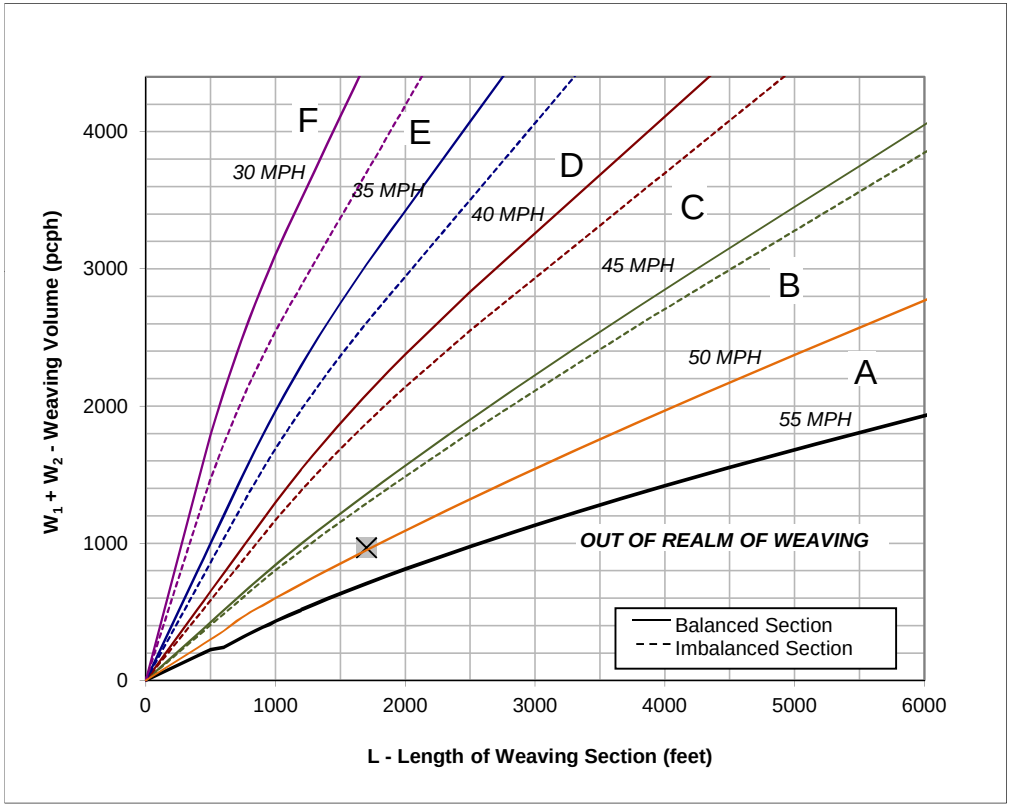
Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,700

Project Information	
Project	LBNL
Scenario	Existing + Project (Phase 1) PM
Freeway	EB I-580
On-ramp	Harbour Way
Off-ramp	Marina Bay Pkwy

	Total Weaving Section (V)	On-ramp to Mainline (W_1)	Mainline to Off-ramp (W_2)
Volume (vph)*	2,536	600	340
Truck Percentage	6%	6%	6%
PCE for Trucks	1.5	1.5	1.5
Volume (pcph)	2,612	618	350



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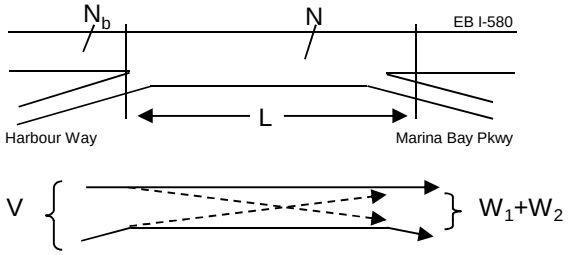

Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **49.6**
4. Weaving Intensity Factor (k) **1.25**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **675**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

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Leisch Method for Weaving Analysis

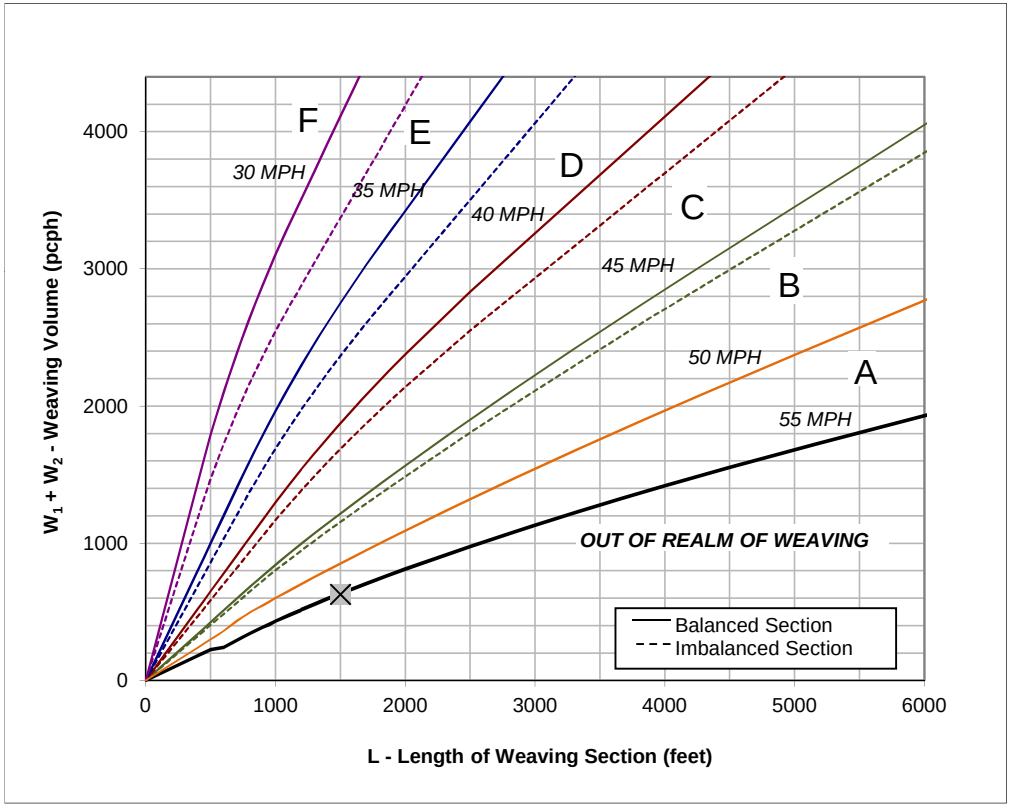
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,500

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,010	Volume (vph)*	220	Volume (vph)*	390
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,070	Volume (pcph)	227	Volume (pcph)	402

Project Information

Project	LBNL
Scenario	Existing + Project (Phase 1) PM
Freeway	WB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Harbour Way



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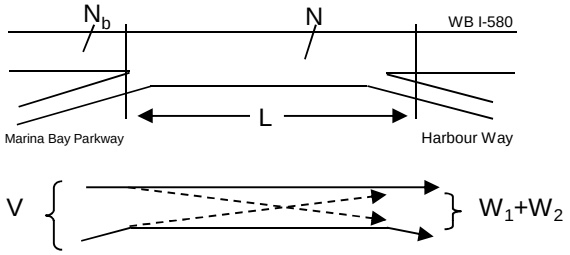


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **55.1**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **518**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

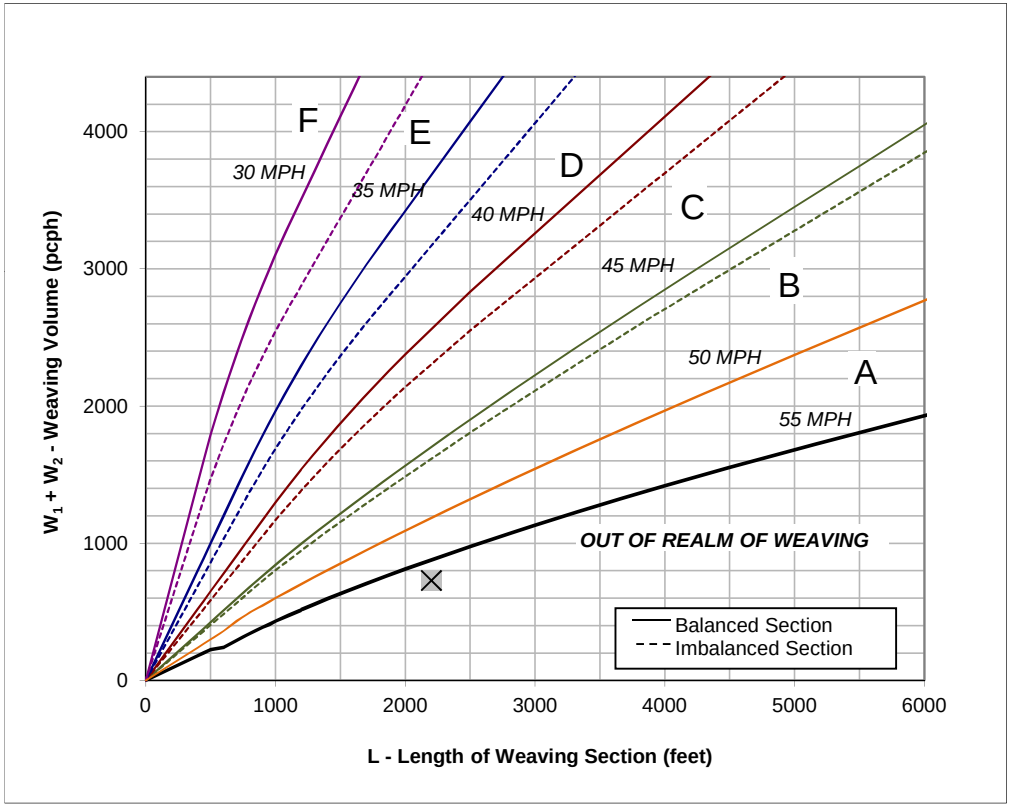
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,777	Volume (vph)*	581	Volume (vph)*	127
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,860	Volume (pcph)	598	Volume (pcph)	131

Project Information

Project	LBNL
Scenario	Existing + Project (Phase 1) PM
Freeway	EB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Regatta Blvd



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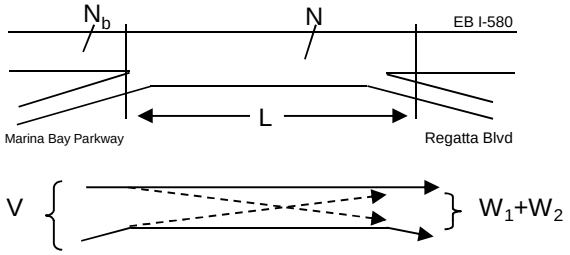

Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **57.5**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **715**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

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Leisch Method for Weaving Analysis

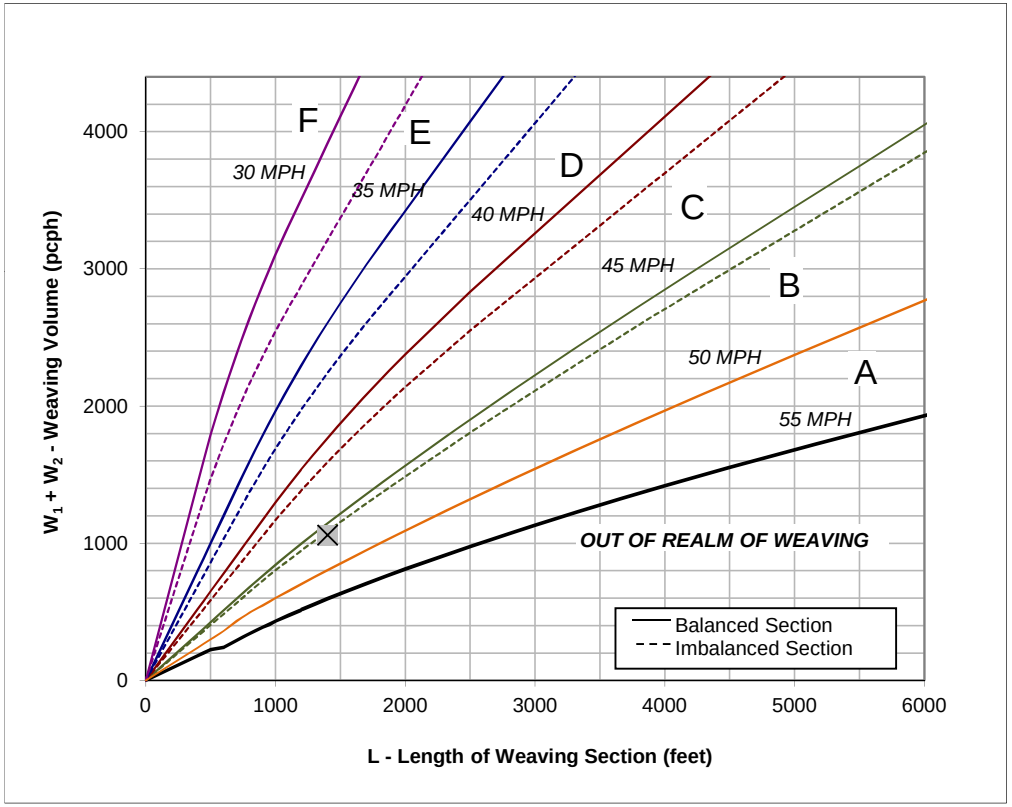
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,400

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,715	Volume (vph)*	105	Volume (vph)*	925
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,796	Volume (pcph)	108	Volume (pcph)	953

Project Information

Project	LBNL
Scenario	Existing + Project (Phase 1) PM
Freeway	WB I-580
On-ramp	Regatta Blvd
Off-ramp	Marina Bay Parkway



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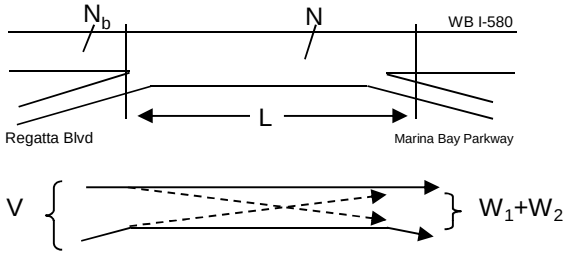


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   45 MPH and **50 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **45.5**
4. Weaving Intensity Factor (k) **2.53**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **741**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

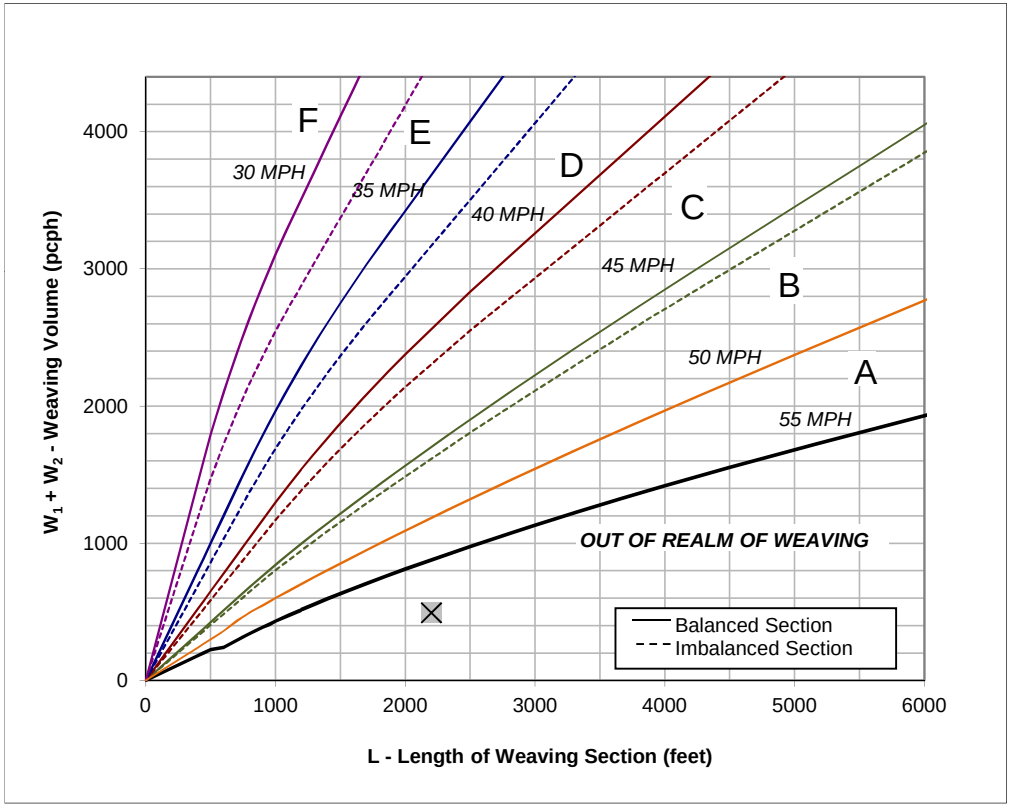
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,730	Volume (vph)*	400	Volume (vph)*	80
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,812	Volume (pcph)	412	Volume (pcph)	82

Project Information

Project	LBNL
Scenario	Existing + Project (Phase 1) PM
Freeway	EB I-580
On-ramp	Regatta Blvd
Off-ramp	Bayview Ave



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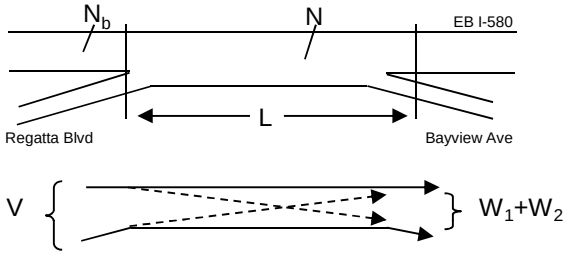


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **61.3**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **703**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

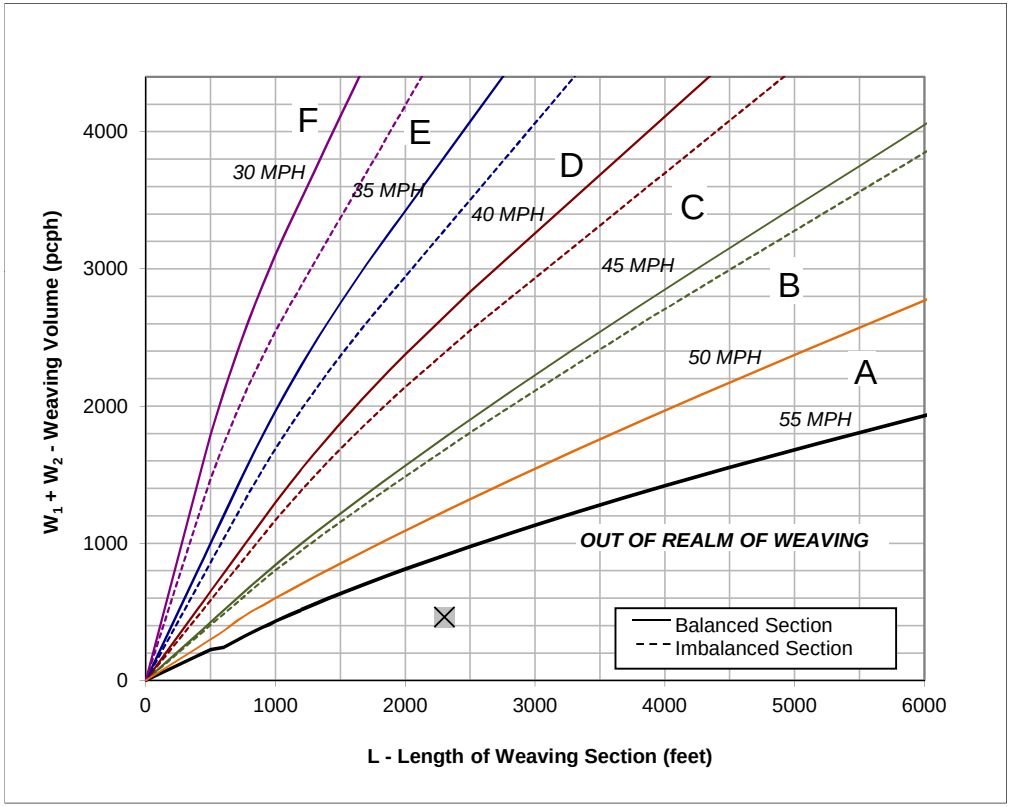
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,300

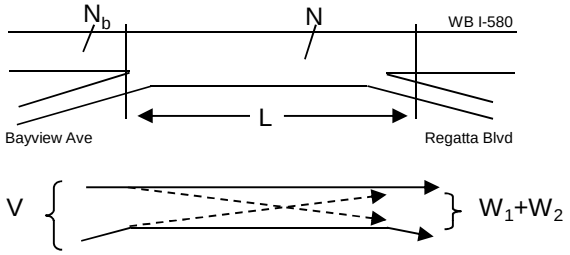
Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,780	Volume (vph)*	290	Volume (vph)*	160
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,863	Volume (pcph)	299	Volume (pcph)	165

Project Information

Project	LBNL
Scenario	Existing + Project (Phase 1) PM
Freeway	WB I-580
On-ramp	Bayview Ave
Off-ramp	Regatta Blvd



Figure



Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **62.1**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **716**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Existing Plus Project Buildout Conditions

FEHR PEERS

HCM 2000
Basic Freeway Segments
Capacity Analysis

Jurisdiction
Analysis Year Existing + Project (Buildout)
Analyst EK

Agency or Company
Date
Project Description

General Information | *Flow Rate Calculation* | *Speed Calculation* | *Results*

	Freeway/ Direction	From/To	Analysis Time Period	Volume (vph)	PHF	Lanes	HOV Lane?	HOV Lane Volume	Terrain	Truck/ Bus %	RV %	E_T	E_R	f_{HV}	f_P	Flow Rate v_p (pcphpl)	Measured FFS (mph)	S (mph)	Density, D (pcplpm)	Level of Service
R-5	I-580 EB	I-580 between Bayview Avenue and Central Avenue	AM	2,779	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,037	65.0	65.0	**16.0**	**B**
R-6	I-580 EB	I-580 between Central Avenue and I-80	AM	2,829	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,584	65.0	64.9	**24.4**	**C**
R-7	I-80 EB	I-80 between Carlson Boulevard and Potrero Avenue	AM	4,091	0.92	4	Yes	290	Level	4%	0%	1.5	1.2	0.980	1.00	1,405	65.0	65.0	**21.6**	**C**
R-8	I-80 EB	I-80 @ Gilman Overpass	AM	6,460	0.92	5	Yes	780	Level	5%	0%	1.5	1.2	0.976	1.00	1,582	65.0	64.9	**24.4**	**C**
R-5	I-580 WB	I-580 between Bayview Avenue and Central Avenue	AM	3,110	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,161	65.0	65.0	**17.9**	**B**
R-6	I-580 WB	I-580 between Central Avenue and I-80	AM	3,510	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,965	65.0	62.0	**31.7**	**D**
R-7	I-80 WB	I-80 between Carlson Boulevard and Potrero Avenue	AM	6,329	0.92	4	Yes	960	Level	4%	0%	1.5	1.2	0.980	1.00	1,984	65.0	61.7	**32.2**	**D**
R-8	I-80 WB	I-80 @ Gilman Overpass	AM	8,449	0.92	5	Yes	1410	Level	5%	0%	1.5	1.2	0.976	1.00	1,961	65.0	62.1	**31.6**	**D**
R-5	I-580 EB	I-580 between Bayview Avenue and Central Avenue	PM	3,027	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,130	65.0	65.0	**17.4**	**B**
R-6	I-580 EB	I-580 between Central Avenue and I-80	PM	3,847	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	2,153	65.0	58.3	**37.0**	**E**
R-7	I-80 EB	I-80 between Carlson Boulevard and Potrero Avenue	PM	6,302	0.92	4	Yes	1260	Level	4%	0%	1.5	1.2	0.980	1.00	1,863	65.0	63.3	**29.4**	**D**
R-8	I-80 EB	I-80 @ Gilman Overpass	PM	7,401	0.92	5	Yes	1020	Level	5%	0%	1.5	1.2	0.976	1.00	1,777	65.0	64.1	**27.7**	**D**
R-5	I-580 WB	I-580 between Bayview Avenue and Central Avenue	PM	3,031	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,131	65.0	65.0	**17.4**	**B**
R-6	I-580 WB	I-580 between Central Avenue and I-80	PM	2,711	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,518	65.0	65.0	**23.4**	**C**
R-7	I-80 WB	I-80 between Carlson Boulevard and Potrero Avenue	PM	4,597	0.92	4	Yes	330	Level	4%	0%	1.5	1.2	0.980	1.00	1,577	65.0	64.9	**24.3**	**C**
R-8	I-80 WB	I-80 @ Gilman Overpass	PM	7,167	0.92	5	Yes	630	Level	5%	0%	1.5	1.2	0.976	1.00	1,821	65.0	63.7	**28.6**	**D**

Leisch Method for Weaving Analysis

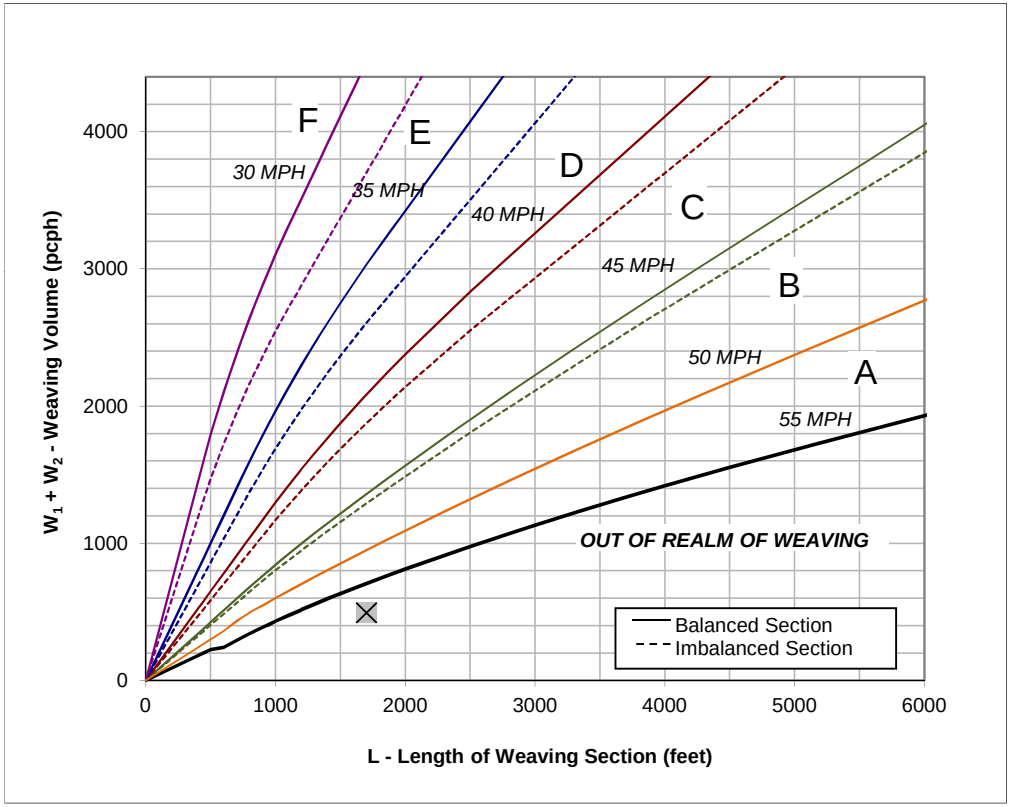
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,700

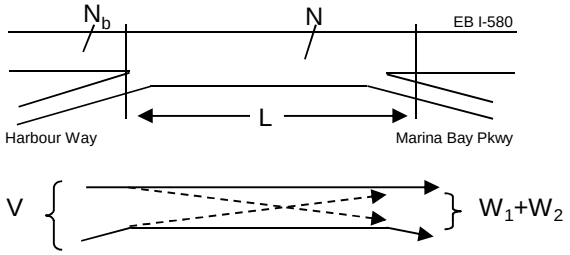
Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,423	Volume (vph)*	320	Volume (vph)*	160
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,496	Volume (pcph)	330	Volume (pcph)	165

Project Information

Project	LBNL
Scenario	Existing + Project (Buildout) AM
Freeway	EB I-580
On-ramp	Harbour Way
Off-ramp	Marina Bay Pkwy



Figure



Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **59.4**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **624**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

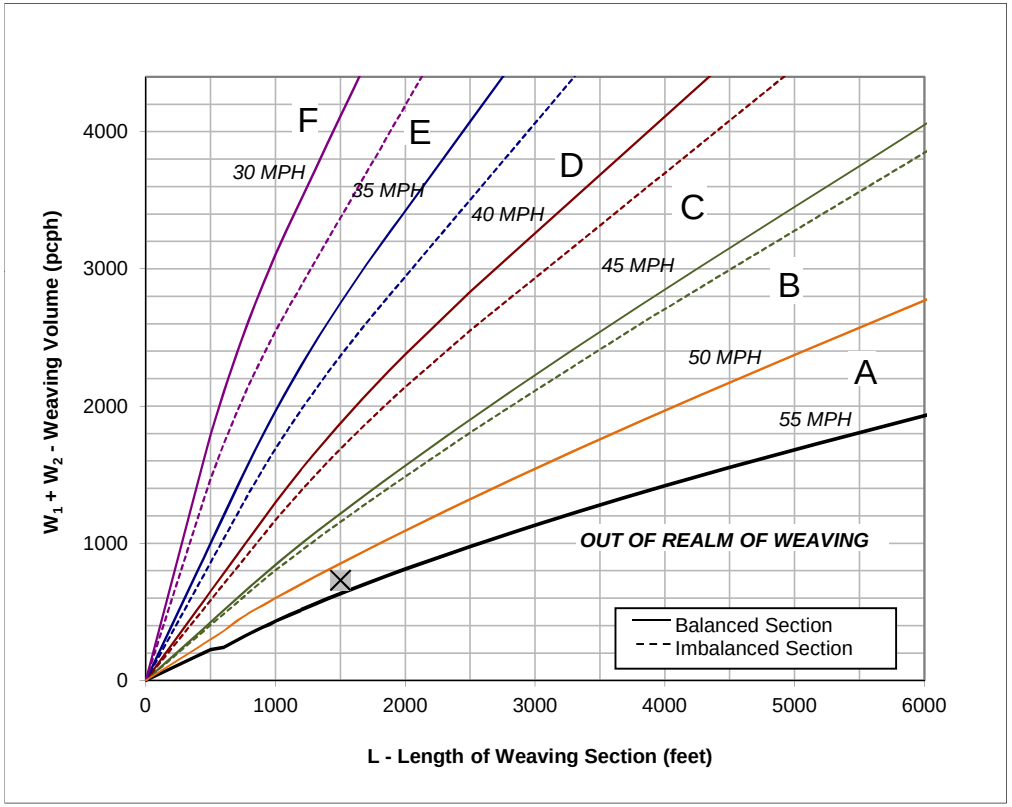
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,500

	Total Weaving Section (V)	On-ramp to Mainline (W_1)	Mainline to Off-ramp (W_2)
Volume (vph)*	2,252	320	390
Truck Percentage	6%	6%	6%
PCE for Trucks	1.5	1.5	1.5
Volume (pcph)	2,320	330	402

Project Information

Project	LBNL
Scenario	Existing + Project (Buildout) AM
Freeway	WB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Harbour Way



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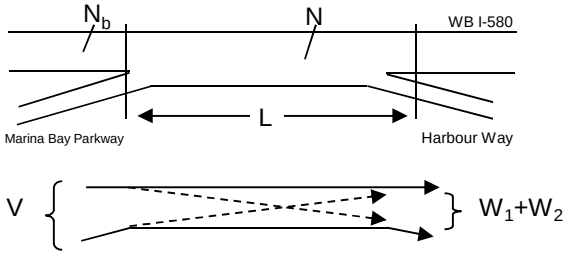


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **52.8**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **580**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

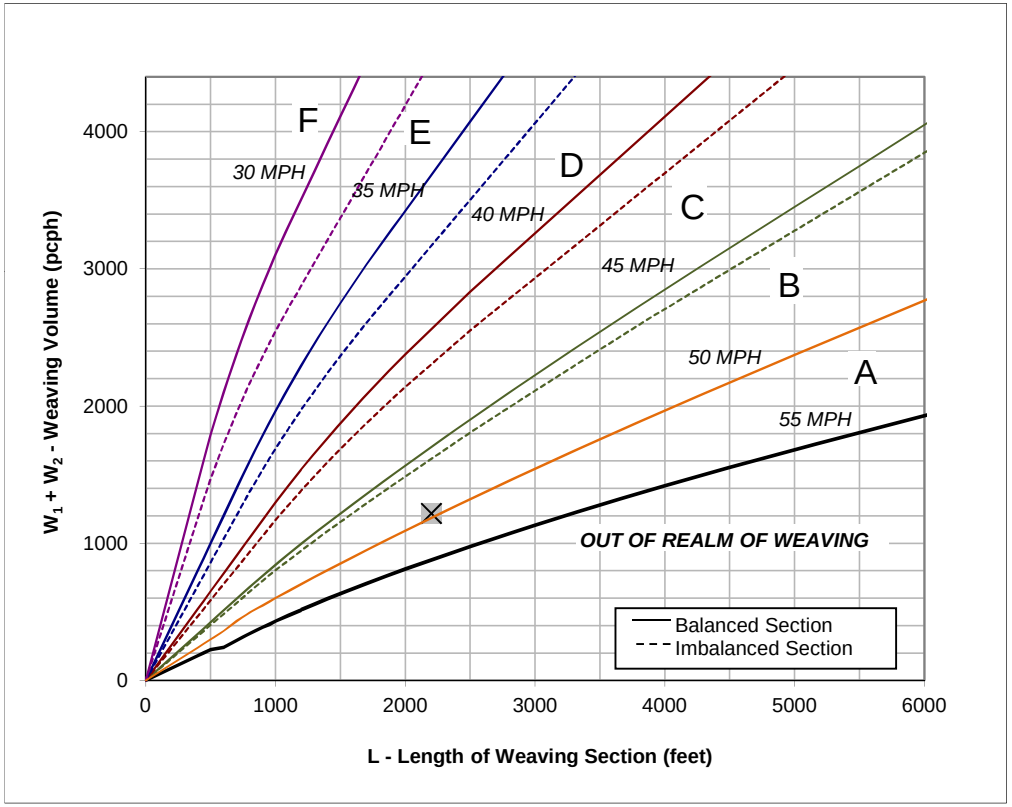
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,083	Volume (vph)*	820	Volume (vph)*	363
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,175	Volume (pcph)	845	Volume (pcph)	374

Project Information

Project	LBNL
Scenario	Existing + Project (Buildout) AM
Freeway	EB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Regatta Blvd



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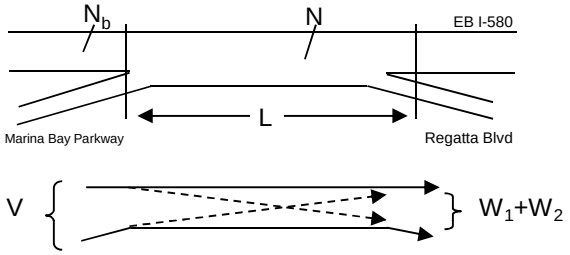


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **49.4**
4. Weaving Intensity Factor (k) **1.28**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **820**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

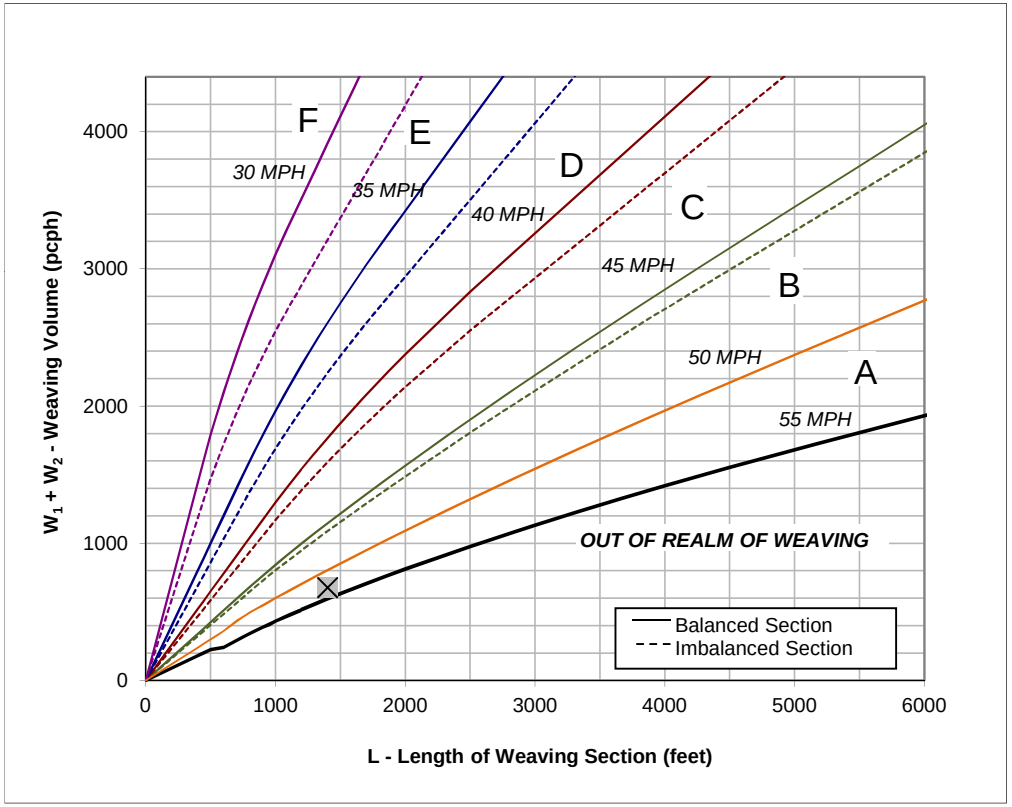
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,400

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,835	Volume (vph)*	175	Volume (vph)*	483
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,920	Volume (pcph)	180	Volume (pcph)	497

Project Information

Project	LBNL
Scenario	Existing + Project (Buildout) AM
Freeway	WB I-580
On-ramp	Regatta Blvd
Off-ramp	Marina Bay Parkway



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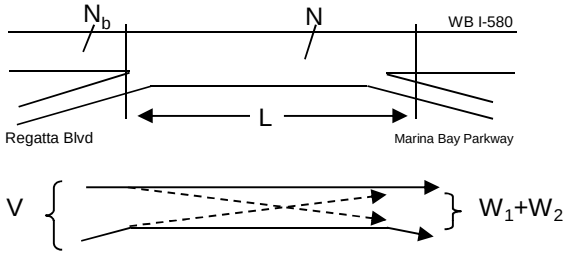


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **53.0**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **730**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

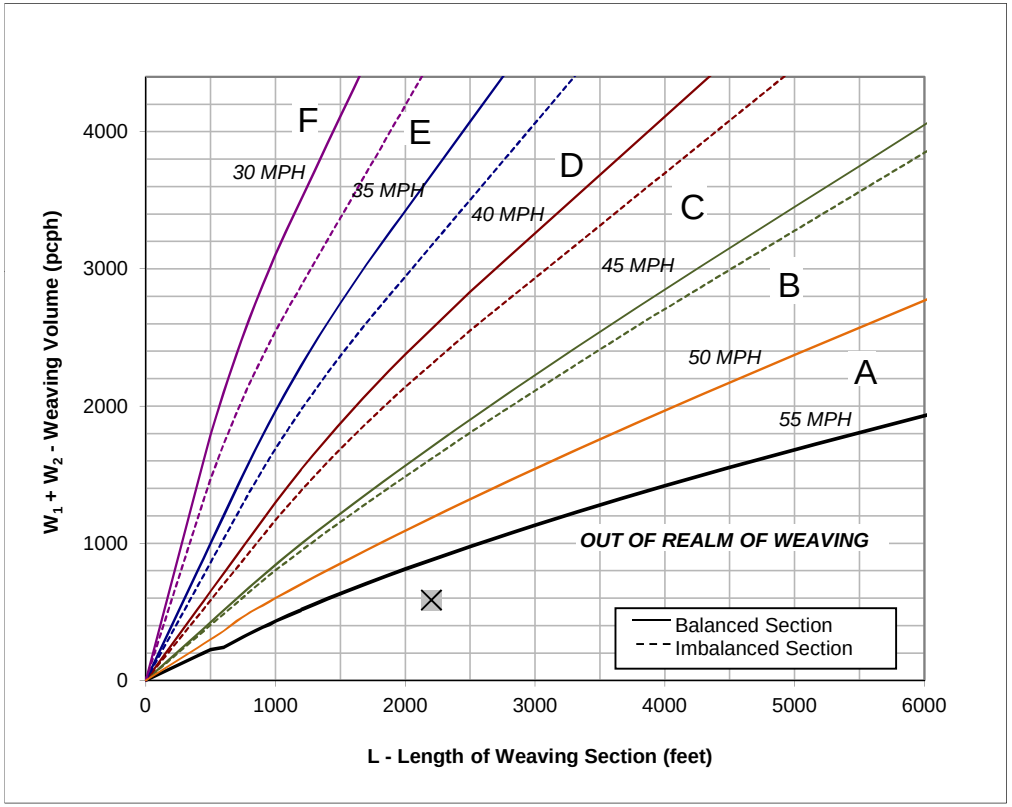
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,870	Volume (vph)*	140	Volume (vph)*	430
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,956	Volume (pcph)	144	Volume (pcph)	443

Project Information

Project	LBNL
Scenario	Existing + Project (Buildout) AM
Freeway	EB I-580
On-ramp	Regatta Blvd
Off-ramp	Bayview Ave



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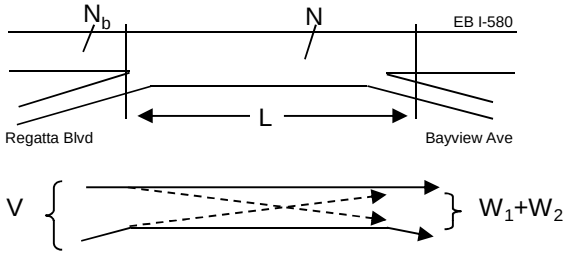


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **59.8**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **739**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

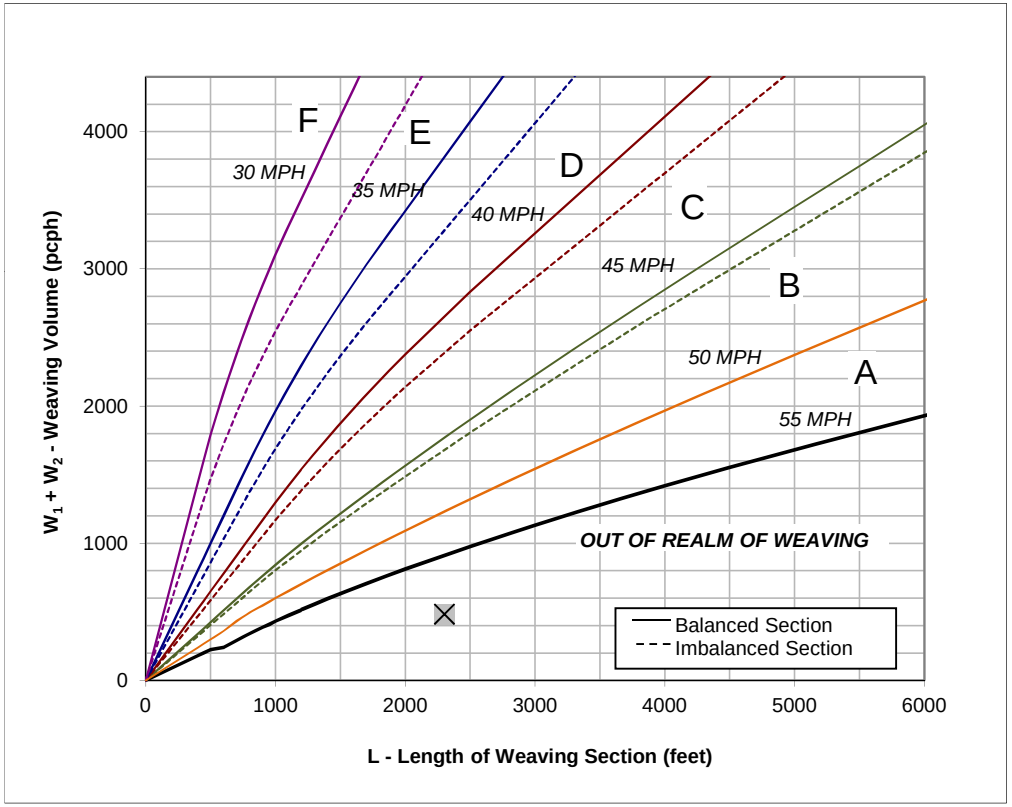
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,300

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,750	Volume (vph)*	380	Volume (vph)*	90
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,833	Volume (pcph)	391	Volume (pcph)	93

Project Information

Project	LBNL
Scenario	Existing + Project (Buildout) AM
Freeway	WB I-580
On-ramp	Bayview Ave
Off-ramp	Regatta Blvd



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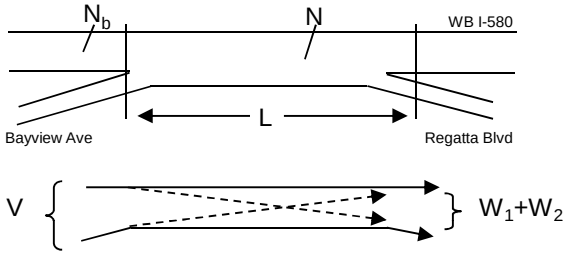


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **61.7**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **708**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

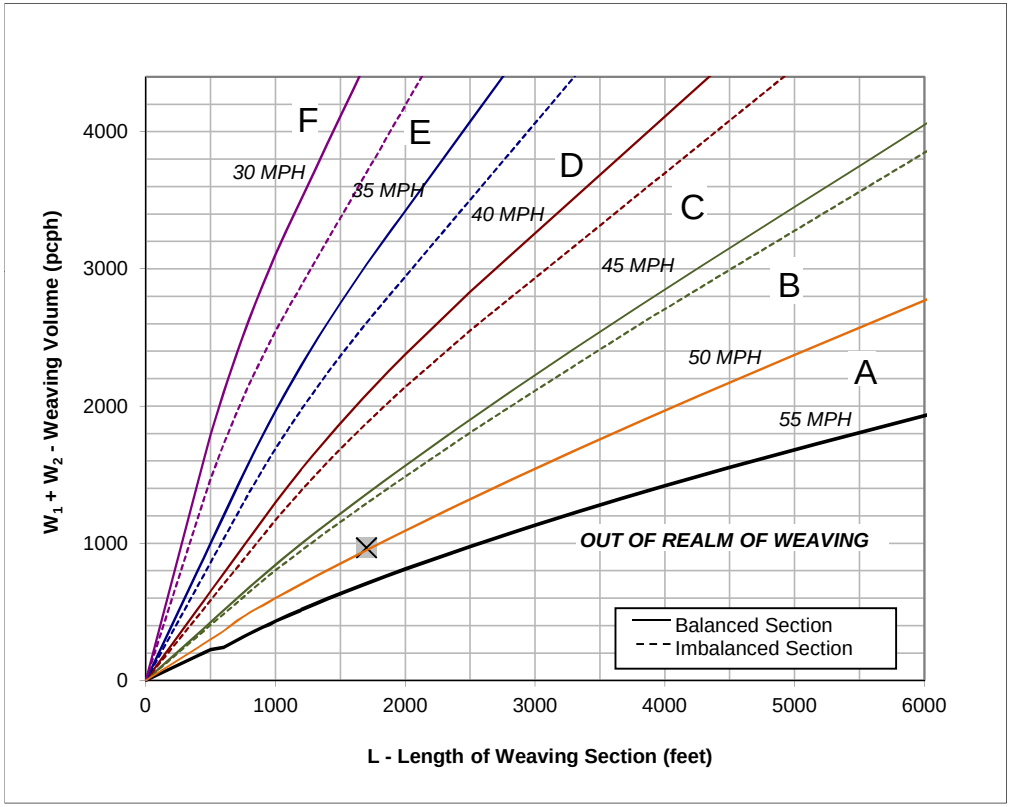
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,700

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,559	Volume (vph)*	600	Volume (vph)*	340
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,636	Volume (pcph)	618	Volume (pcph)	350

Project Information

Project	LBNL
Scenario	Existing + Project (Buildout) PM
Freeway	EB I-580
On-ramp	Harbour Way
Off-ramp	Marina Bay Pkwy



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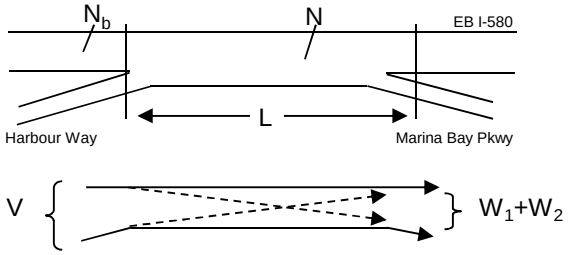


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **49.6**
4. Weaving Intensity Factor (k) **1.25**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **681**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

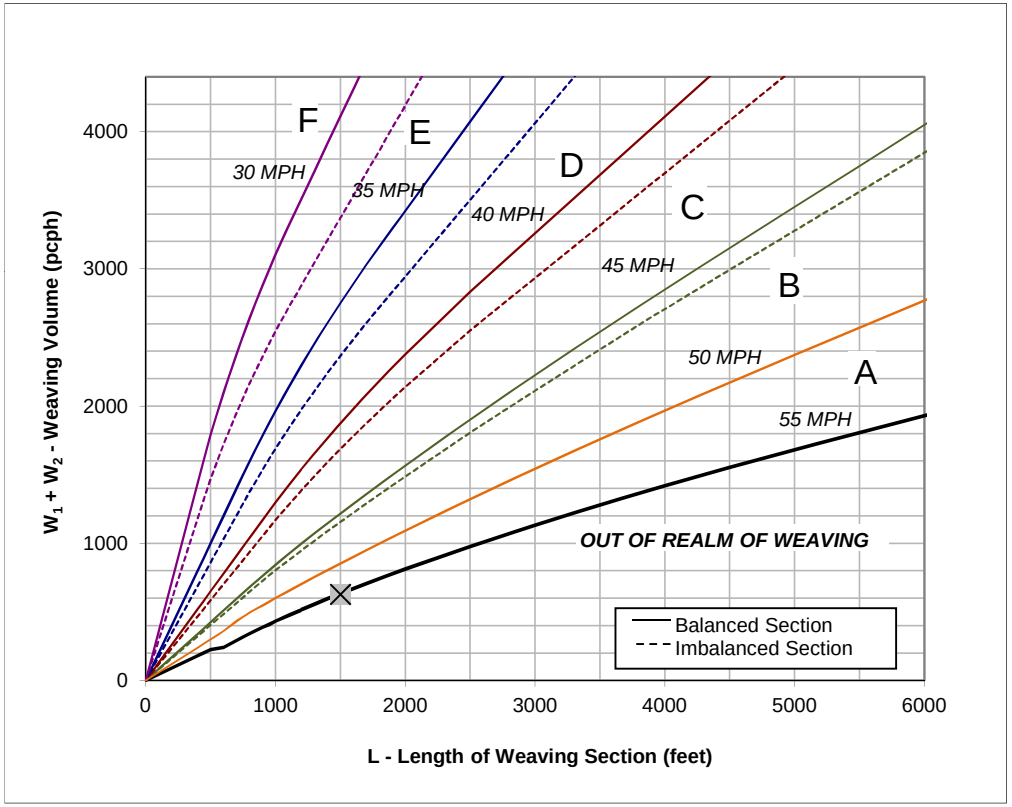
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,500

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,162	Volume (vph)*	220	Volume (vph)*	390
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,227	Volume (pcph)	227	Volume (pcph)	402

Project Information

Project	LBNL
Scenario	Existing + Project (Buildout) PM
Freeway	WB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Harbour Way



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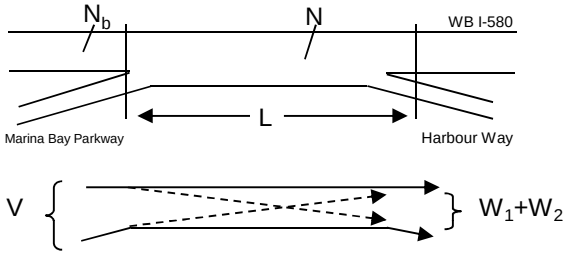


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **55.1**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **557**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

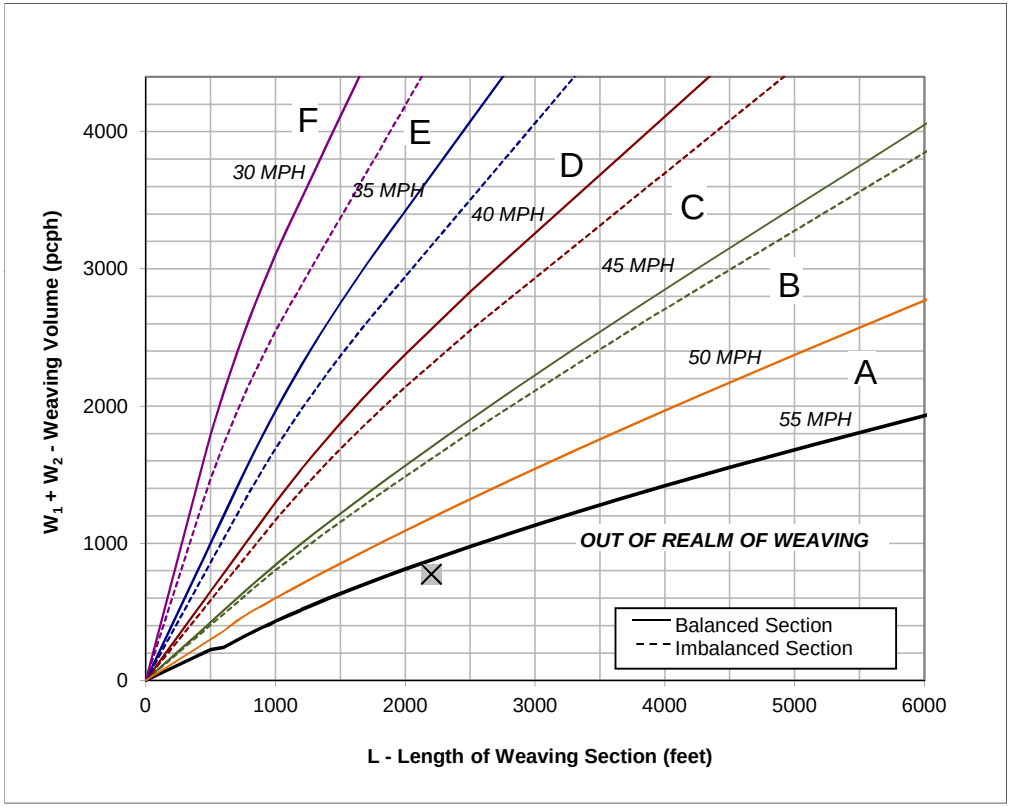
Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Project Information	
Project	LBNL
Scenario	Existing + Project (Buildout) PM
Freeway	EB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Regatta Blvd

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,811	Volume (vph)*	592	Volume (vph)*	161
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,895	Volume (pcph)	610	Volume (pcph)	166



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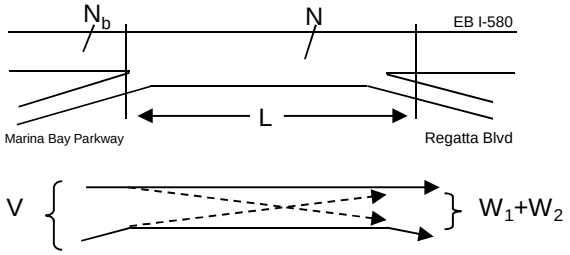


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **56.7**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **724**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

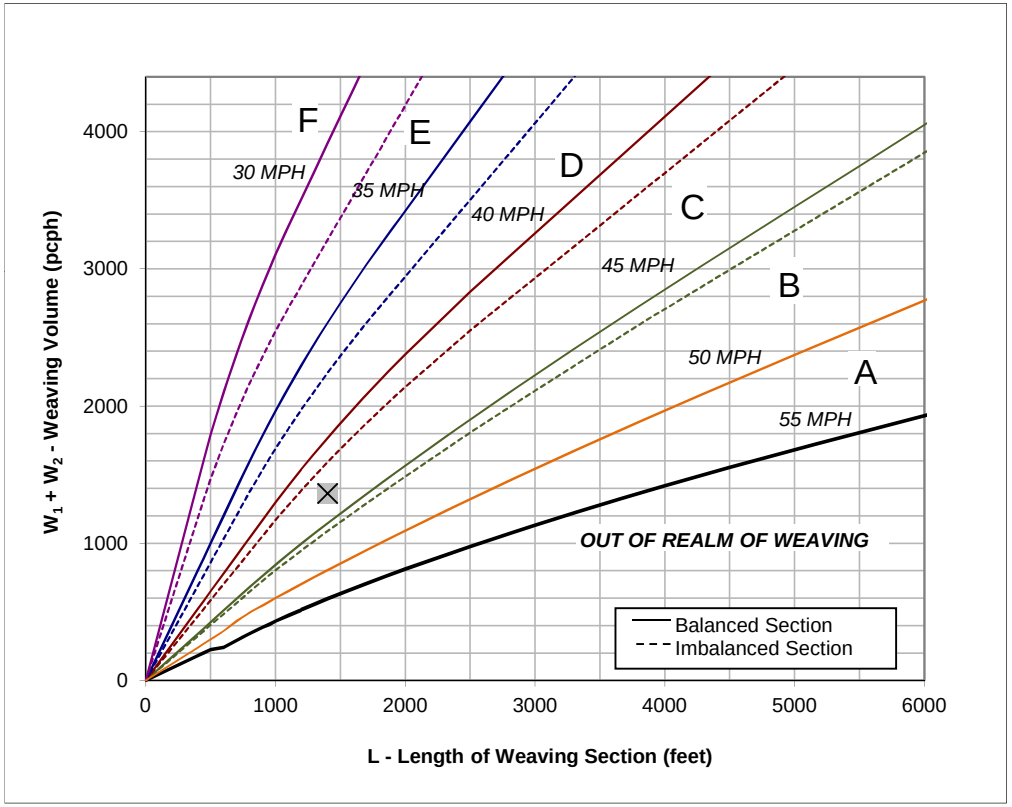
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,400

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,938	Volume (vph)*	328	Volume (vph)*	996
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,026	Volume (pcph)	338	Volume (pcph)	1,026

Project Information

Project	LBNL
Scenario	Existing + Project (Buildout) PM
Freeway	WB I-580
On-ramp	Regatta Blvd
Off-ramp	Marina Bay Parkway



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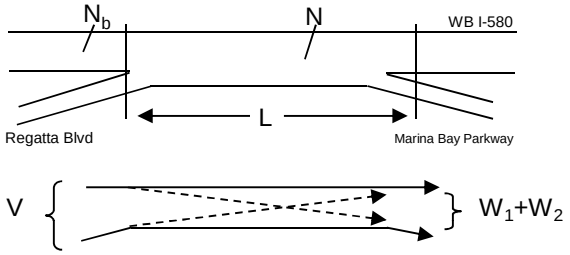


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   40 MPH and **45 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **42.3**
4. Weaving Intensity Factor (k) **3.05**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **930**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

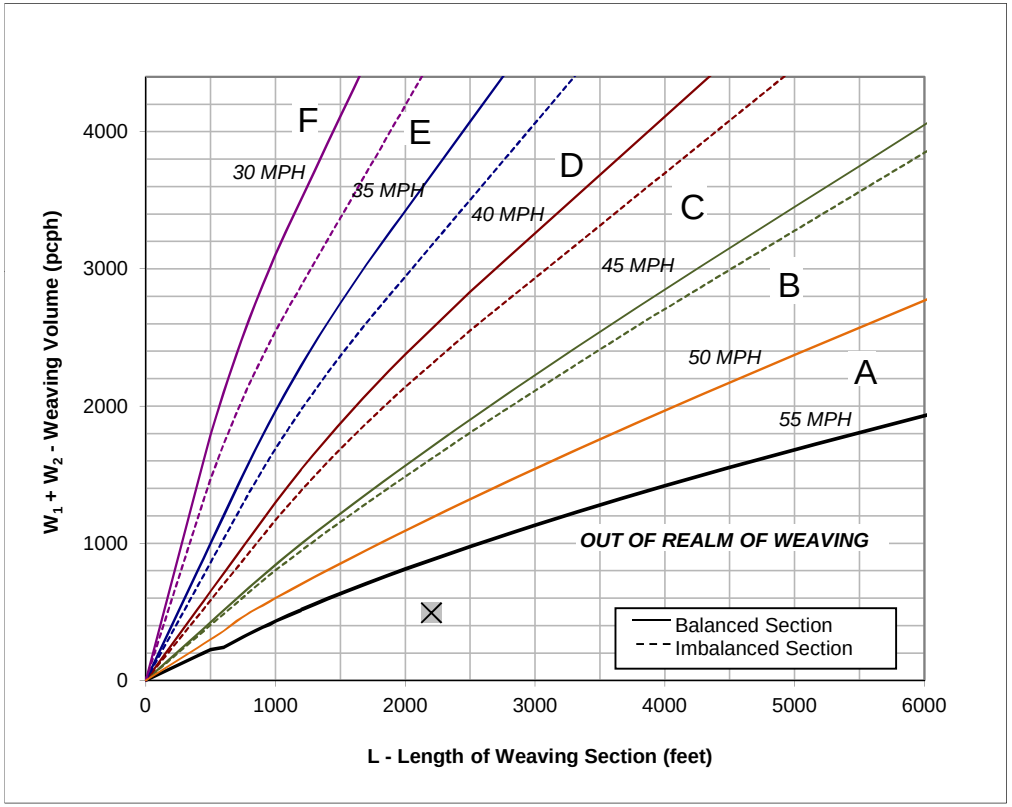
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,730	Volume (vph)*	400	Volume (vph)*	80
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,812	Volume (pcph)	412	Volume (pcph)	82

Project Information

Project	LBNL
Scenario	Existing + Project (Buildout) PM
Freeway	EB I-580
On-ramp	Regatta Blvd
Off-ramp	Bayview Ave



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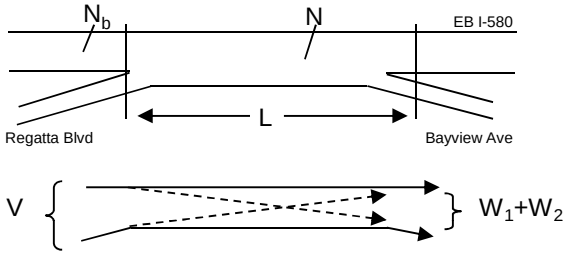


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **61.3**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **703**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

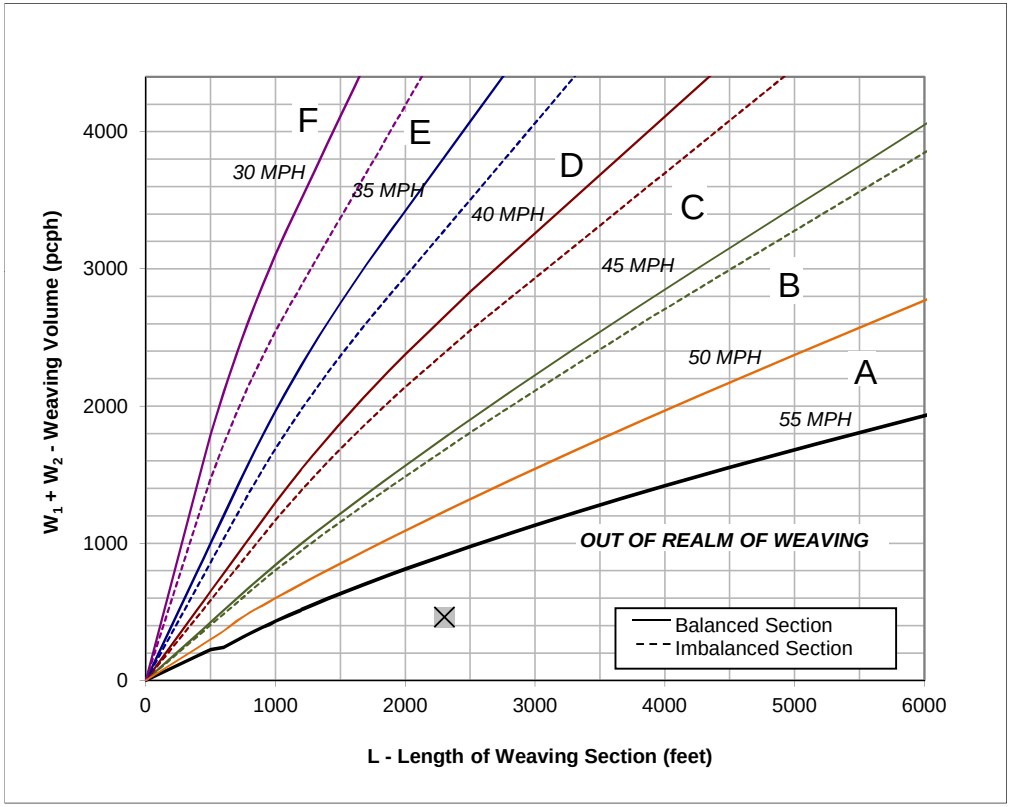
Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,300

Project Information	
Project	LBNL
Scenario	Existing + Project (Buildout) PM
Freeway	WB I-580
On-ramp	Bayview Ave
Off-ramp	Regatta Blvd

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,780	Volume (vph)*	290	Volume (vph)*	160
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,863	Volume (pcph)	299	Volume (pcph)	165



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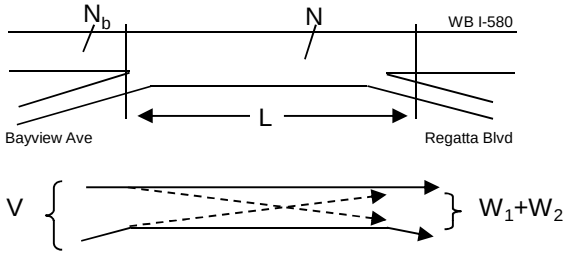


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **62.1**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **716**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Near-Term (2018) No Project Conditions

FEHR PEERS

HCM 2000
Basic Freeway Segments
Capacity Analysis

Jurisdiction
Analysis Year Near-Term
Analyst TL

Agency or Company
Date
Project Description

General Information | *Flow Rate Calculation* | *Speed Calculation* | *Results*

	Freeway/ Direction	From/To	Analysis Time Period	Volume (vph)	PHF	Lanes	HOV Lane?	HOV Lane Volume	Terrain	Truck/ Bus %	RV %	E_T	E_R	f_{HV}	f_P	Flow Rate v_p (pcphpl)	Measured FFS (mph)	S (mph)	Density, D (pcplpm)	Level of Service
R-5	I-580 EB	I-580 between Bayview Avenue and Central Avenue	AM	3,100	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,157	65.0	65.0	**17.8**	**B**
R-6	I-580 EB	I-580 between Central Avenue and I-80	AM	3,010	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,685	65.0	64.6	**26.1**	**D**
R-7	I-80 EB	I-80 between Carlson Boulevard and Potrero Avenue	AM	4,320	0.92	4	Yes	290	Level	4%	0%	1.5	1.2	0.980	1.00	1,489	65.0	65.0	**22.9**	**C**
R-8	I-80 EB	I-80 @ Gilman Overpass	AM	6,140	0.92	5	Yes	780	Level	5%	0%	1.5	1.2	0.976	1.00	1,493	65.0	65.0	**23.0**	**C**
R-5	I-580 WB	I-580 between Bayview Avenue and Central Avenue	AM	3,010	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,123	65.0	65.0	**17.3**	**B**
R-6	I-580 WB	I-580 between Central Avenue and I-80	AM	3,300	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,847	65.0	63.5	**29.1**	**D**
R-7	I-80 WB	I-80 between Carlson Boulevard and Potrero Avenue	AM	6,280	0.92	4	Yes	1000	Level	4%	0%	1.5	1.2	0.980	1.00	1,951	65.0	62.2	**31.4**	**D**
R-8	I-80 WB	I-80 @ Gilman Overpass	AM	8,530	0.92	5	Yes	1410	Level	5%	0%	1.5	1.2	0.976	1.00	1,983	65.0	61.7	**32.1**	**D**
R-5	I-580 EB	I-580 between Bayview Avenue and Central Avenue	PM	2,970	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,108	65.0	65.0	**17.1**	**B**
R-6	I-580 EB	I-580 between Central Avenue and I-80	PM	3,590	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	2,010	65.0	61.3	**32.8**	**D**
R-7	I-80 EB	I-80 between Carlson Boulevard and Potrero Avenue	PM	6,180	0.92	4	Yes	1300	Level	4%	0%	1.5	1.2	0.980	1.00	1,803	65.0	63.9	**28.2**	**D**
R-8	I-80 EB	I-80 @ Gilman Overpass	PM	7,570	0.92	5	Yes	1070	Level	5%	0%	1.5	1.2	0.976	1.00	1,810	65.0	63.8	**28.4**	**D**
R-5	I-580 WB	I-580 between Bayview Avenue and Central Avenue	PM	3,240	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,209	65.0	65.0	**18.6**	**C**
R-6	I-580 WB	I-580 between Central Avenue and I-80	PM	2,790	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,562	65.0	64.9	**24.0**	**C**
R-7	I-80 WB	I-80 between Carlson Boulevard and Potrero Avenue	PM	4,770	0.92	4	Yes	330	Level	4%	0%	1.5	1.2	0.980	1.00	1,641	65.0	64.8	**25.3**	**C**
R-8	I-80 WB	I-80 @ Gilman Overpass	PM	6,740	0.92	5	Yes	650	Level	5%	0%	1.5	1.2	0.976	1.00	1,696	65.0	64.6	**26.3**	**D**

Leisch Method for Weaving Analysis

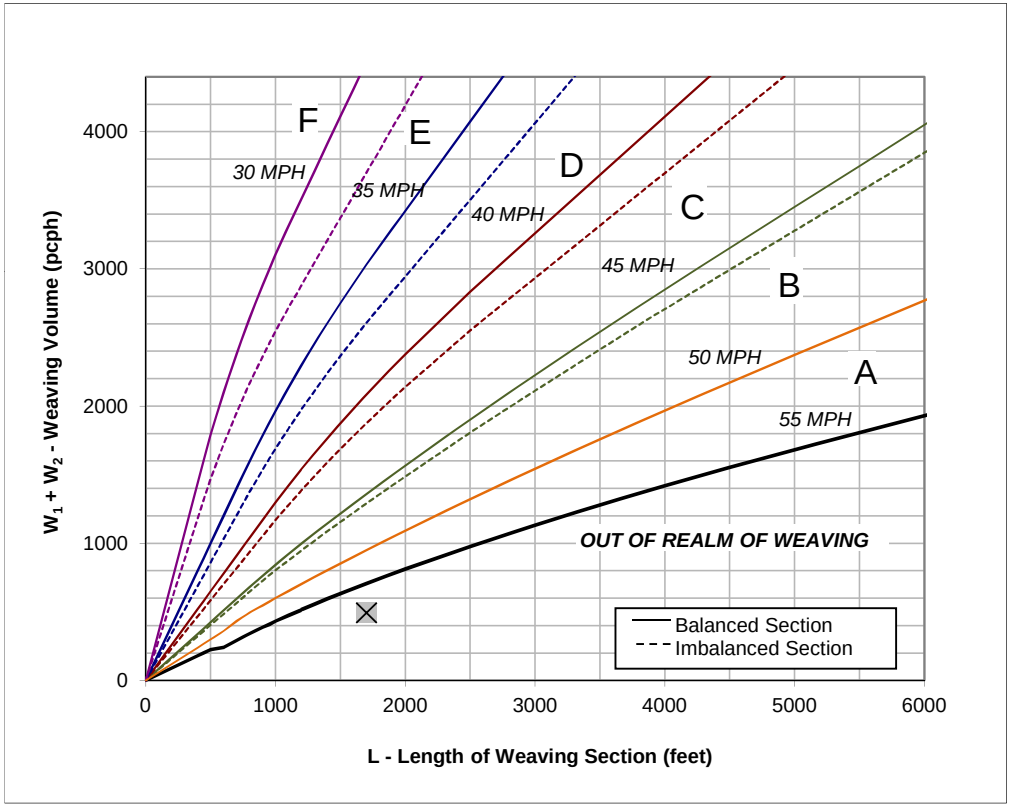
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,700

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,410	Volume (vph)*	320	Volume (vph)*	160
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,482	Volume (pcph)	330	Volume (pcph)	165

Project Information

Project	LBNL
Scenario	Near-Term AM
Freeway	EB I-580
On-ramp	Harbour Way
Off-ramp	Marina Bay Pkwy



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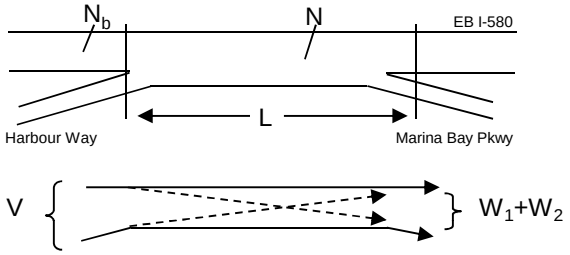


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **59.4**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **621**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

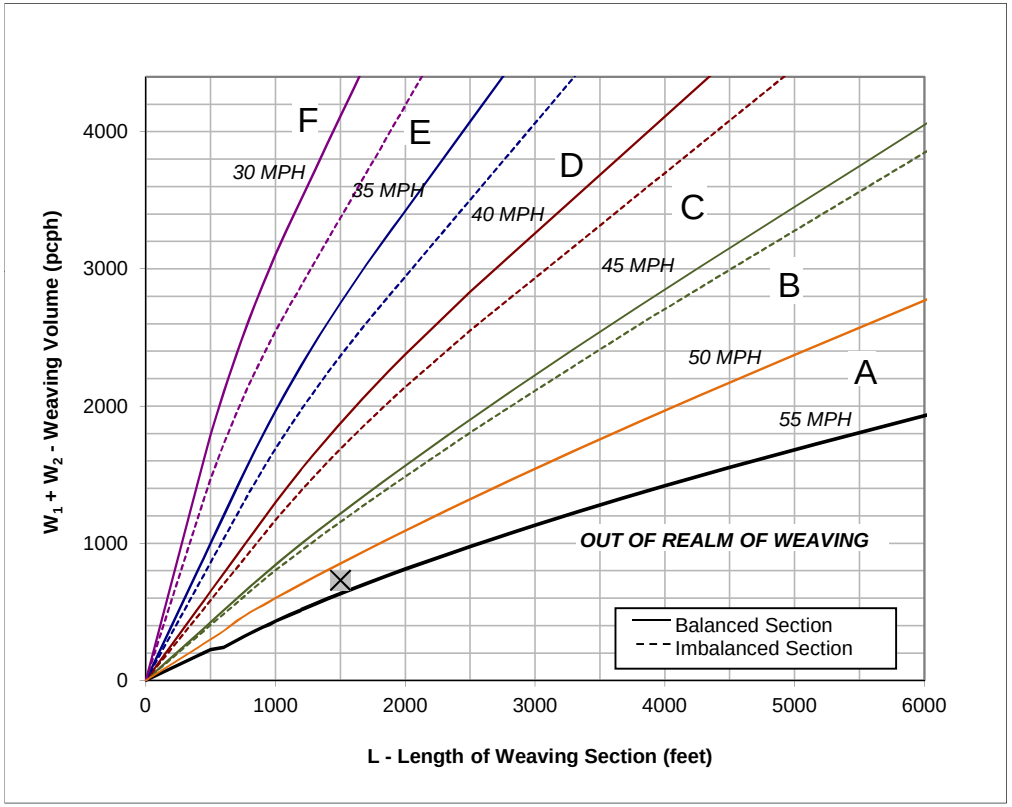
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,500

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,780	Volume (vph)*	320	Volume (vph)*	390
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,863	Volume (pcph)	330	Volume (pcph)	402

Project Information

Project	LBNL
Scenario	Near-Term AM
Freeway	WB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Harbour Way



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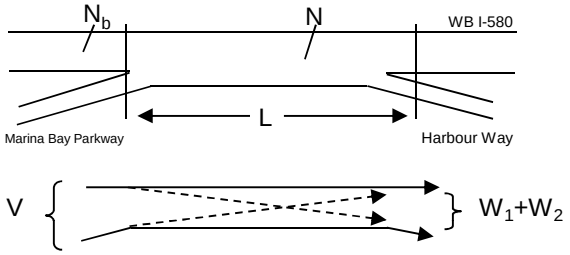


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **52.8**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **716**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

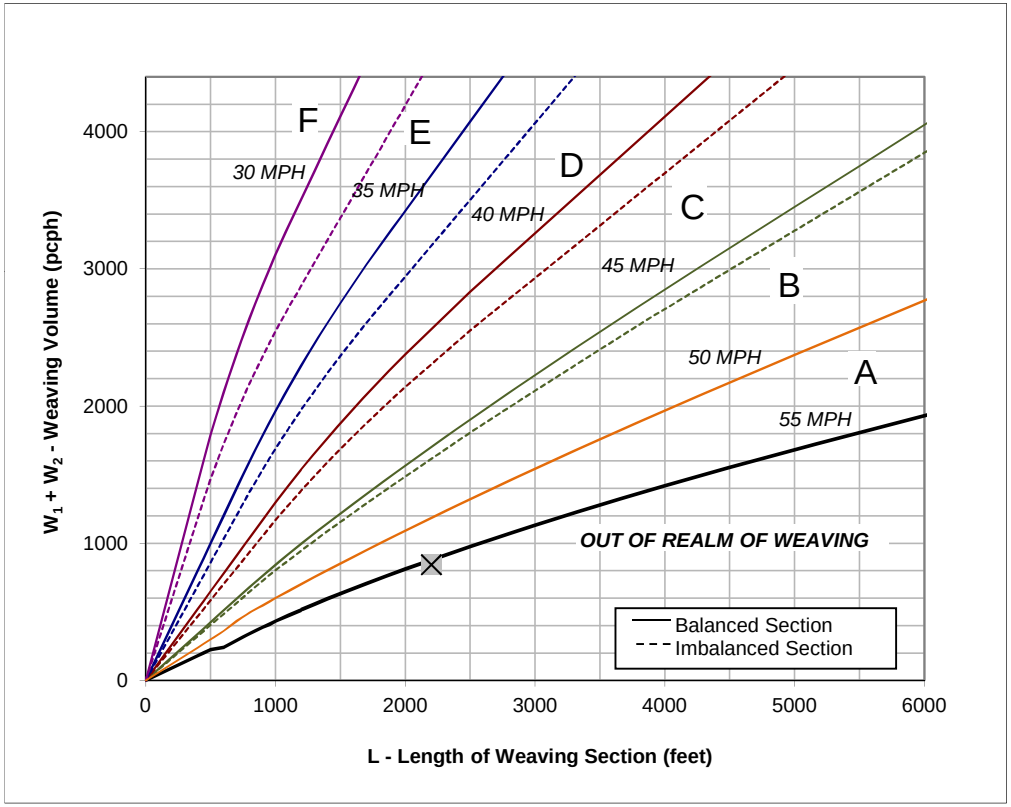
Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Project Information	
Project	LBNL
Scenario	Near-Term AM
Freeway	EB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Regatta Blvd

	Total Weaving Section (V)	On-ramp to Mainline (W_1)	Mainline to Off-ramp (W_2)
Volume (vph)*	3,080	740	80
Truck Percentage	6%	6%	6%
PCE for Trucks	1.5	1.5	1.5
Volume (pcph)	3,172	762	82



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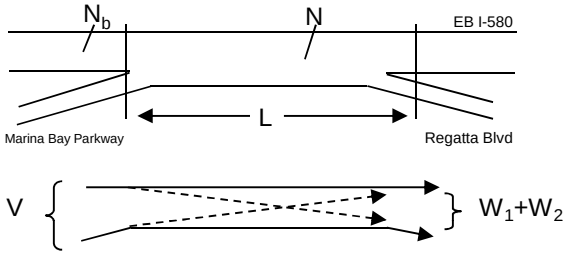


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **55.6**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **793**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

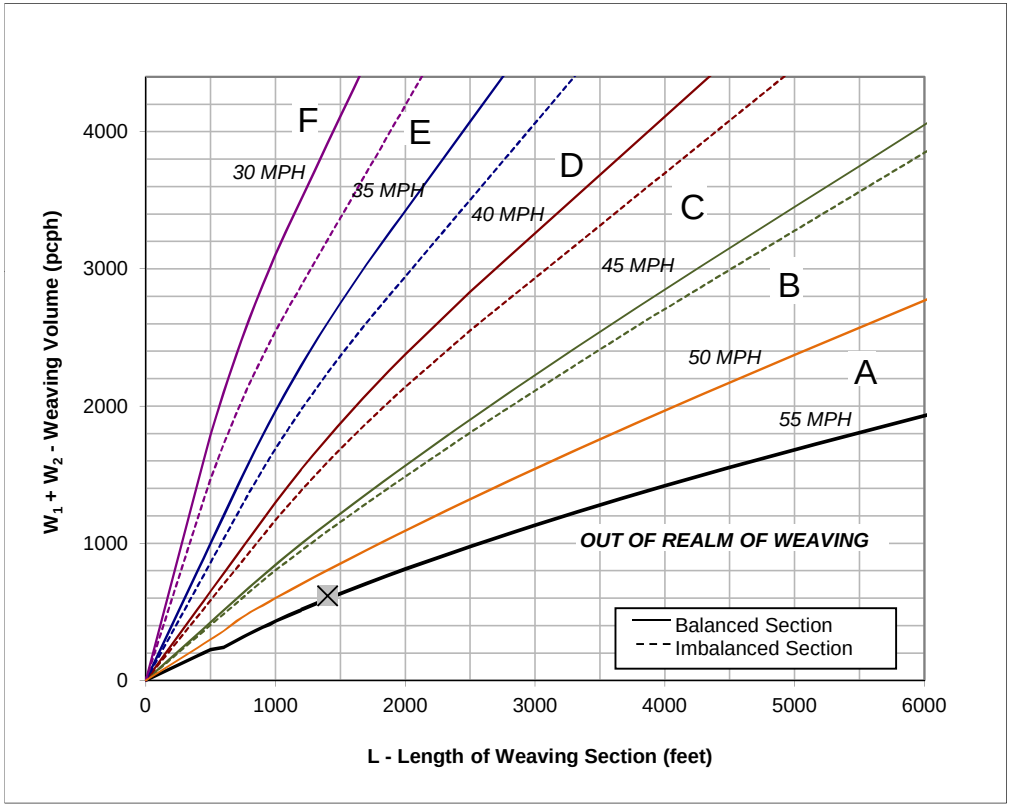
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,400

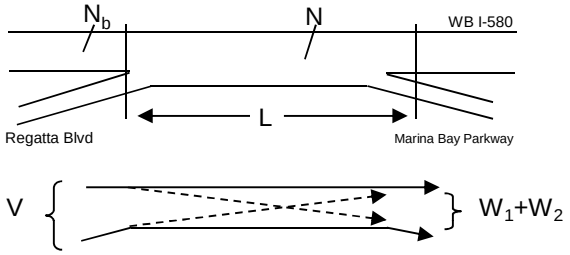
Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,350	Volume (vph)*	130	Volume (vph)*	470
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,451	Volume (pcph)	134	Volume (pcph)	484

Project Information

Project	LBNL
Scenario	Near-Term AM
Freeway	WB I-580
On-ramp	Regatta Blvd
Off-ramp	Marina Bay Parkway



Figure



Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **54.4**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **863**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

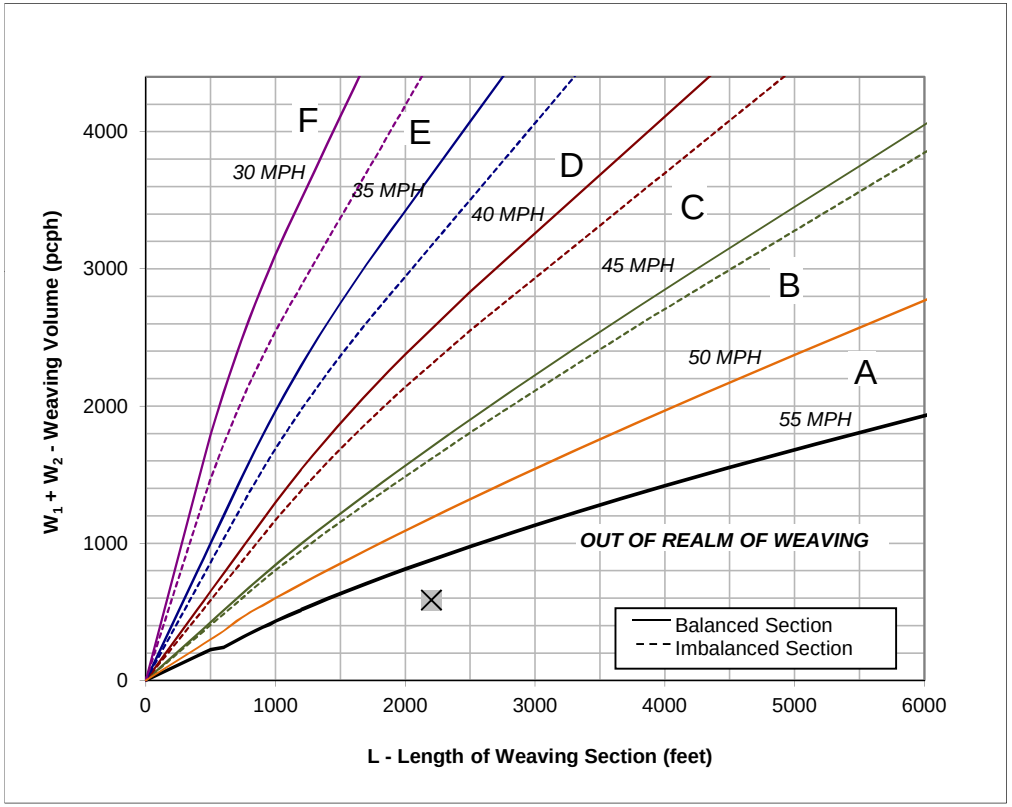
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,270	Volume (vph)*	140	Volume (vph)*	430
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,368	Volume (pcph)	144	Volume (pcph)	443

Project Information

Project	LBNL
Scenario	Near-Term AM
Freeway	EB I-580
On-ramp	Regatta Blvd
Off-ramp	Bayview Ave



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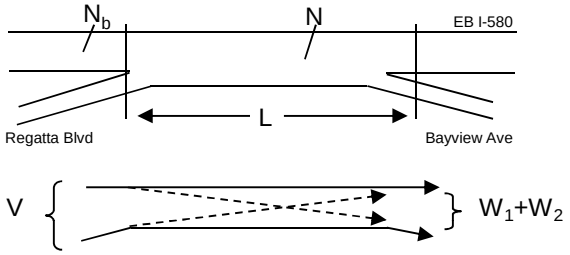


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **59.8**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **842**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

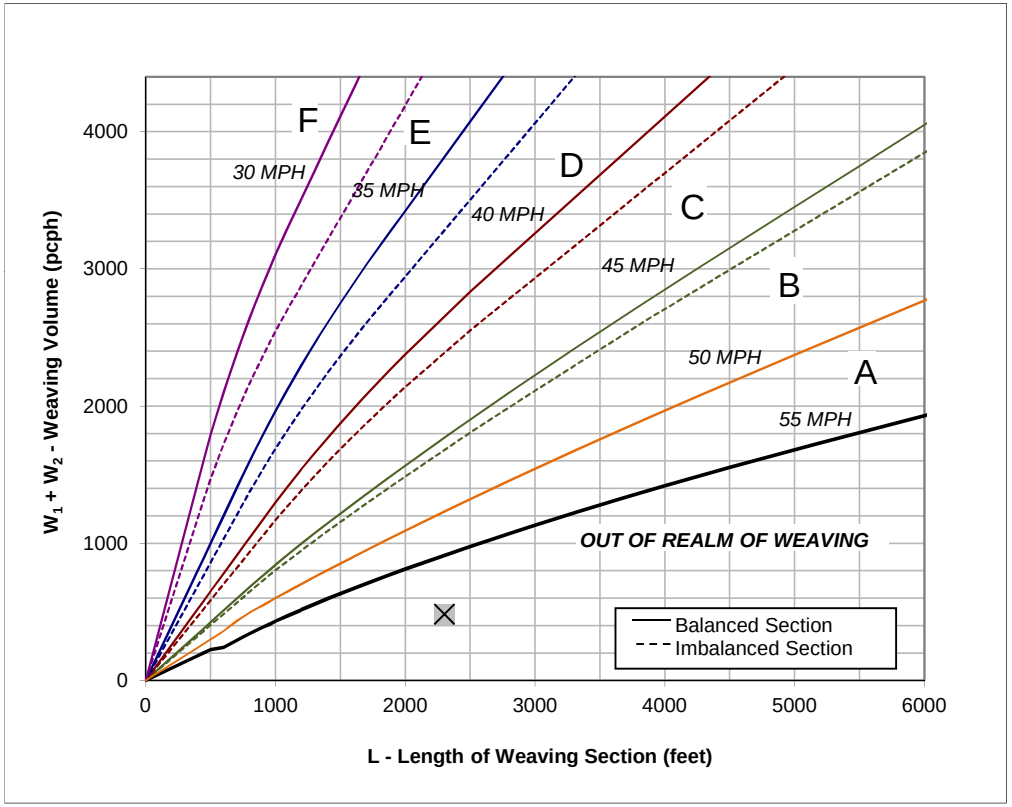
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,300

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,310	Volume (vph)*	380	Volume (vph)*	90
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,409	Volume (pcph)	391	Volume (pcph)	93

Project Information

Project	LBNL
Scenario	Near-Term AM
Freeway	WB I-580
On-ramp	Bayview Ave
Off-ramp	Regatta Blvd



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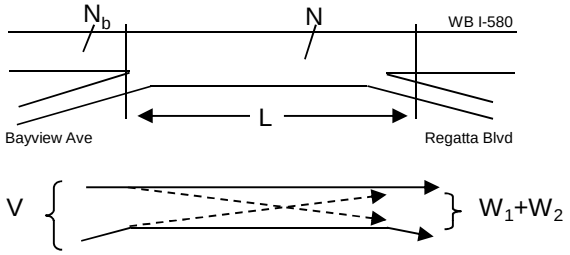


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **61.7**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **852**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

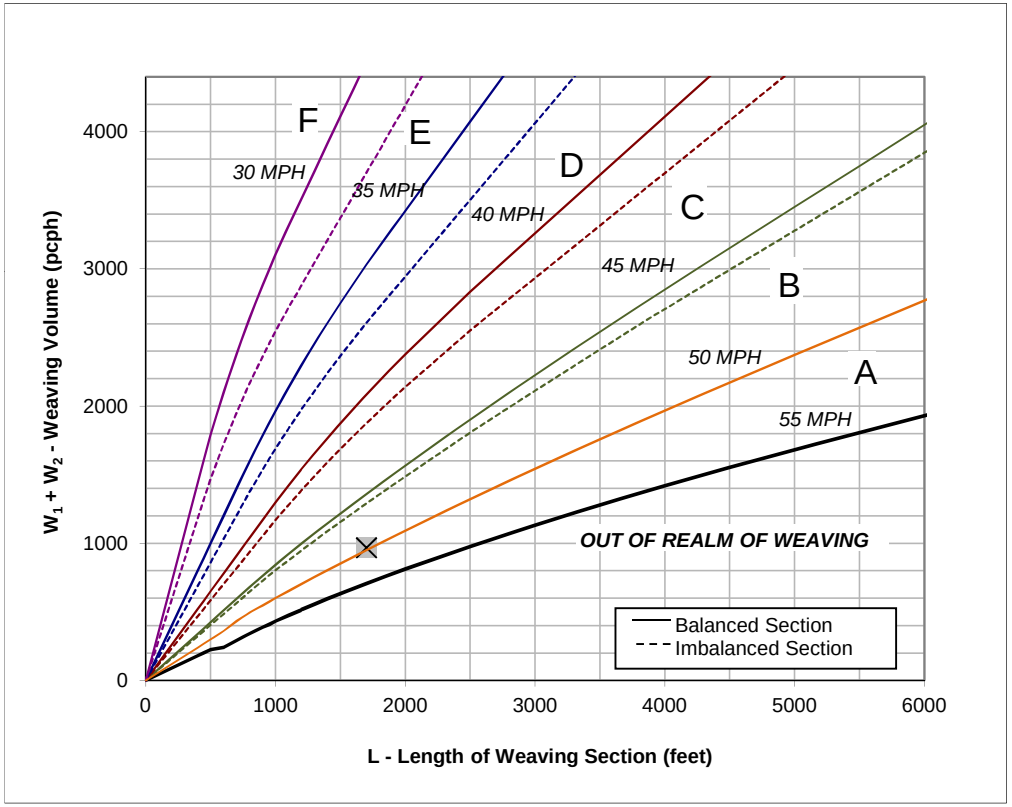
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,700

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,100	Volume (vph)*	600	Volume (vph)*	340
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,193	Volume (pcph)	618	Volume (pcph)	350

Project Information

Project	LBNL
Scenario	Near-Term PM
Freeway	EB I-580
On-ramp	Harbour Way
Off-ramp	Marina Bay Pkwy



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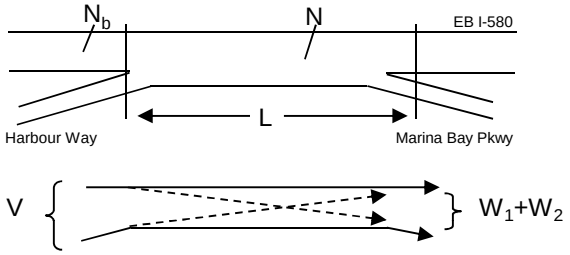


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **49.6**
4. Weaving Intensity Factor (k) **1.25**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **820**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

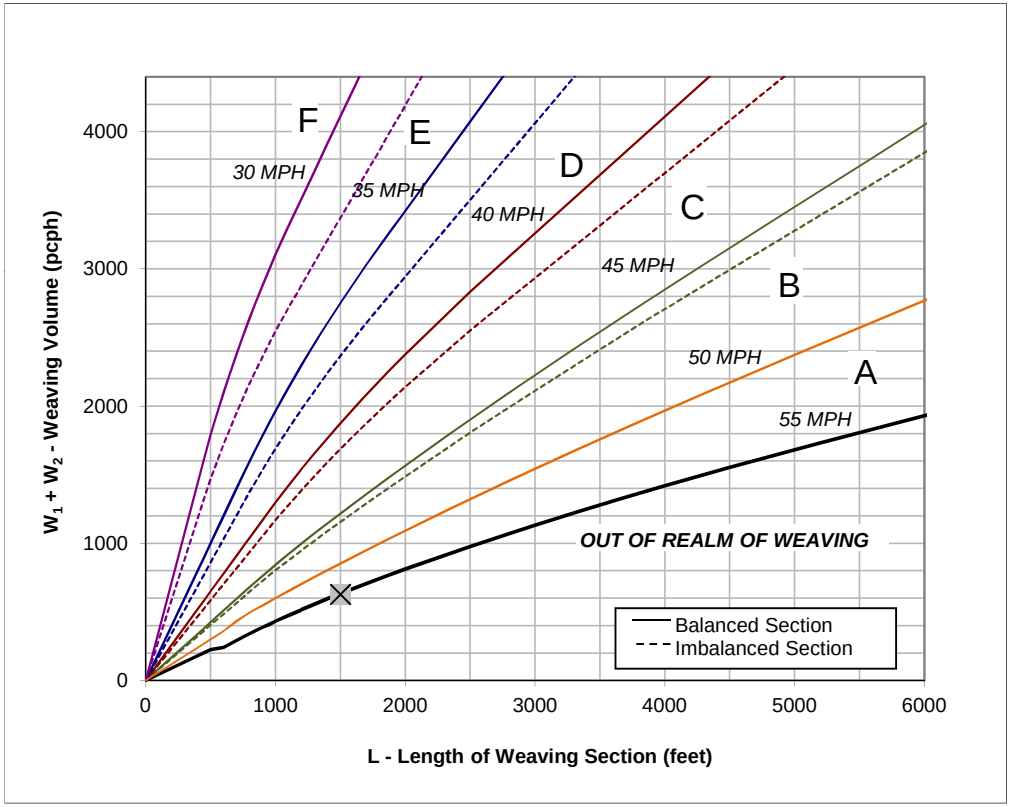
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,500

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,170	Volume (vph)*	220	Volume (vph)*	390
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,235	Volume (pcph)	227	Volume (pcph)	402

Project Information

Project	LBNL
Scenario	Near-Term PM
Freeway	WB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Harbour Way



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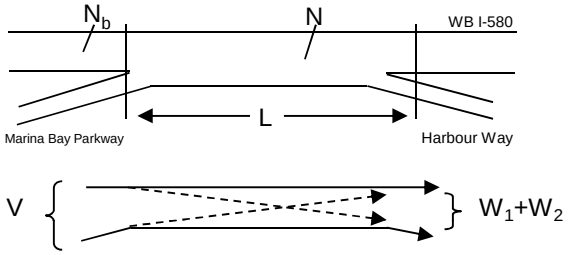


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **55.1**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **559**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

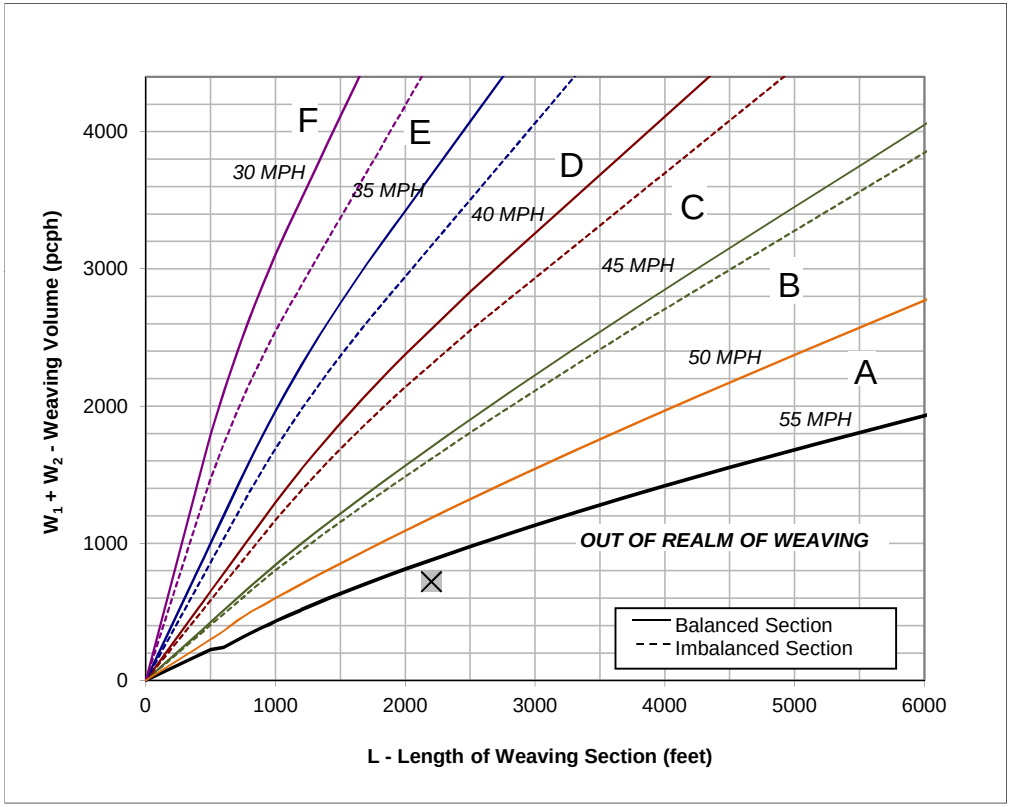
Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Project Information	
Project	LBNL
Scenario	Near-Term PM
Freeway	EB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Regatta Blvd

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,250	Volume (vph)*	580	Volume (vph)*	120
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,348	Volume (pcph)	597	Volume (pcph)	124



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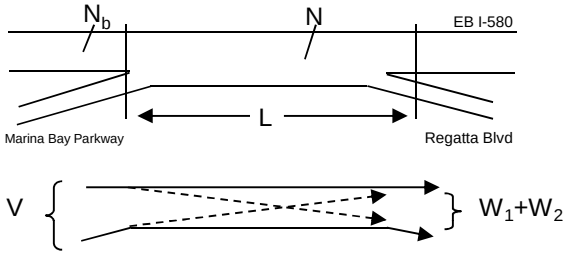


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **57.6**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **837**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

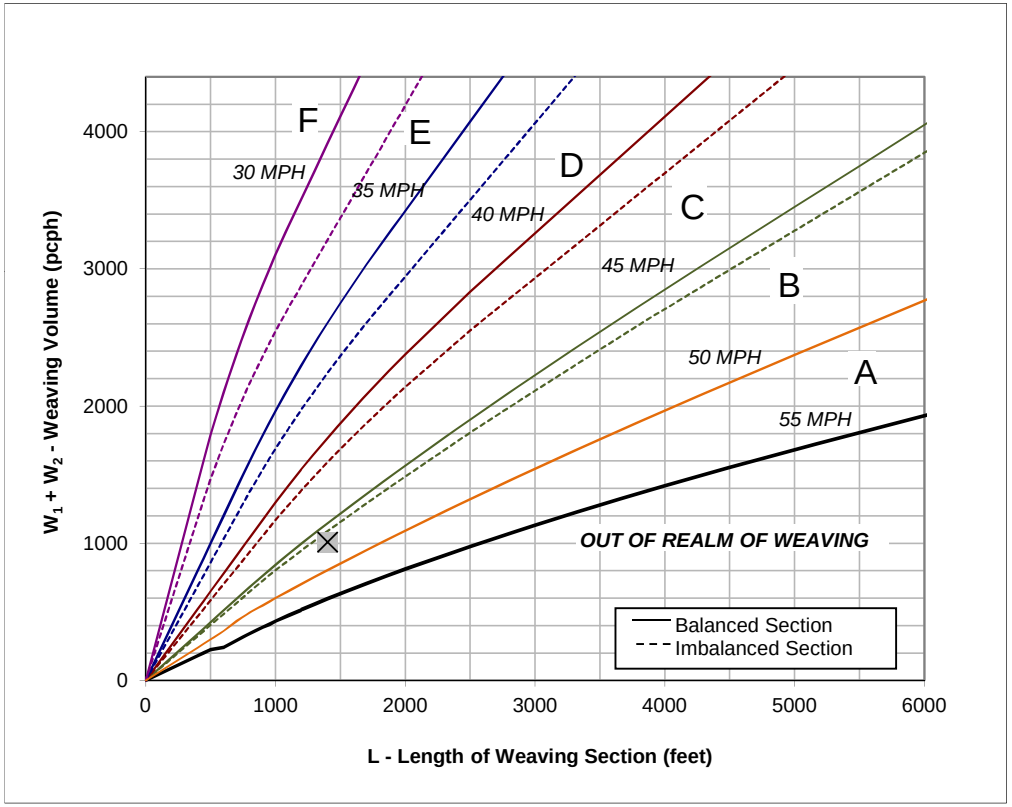
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,400

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,850	Volume (vph)*	60	Volume (vph)*	920
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,936	Volume (pcph)	62	Volume (pcph)	948

Project Information

Project	LBNL
Scenario	Near-Term PM
Freeway	WB I-580
On-ramp	Regatta Blvd
Off-ramp	Marina Bay Parkway



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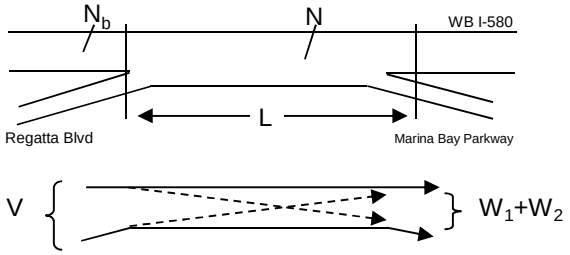


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   45 MPH and **50 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **46.4**
4. Weaving Intensity Factor (k) **2.30**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **754**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

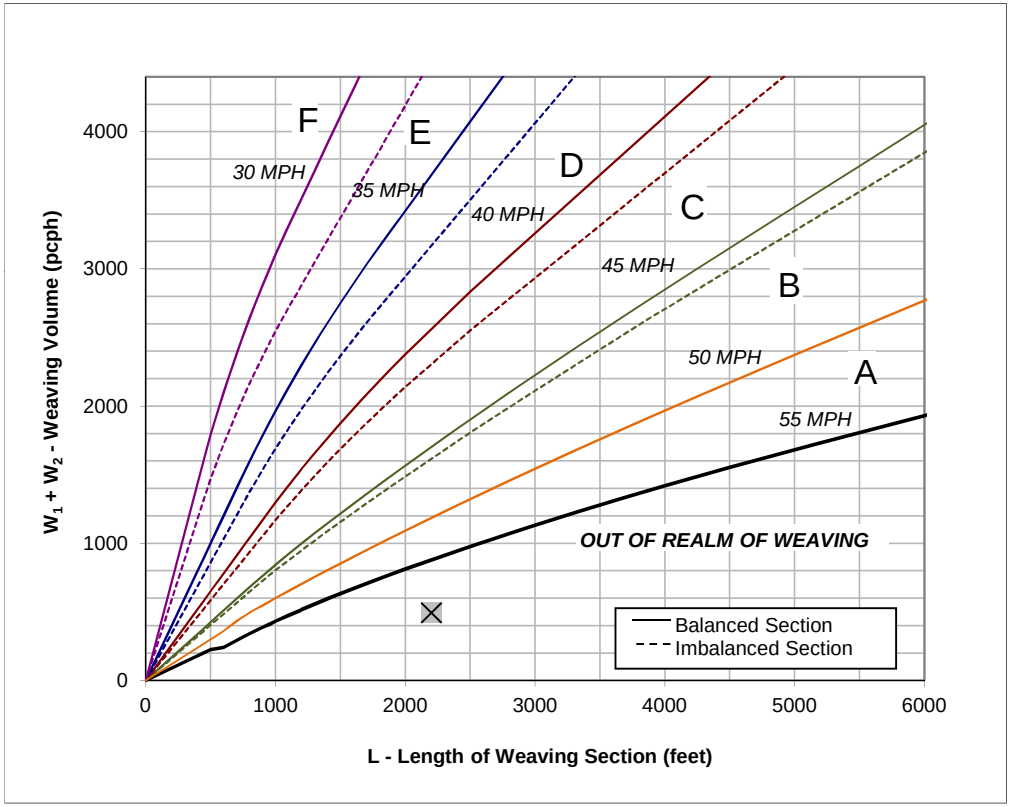
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,260	Volume (vph)*	400	Volume (vph)*	80
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,358	Volume (pcph)	412	Volume (pcph)	82

Project Information

Project	LBNL
Scenario	Near-Term PM
Freeway	EB I-580
On-ramp	Regatta Blvd
Off-ramp	Bayview Ave



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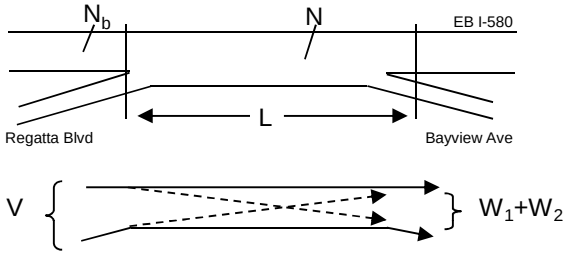


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **61.3**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **839**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

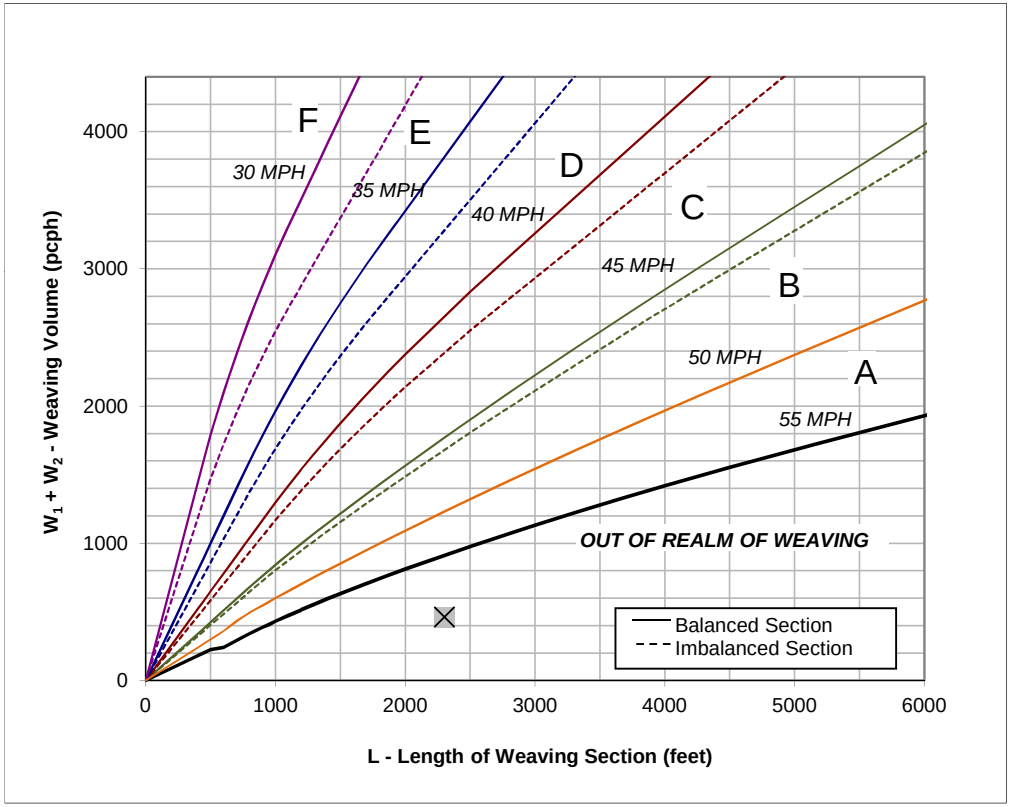
Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,300

Project Information	
Project	LBNL
Scenario	Near-Term PM
Freeway	WB I-580
On-ramp	Bayview Ave
Off-ramp	Regatta Blvd

	Total Weaving Section (V)	On-ramp to Mainline (W_1)	Mainline to Off-ramp (W_2)
Volume (vph)*	3,080	290	160
Truck Percentage	6%	6%	6%
PCE for Trucks	1.5	1.5	1.5
Volume (pcph)	3,172	299	165



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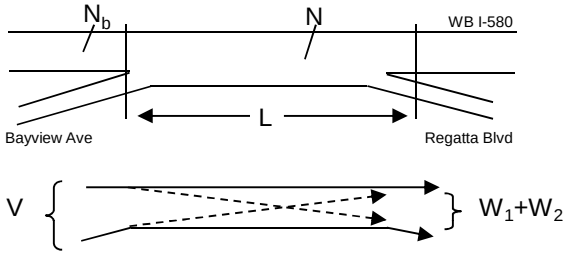


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **62.1**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **793**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Near-Term (2018) Plus Phase 1 Project Conditions

FEHR PEERS

HCM 2000
Basic Freeway Segments
Capacity Analysis

Jurisdiction
Analysis Year Near-Term + Project (Phase 1)
Analyst TL

Agency or Company
Date
Project Description

General Information				*Flow Rate Calculation*														*Speed Calculation*		*Results*	
	Freeway/ Direction	From/To	Analysis Time Period	Volume (vph)	PHF	Lanes	HOV Lane?	HOV Lane Volume	Terrain	Truck/ Bus %	RV %	E_T	E_R	f_{HV}	f_P	Flow Rate v_p (pcphpl)	Measured FFS (mph)	S (mph)	Density, D (pcplpm)	Level of Service
R-5	I-580 EB	I-580 between Bayview Avenue and Central Avenue	AM	3,110	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,161	65.0	65.0	**17.9**	**B**
R-6	I-580 EB	I-580 between Central Avenue and I-80	AM	3,020	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,691	65.0	64.6	**26.2**	**D**
R-7	I-80 EB	I-80 between Carlson Boulevard and Potrero Avenue	AM	4,325	0.92	4	Yes	290	Level	4%	0%	1.5	1.2	0.980	1.00	1,491	65.0	65.0	**22.9**	**C**
R-8	I-80 EB	I-80 @ Gilman Overpass	AM	6,204	0.92	5	Yes	780	Level	5%	0%	1.5	1.2	0.976	1.00	1,511	65.0	65.0	**23.2**	**C**
R-5	I-580 WB	I-580 between Bayview Avenue and Central Avenue	AM	3,074	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,147	65.0	65.0	**17.6**	**B**
R-6	I-580 WB	I-580 between Central Avenue and I-80	AM	3,364	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,883	65.0	63.1	**29.8**	**D**
R-7	I-80 WB	I-80 between Carlson Boulevard and Potrero Avenue	AM	6,313	0.92	4	Yes	1000	Level	4%	0%	1.5	1.2	0.980	1.00	1,964	65.0	62.0	**31.7**	**D**
R-8	I-80 WB	I-80 @ Gilman Overpass	AM	8,540	0.92	5	Yes	1410	Level	5%	0%	1.5	1.2	0.976	1.00	1,986	65.0	61.7	**32.2**	**D**
R-5	I-580 EB	I-580 between Bayview Avenue and Central Avenue	PM	3,030	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,131	65.0	65.0	**17.4**	**B**
R-6	I-580 EB	I-580 between Central Avenue and I-80	PM	3,650	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	2,043	65.0	60.7	**33.7**	**D**
R-7	I-80 EB	I-80 between Carlson Boulevard and Potrero Avenue	PM	6,211	0.92	4	Yes	1300	Level	4%	0%	1.5	1.2	0.980	1.00	1,815	65.0	63.8	**28.5**	**D**
R-8	I-80 EB	I-80 @ Gilman Overpass	PM	7,579	0.92	5	Yes	1070	Level	5%	0%	1.5	1.2	0.976	1.00	1,813	65.0	63.8	**28.4**	**D**
R-5	I-580 WB	I-580 between Bayview Avenue and Central Avenue	PM	3,249	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,212	65.0	65.0	**18.7**	**C**
R-6	I-580 WB	I-580 between Central Avenue and I-80	PM	2,799	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,567	65.0	64.9	**24.1**	**C**
R-7	I-80 WB	I-80 between Carlson Boulevard and Potrero Avenue	PM	4,775	0.92	4	Yes	330	Level	4%	0%	1.5	1.2	0.980	1.00	1,643	65.0	64.8	**25.4**	**C**
R-8	I-80 WB	I-80 @ Gilman Overpass	PM	6,800	0.92	5	Yes	650	Level	5%	0%	1.5	1.2	0.976	1.00	1,713	65.0	64.5	**26.6**	**D**

Leisch Method for Weaving Analysis

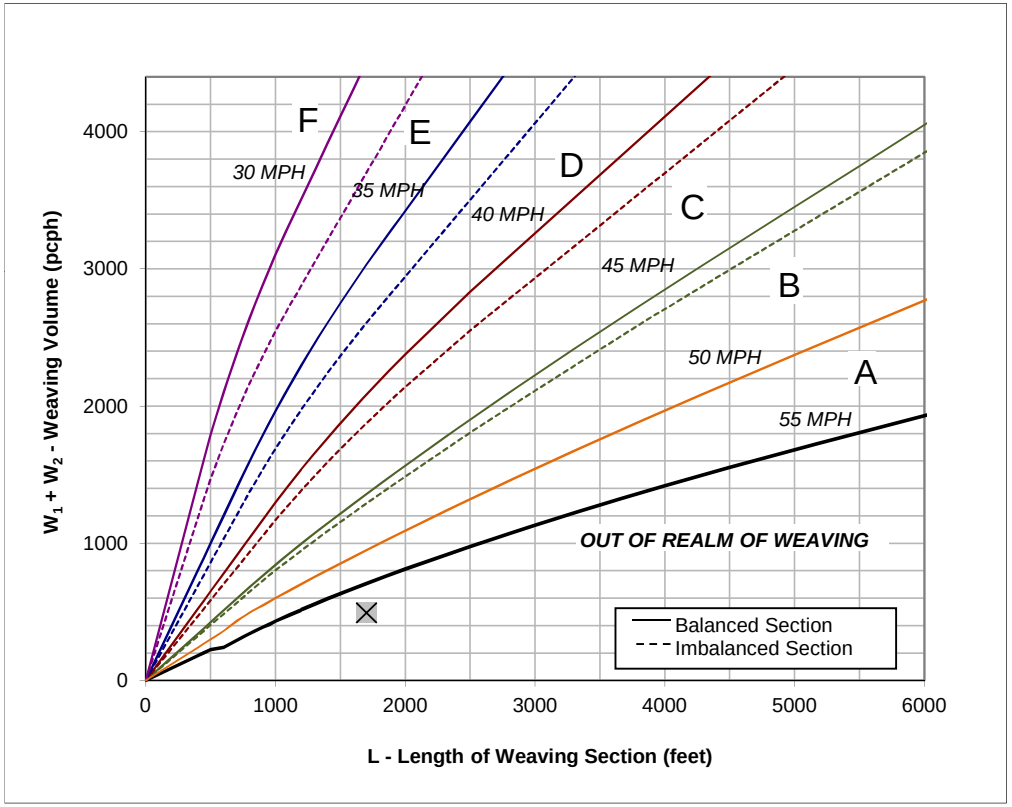
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,700

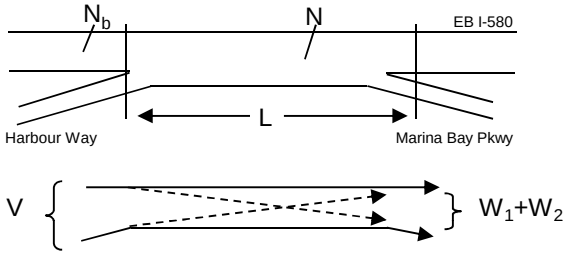
Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,452	Volume (vph)*	320	Volume (vph)*	160
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,526	Volume (pcph)	330	Volume (pcph)	165

Project Information

Project	LBNL
Scenario	Near-Term Plus Phase 1 AM
Freeway	EB I-580
On-ramp	Harbour Way
Off-ramp	Marina Bay Pkwy



Figure



Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **59.4**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **631**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

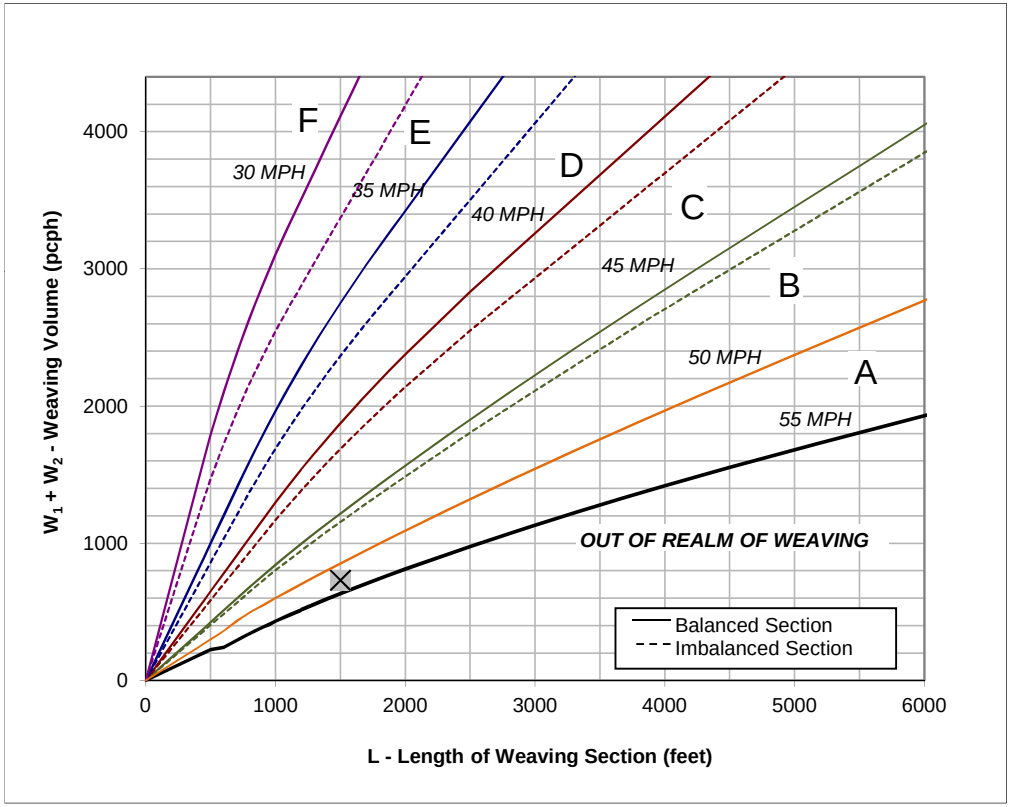
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,500

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,787	Volume (vph)*	320	Volume (vph)*	390
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,871	Volume (pcph)	330	Volume (pcph)	402

Project Information

Project	LBNL
Scenario	Near-Term Plus Phase 1 AM
Freeway	WB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Harbour Way



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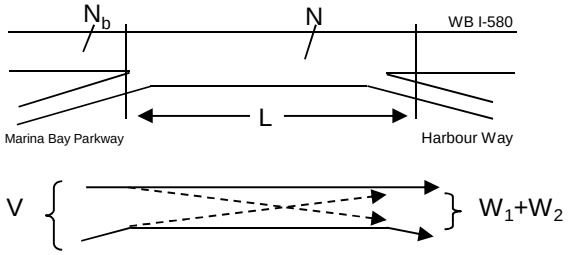


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **52.8**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **718**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

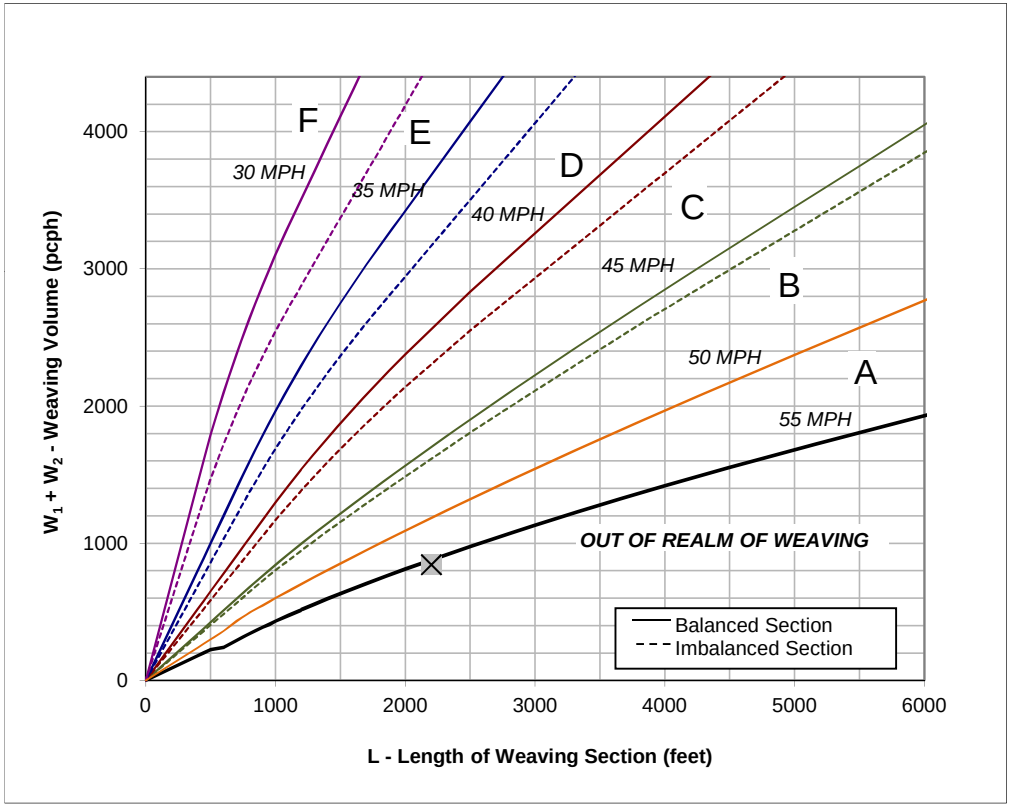
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,127	Volume (vph)*	740	Volume (vph)*	80
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,221	Volume (pcph)	762	Volume (pcph)	82

Project Information

Project	LBNL
Scenario	Near-Term Plus Phase 1 AM
Freeway	EB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Regatta Blvd



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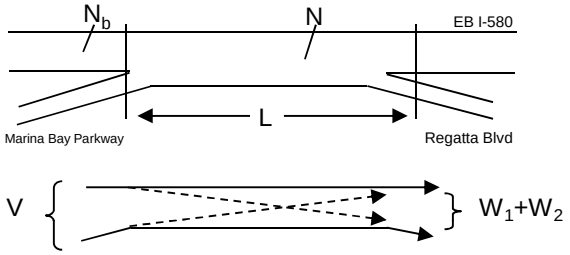


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **55.6**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **805**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

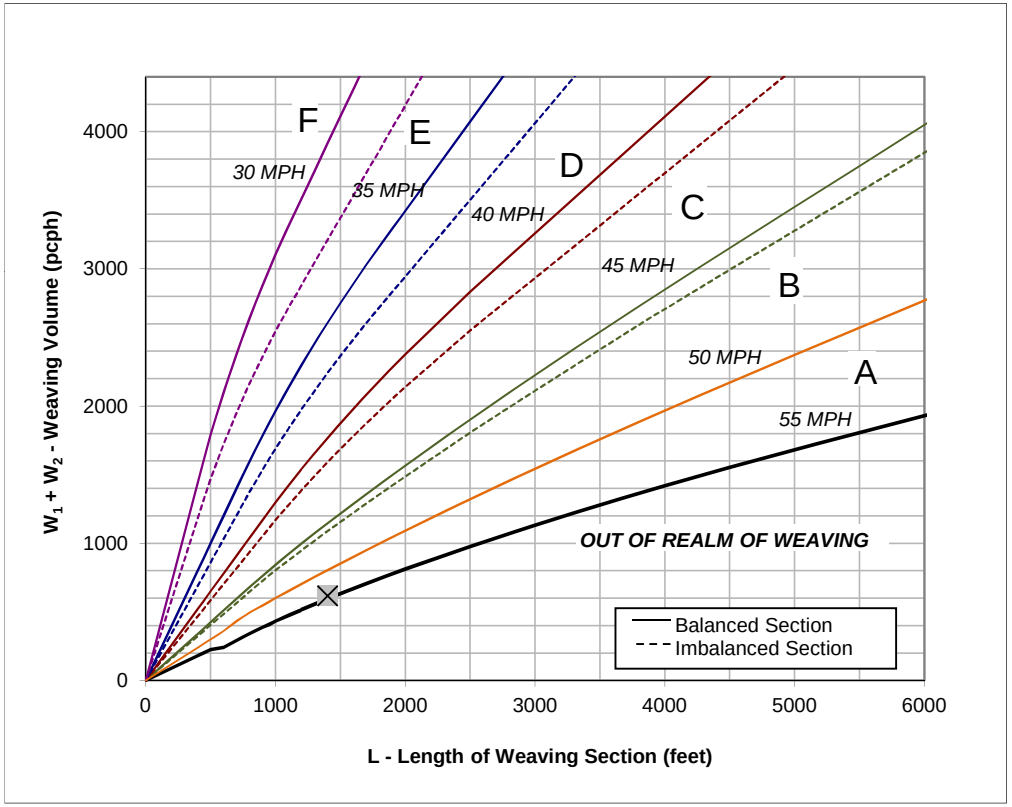
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,400

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,358	Volume (vph)*	130	Volume (vph)*	470
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,459	Volume (pcph)	134	Volume (pcph)	484

Project Information

Project	LBNL
Scenario	Near-Term Plus Phase 1 AM
Freeway	WB I-580
On-ramp	Regatta Blvd
Off-ramp	Marina Bay Parkway



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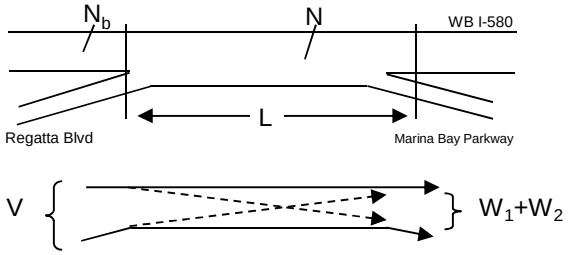


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **54.4**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **865**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

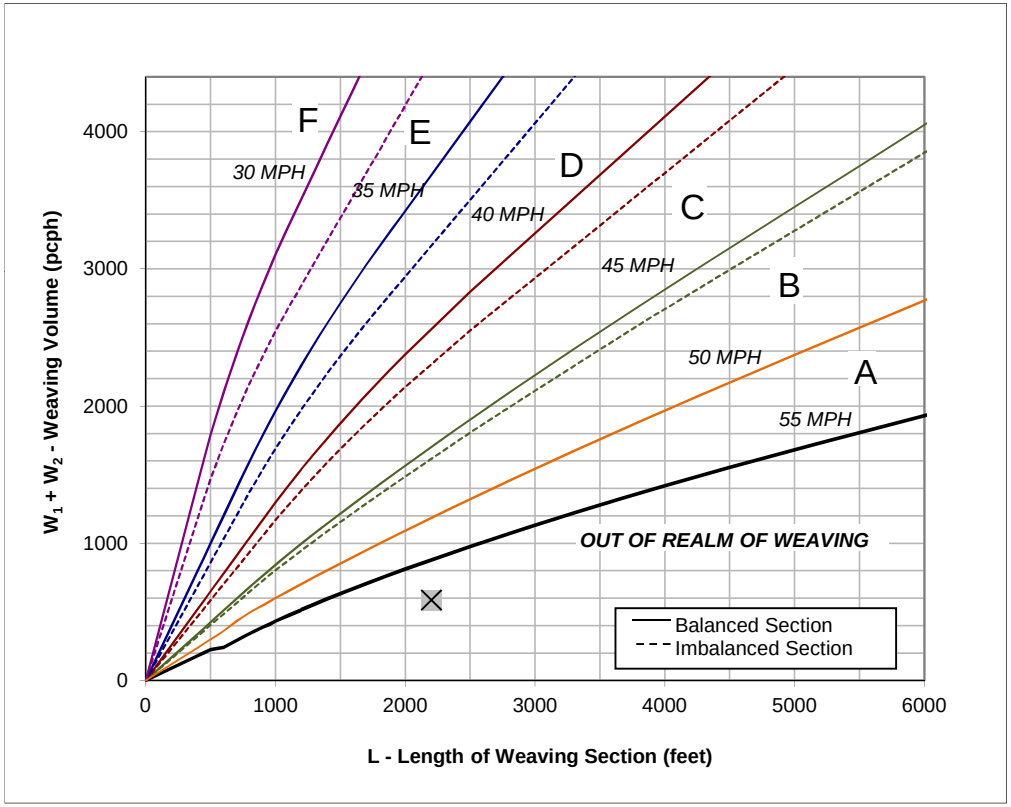
Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Project Information	
Project	LBNL
Scenario	Near-Term Plus Phase 1 AM
Freeway	EB I-580
On-ramp	Regatta Blvd
Off-ramp	Bayview Ave

	Total Weaving Section (V)	On-ramp to Mainline (W_1)	Mainline to Off-ramp (W_2)
Volume (vph)*	3,270	140	430
Truck Percentage	6%	6%	6%
PCE for Trucks	1.5	1.5	1.5
Volume (pcph)	3,368	144	443



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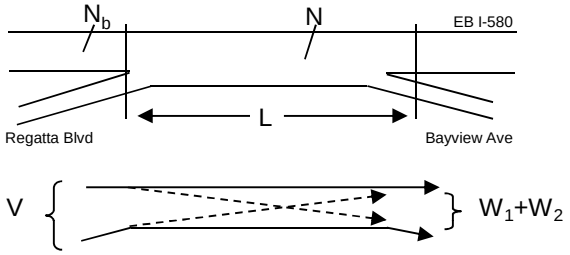


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **59.8**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **842**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

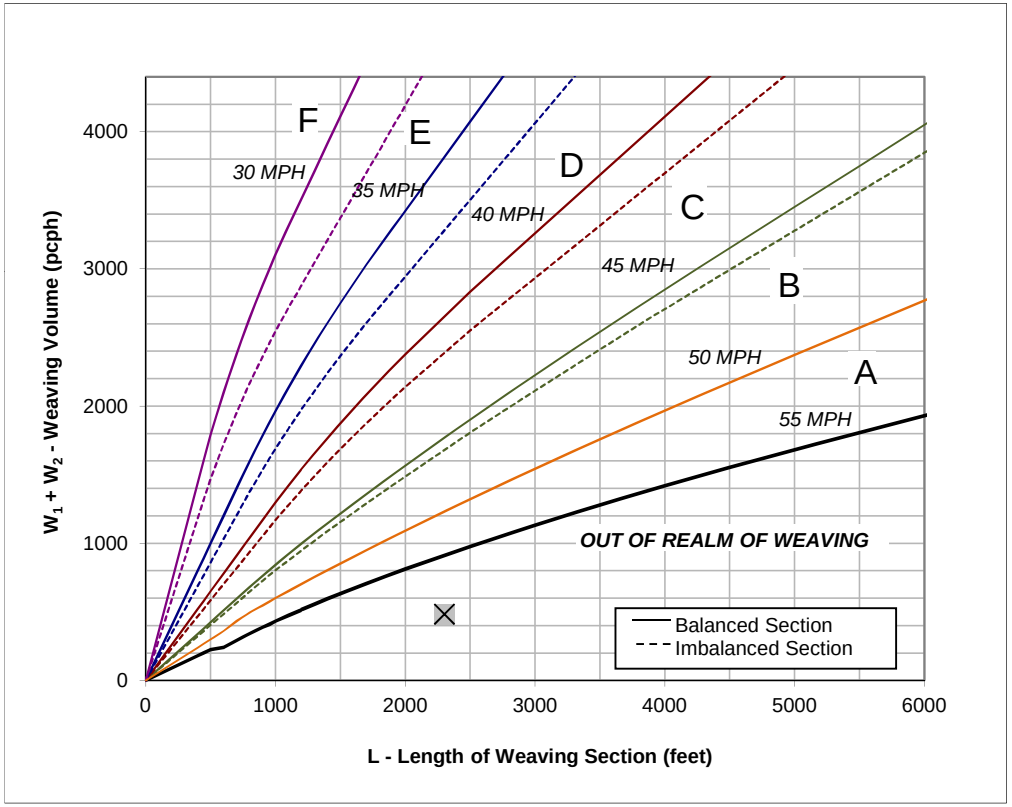
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,300

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,310	Volume (vph)*	380	Volume (vph)*	90
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,409	Volume (pcph)	391	Volume (pcph)	93

Project Information

Project	LBNL
Scenario	Near-Term Plus Phase 1 AM
Freeway	WB I-580
On-ramp	Bayview Ave
Off-ramp	Regatta Blvd



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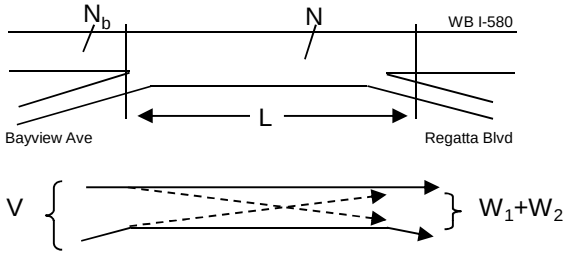


Capacity Analysis

1. Is the weaving section balanced (Y / N)? [If optional exit lane, then "Y". Otherwise "N".]	N
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?	**50 MPH** and **55 MPH**
If below the 55 MPH curve, out of the realm of weaving. If left of the 30 MPH curve, LOS is F.	
3. Interpolated Weaving Speed (S_w, mph)	61.7
4. Weaving Intensity Factor (k)	1.00
5. Service Volume (SV, pcph) $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$	852
6. Level of Service (LOS)	B

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

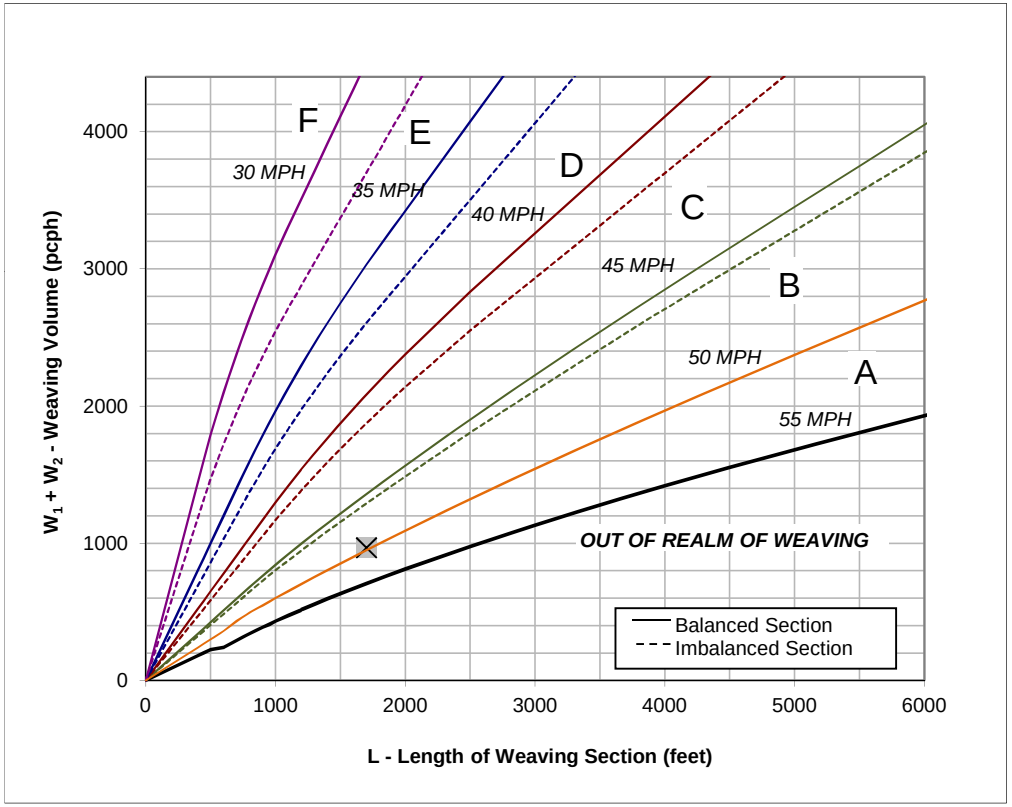
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,700

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,106	Volume (vph)*	600	Volume (vph)*	340
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,199	Volume (pcph)	618	Volume (pcph)	350

Project Information

Project	LBNL
Scenario	Near-Term Plus Phase 1 PM
Freeway	EB I-580
On-ramp	Harbour Way
Off-ramp	Marina Bay Pkwy



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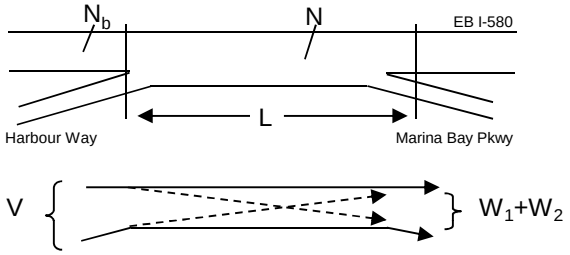


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **49.6**
4. Weaving Intensity Factor (k) **1.25**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **822**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

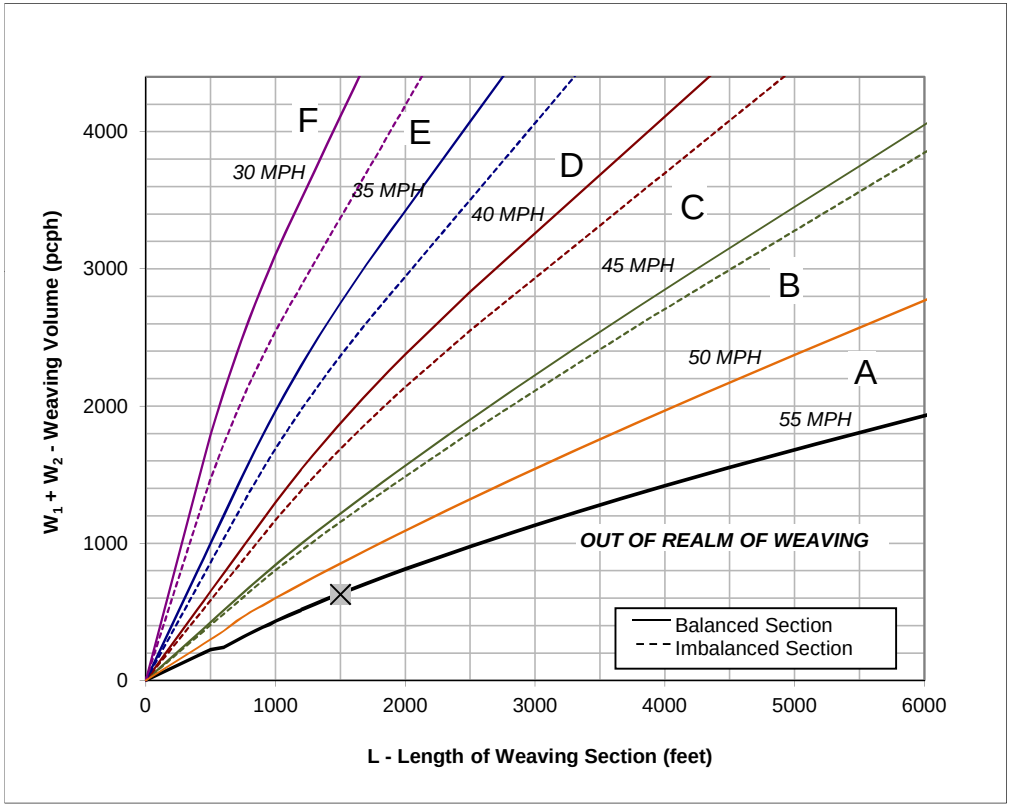
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,500

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,210	Volume (vph)*	220	Volume (vph)*	390
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,276	Volume (pcph)	227	Volume (pcph)	402

Project Information

Project	LBNL
Scenario	Near-Term Plus Phase 1 PM
Freeway	WB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Harbour Way



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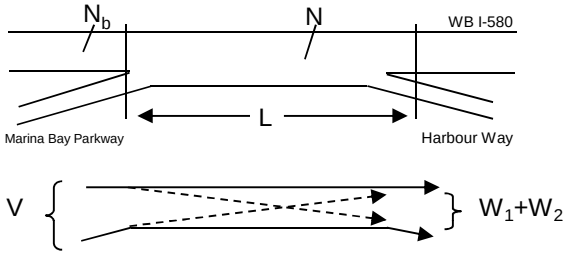


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **55.1**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **569**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

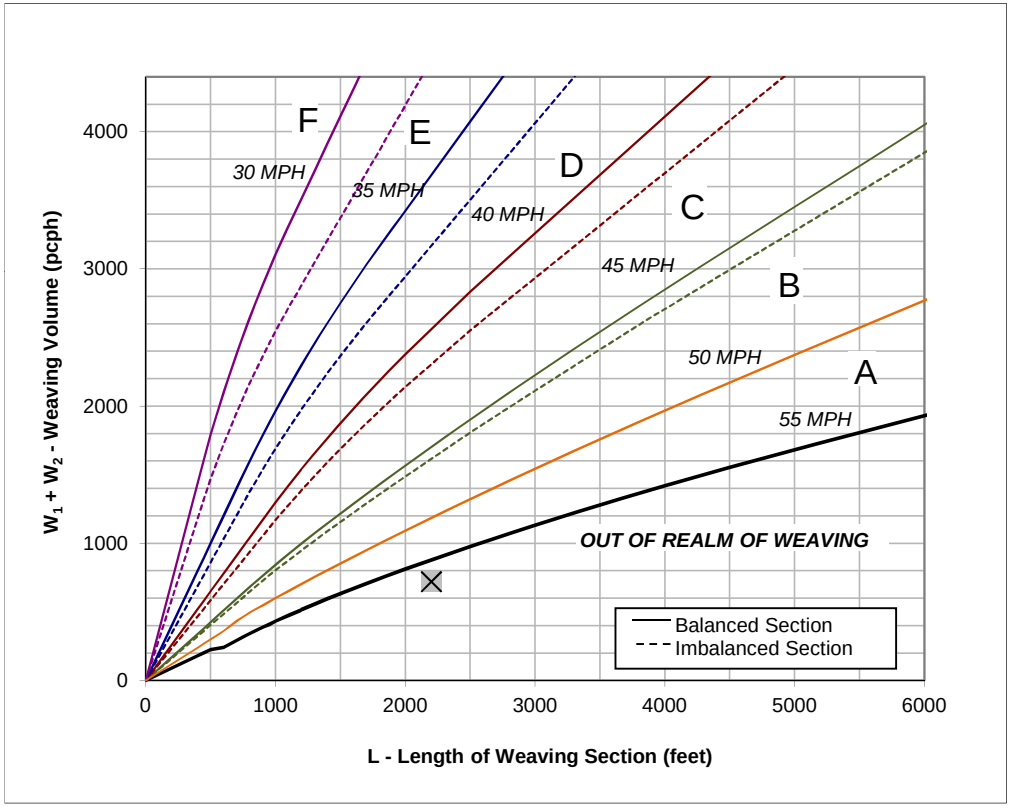
Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

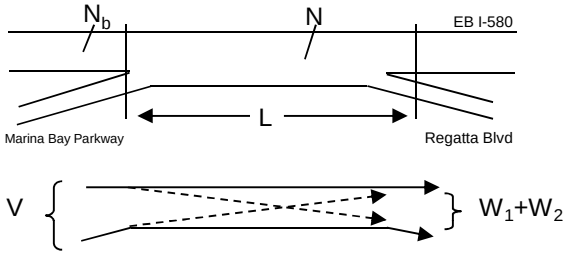
Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Project Information	
Project	LBNL
Scenario	Near-Term Plus Phase 1 PM
Freeway	EB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Regatta Blvd

	Total Weaving Section (V)	On-ramp to Mainline (W_1)	Mainline to Off-ramp (W_2)
Volume (vph)*	3,257	580	120
Truck Percentage	6%	6%	6%
PCE for Trucks	1.5	1.5	1.5
Volume (pcph)	3,355	597	124



Figure



Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **57.6**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **839**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

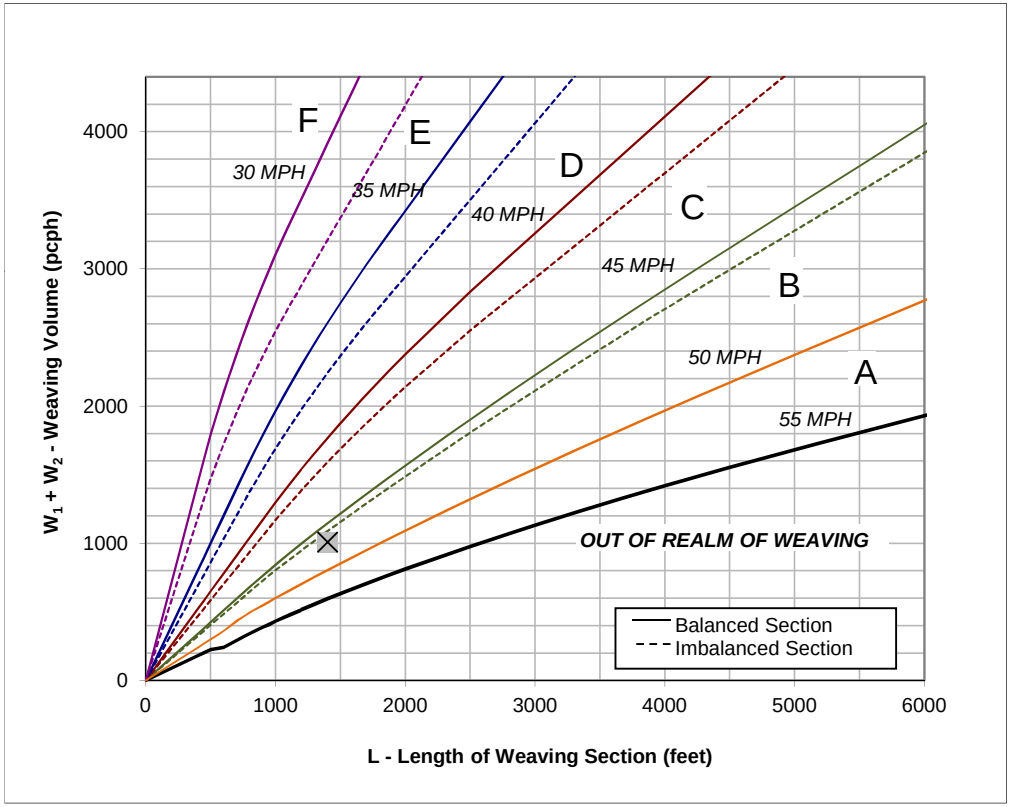
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,400

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,895	Volume (vph)*	60	Volume (vph)*	920
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,982	Volume (pcph)	62	Volume (pcph)	948

Project Information

Project	LBNL
Scenario	Near-Term Plus Phase 1 PM
Freeway	WB I-580
On-ramp	Regatta Blvd
Off-ramp	Marina Bay Parkway



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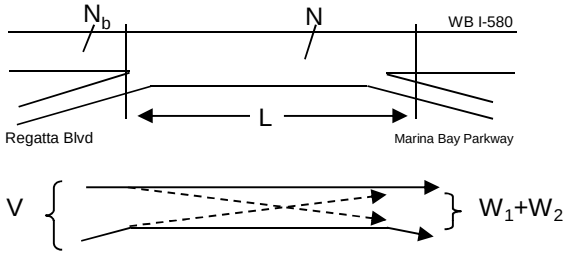


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   45 MPH and **50 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **46.4**
4. Weaving Intensity Factor (k) **2.30**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **766**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

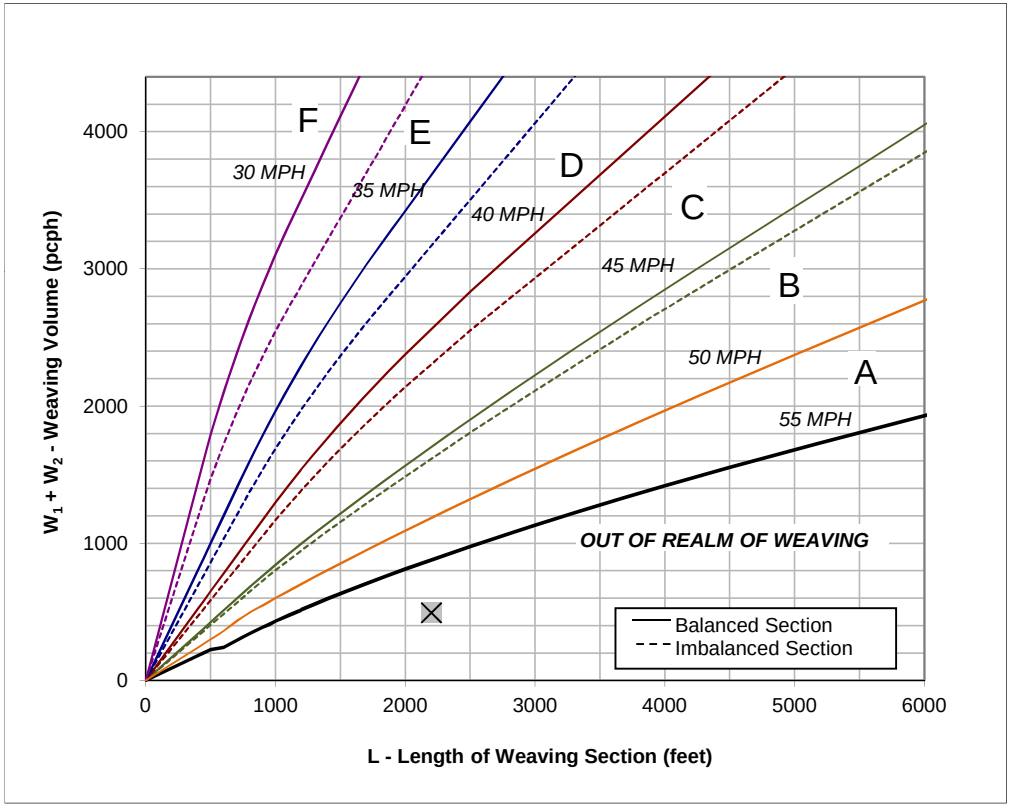
Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Project Information	
Project	LBNL
Scenario	Near-Term Plus Phase 1 PM
Freeway	EB I-580
On-ramp	Regatta Blvd
Off-ramp	Bayview Ave

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,260	Volume (vph)*	400	Volume (vph)*	80
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,358	Volume (pcph)	412	Volume (pcph)	82



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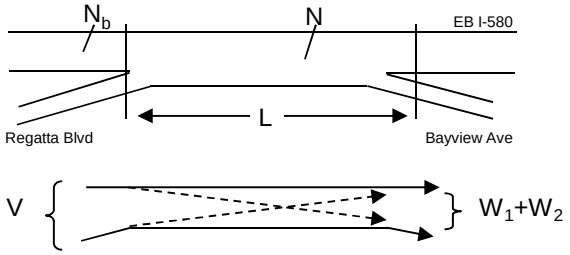


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **61.3**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **839**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

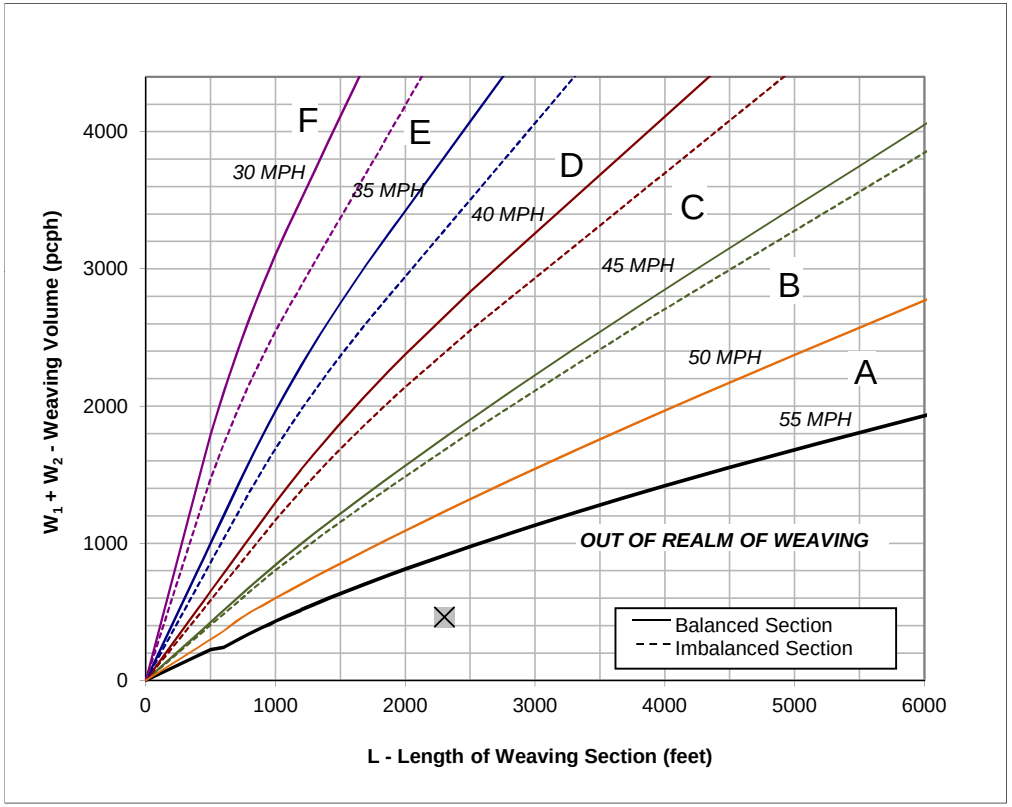
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,300

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,080	Volume (vph)*	290	Volume (vph)*	160
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,172	Volume (pcph)	299	Volume (pcph)	165

Project Information

Project	LBNL
Scenario	Near-Term Plus Phase 1 PM
Freeway	WB I-580
On-ramp	Bayview Ave
Off-ramp	Regatta Blvd



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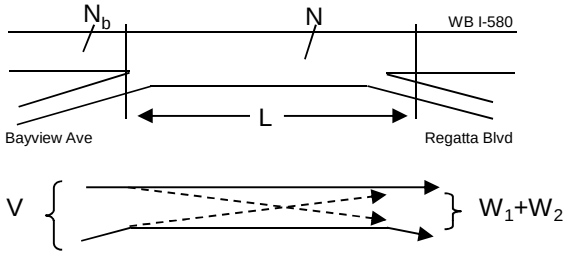


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **62.1**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **793**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Cumulative (2035) No Project Conditions

FEHR PEERS

HCM 2000
Basic Freeway Segments
Capacity Analysis

Jurisdiction
Analysis Year Cumulative
Analyst TL

Agency or Company
Date
Project Description

General Information | *Flow Rate Calculation* | *Speed Calculation* | *Results*

	Freeway/ Direction	From/To	Analysis Time Period	Volume (vph)	PHF	Lanes	HOV Lane?	HOV Lane Volume	Terrain	Truck/ Bus %	RV %	E_T	E_R	f_{HV}	f_P	Flow Rate v_p (pcphpl)	Measured FFS (mph)	S (mph)	Density, D (pcplpm)	Level of Service
R-5	I-580 EB	I-580 between Bayview Avenue and Central Avenue	AM	4,260	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,590	65.0	64.9	**24.5**	**C**
R-6	I-580 EB	I-580 between Central Avenue and I-80	AM	3,800	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	2,127	65.0	58.9	**36.1**	**E**
R-7	I-80 EB	I-80 between Carlson Boulevard and Potrero Avenue	AM	5,080	0.92	4	Yes	350	Level	4%	0%	1.5	1.2	0.980	1.00	1,748	65.0	64.3	**27.2**	**D**
R-8	I-80 EB	I-80 @ Gilman Overpass	AM	6,980	0.92	5	Yes	900	Level	5%	0%	1.5	1.2	0.976	1.00	1,693	65.0	64.6	**26.2**	**D**
R-5	I-580 WB	I-580 between Bayview Avenue and Central Avenue	AM	4,480	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,672	65.0	64.7	**25.9**	**C**
R-6	I-580 WB	I-580 between Central Avenue and I-80	AM	4,430	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	2,480	65.0	-	**-**	**F**
R-7	I-80 WB	I-80 between Carlson Boulevard and Potrero Avenue	AM	7,030	0.92	4	Yes	1150	Level	4%	0%	1.5	1.2	0.980	1.00	2,173	65.0	57.8	**37.6**	**E**
R-8	I-80 WB	I-80 @ Gilman Overpass	AM	9,020	0.92	5	Yes	1500	Level	5%	0%	1.5	1.2	0.976	1.00	2,095	65.0	59.6	**35.1**	**E**
R-5	I-580 EB	I-580 between Bayview Avenue and Central Avenue	PM	4,470	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,668	65.0	64.7	**25.8**	**C**
R-6	I-580 EB	I-580 between Central Avenue and I-80	PM	4,500	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	2,519	65.0	-	**-**	**F**
R-7	I-80 EB	I-80 between Carlson Boulevard and Potrero Avenue	PM	6,690	0.92	4	Yes	1400	Level	4%	0%	1.5	1.2	0.980	1.00	1,955	65.0	62.2	**31.5**	**D**
R-8	I-80 EB	I-80 @ Gilman Overpass	PM	8,280	0.92	5	Yes	1150	Level	5%	0%	1.5	1.2	0.976	1.00	1,986	65.0	61.7	**32.2**	**D**
R-5	I-580 WB	I-580 between Bayview Avenue and Central Avenue	PM	4,090	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,526	65.0	65.0	**23.5**	**C**
R-6	I-580 WB	I-580 between Central Avenue and I-80	PM	3,270	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,830	65.0	63.6	**28.8**	**D**
R-7	I-80 WB	I-80 between Carlson Boulevard and Potrero Avenue	PM	5,360	0.92	4	Yes	400	Level	4%	0%	1.5	1.2	0.980	1.00	1,833	65.0	63.6	**28.8**	**D**
R-8	I-80 WB	I-80 @ Gilman Overpass	PM	7,190	0.92	5	Yes	700	Level	5%	0%	1.5	1.2	0.976	1.00	1,808	65.0	63.8	**28.3**	**D**

Leisch Method for Weaving Analysis

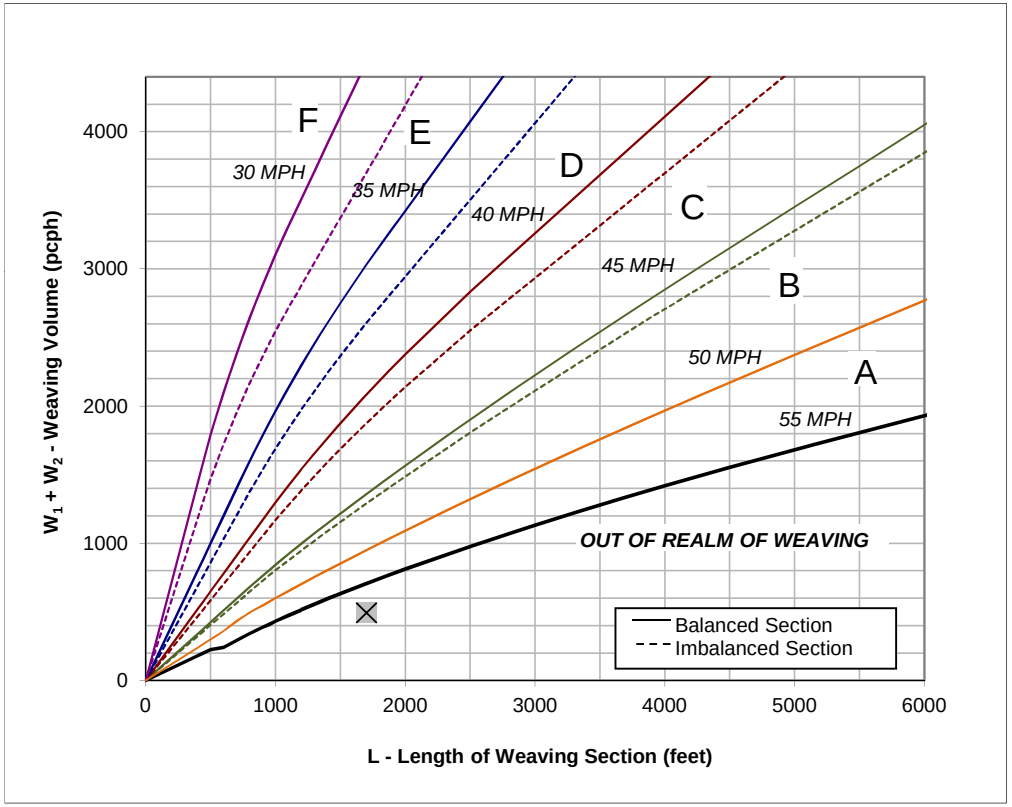
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,700

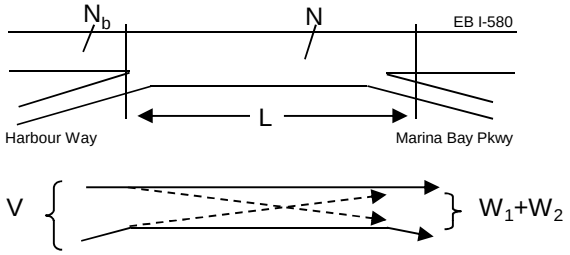
Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,930	Volume (vph)*	320	Volume (vph)*	160
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,018	Volume (pcph)	330	Volume (pcph)	165

Project Information

Project	LBNL
Scenario	Cumulative AM
Freeway	EB I-580
On-ramp	Harbour Way
Off-ramp	Marina Bay Pkwy



Figure



Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **59.4**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **754**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

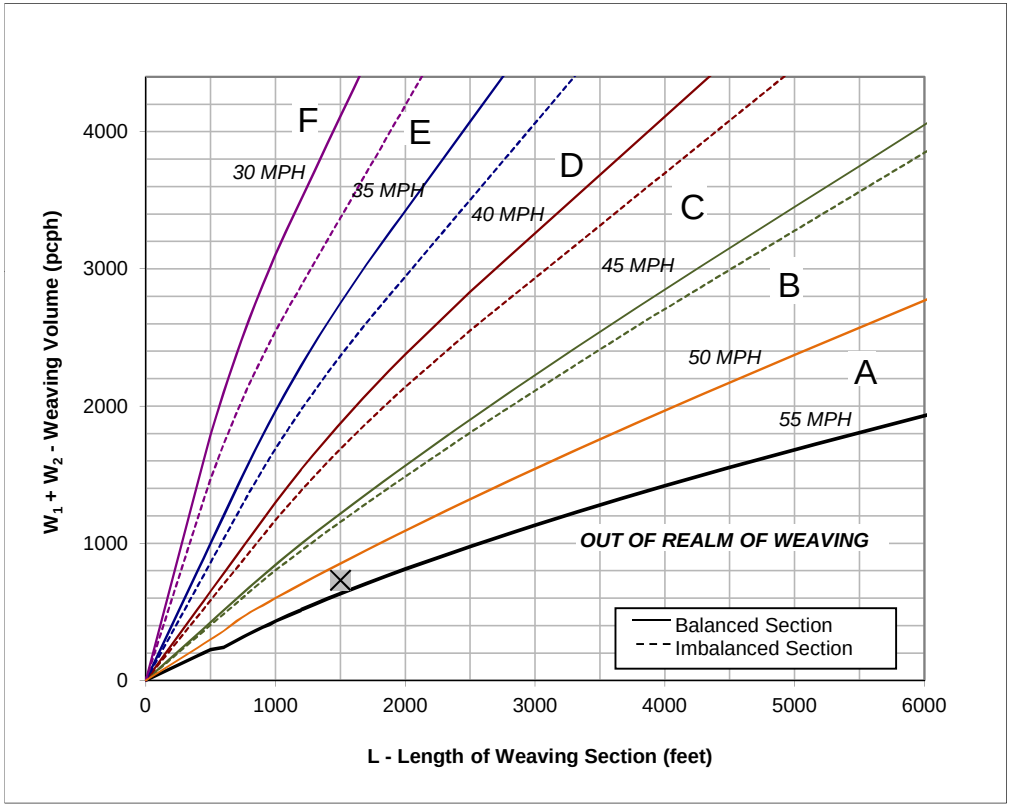
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,500

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	4,350	Volume (vph)*	320	Volume (vph)*	390
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	4,481	Volume (pcph)	330	Volume (pcph)	402

Project Information

Project	LBNL
Scenario	Cumulative AM
Freeway	WB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Harbour Way



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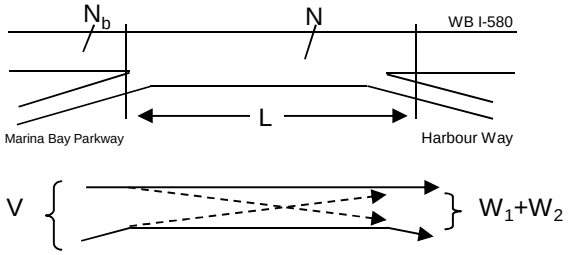


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **52.8**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **1,120**
6. Level of Service (LOS) **C**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

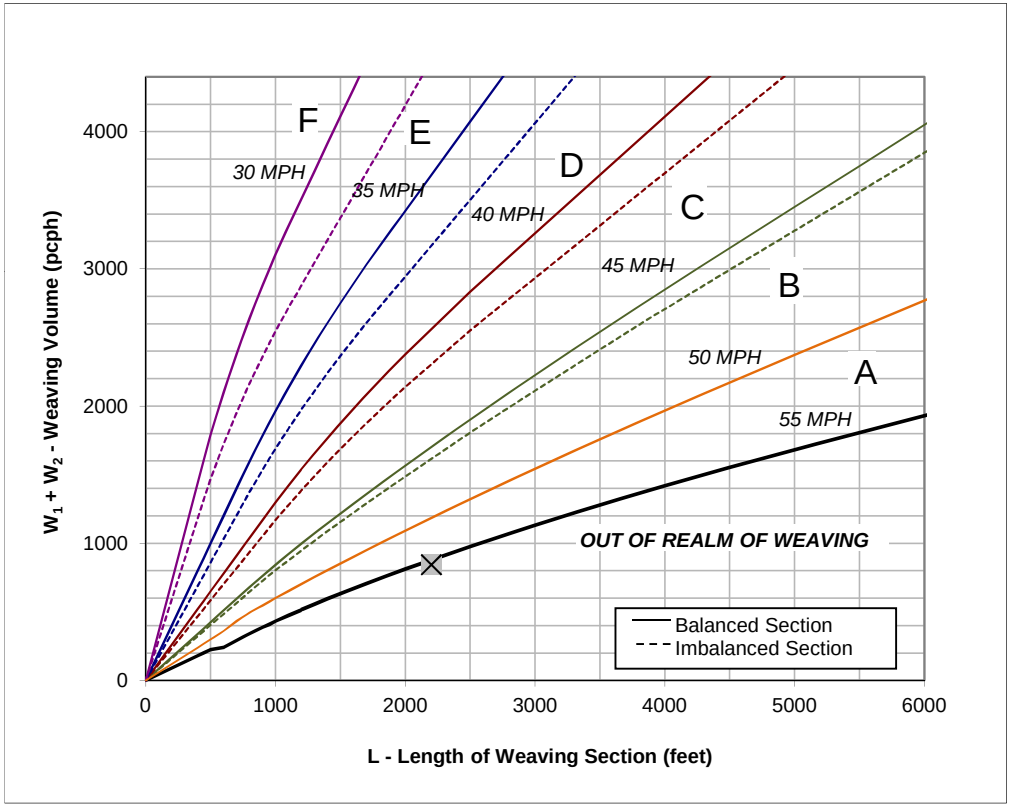
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,840	Volume (vph)*	740	Volume (vph)*	80
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,955	Volume (pcph)	762	Volume (pcph)	82

Project Information

Project	LBNL
Scenario	Cumulative AM
Freeway	EB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Regatta Blvd



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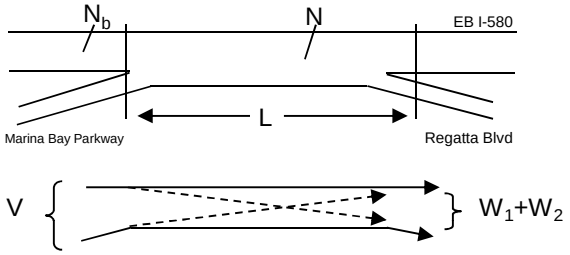


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **55.6**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **989**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

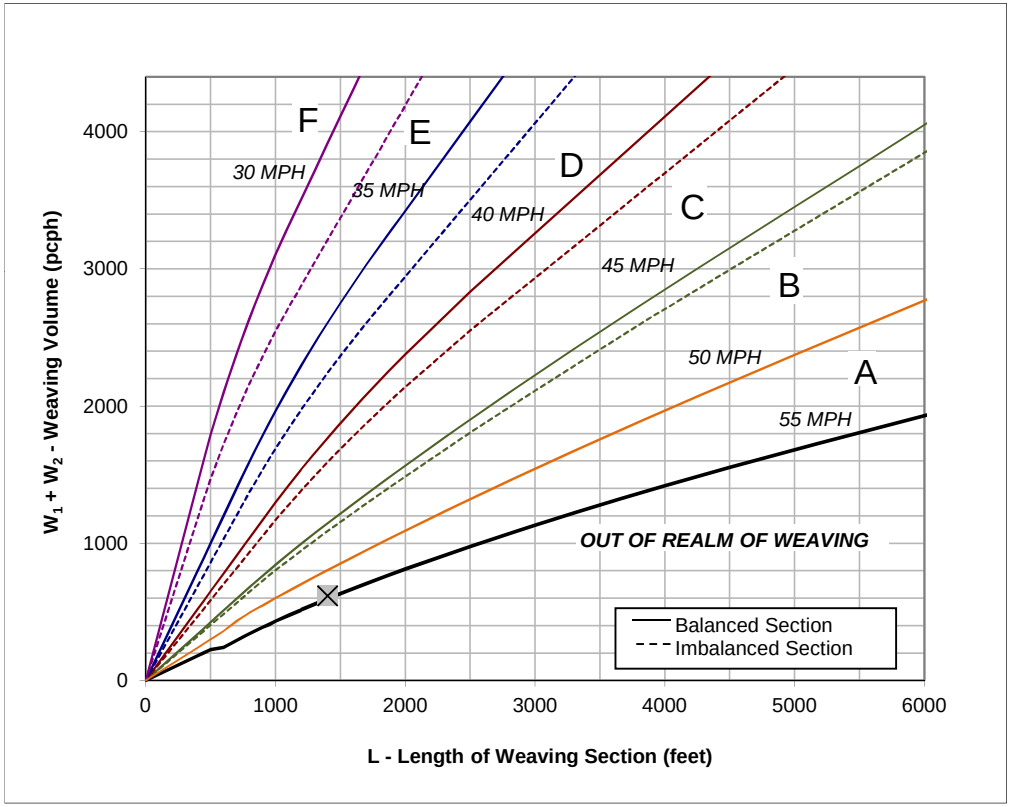
Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,400

Project Information	
Project	LBNL
Scenario	Cumulative AM
Freeway	WB I-580
On-ramp	Regatta Blvd
Off-ramp	Marina Bay Parkway

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	4,920	Volume (vph)*	130	Volume (vph)*	470
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	5,068	Volume (pcph)	134	Volume (pcph)	484



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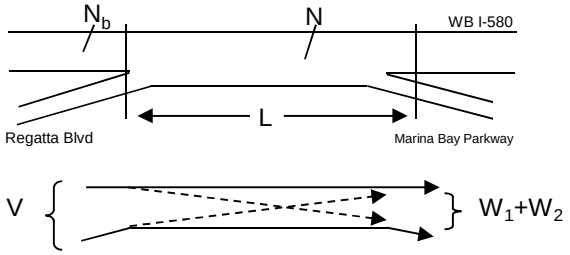

Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **54.4**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **1,267**
6. Level of Service (LOS) **C**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

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Leisch Method for Weaving Analysis

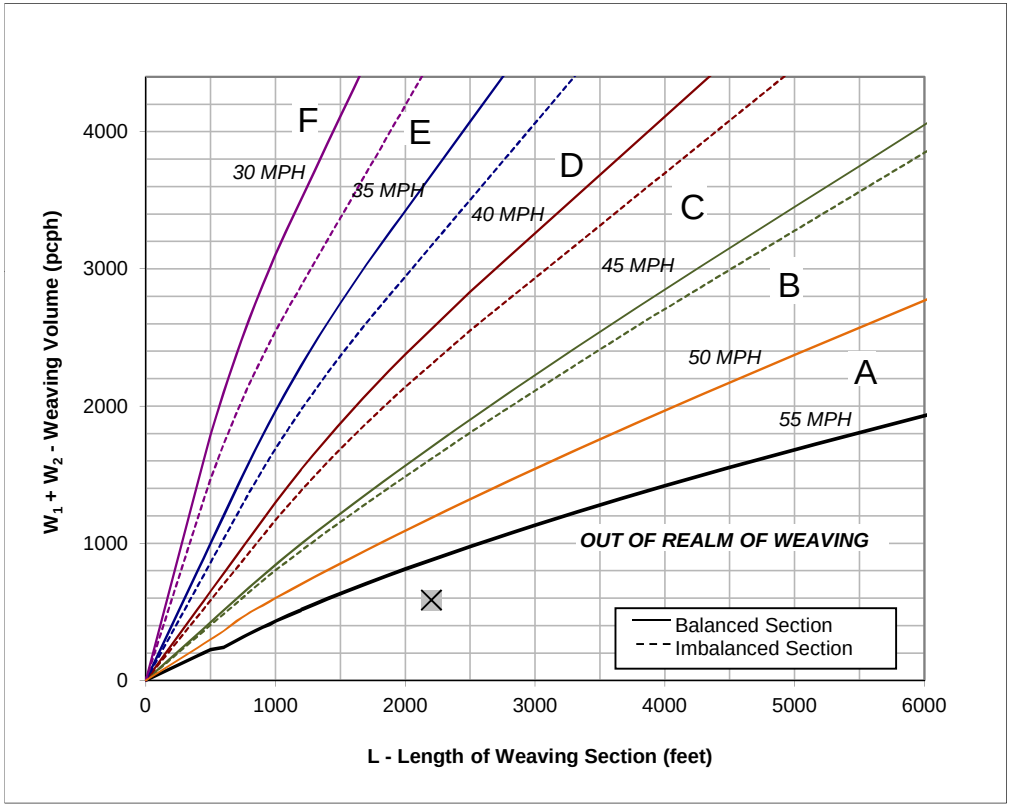
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

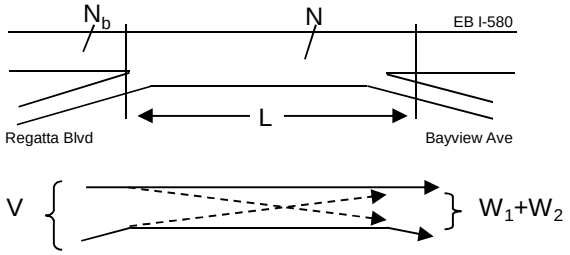
Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	4,390	Volume (vph)*	140	Volume (vph)*	430
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	4,522	Volume (pcph)	144	Volume (pcph)	443

Project Information

Project	LBNL
Scenario	Cumulative AM
Freeway	EB I-580
On-ramp	Regatta Blvd
Off-ramp	Bayview Ave



Figure



Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **59.8**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **1,130**
6. Level of Service (LOS) **C**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

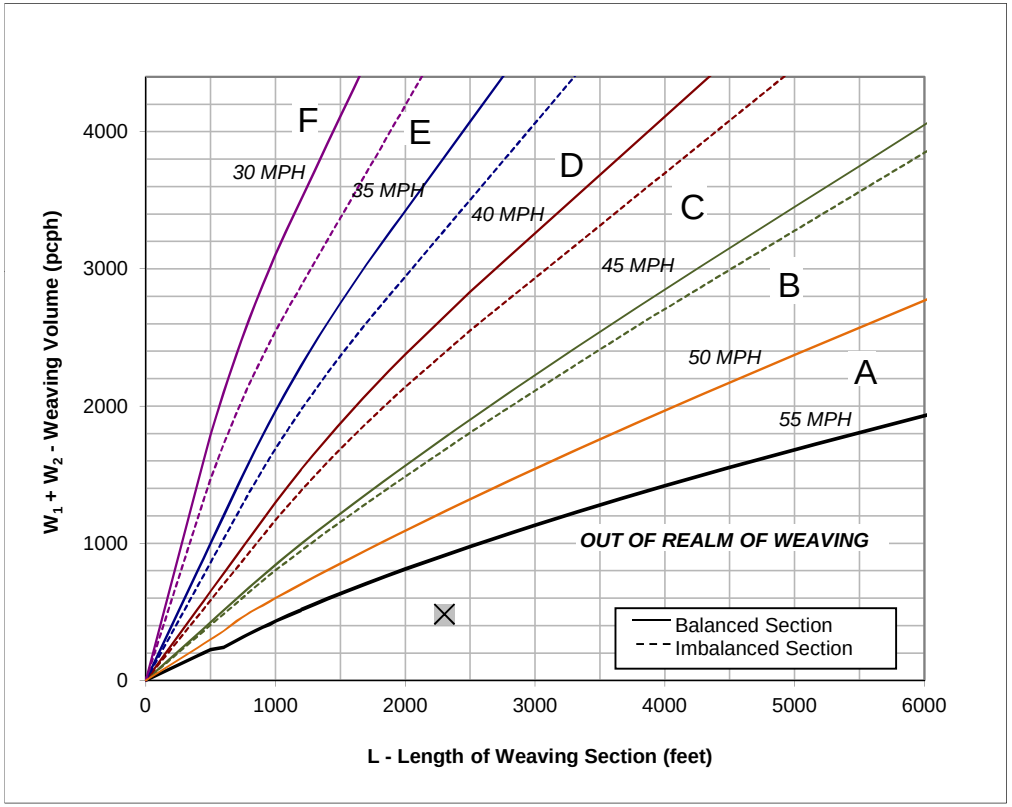
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,300

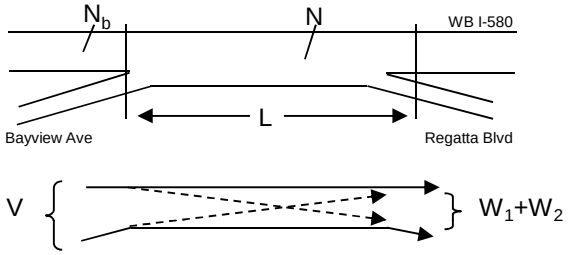
Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	4,890	Volume (vph)*	380	Volume (vph)*	90
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	5,037	Volume (pcph)	391	Volume (pcph)	93

Project Information

Project	LBNL
Scenario	Cumulative AM
Freeway	WB I-580
On-ramp	Bayview Ave
Off-ramp	Regatta Blvd



Figure



Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **61.7**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **1,259**
6. Level of Service (LOS) **C**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

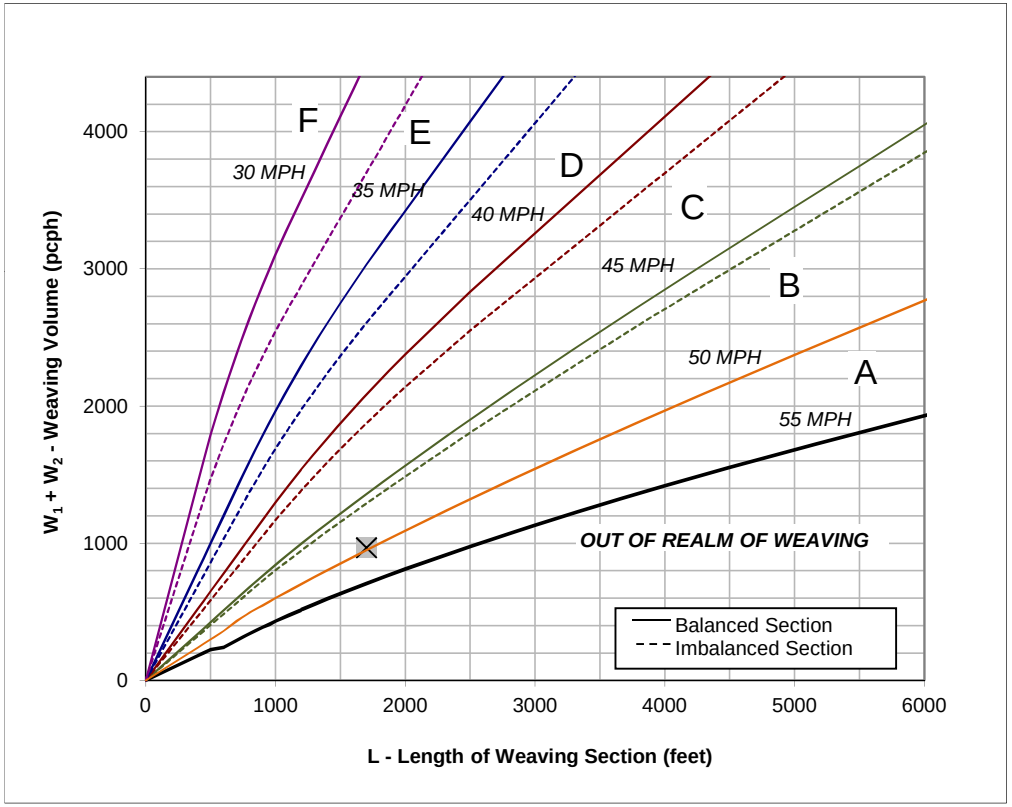
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,700

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	4,710	Volume (vph)*	600	Volume (vph)*	340
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	4,851	Volume (pcph)	618	Volume (pcph)	350

Project Information

Project	LBNL
Scenario	Cumulative PM
Freeway	EB I-580
On-ramp	Harbour Way
Off-ramp	Marina Bay Pkwy



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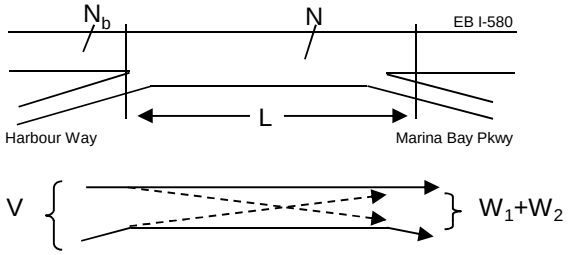


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **49.6**
4. Weaving Intensity Factor (k) **1.25**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **1,235**
6. Level of Service (LOS) **C**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

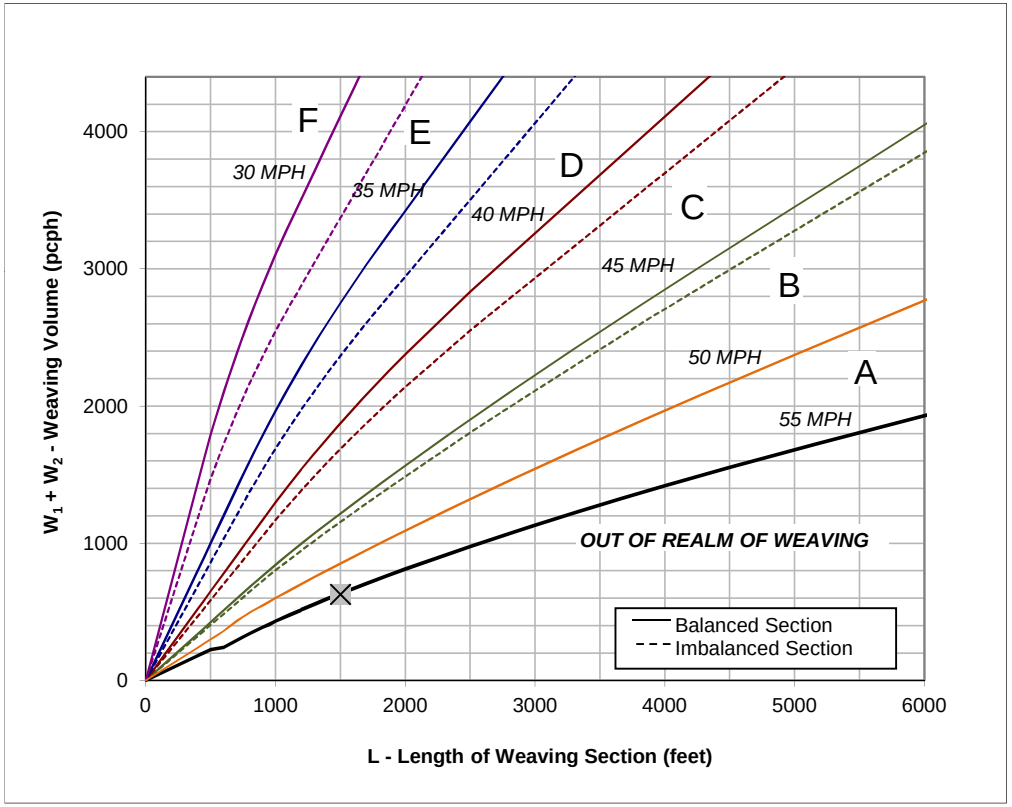
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,500

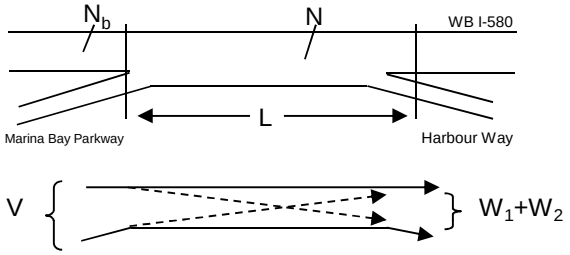
Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,710	Volume (vph)*	220	Volume (vph)*	390
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,791	Volume (pcph)	227	Volume (pcph)	402

Project Information

Project	LBNL
Scenario	Cumulative PM
Freeway	WB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Harbour Way



Figure



Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **55.1**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **698**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

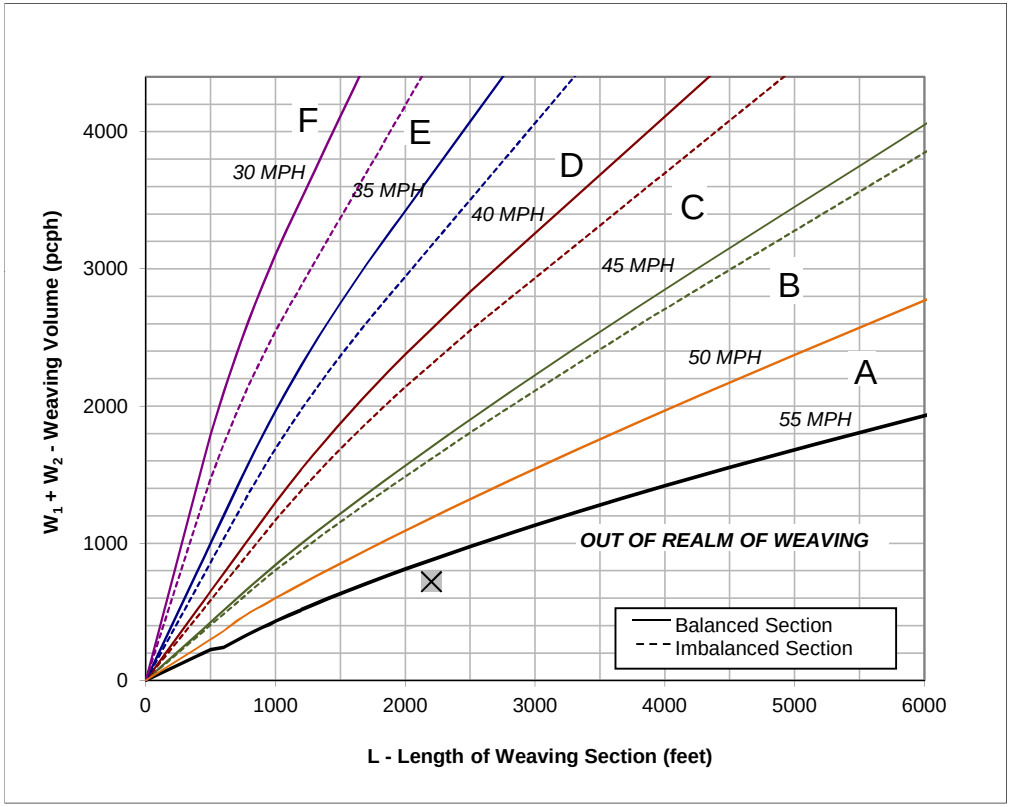
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	4,600	Volume (vph)*	580	Volume (vph)*	120
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	4,738	Volume (pcph)	597	Volume (pcph)	124

Project Information

Project	LBNL
Scenario	Cumulative PM
Freeway	EB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Regatta Blvd



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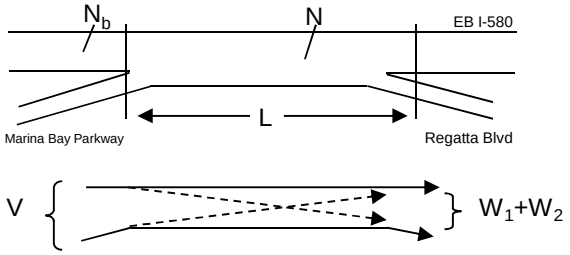


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **57.6**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **1,185**
6. Level of Service (LOS) **C**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

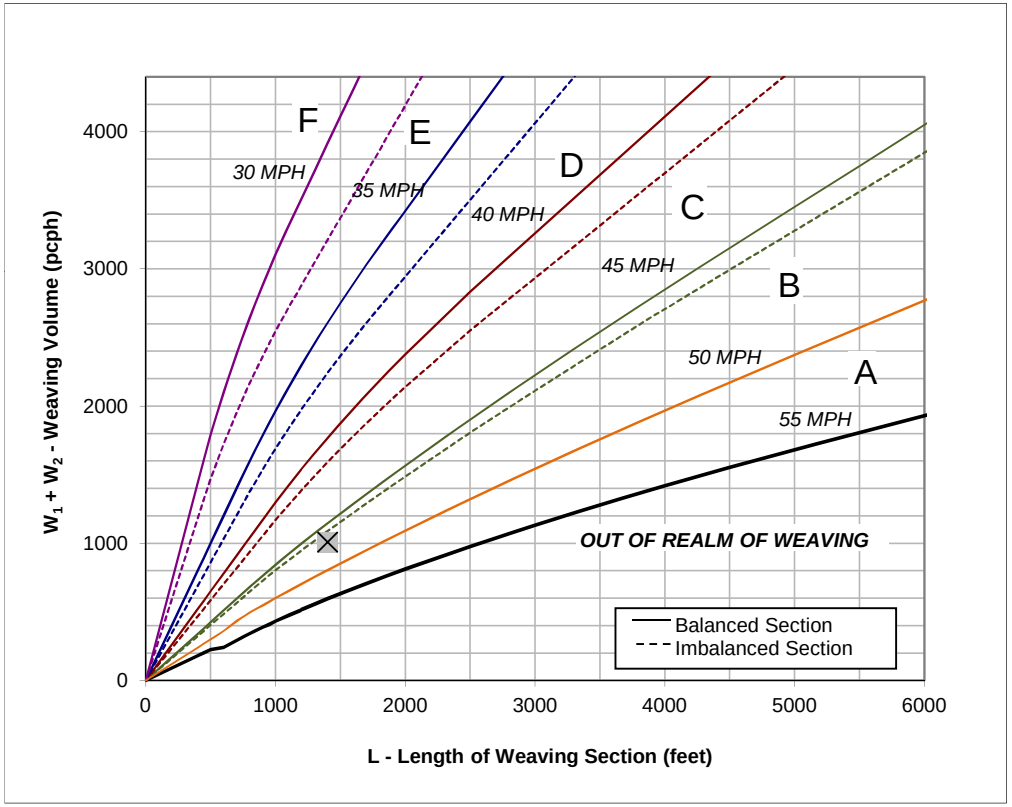
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,400

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,360	Volume (vph)*	60	Volume (vph)*	920
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,461	Volume (pcph)	62	Volume (pcph)	948

Project Information

Project	LBNL
Scenario	Cumulative PM
Freeway	WB I-580
On-ramp	Regatta Blvd
Off-ramp	Marina Bay Parkway



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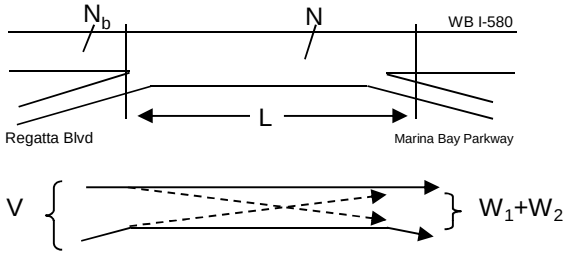

Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   45 MPH and **50 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **46.4**
4. Weaving Intensity Factor (k) **2.30**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **885**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

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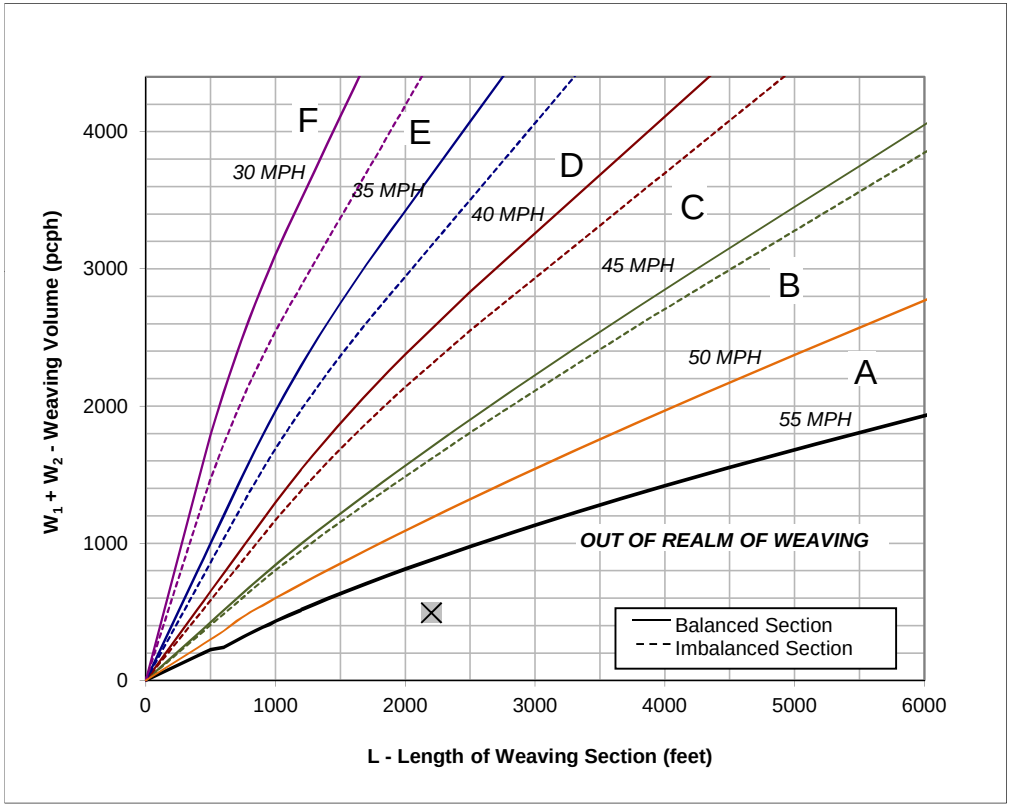
Leisch Method for Weaving Analysis

Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Project Information	
Project	LBNL
Scenario	Cumulative PM
Freeway	EB I-580
On-ramp	Regatta Blvd
Off-ramp	Bayview Ave

	Total Weaving Section (V)	On-ramp to Mainline (W_1)	Mainline to Off-ramp (W_2)
Volume (vph)*	4,760	400	80
Truck Percentage	6%	6%	6%
PCE for Trucks	1.5	1.5	1.5
Volume (pcph)	4,903	412	82



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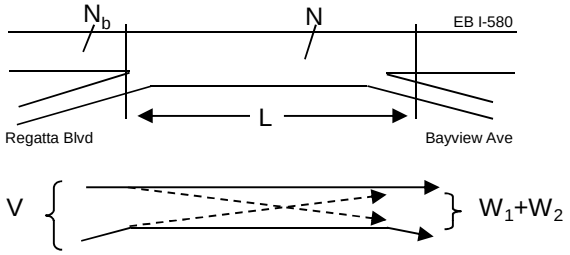

Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **61.3**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **1,226**
6. Level of Service (LOS) **C**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

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Leisch Method for Weaving Analysis

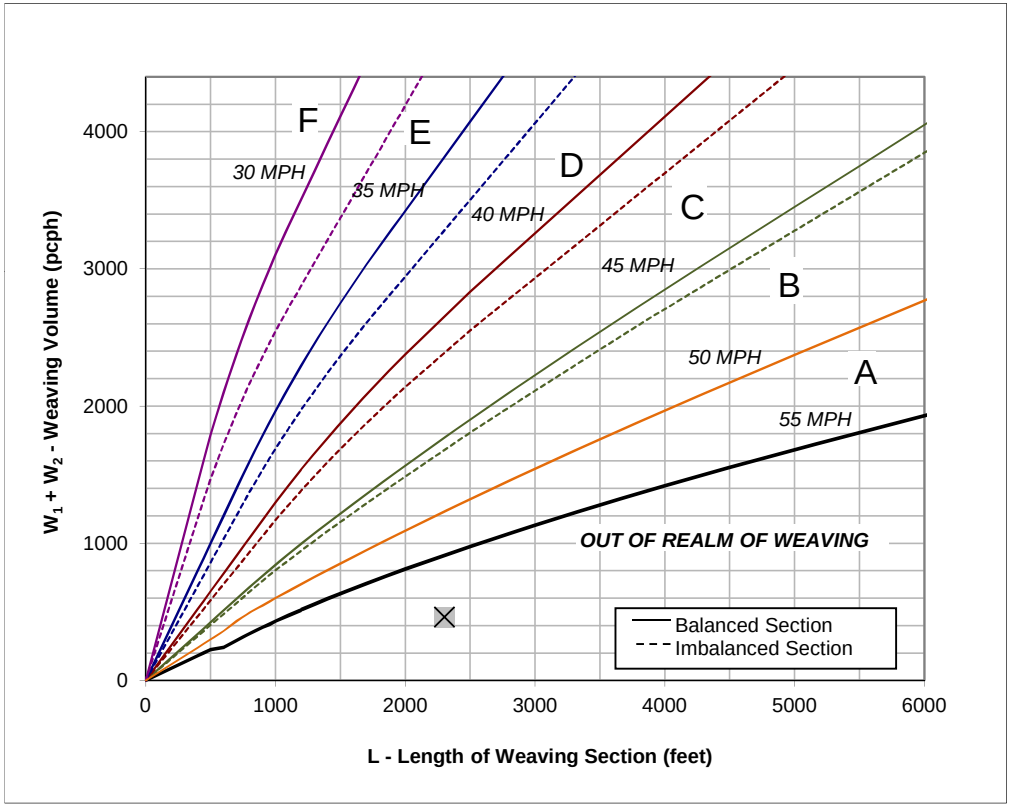
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,300

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,900	Volume (vph)*	290	Volume (vph)*	160
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	4,017	Volume (pcph)	299	Volume (pcph)	165

Project Information

Project	LBNL
Scenario	Cumulative PM
Freeway	WB I-580
On-ramp	Bayview Ave
Off-ramp	Regatta Blvd



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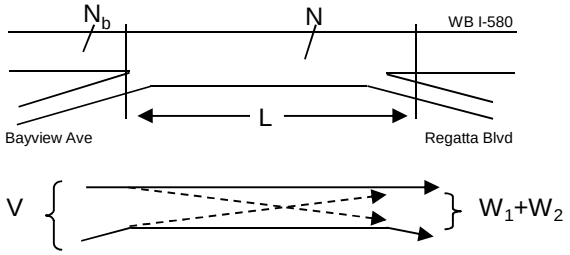

Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **62.1**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **1,004**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

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Cumulative (2035) Plus Project Buildout Conditions

FEHR PEERS

HCM 2000
Basic Freeway Segments
Capacity Analysis

Jurisdiction
Analysis Year Cumulative
Analyst TL

Agency or Company
Date
Project Description

General Information | *Flow Rate Calculation* | *Speed Calculation* | *Results*

	Freeway/ Direction	From/To	Analysis Time Period	Volume (vph)	PHF	Lanes	HOV Lane?	HOV Lane Volume	Terrain	Truck/ Bus %	RV %	E_T	E_R	f_{HV}	f_P	Flow Rate v_p (pcphpl)	Measured FFS (mph)	S (mph)	Density, D (pcplpm)	Level of Service
R-5	I-580 EB	I-580 between Bayview Avenue and Central Avenue	AM	4,359	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,627	65.0	64.8	**25.1**	**C**
R-6	I-580 EB	I-580 between Central Avenue and I-80	AM	3,899	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	2,183	65.0	57.5	**37.9**	**E**
R-7	I-80 EB	I-80 between Carlson Boulevard and Potrero Avenue	AM	5,131	0.92	4	Yes	350	Level	4%	0%	1.5	1.2	0.980	1.00	1,767	65.0	64.2	**27.5**	**D**
R-8	I-80 EB	I-80 @ Gilman Overpass	AM	7,600	0.92	5	Yes	900	Level	5%	0%	1.5	1.2	0.976	1.00	1,866	65.0	63.3	**29.5**	**D**
R-5	I-580 WB	I-580 between Bayview Avenue and Central Avenue	AM	5,100	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,903	65.0	62.9	**30.3**	**D**
R-6	I-580 WB	I-580 between Central Avenue and I-80	AM	5,050	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	2,827	65.0	-	**-**	**F**
R-7	I-80 WB	I-80 between Carlson Boulevard and Potrero Avenue	AM	7,349	0.92	4	Yes	1150	Level	4%	0%	1.5	1.2	0.980	1.00	2,291	65.0	54.3	**42.2**	**E**
R-8	I-80 WB	I-80 @ Gilman Overpass	AM	9,119	0.92	5	Yes	1500	Level	5%	0%	1.5	1.2	0.976	1.00	2,122	65.0	59.0	**36.0**	**E**
R-5	I-580 EB	I-580 between Bayview Avenue and Central Avenue	PM	5,057	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,887	65.0	63.0	**29.9**	**D**
R-6	I-580 EB	I-580 between Central Avenue and I-80	PM	5,087	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	2,848	65.0	-	**-**	**F**
R-7	I-80 EB	I-80 between Carlson Boulevard and Potrero Avenue	PM	6,992	0.92	4	Yes	1400	Level	4%	0%	1.5	1.2	0.980	1.00	2,067	65.0	60.2	**34.3**	**D**
R-8	I-80 EB	I-80 @ Gilman Overpass	PM	8,371	0.92	5	Yes	1150	Level	5%	0%	1.5	1.2	0.976	1.00	2,011	65.0	61.3	**32.8**	**D**
R-5	I-580 WB	I-580 between Bayview Avenue and Central Avenue	PM	4,181	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,560	65.0	64.9	**24.0**	**C**
R-6	I-580 WB	I-580 between Central Avenue and I-80	PM	3,361	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,881	65.0	63.1	**29.8**	**D**
R-7	I-80 WB	I-80 between Carlson Boulevard and Potrero Avenue	PM	5,407	0.92	4	Yes	400	Level	4%	0%	1.5	1.2	0.980	1.00	1,850	65.0	63.4	**29.2**	**D**
R-8	I-80 WB	I-80 @ Gilman Overpass	PM	7,777	0.92	5	Yes	700	Level	5%	0%	1.5	1.2	0.976	1.00	1,971	65.0	61.9	**31.8**	**D**

Leisch Method for Weaving Analysis

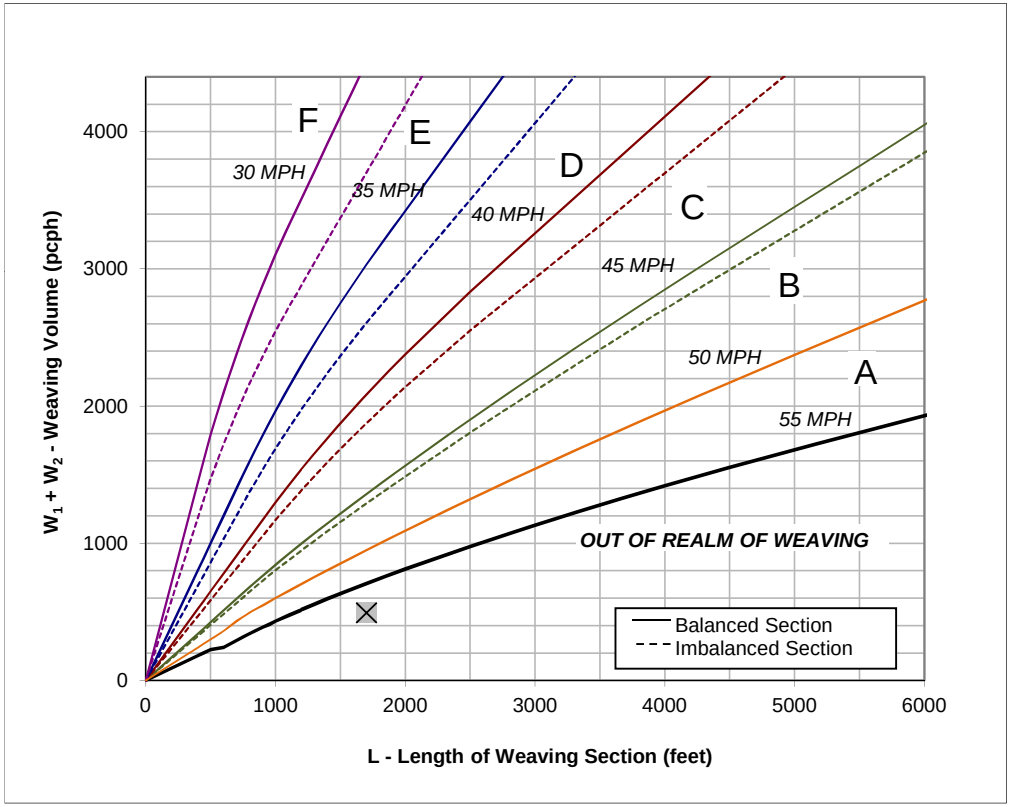
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,700

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,133	Volume (vph)*	320	Volume (vph)*	160
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,227	Volume (pcph)	330	Volume (pcph)	165

Project Information

Project	LBNL
Scenario	Cumulative Plus Buildout AM
Freeway	EB I-580
On-ramp	Harbour Way
Off-ramp	Marina Bay Pkwy



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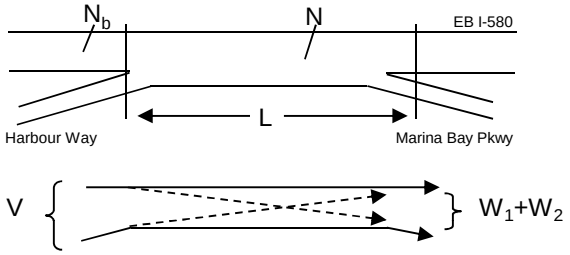


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **59.4**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **807**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

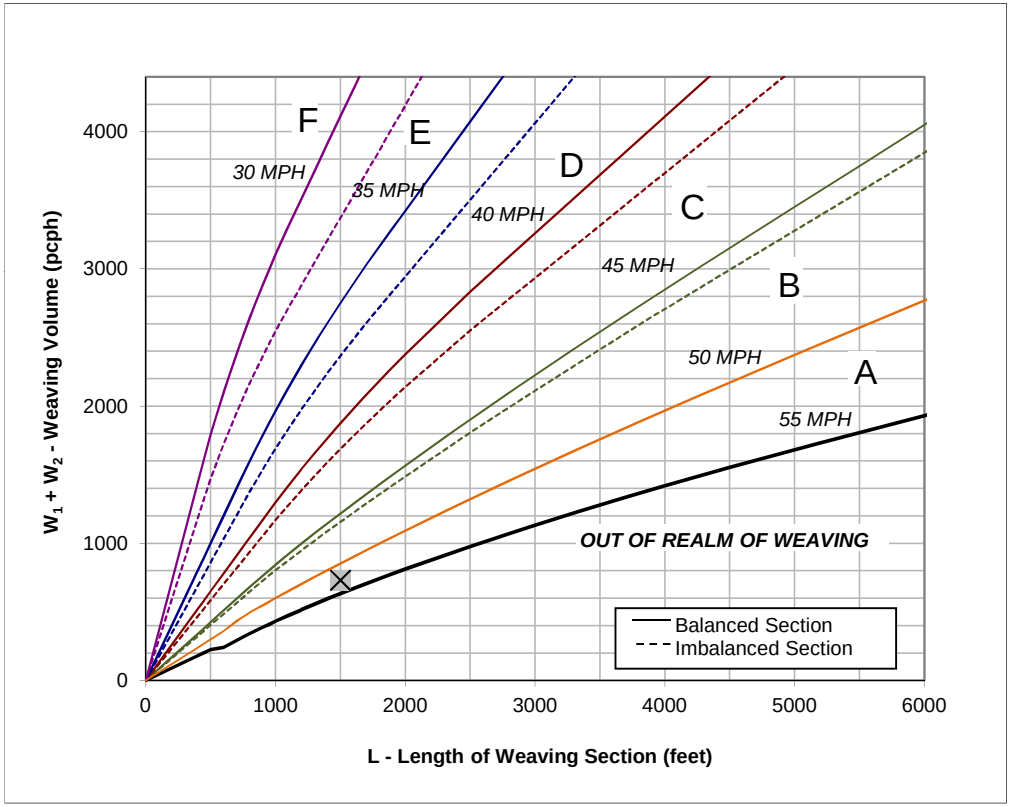
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,500

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	4,382	Volume (vph)*	320	Volume (vph)*	390
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	4,513	Volume (pcph)	330	Volume (pcph)	402

Project Information

Project	LBNL
Scenario	Cumulative Plus Buildout AM
Freeway	WB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Harbour Way



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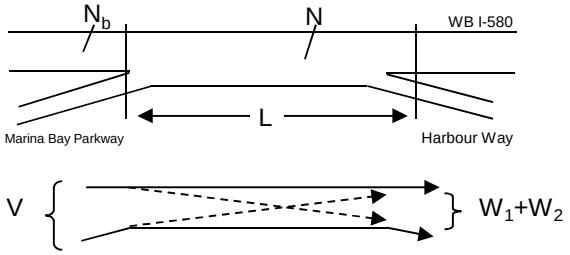


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **52.8**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **1,128**
6. Level of Service (LOS) **C**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

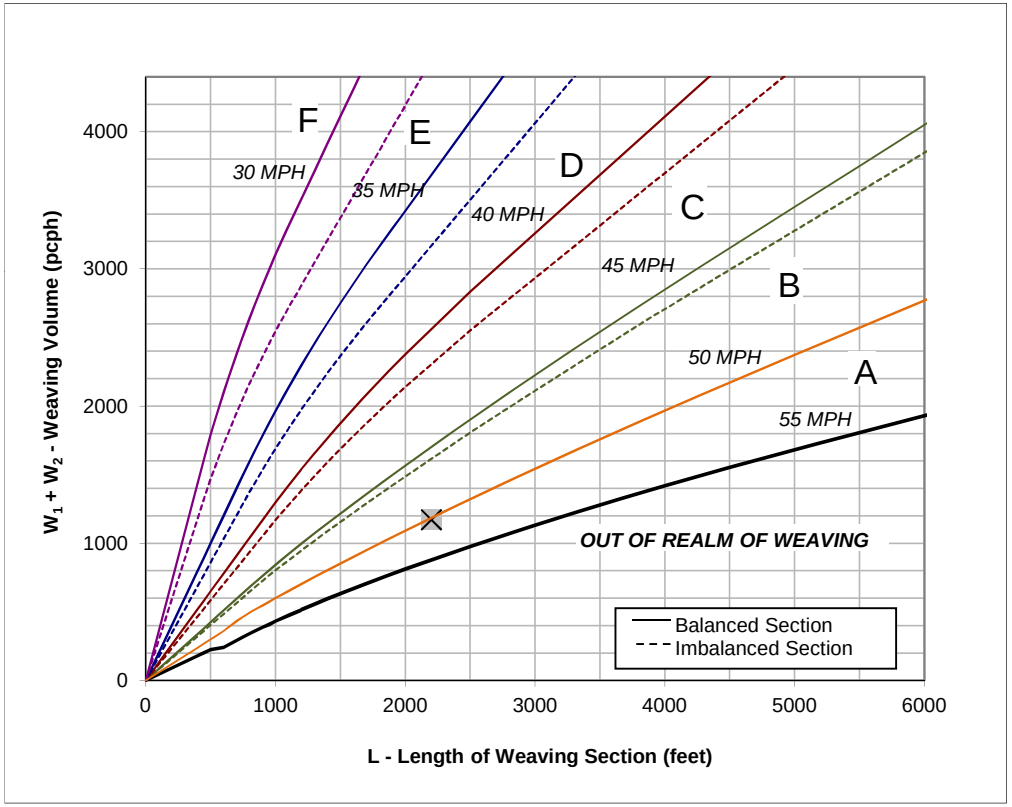
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	4,123	Volume (vph)*	820	Volume (vph)*	318
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	4,247	Volume (pcph)	845	Volume (pcph)	328

Project Information

Project	LBNL
Scenario	Cumulative Plus Buildout AM
Freeway	EB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Regatta Blvd



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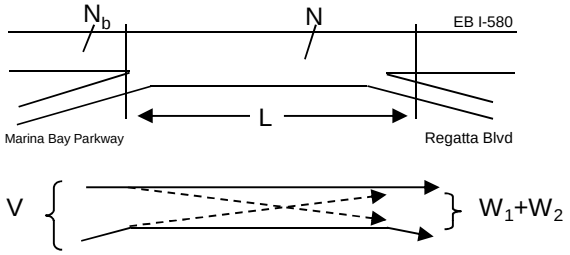


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **50.2**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **1,062**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

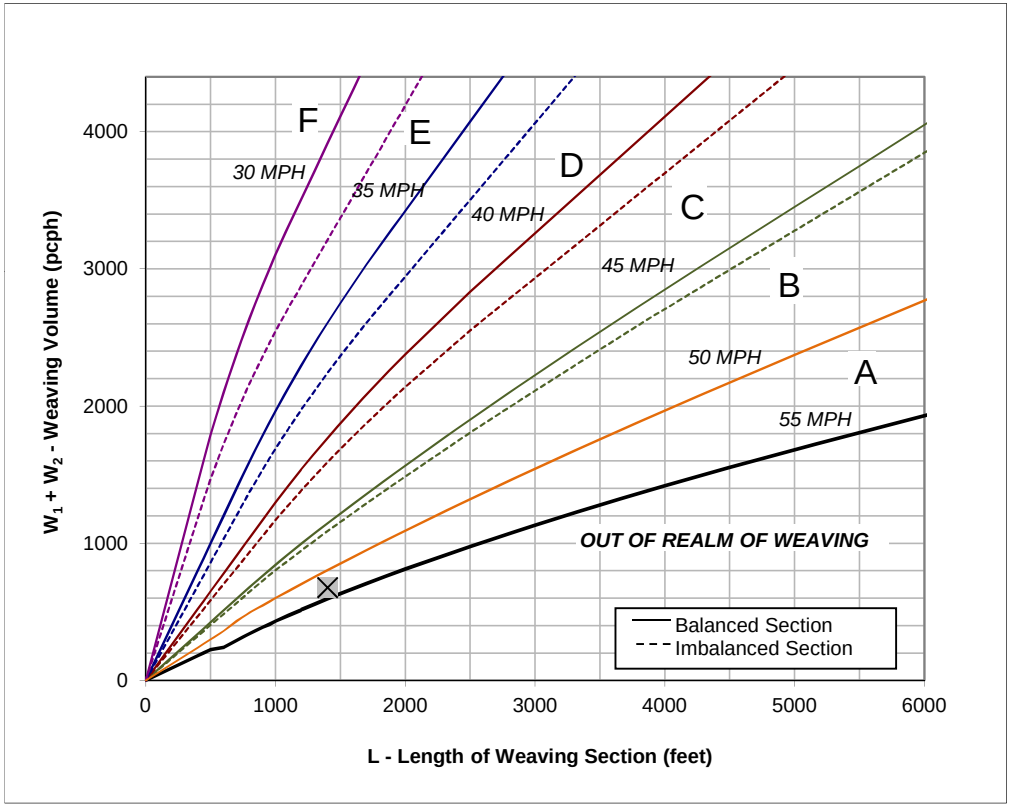
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,400

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	4,965	Volume (vph)*	175	Volume (vph)*	483
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	5,114	Volume (pcph)	180	Volume (pcph)	497

Project Information

Project	LBNL
Scenario	Cumulative Plus Buildout AM
Freeway	WB I-580
On-ramp	Regatta Blvd
Off-ramp	Marina Bay Parkway



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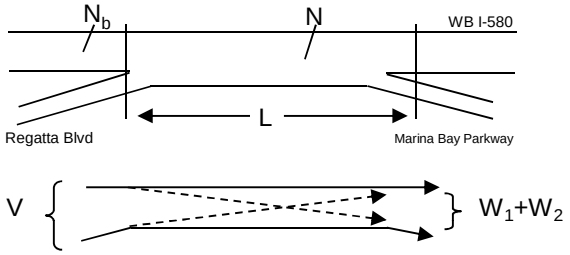


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **53.0**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **1,278**
6. Level of Service (LOS) **C**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

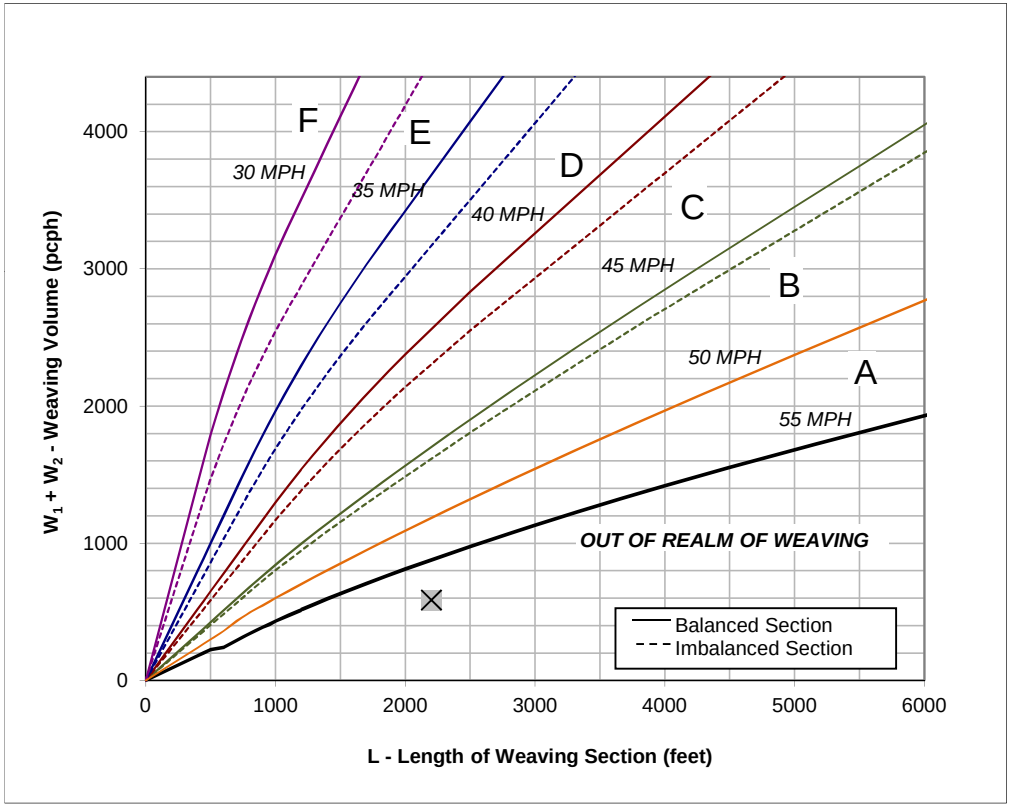
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	4,390	Volume (vph)*	140	Volume (vph)*	430
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	4,522	Volume (pcph)	144	Volume (pcph)	443

Project Information

Project	LBNL
Scenario	Cumulative Plus Buildout AM
Freeway	EB I-580
On-ramp	Regatta Blvd
Off-ramp	Bayview Ave



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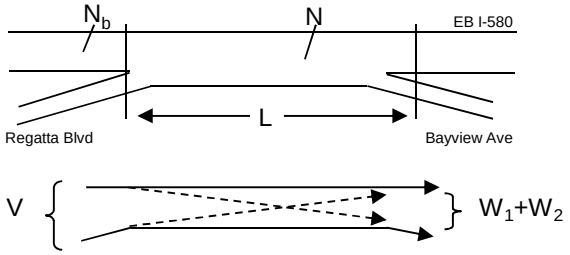


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **59.8**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **1,130**
6. Level of Service (LOS) **C**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

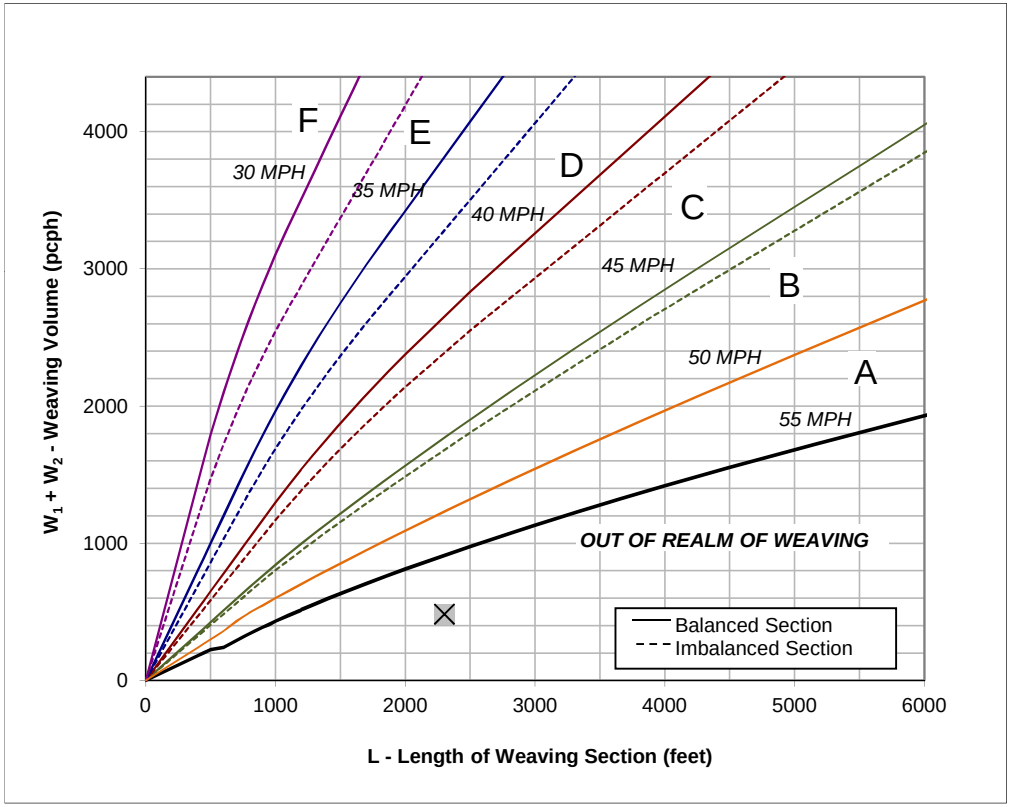
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,300

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	4,890	Volume (vph)*	380	Volume (vph)*	90
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	5,037	Volume (pcph)	391	Volume (pcph)	93

Project Information

Project	LBNL
Scenario	Cumulative Plus Buildout AM
Freeway	WB I-580
On-ramp	Bayview Ave
Off-ramp	Regatta Blvd



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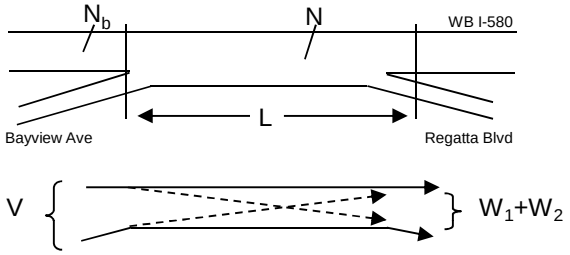


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **61.7**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **1,259**
6. Level of Service (LOS) **C**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

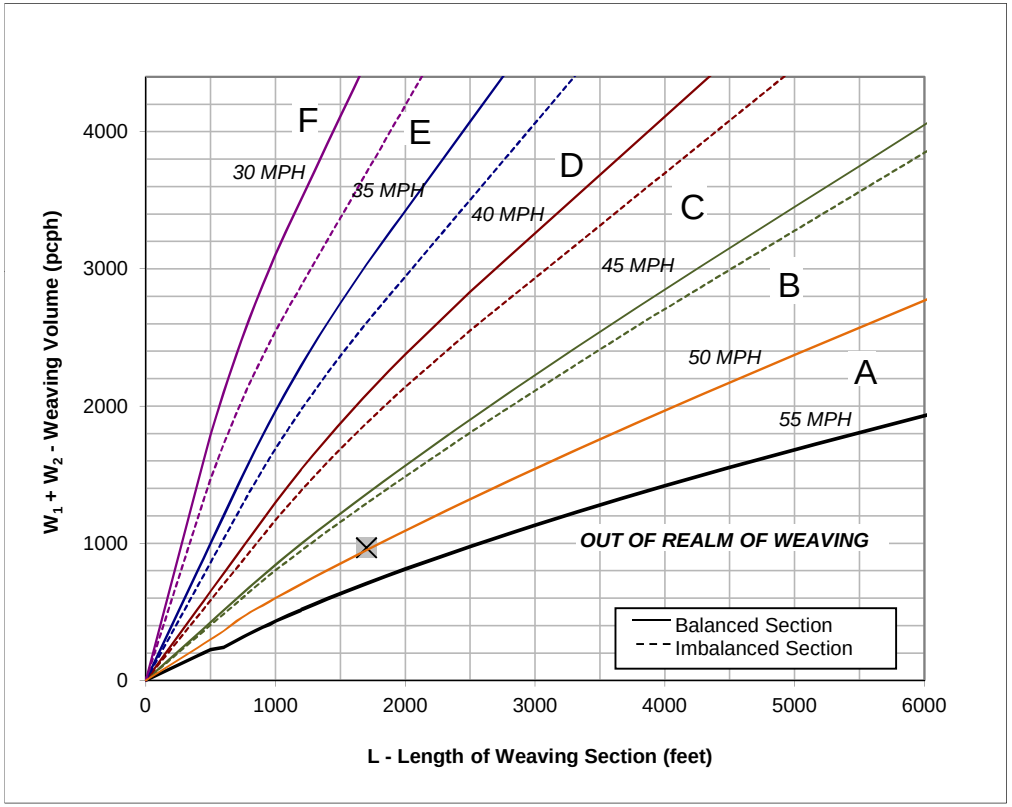
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,700

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	4,739	Volume (vph)*	600	Volume (vph)*	340
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	4,881	Volume (pcph)	618	Volume (pcph)	350

Project Information

Project	LBNL
Scenario	Cumulative Plus Buildout PM
Freeway	EB I-580
On-ramp	Harbour Way
Off-ramp	Marina Bay Pkwy



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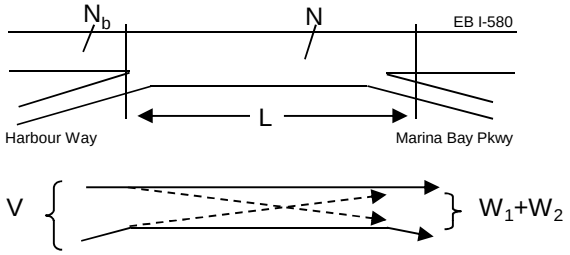


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **49.6**
4. Weaving Intensity Factor (k) **1.25**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **1,242**
6. Level of Service (LOS) **C**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

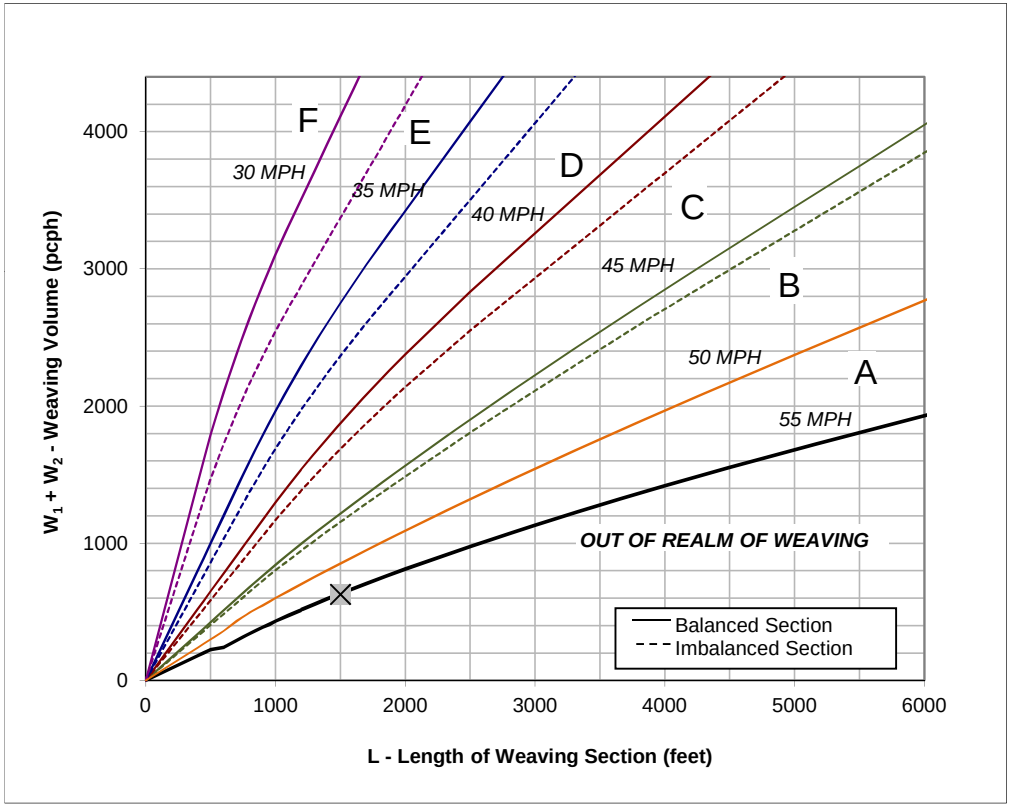
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,500

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,902	Volume (vph)*	220	Volume (vph)*	390
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,989	Volume (pcph)	227	Volume (pcph)	402

Project Information

Project	LBNL
Scenario	Cumulative Plus Buildout PM
Freeway	WB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Harbour Way



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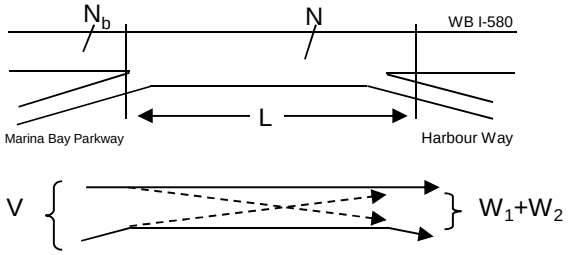


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **55.1**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **747**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

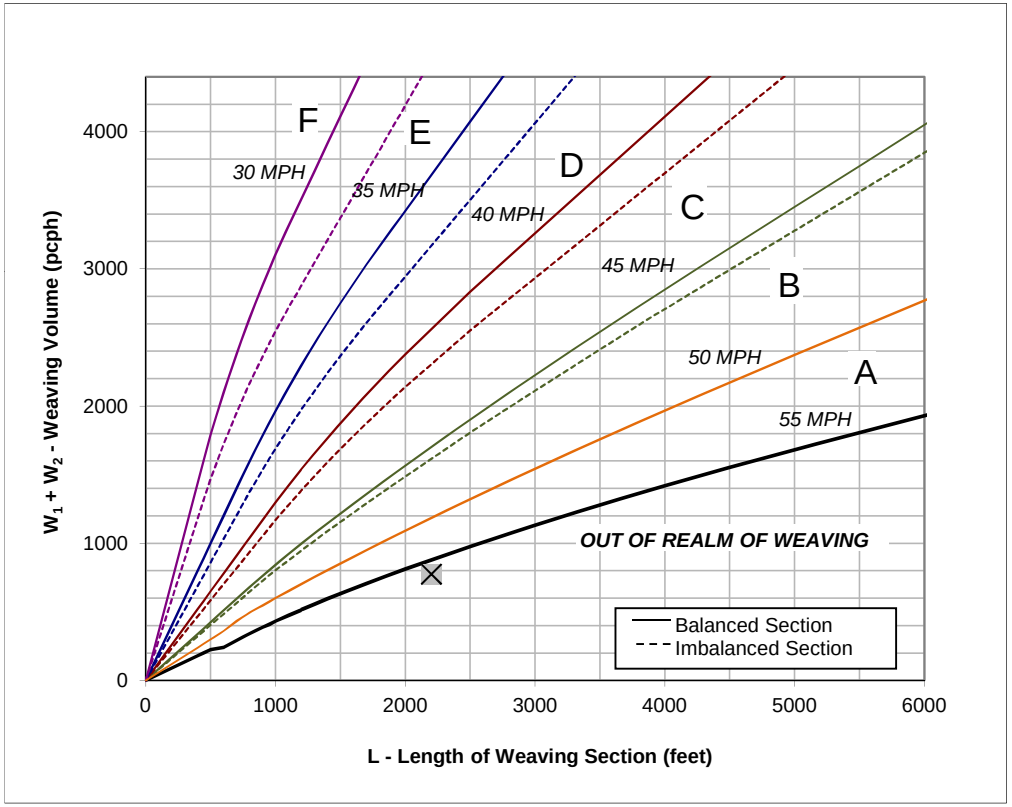
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	4,641	Volume (vph)*	592	Volume (vph)*	161
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	4,780	Volume (pcph)	610	Volume (pcph)	166

Project Information

Project	LBNL
Scenario	Cumulative Plus Buildout PM
Freeway	EB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Regatta Blvd



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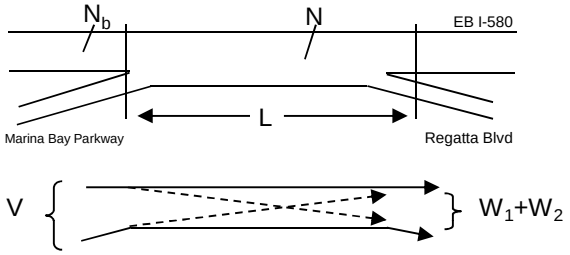


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **56.7**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **1,195**
6. Level of Service (LOS) **C**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

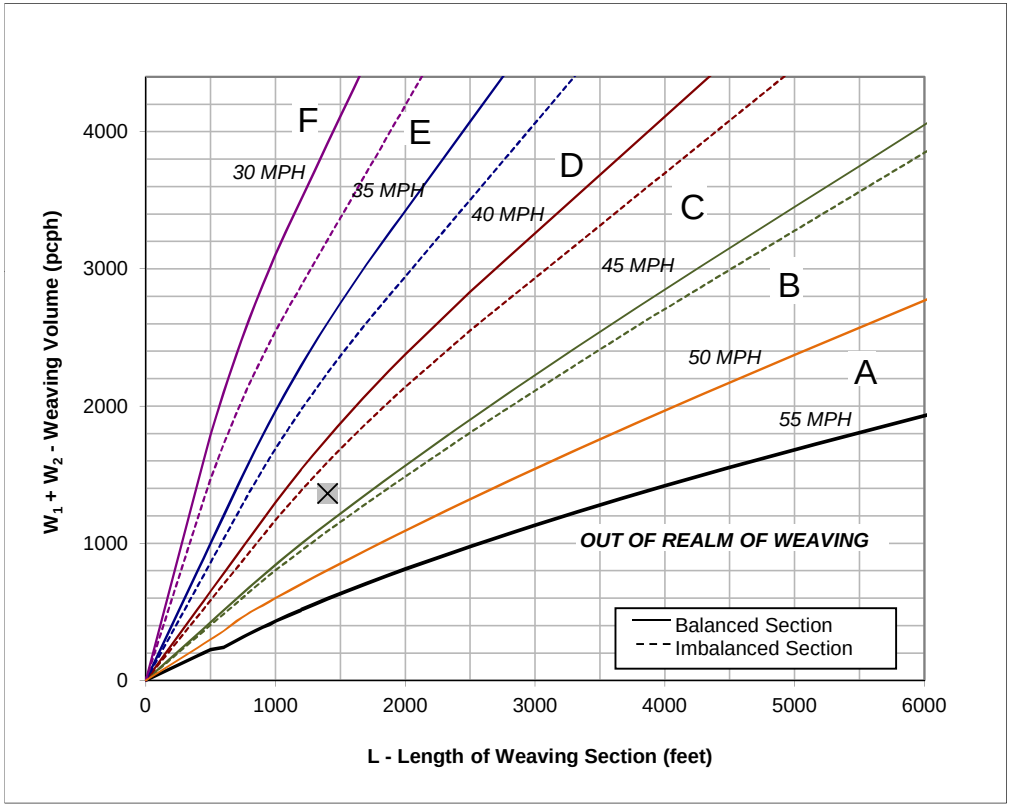
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,400

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,628	Volume (vph)*	328	Volume (vph)*	996
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,737	Volume (pcph)	338	Volume (pcph)	1,026

Project Information

Project	LBNL
Scenario	Cumulative Plus Buildout PM
Freeway	WB I-580
On-ramp	Regatta Blvd
Off-ramp	Marina Bay Parkway



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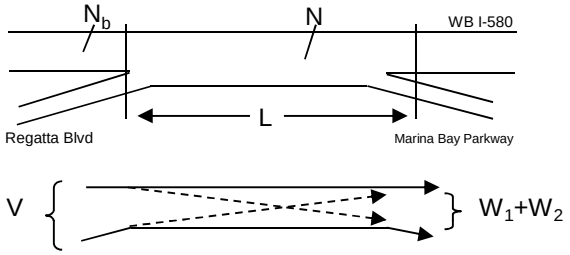


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   45 MPH and **50 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **40.1**
4. Weaving Intensity Factor (k) **2.98**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **1,101**
6. Level of Service (LOS) **C**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

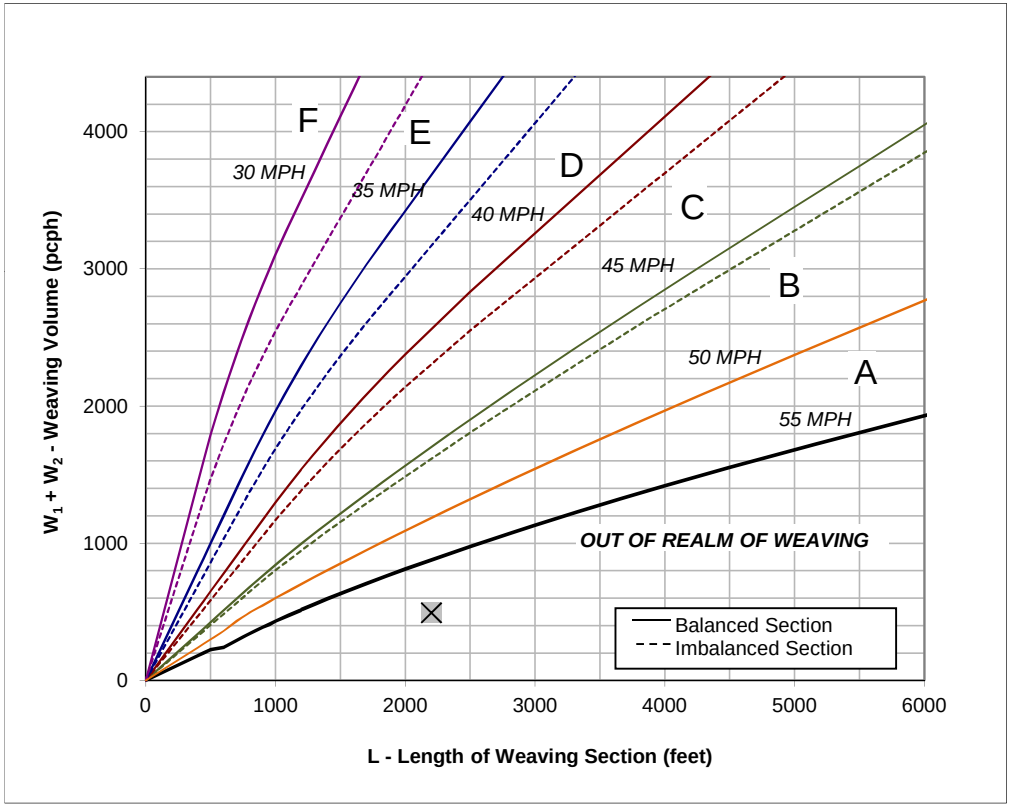
Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Project Information	
Project	LBNL
Scenario	Cumulative Plus Buildout PM
Freeway	EB I-580
On-ramp	Regatta Blvd
Off-ramp	Bayview Ave

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	4,760	Volume (vph)*	400	Volume (vph)*	80
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	4,903	Volume (pcph)	412	Volume (pcph)	82



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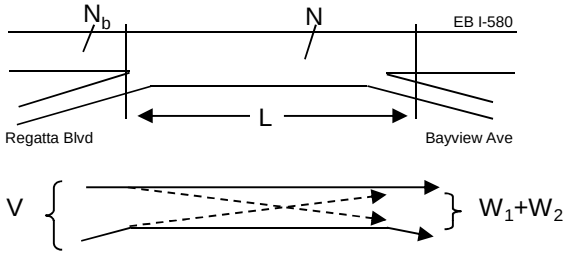


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **61.3**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **1,226**
6. Level of Service (LOS) **C**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

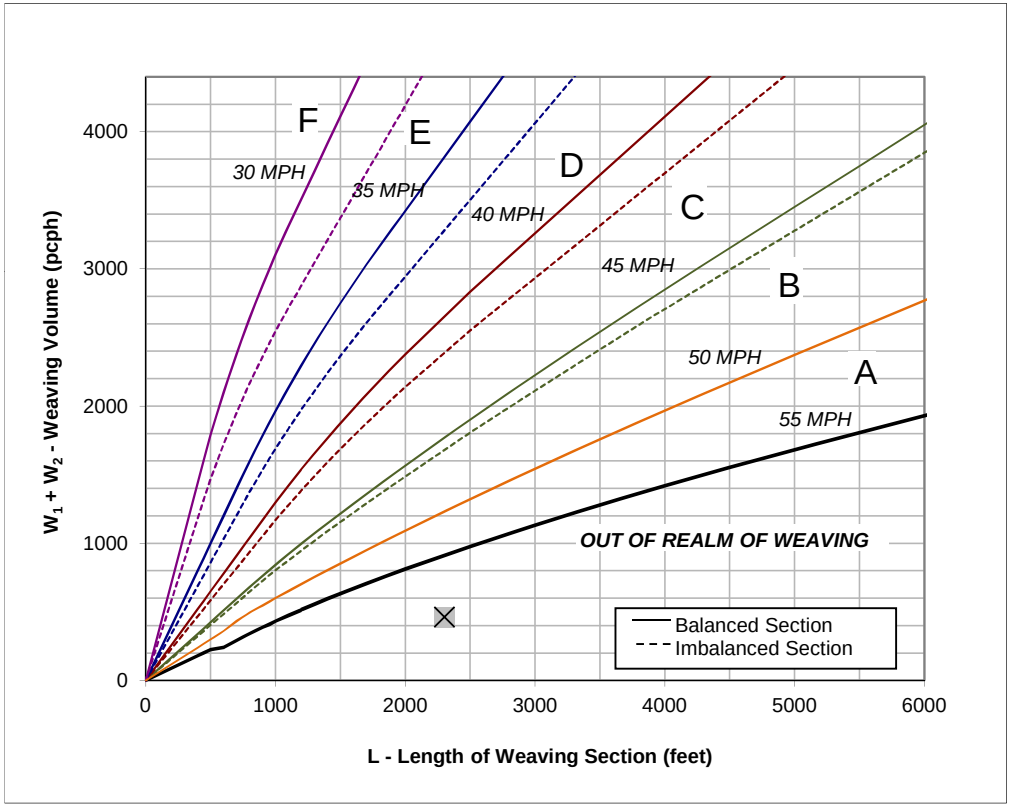
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,300

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,900	Volume (vph)*	290	Volume (vph)*	160
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	4,017	Volume (pcph)	299	Volume (pcph)	165

Project Information

Project	LBNL
Scenario	Cumulative Plus Buildout PM
Freeway	WB I-580
On-ramp	Bayview Ave
Off-ramp	Regatta Blvd



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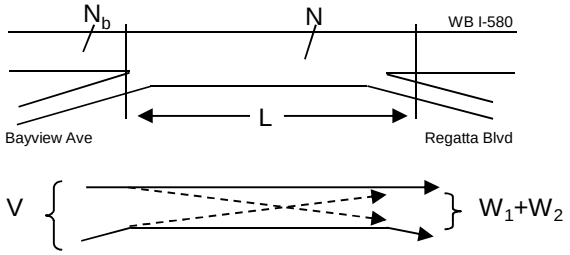


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **62.1**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **1,004**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Near-Term (2018) Plus Additional Employment Alternative Conditions

FEHR PEERS

HCM 2000
Basic Freeway Segments
Capacity Analysis

Jurisdiction
Analysis Year Near-Term + Phase 1 Alternative
Analyst SN
Agency or Company
Date
Project Description

General Information *Flow Rate Calculation* *Speed Calculation* *Results*

	Freeway/ Direction	From/To	Analysis Time Period	Volume (vph)	PHF	Lanes	HOV Lane?	HOV Lane Volume	Terrain	Truck/ Bus %	RV %	E_T	E_R	f_{HV}	f_P	Flow Rate v_p (pcphpl)	Measured FFS (mph)	S (mph)	Density, D (pcplpm)	Level of Service
R-5	I-580 EB	I-580 between Bayview Avenue and Central Avenue	AM	3,117	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,163	65.0	65.0	**17.9**	**B**
R-6	I-580 EB	I-580 between Central Avenue and I-80	AM	3,027	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,694	65.0	64.6	**26.2**	**D**
R-7	I-80 EB	I-80 between Carlson Boulevard and Potrero Avenue	AM	4,329	0.92	4	Yes	290	Level	4%	0%	1.5	1.2	0.980	1.00	1,493	65.0	65.0	**23.0**	**C**
R-8	I-80 EB	I-80 @ Gilman Overpass	AM	6,248	0.92	5	Yes	780	Level	5%	0%	1.5	1.2	0.976	1.00	1,523	65.0	65.0	**23.4**	**C**
R-5	I-580 WB	I-580 between Bayview Avenue and Central Avenue	AM	3,118	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,164	65.0	65.0	**17.9**	**B**
R-6	I-580 WB	I-580 between Central Avenue and I-80	AM	3,408	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,908	65.0	62.8	**30.4**	**D**
R-7	I-80 WB	I-80 between Carlson Boulevard and Potrero Avenue	AM	6,336	0.92	4	Yes	1000	Level	4%	0%	1.5	1.2	0.980	1.00	1,972	65.0	61.9	**31.9**	**D**
R-8	I-80 WB	I-80 @ Gilman Overpass	AM	8,547	0.92	5	Yes	1410	Level	5%	0%	1.5	1.2	0.976	1.00	1,988	65.0	61.6	**32.2**	**D**
R-5	I-580 EB	I-580 between Bayview Avenue and Central Avenue	PM	3,073	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,147	65.0	65.0	**17.6**	**B**
R-6	I-580 EB	I-580 between Central Avenue and I-80	PM	3,693	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	2,067	65.0	60.2	**34.3**	**D**
R-7	I-80 EB	I-80 between Carlson Boulevard and Potrero Avenue	PM	6,233	0.92	4	Yes	1300	Level	4%	0%	1.5	1.2	0.980	1.00	1,823	65.0	63.7	**28.6**	**D**
R-8	I-80 EB	I-80 @ Gilman Overpass	PM	7,586	0.92	5	Yes	1070	Level	5%	0%	1.5	1.2	0.976	1.00	1,815	65.0	63.8	**28.5**	**D**
R-5	I-580 WB	I-580 between Bayview Avenue and Central Avenue	PM	3,256	0.92	3	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,215	65.0	65.0	**18.7**	**C**
R-6	I-580 WB	I-580 between Central Avenue and I-80	PM	2,806	0.92	2	No		Level	6%	0%	1.5	1.2	0.971	1.00	1,571	65.0	64.9	**24.2**	**C**
R-7	I-80 WB	I-80 between Carlson Boulevard and Potrero Avenue	PM	4,778	0.92	4	Yes	330	Level	4%	0%	1.5	1.2	0.980	1.00	1,644	65.0	64.8	**25.4**	**C**
R-8	I-80 WB	I-80 @ Gilman Overpass	PM	6,843	0.92	5	Yes	650	Level	5%	0%	1.5	1.2	0.976	1.00	1,725	65.0	64.4	**26.8**	**D**

Leisch Method for Weaving Analysis

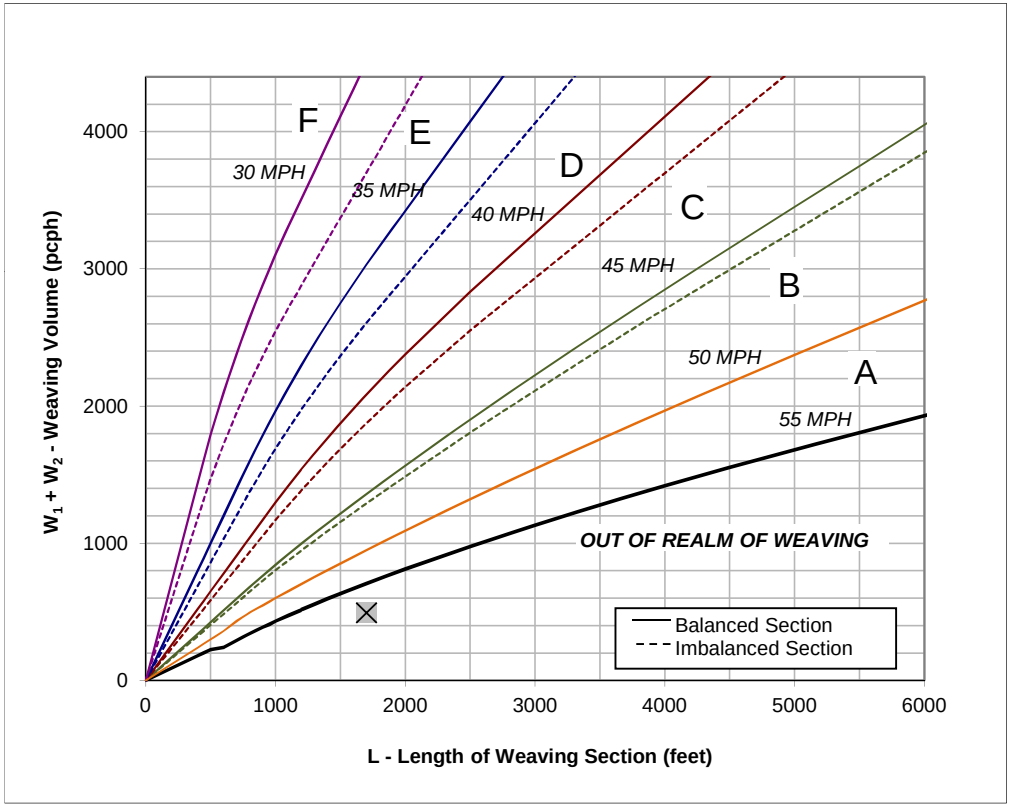
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,700

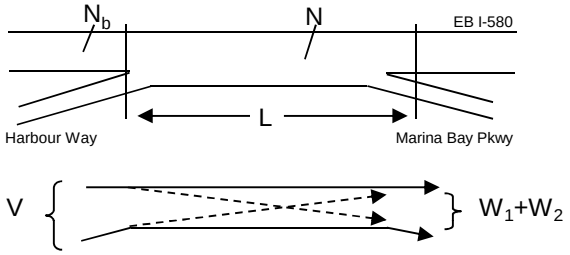
Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,481	Volume (vph)*	320	Volume (vph)*	160
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,555	Volume (pcph)	330	Volume (pcph)	165

Project Information

Project	LBNL
Scenario	Near-Term + Project Alt AM
Freeway	EB I-580
On-ramp	Harbour Way
Off-ramp	Marina Bay Pkwy



Figure



Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **59.4**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **639**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

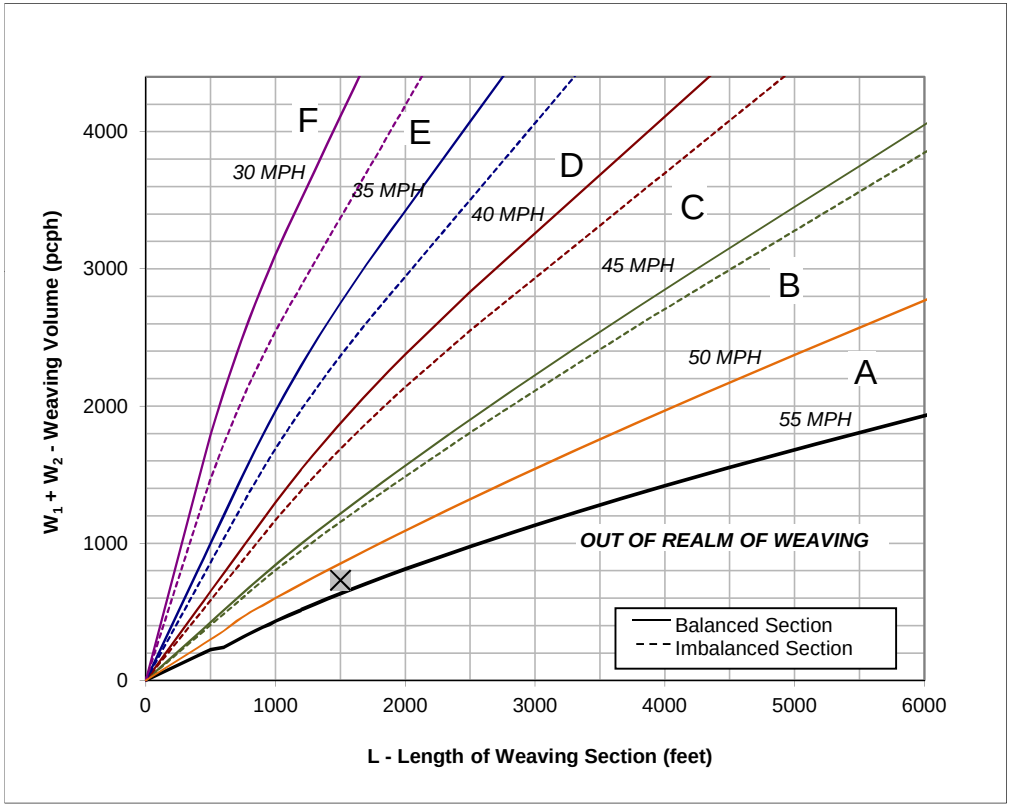
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,500

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,791	Volume (vph)*	320	Volume (vph)*	390
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,875	Volume (pcph)	330	Volume (pcph)	402

Project Information

Project	LBNL
Scenario	Near-Term + Project Alt AM
Freeway	WB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Harbour Way



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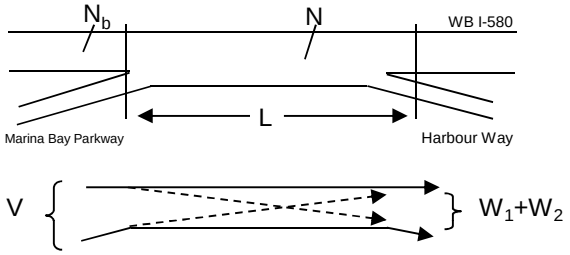


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **52.8**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **719**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

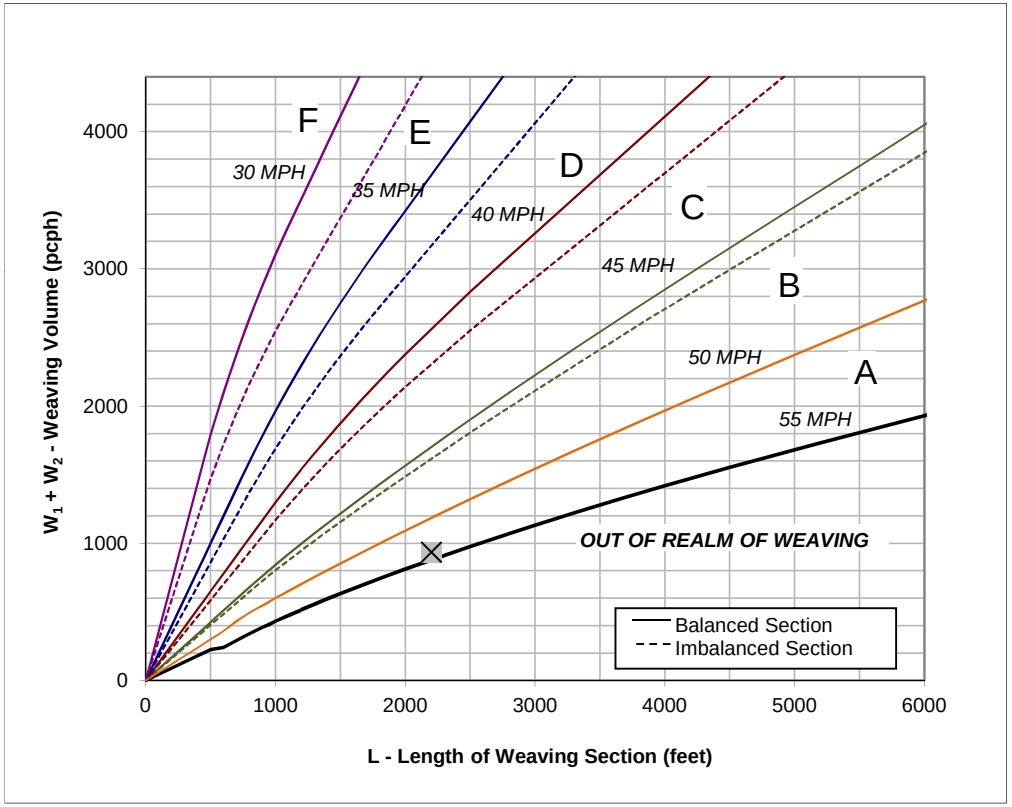
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,160	Volume (vph)*	749	Volume (vph)*	160
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,255	Volume (pcph)	771	Volume (pcph)	165

Project Information

Project	LBNL
Scenario	Near-Term + Project Alt AM
Freeway	EB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Regatta Blvd



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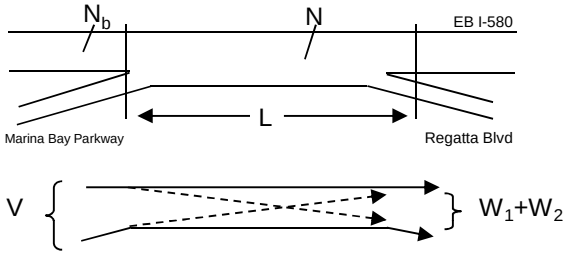

Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **54.1**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **814**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

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Leisch Method for Weaving Analysis

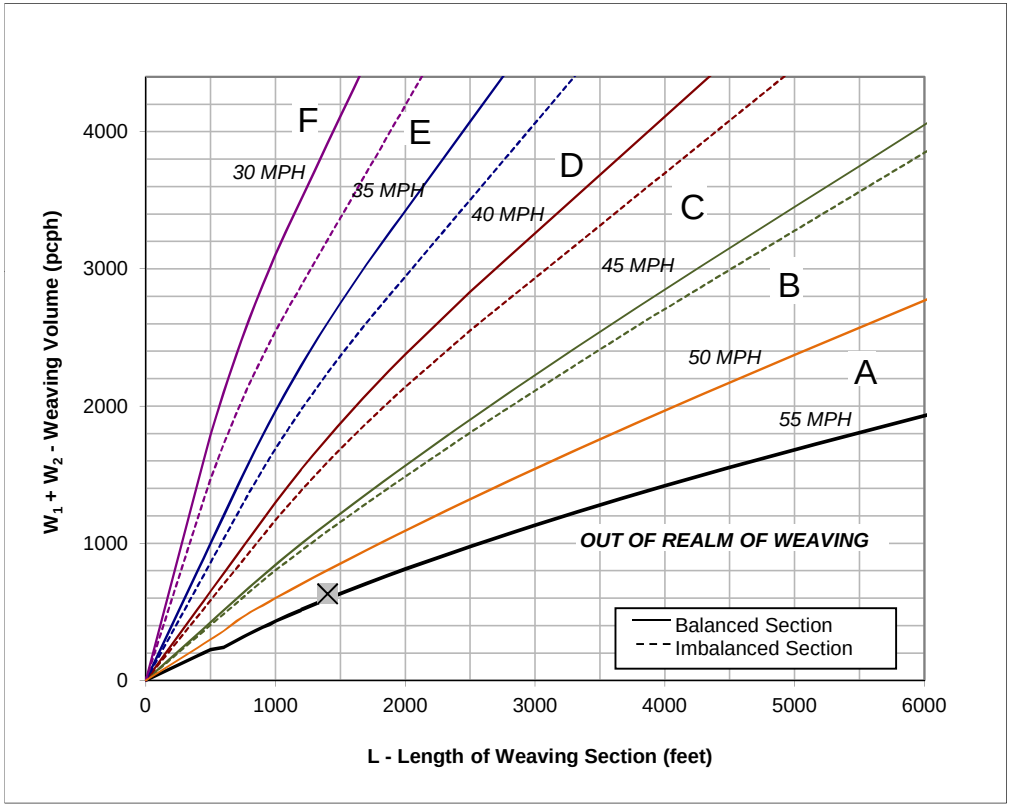
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,400

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,363	Volume (vph)*	143	Volume (vph)*	471
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,464	Volume (pcph)	147	Volume (pcph)	485

Project Information

Project	LBNL
Scenario	Near-Term + Project Alt AM
Freeway	WB I-580
On-ramp	Regatta Blvd
Off-ramp	Marina Bay Parkway



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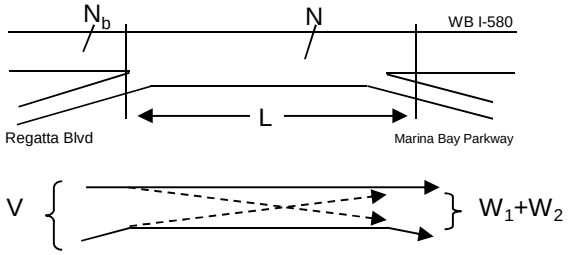

Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **54.1**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **866**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

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Leisch Method for Weaving Analysis

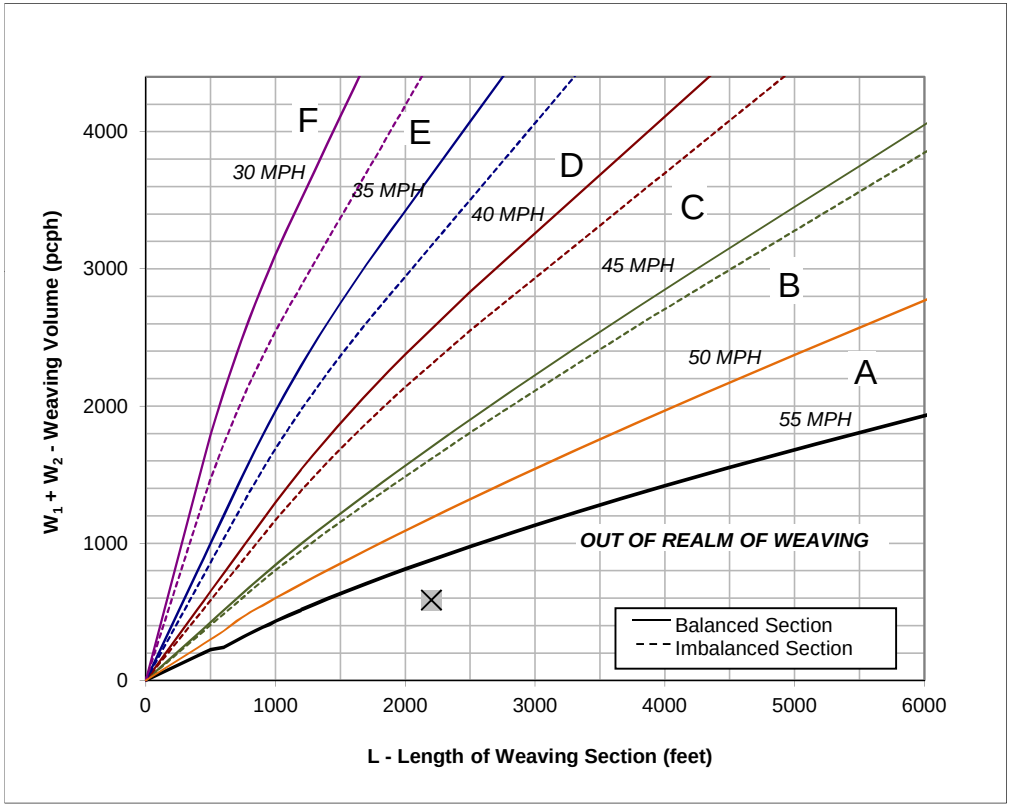
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,270	Volume (vph)*	140	Volume (vph)*	430
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,368	Volume (pcph)	144	Volume (pcph)	443

Project Information

Project	LBNL
Scenario	Near-Term + Project Alt AM
Freeway	EB I-580
On-ramp	Regatta Blvd
Off-ramp	Bayview Ave



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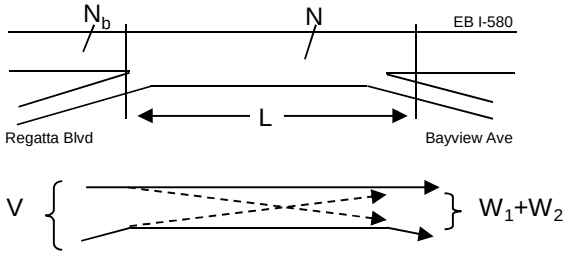


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **59.8**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **842**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

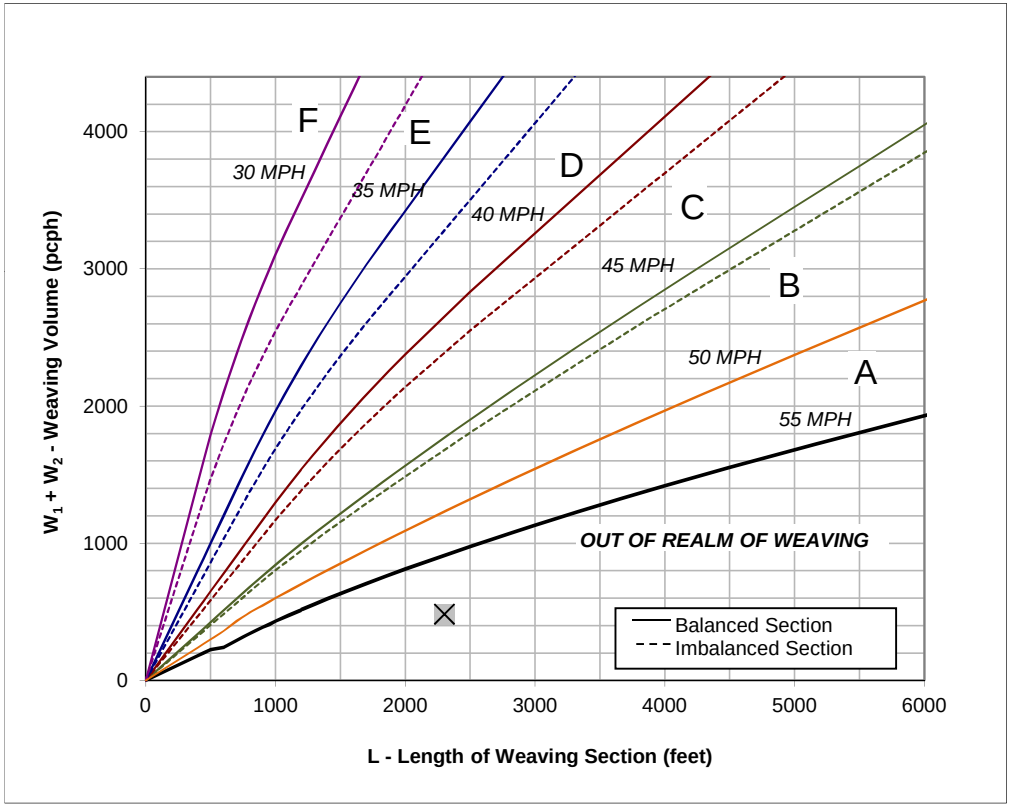
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,300

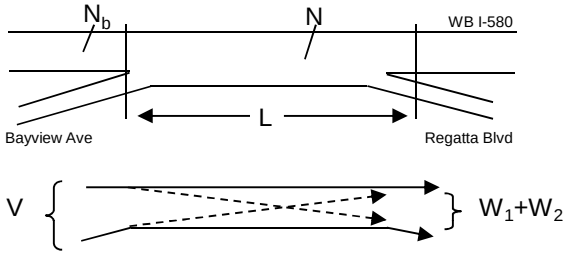
Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,310	Volume (vph)*	380	Volume (vph)*	90
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,409	Volume (pcph)	391	Volume (pcph)	93

Project Information

Project	LBNL
Scenario	Near-Term + Project Alt AM
Freeway	WB I-580
On-ramp	Bayview Ave
Off-ramp	Regatta Blvd



Figure



Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **61.7**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **852**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

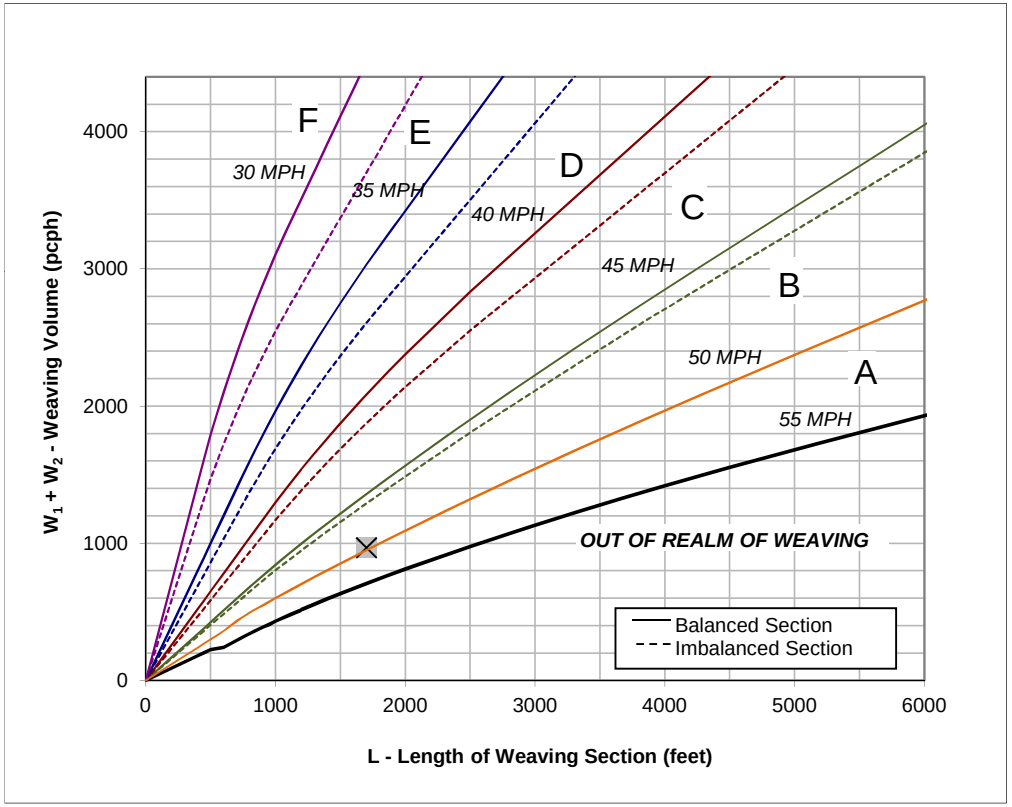
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,700

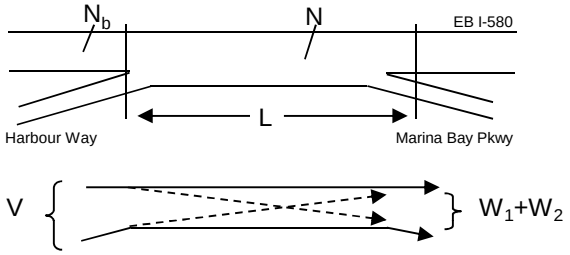
Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,110	Volume (vph)*	600	Volume (vph)*	340
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,203	Volume (pcph)	618	Volume (pcph)	350

Project Information

Project	LBNL
Scenario	Near-Term PM
Freeway	EB I-580
On-ramp	Harbour Way
Off-ramp	Marina Bay Pkwy



Figure



Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **49.6**
4. Weaving Intensity Factor (k) **1.25**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **823**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

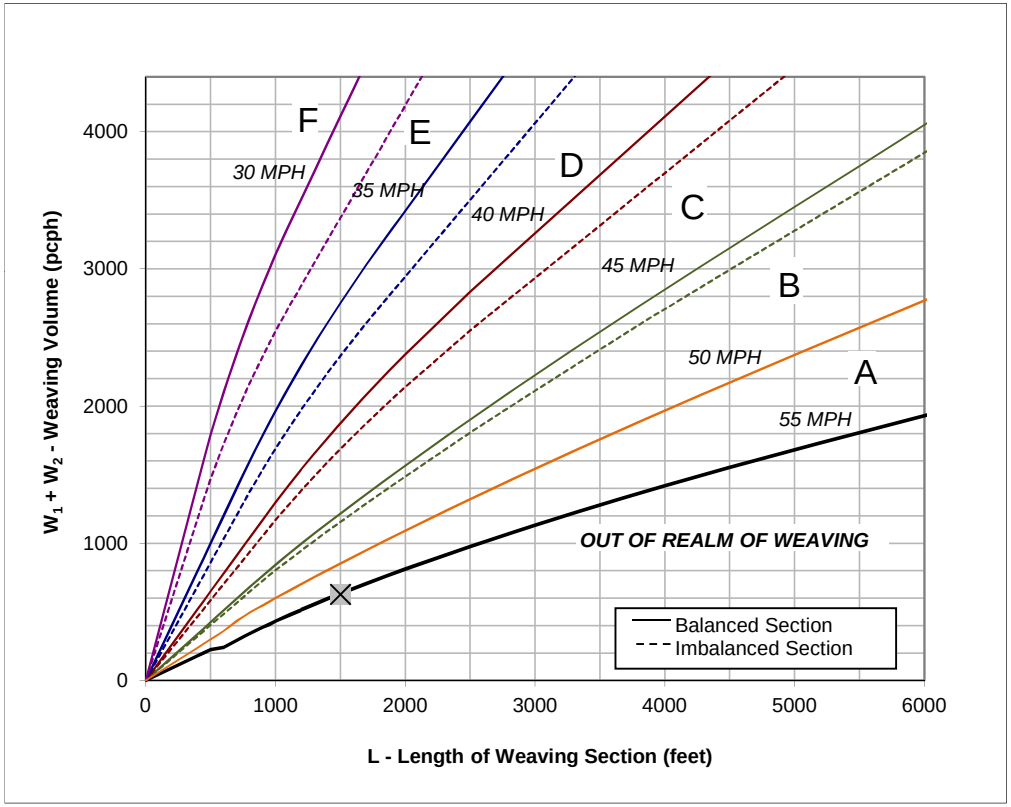
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,500

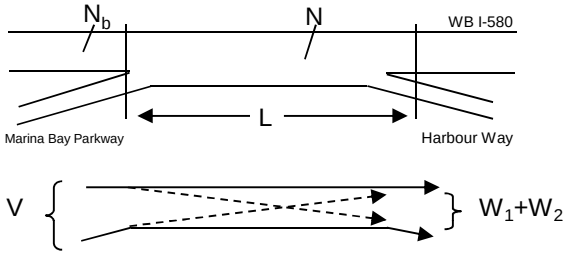
Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,237	Volume (vph)*	220	Volume (vph)*	390
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	2,304	Volume (pcph)	227	Volume (pcph)	402

Project Information

Project	LBNL
Scenario	Near-Term PM
Freeway	WB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Harbour Way



Figure



Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **55.1**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **576**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

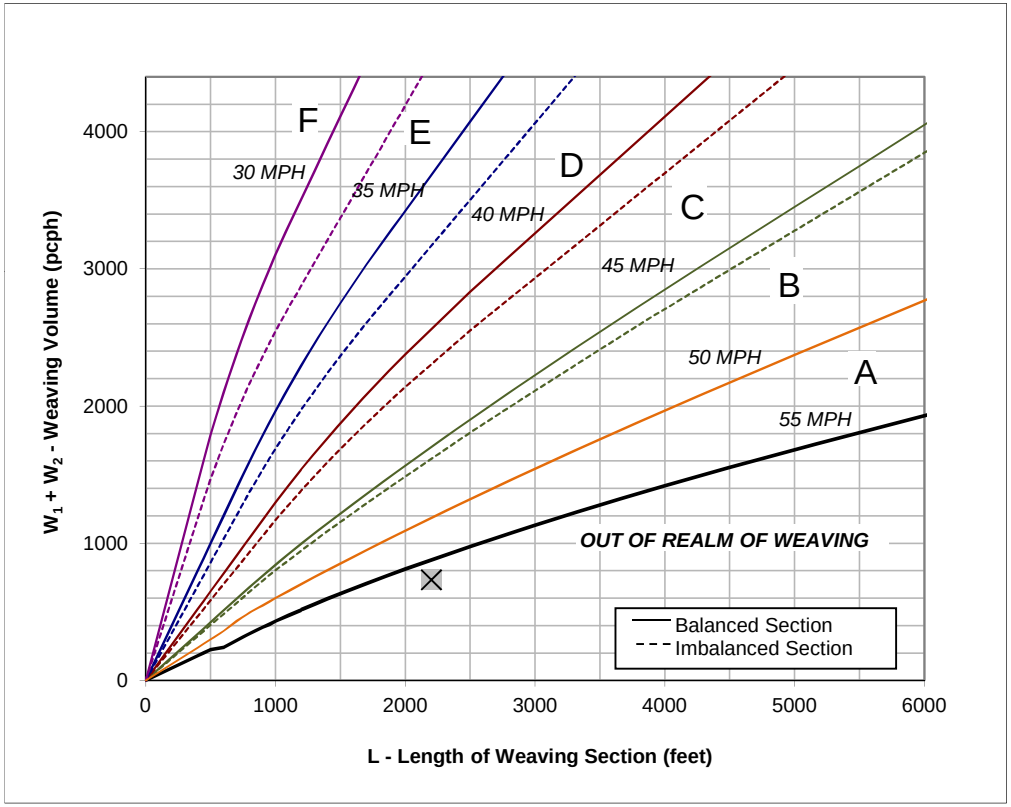
Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

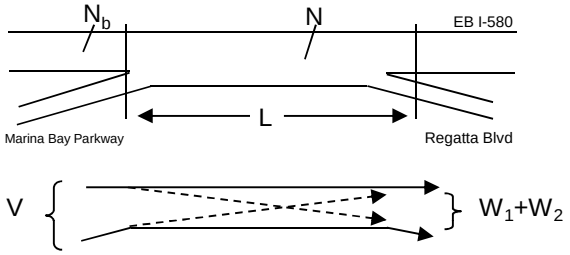
Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Project Information	
Project	LBNL
Scenario	Near-Term PM
Freeway	EB I-580
On-ramp	Marina Bay Parkway
Off-ramp	Regatta Blvd

	Total Weaving Section (V)	On-ramp to Mainline (W_1)	Mainline to Off-ramp (W_2)
Volume (vph)*	3,262	581	132
Truck Percentage	6%	6%	6%
PCE for Trucks	1.5	1.5	1.5
Volume (pcph)	3,360	598	136



Figure



Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **57.4**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **840**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

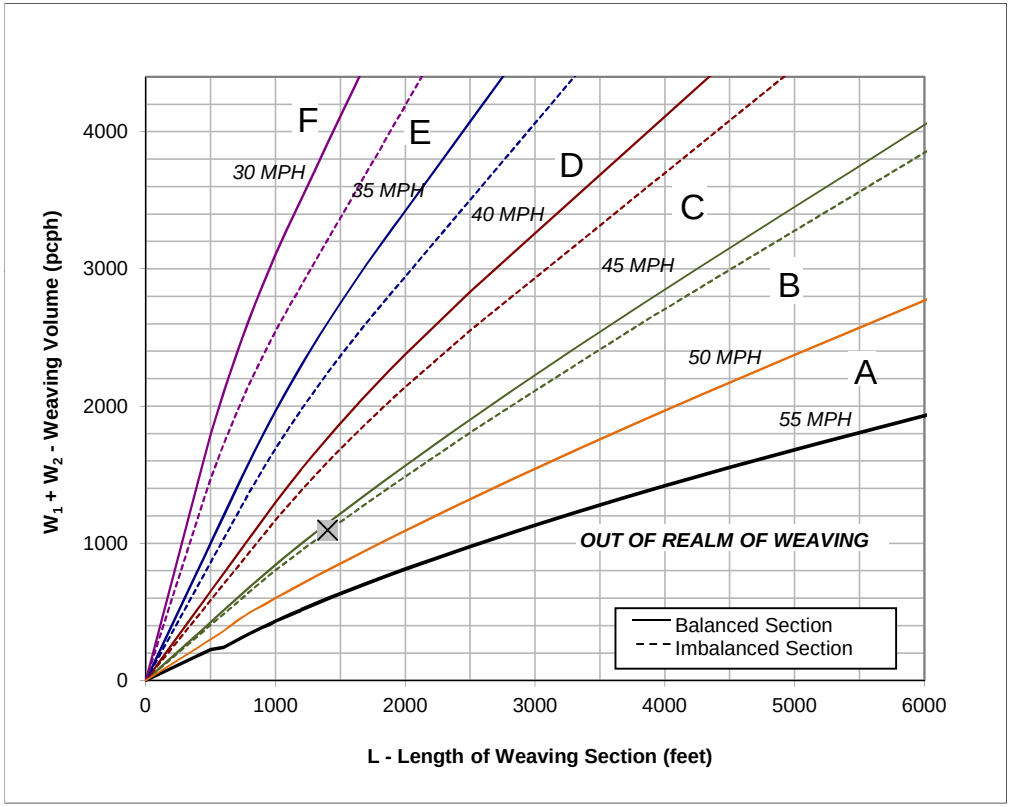
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	1,400

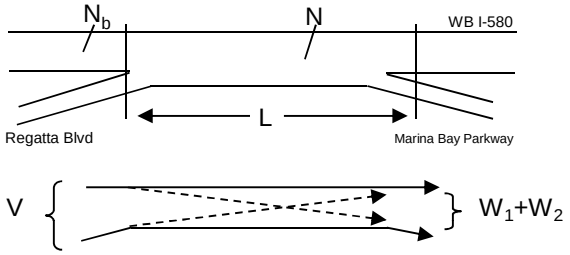
Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	2,926	Volume (vph)*	136	Volume (vph)*	929
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,014	Volume (pcph)	140	Volume (pcph)	957

Project Information

Project	LBNL
Scenario	Near-Term PM
Freeway	WB I-580
On-ramp	Regatta Blvd
Off-ramp	Marina Bay Parkway



Figure



Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   45 MPH and **50 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **44.8**
4. Weaving Intensity Factor (k) **2.69**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **813**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

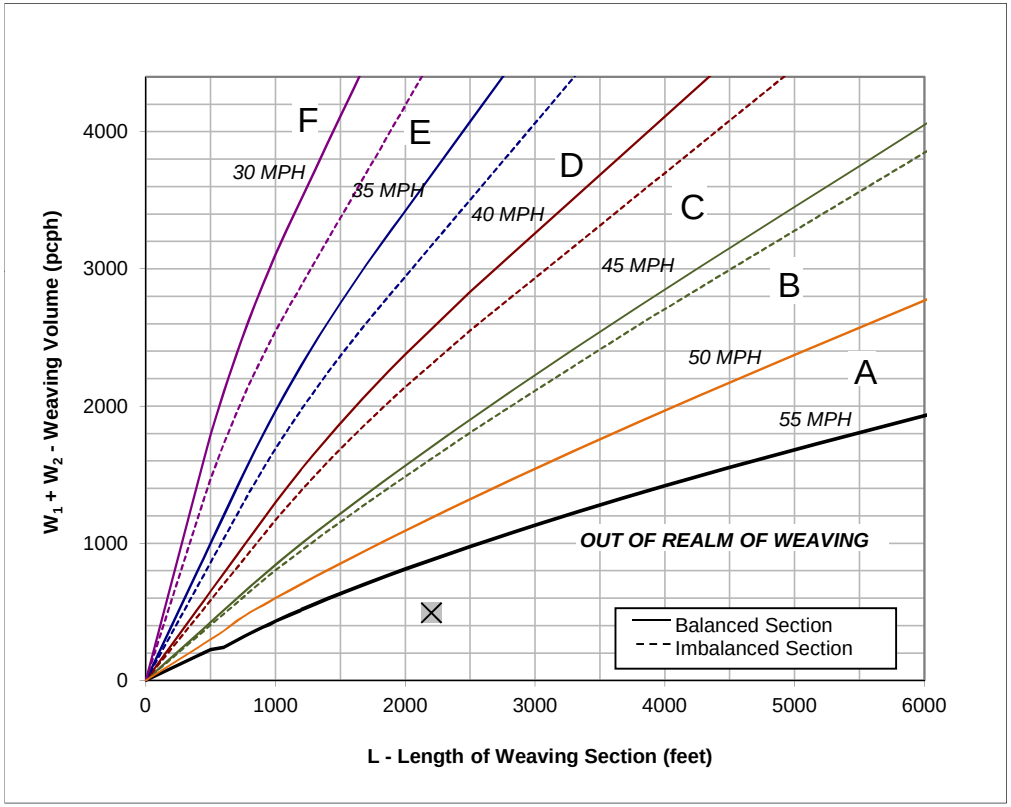
Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

Data Input		
Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,200

Project Information	
Project	LBNL
Scenario	Near-Term PM
Freeway	EB I-580
On-ramp	Regatta Blvd
Off-ramp	Bayview Ave

	Total Weaving Section (V)	On-ramp to Mainline (W_1)	Mainline to Off-ramp (W_2)
Volume (vph)*	3,260	400	80
Truck Percentage	6%	6%	6%
PCE for Trucks	1.5	1.5	1.5
Volume (pcph)	3,358	412	82



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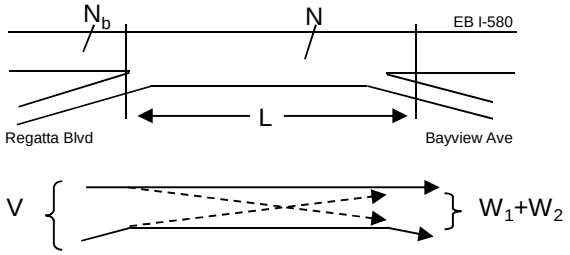


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **61.3**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **839**
6. Level of Service (LOS) **B**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Leisch Method for Weaving Analysis

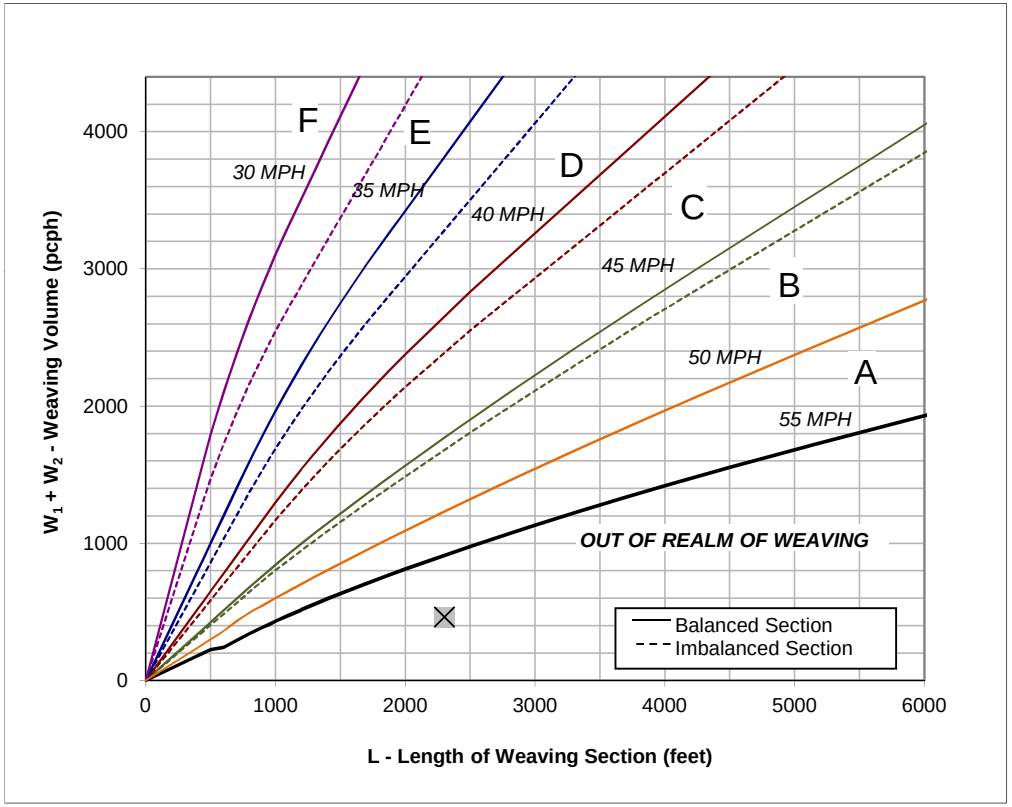
Data Input

Number of Entering Mainline Lanes	N_b	3
Number of Lanes in Weaving Section	N	4
Length of Weaving Section (feet)	L	2,300

Total Weaving Section (V)		On-ramp to Mainline (W_1)		Mainline to Off-ramp (W_2)	
Volume (vph)*	3,080	Volume (vph)*	290	Volume (vph)*	160
Truck Percentage	6%	Truck Percentage	6%	Truck Percentage	6%
PCE for Trucks	1.5	PCE for Trucks	1.5	PCE for Trucks	1.5
Volume (pcph)	3,172	Volume (pcph)	299	Volume (pcph)	165

Project Information

Project	LBNL
Scenario	Near-Term PM
Freeway	WB I-580
On-ramp	Bayview Ave
Off-ramp	Regatta Blvd



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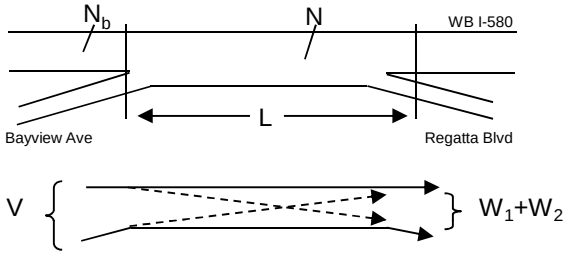


Capacity Analysis

1. Is the weaving section balanced (Y / N)? **N**
   [If optional exit lane, then "Y". Otherwise "N".]
2. In the Weaving Speed Chart to the left, which two speed curves is the black "x" between?
   50 MPH and **55 MPH**
   If below the 55 MPH curve, out of the realm of weaving.
   If left of the 30 MPH curve, LOS is F.
3. Interpolated Weaving Speed (S_w, mph) **62.1**
4. Weaving Intensity Factor (k) **1.00**
5. Service Volume (SV, pcph)
   $SV = (1/N)*[V + (k - 1)*\min(W_1, W_2)]$ **793**
6. Level of Service (LOS) **A**

The LOS in the chart above refers to the capacity of weaving traffic only; through and ramp to ramp traffic is not included.

* Note: **Do not adjust by a Peak Hour Factor (PHF).** The methodology incorporates the PHF in the Service Volume tables.

Sources: *Completion of Procedures for Analysis and Design of Traffic Weaving Sections* , Jack E. Leisch & Associates, September 1983 and *Highway Design Manual* , California Department of Transportation, July 24, 2009

Appendix D: Intersection Count Data Sheets
Alameda Point

FEHR PEERS

Study Name WC12-2953_A1 1. Willie Stargell Avenue (sometimes called Tinker Ave)/We
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound			Northbound Street Northbound			Eastbound Street Eastbound		
Start Time	Right	Thru	U-Turn	Thru	Left	U-Turn	Right	Left	U-Turn
4:00 PM	0	1	0	2	0	0	1	0	0
4:15 PM	0	1	0	1	0	0	0	0	0
4:30 PM	0	0	0	0	0	0	0	0	0
4:45 PM	0	1	0	1	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	0	0	1	0
5:30 PM	0	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	1	0	0	0	0	0
7:00 AM	0	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_A1 1. Willie Stargell Avenue (sometimes called Tink
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
4:00 PM	0	0	2	1	2	0	0	2
4:15 PM	0	0	0	0	2	3	0	0
4:30 PM	0	0	0	1	0	0	0	0
4:45 PM	0	0	1	1	1	2	0	0
5:00 PM	0	0	3	1	5	1	0	0
5:15 PM	0	0	1	0	2	0	0	0
5:30 PM	1	0	0	1	5	2	1	0
5:45 PM	1	0	1	0	2	0	1	0
7:00 AM	0	0	0	0	1	0	0	0
7:15 AM	0	0	1	0	1	1	0	0
7:30 AM	0	0	1	0	3	3	0	0
7:45 AM	0	1	3	1	3	0	0	1
8:00 AM	0	0	1	1	1	0	0	0
8:15 AM	0	2	2	0	2	3	0	2
8:30 AM	0	1	1	2	2	0	0	1
8:45 AM	0	1	1	1	2	0	0	2

Study Name WC12-2953_A1 1. Willie Stargell Avenue (sometimes called Tinker Ave)/We
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound			Northbound Street Northbound			Eastbound Street Eastbound		
Start Time	Right	Thru	U-Turn	Thru	Left	U-Turn	Right	Left	U-Turn
4:00 PM	67	188	0	187	5	0	18	72	0
4:15 PM	60	220	0	149	9	1	15	78	0
4:30 PM	78	205	0	166	3	0	19	66	0
4:45 PM	104	261	0	165	16	0	14	62	0
5:00 PM	87	238	0	181	16	1	16	87	0
5:15 PM	108	318	0	167	16	0	20	60	0
5:30 PM	145	308	0	183	17	0	19	62	0
5:45 PM	137	310	0	191	12	0	25	75	0
7:00 AM	53	90	0	197	2	2	2	46	0
7:15 AM	81	128	0	222	7	0	10	40	0
7:30 AM	107	166	0	283	2	1	4	57	0
7:45 AM	118	242	0	307	5	0	10	82	0
8:00 AM	100	176	0	359	5	0	7	107	0
8:15 AM	84	134	0	247	4	0	7	94	0
8:30 AM	76	113	0	254	14	1	9	68	0
8:45 AM	74	141	0	222	8	0	4	62	0

Totals

Study Name WC12-2953_A2 Main Street/Atlantic Avenue (also called Ralph Appezzato Memorial Pkwy)
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0
7:15 AM	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
7:30 AM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
7:45 AM	0	1	1	0	0	3	0	0	0	0	2	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
8:30 AM	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
4:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:30 PM	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 PM	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
5:15 PM	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
5:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_A2 Main Street/Atlantic Avenue (also called Ralph Ap
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	0	0	2	0	0	0	0	0
7:15 AM	0	0	0	0	1	0	0	1
7:30 AM	0	1	1	1	0	1	0	1
7:45 AM	0	0	0	1	2	0	5	3
8:00 AM	2	0	2	1	0	0	0	0
8:15 AM	0	0	1	1	2	0	0	0
8:30 AM	0	0	0	1	1	1	1	0
8:45 AM	1	0	1	4	1	0	2	0
4:00 PM	0	0	0	4	0	1	0	0
4:15 PM	1	0	0	0	0	0	0	0
4:30 PM	0	0	0	1	0	1	0	0
4:45 PM	0	0	0	1	0	3	0	2
5:00 PM	0	0	1	0	1	0	1	0
5:15 PM	0	0	0	0	0	0	0	0
5:30 PM	1	0	1	0	0	0	0	0
5:45 PM	0	0	0	0	0	1	0	1

Study Name WC12-2953_A2 Main Street/Atlantic Avenue (also called Ralph Appezzato Memorial Pkwy)
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	5	10	6	0	25	28	8	0	10	68	4	0	6	9	0	0
7:15 AM	2	8	3	0	6	16	3	1	4	9	3	0	1	8	0	0
7:30 AM	7	11	5	0	2	22	15	0	8	9	4	0	3	6	0	0
7:45 AM	5	34	7	0	17	17	28	0	21	29	15	0	3	5	0	0
8:00 AM	1	18	5	0	34	14	16	0	15	89	12	0	3	7	1	0
8:15 AM	3	15	3	0	17	21	4	0	5	33	13	0	3	12	3	0
8:30 AM	1	12	8	0	15	30	10	0	8	26	11	0	6	10	0	0
8:45 AM	2	17	12	0	8	35	18	0	12	22	9	0	4	10	1	0
4:00 PM	3	14	14	0	5	23	6	0	5	17	10	0	10	21	3	1
4:15 PM	1	25	16	0	14	19	10	1	7	16	6	0	9	23	4	0
4:30 PM	1	44	24	0	15	12	6	0	9	10	8	0	11	26	4	0
4:45 PM	2	17	5	0	11	19	13	0	7	14	11	0	16	34	5	0
5:00 PM	2	21	11	0	10	15	6	0	8	14	8	0	20	36	3	0
5:15 PM	0	28	18	0	5	36	8	0	5	16	22	0	8	25	0	0
5:30 PM	1	40	23	0	11	20	12	0	10	14	9	0	17	39	8	0
5:45 PM	1	51	27	0	18	21	11	0	8	28	9	0	2	28	0	0

Totals

Study Name WC12-2953_A3 Third Street/Atlantic Avenue
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
7:30 AM	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0
8:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 PM	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:15 PM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
4:30 PM	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_A3 Third Street/Atlantic Avenue
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	1	0	0	0	0	0	0	0
7:15 AM	2	0	2	0	0	0	1	0
7:30 AM	0	0	1	0	2	2	1	7
7:45 AM	2	0	1	13	2	3	7	8
8:00 AM	0	0	0	0	2	3	2	10
8:15 AM	0	3	0	3	2	0	4	11
8:30 AM	0	4	0	4	0	0	2	4
8:45 AM	1	1	0	8	0	0	3	1
4:00 PM	3	1	0	0	3	1	5	3
4:15 PM	1	1	1	0	0	0	0	0
4:30 PM	0	0	1	1	0	0	2	0
4:45 PM	0	0	2	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0
5:15 PM	1	0	0	0	0	0	6	0
5:30 PM	0	0	0	0	0	0	0	6
5:45 PM	0	0	0	0	0	0	11	0

Study Name WC12-2953_A3 Third Street/Atlantic Avenue
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	3	5	0	2	60	13	0	27	4	0	0	1	22	1	1
7:15 AM	0	0	1	0	3	27	14	1	42	2	0	0	2	15	0	0
7:30 AM	2	11	6	0	1	34	17	0	44	10	0	0	1	16	2	1
7:45 AM	5	18	8	0	3	53	26	0	62	19	2	0	2	28	1	0
8:00 AM	4	25	8	0	4	58	28	0	51	29	2	0	1	21	2	0
8:15 AM	0	24	4	0	3	39	25	0	47	22	1	0	0	20	0	0
8:30 AM	3	8	5	0	5	49	22	0	32	8	1	0	1	23	1	1
8:45 AM	0	11	3	0	0	62	51	0	45	15	1	0	3	30	0	1
4:00 PM	1	8	2	0	4	31	23	0	34	6	2	0	2	43	0	0
4:15 PM	0	4	6	0	4	38	37	0	15	7	1	0	0	39	0	3
4:30 PM	0	6	4	0	2	33	33	0	23	5	1	0	3	59	1	0
4:45 PM	2	5	3	0	6	40	36	1	21	6	1	0	3	44	0	1
5:00 PM	1	5	2	0	10	32	31	0	35	6	0	0	2	45	1	1
5:15 PM	1	7	7	0	4	47	42	0	24	8	1	0	3	51	0	0
5:30 PM	2	8	7	0	8	43	42	0	27	8	1	0	1	63	1	0
5:45 PM	1	14	9	0	7	50	61	0	25	6	0	0	0	67	3	0

Totals

Study Name WC12-2953_A4 Webster Street/Atlantic Avenue
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
4:00 PM	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
4:15 PM	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
4:30 PM	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0
7:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_A4 Webster Street/Atlantic Avenue
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
4:00 PM	5	7	4	2	4	3	8	8
4:15 PM	4	4	6	1	3	2	11	2
4:30 PM	2	4	3	8	3	3	2	3
4:45 PM	3	7	4	8	3	2	1	4
5:00 PM	3	3	4	1	1	1	2	3
5:15 PM	7	3	1	1	7	3	8	3
5:30 PM	5	5	2	3	2	1	8	7
5:45 PM	10	4	3	5	4	2	2	10
7:00 AM	0	0	1	0	0	0	0	0
7:15 AM	1	0	2	0	0	0	1	8
7:30 AM	1	0	0	0	0	0	0	6
7:45 AM	0	0	3	1	0	0	0	11
8:00 AM	0	0	1	1	0	0	0	1
8:15 AM	6	0	6	2	0	0	0	10
8:30 AM	0	1	1	5	0	0	0	2
8:45 AM	2	0	5	5	0	0	4	6

Study Name WC12-2953_A4 Webster Street/Atlantic Avenue
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
4:00 PM	41	147	24	0	11	42	8	0	15	123	18	0	13	35	56	1
4:15 PM	55	156	17	0	12	33	12	0	22	108	14	0	20	28	40	0
4:30 PM	48	160	28	0	11	44	14	0	20	114	12	0	18	52	53	0
4:45 PM	54	201	22	0	21	48	11	0	18	117	23	0	21	44	43	0
5:00 PM	53	179	30	0	21	51	18	0	20	138	21	0	11	37	54	0
5:15 PM	80	223	25	0	8	47	14	0	19	126	20	0	13	40	47	0
5:30 PM	86	196	24	0	10	76	16	0	21	112	20	0	21	66	58	0
5:45 PM	97	213	27	0	12	76	20	0	17	127	29	0	21	56	64	0
7:00 AM	36	44	8	0	7	18	1	0	6	130	6	0	1	8	47	0
7:15 AM	37	74	19	0	9	17	7	0	3	175	7	0	4	17	52	0
7:30 AM	60	92	21	0	6	38	6	0	3	188	11	0	9	37	74	0
7:45 AM	101	126	15	0	15	72	15	0	7	239	20	0	16	88	89	0
8:00 AM	66	102	9	0	11	67	3	0	12	245	24	0	27	60	83	0
8:15 AM	45	91	10	0	16	39	5	0	19	191	25	0	19	48	56	0
8:30 AM	39	57	15	0	15	46	4	0	13	186	31	0	12	28	39	0
8:45 AM	56	73	9	0	9	34	7	0	4	148	20	0	22	30	53	0

Totals

Study Name WC12-2953_A5 Constitution Way/Atlantic Street
Start Date 12/13/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	1	0	0	1	0	0	0	0	2	0	0
7:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peak Hour Bike Counts																
AM	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0

Study Name WC12-2953_A5 Constitution Way/Atlantic Street
Start Date 12/13/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	2	1	0	1	0	1	0	1
7:15 AM	1	2	0	0	0	2	1	3
7:30 AM	1	0	2	0	1	1	0	0
7:45 AM	0	0	0	1	0	5	0	3
8:00 AM	0	2	2	0	0	0	2	1
8:15 AM	3	3	3	0	0	0	1	4
8:30 AM	2	1	0	0	0	2	0	0
8:45 AM	0	2	1	0	0	0	0	1

Study Name WC12-2953_A5 Constitution Way/Atlantic Street
Start Date 12/13/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	8	43	10	0	21	15	3	0	3	126	7	0	5	9	10	0
7:15 AM	6	61	11	0	19	12	3	0	2	163	11	0	4	15	15	0
7:30 AM	13	52	10	0	23	20	4	0	6	188	15	0	15	17	14	0
7:45 AM	10	84	12	0	21	45	12	0	8	203	37	0	17	38	11	0
8:00 AM	8	72	14	0	18	28	6	0	14	192	30	0	27	49	12	0
8:15 AM	6	68	22	0	23	26	9	0	9	199	15	0	19	31	28	0
8:30 AM	13	64	21	0	29	25	7	0	10	171	29	0	8	35	11	0
8:45 AM	9	86	25	0	19	26	4	0	9	164	13	0	6	37	13	0

Totals

Study Name WC12-2953_A5 Constitution Way/Atlantic Street - PM
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
4:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
4:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peak Hour Bike Counts																
AM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_A5 Constitution Way/Atlantic Street - PM
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
4:00 PM	0	0	0	2	0	1	0	2
4:15 PM	0	0	1	1	2	0	0	0
4:30 PM	2	0	0	1	0	0	0	0
4:45 PM	1	0	2	0	4	0	2	1
5:00 PM	3	1	2	3	1	1	2	0
5:15 PM	3	2	2	1	0	2	0	0
5:30 PM	1	1	0	0	0	1	0	1
5:45 PM	1	1	0	0	0	2	0	0
6:00 PM	0	0	0	0	0	0	0	0

Study Name WC12-2953_A5 Constitution Way/Atlantic Street - PM
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
4:00 PM	19	188	11	0	28	24	8	0	11	94	17	0	17	24	22	0
4:15 PM	23	207	22	0	23	11	6	0	3	123	14	0	20	27	18	0
4:30 PM	22	248	28	0	22	21	8	0	5	114	14	0	12	48	27	0
4:45 PM	25	257	29	0	21	20	11	0	5	105	23	0	14	31	24	0
5:00 PM	32	290	38	0	25	23	12	0	9	111	20	0	18	36	22	0
5:15 PM	17	296	30	0	32	25	10	0	4	118	18	0	27	27	33	0
5:30 PM	24	292	28	0	28	27	10	0	5	112	23	0	28	34	20	0
5:45 PM	38	279	33	0	22	36	8	0	14	118	34	0	22	52	23	0
6:00 PM	1	15	3	0	1	1	0	0	0	4	0	0	1	1	1	0

Totals

Study Name WC12-2953_A6 Main Street/Pacific Avenue
Start Date 12/13/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound					Westbound Street Westbound					Northbound Street Northbound					Eastbound Street Eastbound				
Start Time	Right	Thru	Left	Hard Left	U-Turn	Hard Right	Right	Thru	Left	U-Turn	Right	Bear Right	Thru	Left	U-Turn	Right	Thru	Bear Left	Left	U-Turn
7:00 AM	0	0	0	0	0	0	3	0	0	0	0	0	1	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
7:30 AM	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	1	1	0	0	0	0	0	2	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	5	1	0	0	0	0	2	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_A6 Main Street/Pacific Avenue
Start Date 12/13/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	1	0	0	1	1	0	1	0
7:15 AM	0	1	0	1	0	1	0	0
7:30 AM	0	0	0	1	0	0	1	1
7:45 AM	0	0	0	2	0	0	5	5
8:00 AM	0	0	1	7	0	1	1	2
8:15 AM	0	0	0	1	0	0	0	0
8:30 AM	0	1	0	4	0	0	0	0
8:45 AM	0	0	0	2	0	0	0	0

Study Name WC12-2953_A6 Main Street/Pacific Avenue
Start Date 12/13/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound					Westbound Street Westbound					Northbound Street Northbound					Eastbound Street Eastbound				
Start Time	Right	Thru	Left	Hard Left	U-Turn	Hard Right	Right	Thru	Left	U-Turn	Right	Bear Right	Thru	Left	U-Turn	Right	Thru	Bear Left	Left	U-Turn
7:00 AM	1	14	3	0	0	0	19	2	3	0	1	0	60	0	1	0	0	0	0	0
7:15 AM	0	12	5	0	0	0	6	0	5	0	4	1	11	1	0	0	0	0	0	0
7:30 AM	1	31	5	0	0	0	8	0	8	0	3	0	22	0	0	0	1	0	0	0
7:45 AM	0	85	18	0	0	1	22	3	41	0	19	0	56	0	0	0	0	0	0	0
8:00 AM	0	32	10	0	0	1	40	6	17	0	7	1	90	0	0	0	1	0	0	0
8:15 AM	1	27	8	0	0	0	20	3	3	0	1	2	35	0	0	3	0	0	1	0
8:30 AM	0	13	4	0	0	0	15	2	3	0	5	1	21	0	0	0	2	0	0	0
8:45 AM	2	4	5	1	0	0	16	5	1	0	1	0	16	0	0	1	0	0	2	0

Totals

Study Name WC12-2953_A6 Main Street/Pacific Avenue - PM
Start Date 12/13/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound					Westbound Street Westbound					Northbound Street Northbound					Eastbound Street Eastbound					South-Eastbound Street Southeastbound				
Start Time	Hard Right	Right	Thru	Left	U-Turn	Right	Bear Right	Thru	Left	U-Turn	Right	Thru	Bear Left	Left	U-Turn	Right	Thru	Left	Hard Left	U-Turn	Hard Right	Bear Right	Bear Left	Hard Left	U-Turn
4:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
4:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
4:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
5:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
5:45 PM	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0

Study Name WC12-2953_A6 Main Street/Pacific Avenue - PM
Start Date 12/13/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound		South-Eastbound Stree Southeastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
4:00 PM	0	0	0	0	0	0	0	1	0	0
4:15 PM	0	0	0	0	0	0	0	1	0	0
4:30 PM	0	0	2	0	0	0	2	0	0	0
4:45 PM	1	0	1	2	0	0	1	0	0	0
5:00 PM	0	0	0	0	0	0	0	1	0	0
5:15 PM	0	0	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	0	0	0	0	0
5:45 PM	0	0	1	1	0	0	1	0	0	0

Study Name WC12-2953_A6 Main Street/Pacific Avenue - PM
Start Date 12/13/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound					Westbound Street Westbound					Northbound Street Northbound					Eastbound Street Eastbound					South-Eastbound Street Southeastbound				
Start Time	Hard Right	Right	Thru	Left	U-Turn	Right	Bear Right	Thru	Left	U-Turn	Right	Thru	Bear Left	Left	U-Turn	Right	Thru	Left	Hard Left	U-Turn	Hard Right	Bear Right	Bear Left	Hard Left	U-Turn
4:00 PM	0	0	0	0	0	2	3	0	3	0	5	1	18	1	0	0	3	0	1	0	3	30	8	0	0
4:15 PM	0	0	0	0	0	1	8	5	1	0	5	0	30	1	0	0	0	0	1	0	1	24	7	0	0
4:30 PM	0	0	0	0	0	1	5	1	2	0	3	0	18	0	0	0	0	0	0	0	0	41	23	0	0
4:45 PM	0	0	0	0	0	0	5	3	1	0	4	1	26	4	0	0	1	0	0	0	1	23	5	0	0
5:00 PM	0	0	0	0	0	0	4	1	3	0	10	0	25	0	0	1	1	0	1	0	0	42	14	0	0
5:15 PM	0	0	0	0	0	0	12	0	5	0	10	2	29	0	0	0	2	0	0	0	2	37	10	0	0
5:30 PM	0	0	0	0	0	0	7	1	1	0	4	1	18	0	0	0	2	0	2	0	0	54	26	0	0
5:45 PM	0	0	0	0	0	0	5	3	1	0	0	0	26	1	0	1	0	0	1	0	1	40	15	0	0

Totals

Study Name WC12-2953_A7 Webster Street/Lincoln Avenue
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
4:00 PM	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
4:15 PM	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0
4:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
4:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
5:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0
8:00 AM	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
8:30 AM	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0

Study Name WC12-2953_A7 Webster Street/Lincoln Avenue
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
4:00 PM	1	5	6	4	4	4	10	8
4:15 PM	2	3	8	2	5	0	4	4
4:30 PM	2	6	4	2	7	4	4	5
4:45 PM	5	1	3	9	4	1	6	9
5:00 PM	1	0	3	4	5	3	10	9
5:15 PM	5	0	5	2	8	2	5	13
5:30 PM	0	0	2	5	5	2	3	9
5:45 PM	3	1	9	3	3	1	3	11
6:00 PM	0	0	0	0	0	0	0	0
7:00 AM	1	2	3	4	2	3	1	0
7:15 AM	3	2	3	2	1	4	4	2
7:30 AM	6	2	6	4	2	11	3	6
7:45 AM	19	4	9	5	1	2	3	3
8:00 AM	8	1	1	5	8	3	8	4
8:15 AM	12	5	3	1	0	4	3	4
8:30 AM	4	1	6	6	2	1	4	1

Study Name WC12-2953_A7 Webster Street/Lincoln Avenue
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
4:00 PM	17	105	6	0	6	27	7	0	4	92	9	0	7	37	37	0
4:15 PM	23	132	6	0	10	15	1	0	5	89	2	0	9	29	18	0
4:30 PM	18	104	12	0	9	22	8	0	8	87	1	0	12	32	27	0
4:45 PM	19	148	8	0	8	25	3	0	3	85	4	0	8	33	22	0
5:00 PM	22	138	10	0	4	28	11	0	6	102	2	0	10	32	36	0
5:15 PM	22	169	5	0	8	35	10	0	8	88	3	0	7	34	41	0
5:30 PM	19	141	10	0	9	37	12	0	12	100	3	0	11	21	34	0
5:45 PM	22	159	12	0	9	29	16	0	5	114	0	0	7	32	31	0
6:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	8	32	1	0	5	15	4	0	1	73	1	0	5	10	39	0
7:15 AM	4	52	0	0	5	12	3	0	2	92	3	0	4	8	45	0
7:30 AM	20	59	2	0	5	32	5	0	7	102	5	0	12	22	54	0
7:45 AM	30	73	4	0	7	122	11	0	5	120	21	0	10	47	61	0
8:00 AM	20	101	3	0	6	82	14	0	5	162	14	0	20	95	69	0
8:15 AM	13	66	4	0	10	31	5	0	7	152	8	0	9	33	55	0
8:30 AM	13	58	6	0	7	24	11	0	4	154	5	0	7	34	45	0

Totals

Study Name WC12-2953_A8 Constitution Way/Lincoln Avenue
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
4:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:15 PM	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
4:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
5:00 PM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
5:15 PM	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:30 PM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
5:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
7:30 AM	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0
7:45 AM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
8:15 AM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_A8 Constitution Way/Lincoln Avenue
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
4:00 PM	0	0	1	1	1	1	4	2
4:15 PM	0	0	5	3	4	0	0	0
4:30 PM	1	0	6	4	5	1	7	0
4:45 PM	0	0	3	1	2	0	1	0
5:00 PM	0	0	3	1	0	4	0	3
5:15 PM	0	0	2	3	1	0	0	0
5:30 PM	0	0	0	1	1	0	1	2
5:45 PM	0	0	0	0	0	0	4	0
6:00 PM	0	0	0	0	0	0	0	0
7:00 AM	0	0	2	0	0	2	0	0
7:15 AM	0	0	0	0	1	0	1	1
7:30 AM	1	0	1	5	0	6	3	1
7:45 AM	0	0	1	4	0	4	2	1
8:00 AM	0	0	3	5	0	0	4	2
8:15 AM	0	0	4	5	1	3	0	2
8:30 AM	0	0	1	2	0	2	2	1

Study Name WC12-2953_A8 Constitution Way/Lincoln Avenue
Start Date 12/12/2012
Start Time 4:00 PM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
4:00 PM	5	109	88	0	30	29	6	0	11	82	4	0	2	40	0	0
4:15 PM	2	120	71	0	35	23	6	0	3	98	7	0	0	36	0	0
4:30 PM	6	130	79	0	33	27	4	0	4	85	1	0	3	37	0	0
4:45 PM	6	118	122	0	25	23	5	0	7	98	8	0	0	47	1	1
5:00 PM	6	121	120	0	38	36	4	0	10	91	3	0	8	37	2	0
5:15 PM	6	146	141	0	24	39	0	0	7	92	3	0	5	43	1	1
5:30 PM	6	137	136	0	39	46	3	0	13	108	5	0	5	31	4	0
5:45 PM	10	127	125	0	25	33	5	0	6	104	2	0	4	44	3	0
6:00 PM	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0
7:00 AM	1	28	11	0	34	18	1	0	1	102	4	0	2	10	1	0
7:15 AM	1	26	22	0	39	15	1	1	1	119	3	0	2	7	1	0
7:30 AM	2	49	25	1	47	39	2	0	2	121	7	0	4	19	6	0
7:45 AM	6	64	27	0	57	128	1	0	1	133	9	0	9	40	2	0
8:00 AM	2	75	36	0	71	66	1	0	5	126	5	0	11	79	5	0
8:15 AM	4	55	32	0	48	33	4	0	5	151	2	0	6	42	2	0
8:30 AM	2	48	28	0	46	38	6	0	4	131	6	0	4	33	2	0

Totals

Study Name WC12-2953_A9 8th Street/Central Avenue
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
8:30 AM	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0
8:45 AM	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0
9:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 PM	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
4:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:30 PM	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0
4:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
5:00 PM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
5:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Study Name WC12-2953_A9 8th Street/Central Avenue
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	3	1	1	0	0	3	0	0
7:15 AM	3	1	2	0	2	3	3	1
7:30 AM	4	1	1	2	0	6	5	0
7:45 AM	3	1	1	0	1	3	7	2
8:00 AM	2	1	6	0	1	4	4	0
8:15 AM	1	0	2	0	3	2	1	2
8:30 AM	5	0	2	3	2	4	4	0
8:45 AM	5	5	1	2	1	3	4	3
9:00 AM	0	0	0	0	0	0	0	0
4:00 PM	0	6	4	1	0	0	2	5
4:15 PM	1	1	1	2	1	1	0	2
4:30 PM	0	1	2	1	1	1	4	5
4:45 PM	1	1	0	1	1	1	2	3
5:00 PM	3	2	2	2	4	0	3	4
5:15 PM	0	3	2	5	4	1	8	5
5:30 PM	0	2	0	1	1	3	0	4

Study Name WC12-2953_A9 8th Street/Central Avenue
Start Date 12/12/2012
Start Time 7:00 AM
Site Code

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	2	15	7	0	18	43	1	0	1	61	50	0	30	23	2	0
7:15 AM	2	23	6	0	31	37	2	0	2	63	37	0	35	36	1	0
7:30 AM	9	26	18	0	32	73	1	0	4	88	61	0	51	57	2	0
7:45 AM	3	31	18	0	51	105	4	0	2	86	101	0	86	64	0	0
8:00 AM	5	76	20	0	48	106	2	0	5	79	101	0	127	71	4	0
8:15 AM	2	48	20	0	32	79	3	0	1	78	82	0	52	46	2	0
8:30 AM	2	41	15	0	33	75	1	0	5	80	90	0	48	48	2	0
8:45 AM	6	40	10	0	28	88	2	0	5	90	91	0	58	57	3	0
9:00 AM	0	0	0	0	0	0	0	0	0	1	2	0	2	0	0	0
4:00 PM	5	76	18	0	17	73	6	0	5	68	70	0	77	53	1	0
4:15 PM	7	101	16	0	18	48	6	0	4	56	71	0	81	63	2	0
4:30 PM	2	95	17	0	26	52	3	0	3	50	77	0	88	76	2	0
4:45 PM	4	81	23	0	24	79	3	0	5	76	78	0	88	75	1	0
5:00 PM	6	93	19	0	27	72	3	0	2	54	80	0	91	73	3	0
5:15 PM	1	95	35	0	26	72	1	0	9	70	78	0	80	90	4	0
5:30 PM	4	93	19	0	29	76	7	0	4	65	86	0	88	66	4	0

Totals

Study Name 4 TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#4

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 AM	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:30 AM	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:45 AM	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
4:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
4:15 PM	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
4:30 PM	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
5:15 PM	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0
5:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
5:45 PM	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0

Study Name 4 TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#4

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	0	2	1	2	0	1	0	0
7:15 AM	2	9	0	0	0	0	0	0
7:30 AM	9	3	1	2	1	2	0	3
7:45 AM	24	0	1	1	0	0	0	1
8:00 AM	15	4	6	5	0	3	5	12
8:15 AM	18	3	3	2	2	3	1	8
8:30 AM	16	5	5	2	7	1	3	7
8:45 AM	45	8	18	6	3	7	4	17
4:00 PM	4	18	7	5	11	9	24	3
4:15 PM	6	14	7	5	8	4	14	7
4:30 PM	1	15	4	8	9	5	19	5
4:45 PM	2	13	2	7	4	6	4	3
5:00 PM	5	9	6	2	4	12	13	8
5:15 PM	6	5	9	0	4	4	8	5
5:30 PM	10	7	4	7	5	9	8	19
5:45 PM	10	8	3	11	3	6	4	10

Study Name Atlantic/Webster TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#4

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	46	33	8	0	10	22	3	0	4	142	3	0	1	12	50	0
7:15 AM	49	72	12	0	8	16	3	0	7	173	8	0	7	10	59	0
7:30 AM	58	89	13	0	7	24	5	0	10	185	9	0	20	20	59	0
7:45 AM	99	137	24	0	7	75	10	0	8	240	31	0	26	47	65	0
8:00 AM	89	119	16	0	15	79	6	0	6	208	33	0	34	82	114	0
8:15 AM	72	88	13	0	15	52	4	0	25	214	24	0	25	55	62	0
8:30 AM	50	75	10	0	11	57	3	0	21	164	34	0	26	46	50	0
8:45 AM	75	69	14	0	13	65	10	0	16	173	36	0	23	50	52	0
4:00 PM	59	142	17	0	12	34	10	0	18	122	18	0	22	45	62	0
4:15 PM	59	153	31	0	10	27	20	0	14	147	21	0	17	33	65	0
4:30 PM	59	146	30	0	11	30	13	0	18	128	12	0	22	39	56	0
4:45 PM	54	171	19	0	21	38	16	0	12	112	14	0	19	37	48	1
5:00 PM	63	184	30	0	21	43	18	0	13	128	31	0	20	37	47	0
5:15 PM	83	222	25	0	15	27	16	0	20	135	27	0	25	42	71	0
5:30 PM	92	202	23	1	19	53	18	0	10	110	25	0	14	41	45	0
5:45 PM	101	208	37	0	17	85	17	0	16	123	30	0	27	63	40	0

Totals

Study Name 9 TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#9

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	6	0	0	0	0	1	0	0	0	0	0
7:45 AM	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0
8:00 AM	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	0	0	3	2	0	0	1	0	0
8:45 AM	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0
4:00 PM	0	3	0	0	0	2	0	0	0	0	1	0	0	0	0	0
4:15 PM	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
4:30 PM	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
5:00 PM	0	2	0	0	0	1	0	0	0	0	0	0	0	2	0	0
5:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
5:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:45 PM	0	1	0	0	1	2	0	0	0	0	2	0	0	0	0	0

Study Name 9 TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#9

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	1	1	0	0	0	0	1	2
7:15 AM	2	2	3	1	2	5	0	1
7:30 AM	9	2	3	1	2	13	3	5
7:45 AM	3	0	3	0	1	2	4	2
8:00 AM	6	1	5	2	0	3	1	1
8:15 AM	4	0	3	2	0	0	3	0
8:30 AM	1	2	1	2	0	2	1	1
8:45 AM	0	2	0	0	2	0	5	0
4:00 PM	0	1	1	1	3	3	5	0
4:15 PM	0	3	1	7	3	5	2	2
4:30 PM	3	1	1	0	3	2	2	2
4:45 PM	2	2	3	3	7	3	1	2
5:00 PM	3	2	1	3	4	3	3	0
5:15 PM	3	2	1	6	7	3	3	6
5:30 PM	2	2	2	1	9	2	4	5
5:45 PM	3	0	3	5	4	5	3	6

Study Name Central/8th TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#9

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	3	18	7	0	26	32	3	0	1	67	42	0	37	23	2	0
7:15 AM	3	23	9	0	29	41	4	0	1	79	47	0	25	41	1	0
7:30 AM	6	28	9	0	31	73	3	0	5	86	78	0	63	68	1	0
7:45 AM	5	37	17	0	35	136	3	0	2	73	115	0	91	86	4	0
8:00 AM	4	65	17	0	53	112	5	0	4	72	101	0	105	90	4	0
8:15 AM	3	45	21	0	28	87	3	0	6	92	99	0	62	45	2	0
8:30 AM	2	34	9	0	20	58	1	0	5	82	93	0	51	42	2	0
8:45 AM	3	33	14	0	23	74	1	0	1	73	72	0	63	43	4	0
4:00 PM	3	81	25	0	13	69	4	0	7	68	70	0	81	62	3	0
4:15 PM	3	98	13	0	23	62	7	0	6	58	80	0	73	71	6	0
4:30 PM	3	80	24	0	15	53	6	0	5	50	65	0	83	59	3	0
4:45 PM	7	84	22	0	26	69	6	0	8	71	87	0	81	64	2	0
5:00 PM	9	88	21	0	26	75	5	0	7	73	92	0	98	85	3	0
5:15 PM	6	102	19	0	31	65	6	0	5	53	73	0	104	78	2	0
5:30 PM	5	98	27	0	28	65	2	0	7	79	77	0	92	70	5	0
5:45 PM	6	87	23	0	20	77	3	0	8	68	95	0	101	76	2	0

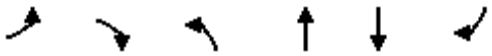
Totals

Appendix E: Intersection LOS Calculation
Alameda Point

FEHR PEERS

Existing Conditions

FEHR PEERS



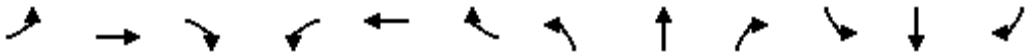
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	347	39	29	1178	775	437
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	1.00	1.00	0.95	0.91	0.88
Frpb, ped/bikes	1.00	0.98	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3400	1535	1752	3505	5036	2760
Flt Permitted	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	3400	1535	1752	3505	5036	2760
Peak-hour factor, PHF	0.85	0.85	0.85	0.85	0.85	0.85
Adj. Flow (vph)	408	46	34	1386	912	514
RTOR Reduction (vph)	0	0	0	0	0	360
Lane Group Flow (vph)	408	46	34	1386	912	154
Confl. Peds. (#/hr)	3	11	4			4
Confl. Bikes (#/hr)		5				5
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%
Turn Type		Perm	Prot			Prot
Protected Phases	4		5	2	6	6
Permitted Phases		4				
Actuated Green, G (s)	26.0	26.0	4.0	26.0	18.0	18.0
Effective Green, g (s)	26.0	26.0	4.0	26.0	18.0	18.0
Actuated g/C Ratio	0.43	0.43	0.07	0.43	0.30	0.30
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Grp Cap (vph)	1473	665	117	1519	1511	828
v/s Ratio Prot	c0.12		0.02	c0.40	0.18	0.06
v/s Ratio Perm		0.03				
v/c Ratio	0.28	0.07	0.29	0.91	0.60	0.19
Uniform Delay, d1	10.9	9.9	26.6	15.9	18.0	15.6
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.5	0.2	6.2	9.9	1.8	0.5
Delay (s)	11.4	10.1	32.8	25.8	19.7	16.1
Level of Service	B	B	C	C	B	B
Approach Delay (s)	11.3			26.0	18.4	
Approach LOS	B			C	B	

Intersection Summary			
HCM Average Control Delay	20.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	65.1%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	3	35	15	63	87	91	47	172	51	23	77	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95			0.95	1.00	1.00	0.95		0.91	0.91	
Frpb, ped/bikes		0.99			1.00	0.98	1.00	0.99		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.96			1.00	0.85	1.00	0.97		1.00	0.98	
Flt Protected		1.00			0.98	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3226			3324	1500	1703	3268		1550	3195	
Flt Permitted		0.94			0.82	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		3042			2790	1500	1703	3268		1550	3195	
Peak-hour factor, PHF	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
Adj. Flow (vph)	4	45	19	82	113	118	61	223	66	30	100	13
RTOR Reduction (vph)	0	13	0	0	0	0	0	37	0	0	11	0
Lane Group Flow (vph)	0	55	0	0	195	118	61	252	0	27	105	0
Confl. Peds. (#/hr)	9		8	8		9	12		17	17		12
Confl. Bikes (#/hr)						3			5			2
Heavy Vehicles (%)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
Turn Type	Perm			Perm		Free	Split			Split		
Protected Phases		2			6		3	3		4	4	
Permitted Phases	2			6		Free						
Actuated Green, G (s)		12.4			11.4	41.9	9.7	9.7		6.8	6.8	
Effective Green, g (s)		12.4			12.4	41.9	9.7	9.7		7.8	7.8	
Actuated g/C Ratio		0.30			0.30	1.00	0.23	0.23		0.19	0.19	
Clearance Time (s)		4.0			5.0		4.0	4.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		900			826	1500	394	757		289	595	
v/s Ratio Prot							0.04	c0.08		0.02	c0.03	
v/s Ratio Perm		0.02			c0.07	0.08						
v/c Ratio		0.06			0.24	0.08	0.15	0.33		0.09	0.18	
Uniform Delay, d1		10.6			11.2	0.0	12.8	13.4		14.1	14.3	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.0			0.1	0.1	0.2	0.3		0.1	0.1	
Delay (s)		10.6			11.3	0.1	13.0	13.7		14.3	14.5	
Level of Service		B			B	A	B	B		B	B	
Approach Delay (s)		10.6			7.1			13.6			14.4	
Approach LOS		B			A			B			B	

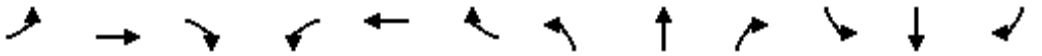
Intersection Summary			
HCM Average Control Delay	11.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.25		
Actuated Cycle Length (s)	41.9	Sum of lost time (s)	12.0
Intersection Capacity Utilization	32.3%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	5	100	4	115	223	15	6	77	210	27	75	12
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			0.97			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	0.99		1.00	0.99			0.90			0.99	
Flt Protected	0.95	1.00		0.95	1.00			1.00			0.99	
Satd. Flow (prot)	1736	3443		1736	3430			1598			1768	
Flt Permitted	0.95	1.00		0.95	1.00			1.00			0.89	
Satd. Flow (perm)	1736	3443		1736	3430			1593			1595	
Peak-hour factor, PHF	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Adj. Flow (vph)	6	116	5	134	259	17	7	90	244	31	87	14
RTOR Reduction (vph)	0	4	0	0	8	0	0	138	0	0	7	0
Lane Group Flow (vph)	6	117	0	134	268	0	0	203	0	0	125	0
Confl. Peds. (#/hr)	11		13	13		11	22		48	48		22
Confl. Bikes (#/hr)			1			2			1			
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Effective Green, g (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Actuated g/C Ratio	0.10	0.27		0.10	0.27			0.43			0.43	
Clearance Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Grp Cap (vph)	174	918		174	915			690			691	
v/s Ratio Prot	0.00	0.03		c0.08	c0.08							
v/s Ratio Perm								c0.13			0.08	
v/c Ratio	0.03	0.13		0.77	0.29			0.29			0.18	
Uniform Delay, d1	24.4	16.7		26.3	17.5			11.0			10.5	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	0.4	0.3		27.4	0.8			1.1			0.6	
Delay (s)	24.8	17.0		53.7	18.3			12.1			11.0	
Level of Service	C	B		D	B			B			B	
Approach Delay (s)		17.4			29.9			12.1			11.0	
Approach LOS		B			C			B			B	

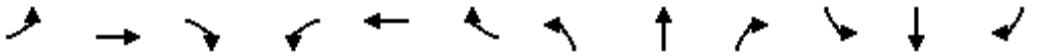
Intersection Summary			
HCM Average Control Delay	19.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.35		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	43.3%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	291	224	111	27	263	56	122	860	51	64	431	319
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	11	12	11	11	12	12	12	12	12	12	12
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.97	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.97	1.00	0.98		1.00	1.00		1.00	1.00	0.95
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.97		1.00	0.99		1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	2828	3020	1357	1510	2888		1562	3091		1562	3124	1283
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (perm)	2828	3020	1357	1510	2888		1562	3091		1562	3124	1283
Peak-hour factor, PHF	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Adj. Flow (vph)	338	260	129	31	306	65	142	1000	59	74	501	371
RTOR Reduction (vph)	0	0	104	0	16	0	0	3	0	0	0	256
Lane Group Flow (vph)	338	260	25	31	355	0	142	1056	0	74	501	115
Confl. Peds. (#/hr)			16			85			25			37
Confl. Bikes (#/hr)						1			1			1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Bus Blockages (#/hr)	0	0	0	0	0	2	0	0	0	0	0	8
Turn Type	Split		Perm	Split			Prot			Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			4									6
Actuated Green, G (s)	17.1	17.1	17.1	16.6	16.6		11.9	31.0		7.7	26.8	26.8
Effective Green, g (s)	17.1	17.1	17.1	16.6	16.6		11.9	32.0		7.7	27.8	27.8
Actuated g/C Ratio	0.19	0.19	0.19	0.19	0.19		0.13	0.36		0.09	0.31	0.31
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	5.0		4.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	541	578	260	280	536		208	1106		135	971	399
v/s Ratio Prot	c0.12	0.09		0.02	c0.12		c0.09	c0.34		0.05	0.16	
v/s Ratio Perm			0.02									0.09
v/c Ratio	0.62	0.45	0.09	0.11	0.66		0.68	0.95		0.55	0.52	0.29
Uniform Delay, d1	33.2	32.0	29.8	30.3	33.8		36.9	28.0		39.2	25.3	23.3
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	2.3	0.6	0.2	0.2	3.1		8.9	17.1		4.5	0.5	0.4
Delay (s)	35.5	32.5	29.9	30.4	36.9		45.9	45.1		43.7	25.7	23.7
Level of Service	D	C	C	C	D		D	D		D	C	C
Approach Delay (s)		33.4			36.4			45.2			26.4	
Approach LOS		C			D			D			C	

Intersection Summary			
HCM Average Control Delay	36.1	HCM Level of Service	D
HCM Volume to Capacity ratio	0.76		
Actuated Cycle Length (s)	89.4	Sum of lost time (s)	12.0
Intersection Capacity Utilization	75.1%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

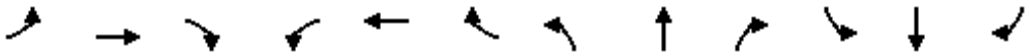


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	62	153	71	34	140	91	127	765	40	69	288	42
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.9	4.9		4.9	4.9		4.3	4.8	4.8	4.3	4.8	4.8
Lane Util. Factor	1.00	0.95		1.00	0.95		0.97	0.95	1.00	0.97	0.95	1.00
Frpb, ped/bikes	1.00	0.99		1.00	0.99		1.00	1.00	0.98	1.00	1.00	0.98
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.95		1.00	0.94		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	3354		1770	3300		3433	3539	1559	3433	3539	1552
Flt Permitted	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	3354		1770	3300		3433	3539	1559	3433	3539	1552
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	67	165	76	37	151	98	137	823	43	74	310	45
RTOR Reduction (vph)	0	56	0	0	83	0	0	0	29	0	0	23
Lane Group Flow (vph)	67	185	0	37	166	0	137	823	14	74	310	22
Confl. Peds. (#/hr)			7			13			6			11
Confl. Bikes (#/hr)						2						
Turn Type	Split			Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases									2			6
Actuated Green, G (s)	10.3	10.3		10.0	10.0		5.3	19.2	19.2	3.2	17.1	17.1
Effective Green, g (s)	9.4	9.4		9.1	9.1		5.0	19.4	19.4	2.9	17.3	17.3
Actuated g/C Ratio	0.16	0.16		0.15	0.15		0.08	0.32	0.32	0.05	0.29	0.29
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	5.0	5.0	4.0	5.0	5.0
Vehicle Extension (s)	2.0	2.0		2.0	2.0		2.0	2.0	2.0	2.0	2.0	2.0
Lane Grp Cap (vph)	279	528		270	503		288	1150	507	167	1026	450
v/s Ratio Prot	0.04	c0.06		0.02	c0.05		c0.04	c0.23		0.02	0.09	
v/s Ratio Perm									0.01			0.01
v/c Ratio	0.24	0.35		0.14	0.33		0.48	0.72	0.03	0.44	0.30	0.05
Uniform Delay, d1	22.0	22.4		21.9	22.6		26.1	17.7	13.7	27.6	16.5	15.3
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.2	0.1		0.1	0.1		0.5	1.8	0.0	0.7	0.1	0.0
Delay (s)	22.2	22.6		22.0	22.7		26.6	19.5	13.7	28.3	16.6	15.3
Level of Service	C	C		C	C		C	B	B	C	B	B
Approach Delay (s)		22.5			22.6			20.2			18.5	
Approach LOS		C			C			C			B	

Intersection Summary			
HCM Average Control Delay	20.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.49		
Actuated Cycle Length (s)	59.7	Sum of lost time (s)	14.1
Intersection Capacity Utilization	57.3%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

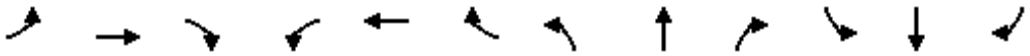
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	1	3	3	64	13	91	0	201	32	40	157	1
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0		4.0		4.0	4.0	
Lane Util. Factor		1.00			1.00	1.00		1.00		1.00	1.00	
Frpb, ped/bikes		0.99			1.00	0.98		0.99		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00		1.00		1.00	1.00	
Frt		0.94			1.00	0.85		0.98		1.00	1.00	
Flt Protected		0.99			0.96	1.00		1.00		0.95	1.00	
Satd. Flow (prot)		1728			1789	1556		1811		1770	1860	
Flt Permitted		0.99			0.96	1.00		1.00		0.95	1.00	
Satd. Flow (perm)		1728			1789	1556		1811		1770	1860	
Peak-hour factor, PHF	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
Adj. Flow (vph)	2	5	5	102	21	144	0	319	51	63	249	2
RTOR Reduction (vph)	0	5	0	0	0	121	0	6	0	0	0	0
Lane Group Flow (vph)	0	7	0	0	123	23	0	364	0	63	251	0
Confl. Peds. (#/hr)	2		1	1		2	13		20	20		13
Confl. Bikes (#/hr)						1			5			
Turn Type	Split			Split		Perm	Split			Split		
Protected Phases	2	2		1	1		4	4		3	3	
Permitted Phases						1						
Actuated Green, G (s)		3.2			9.6	9.6		17.9		14.4	14.4	
Effective Green, g (s)		3.2			9.6	9.6		17.9		14.4	14.4	
Actuated g/C Ratio		0.05			0.16	0.16		0.29		0.24	0.24	
Clearance Time (s)		4.0			4.0	4.0		4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0	3.0		3.0		3.0	3.0	
Lane Grp Cap (vph)		91			281	244		531		417	438	
v/s Ratio Prot		c0.00			c0.07			c0.20		0.04	c0.13	
v/s Ratio Perm						0.01						
v/c Ratio		0.08			0.44	0.09		0.69		0.15	0.57	
Uniform Delay, d1		27.5			23.3	22.0		19.1		18.5	20.6	
Progression Factor		1.00			1.00	1.00		1.00		1.00	1.00	
Incremental Delay, d2		0.4			1.1	0.2		3.7		0.2	1.8	
Delay (s)		27.9			24.4	22.2		22.8		18.7	22.4	
Level of Service		C			C	C		C		B	C	
Approach Delay (s)		27.9			23.2			22.8			21.7	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	22.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	61.1	Sum of lost time (s)	16.0
Intersection Capacity Utilization	40.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	229	209	46	41	257	30	48	583	21	17	297	75
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			0.95			0.95	
Frpb, ped/bikes	1.00	1.00		1.00	0.99			1.00			0.99	
Flpb, ped/bikes	0.98	1.00		0.99	1.00			1.00			1.00	
Frt	1.00	0.97		1.00	0.98			1.00			0.97	
Flt Protected	0.95	1.00		0.95	1.00			1.00			1.00	
Satd. Flow (prot)	1540	3054		1562	3088			3120			3035	
Flt Permitted	0.52	1.00		0.55	1.00			0.88			0.91	
Satd. Flow (perm)	849	3054		912	3088			2768			2767	
Peak-hour factor, PHF	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
Adj. Flow (vph)	290	265	58	52	325	38	61	738	27	22	376	95
RTOR Reduction (vph)	0	28	0	0	13	0	0	3	0	0	30	0
Lane Group Flow (vph)	290	295	0	52	350	0	0	823	0	0	463	0
Confl. Peds. (#/hr)	56		22	22		56	31		42	42		31
Confl. Bikes (#/hr)						2			5			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			4			2			2	
Permitted Phases	4			4			2			2		
Actuated Green, G (s)	30.0	30.0		30.0	30.0			32.0			32.0	
Effective Green, g (s)	29.0	29.0		29.0	29.0			31.0			31.0	
Actuated g/C Ratio	0.43	0.43		0.43	0.43			0.46			0.46	
Clearance Time (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	362	1302		389	1317			1262			1261	
v/s Ratio Prot		0.10			0.11							
v/s Ratio Perm	c0.34			0.06				c0.30			0.17	
v/c Ratio	0.80	0.23		0.13	0.27			0.65			0.37	
Uniform Delay, d1	17.0	12.4		11.9	12.6			14.3			12.1	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	16.9	0.4		0.7	0.5			2.6			0.8	
Delay (s)	33.8	12.8		12.6	13.1			17.0			12.9	
Level of Service	C	B		B	B			B			B	
Approach Delay (s)		22.7			13.0			17.0			12.9	
Approach LOS		C			B			B			B	

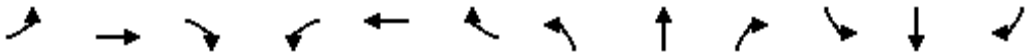
Intersection Summary			
HCM Average Control Delay	16.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	68.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	99.9%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	11	193	30	12	263	222	22	541	15	123	242	14
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0			5.0		5.0	5.0	
Lane Util. Factor		0.95			0.95			0.95		0.97	1.00	
Frpb, ped/bikes		1.00			0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00			1.00		1.00	1.00	
Frt		0.98			0.93			1.00		1.00	0.99	
Flt Protected		1.00			1.00			1.00		0.95	1.00	
Satd. Flow (prot)		3482			3307			3551		3467	1864	
Flt Permitted		0.92			0.94			1.00		0.95	1.00	
Satd. Flow (perm)		3211			3124			3551		3467	1864	
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	12	219	34	14	299	252	25	615	17	140	275	16
RTOR Reduction (vph)	0	16	0	0	194	0	0	2	0	0	3	0
Lane Group Flow (vph)	0	249	0	0	371	0	0	655	0	140	288	0
Confl. Peds. (#/hr)	2		11	11		2	14		25	25		14
Confl. Bikes (#/hr)			1			2						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm			Perm			Split			Split		
Protected Phases		4			4		2	2		3	3	
Permitted Phases	4			4								
Actuated Green, G (s)		13.4			13.4			16.1		15.1	15.1	
Effective Green, g (s)		12.4			12.4			15.1		14.1	14.1	
Actuated g/C Ratio		0.22			0.22			0.27		0.25	0.25	
Clearance Time (s)		4.0			4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		703			684			947		864	464	
v/s Ratio Prot								c0.18		0.04	c0.15	
v/s Ratio Perm		0.08			c0.12							
v/c Ratio		0.35			0.54			0.69		0.16	0.62	
Uniform Delay, d1		18.7			19.6			18.7		16.6	18.9	
Progression Factor		1.00			1.00			1.00		1.00	1.00	
Incremental Delay, d2		0.3			0.9			2.2		0.1	2.6	
Delay (s)		19.0			20.5			20.9		16.7	21.5	
Level of Service		B			C			C		B	C	
Approach Delay (s)		19.0			20.5			20.9			19.9	
Approach LOS		B			C			C			B	

Intersection Summary			
HCM Average Control Delay	20.3	HCM Level of Service	C
HCM Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	56.6	Sum of lost time (s)	15.0
Intersection Capacity Utilization	69.3%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



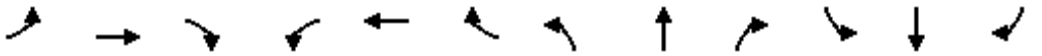
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	12	263	309	12	393	136	408	319	17	64	181	14
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Util. Factor		0.91	0.91		0.95		1.00	1.00			1.00	
Frpb, ped/bikes		0.99	0.96		0.99		1.00	1.00			1.00	
Flpb, ped/bikes		1.00	1.00		1.00		1.00	1.00			1.00	
Frt		0.95	0.85		0.96		1.00	0.99			0.99	
Flt Protected		1.00	1.00		1.00		0.95	1.00			0.99	
Satd. Flow (prot)		2965	1385		3137		1770	1588			1568	
Flt Permitted		0.90	1.00		0.94		0.95	1.00			0.99	
Satd. Flow (perm)		2685	1385		2951		1770	1588			1568	
Peak-hour factor, PHF	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
Adj. Flow (vph)	14	313	368	14	468	162	486	380	20	76	215	17
RTOR Reduction (vph)	0	56	168	0	39	0	0	2	0	0	3	0
Lane Group Flow (vph)	0	418	53	0	605	0	486	398	0	0	305	0
Confl. Peds. (#/hr)	16		21	21		16	20		16	16		20
Confl. Bikes (#/hr)			1			2			1			
Parking (#/hr)		8			8			8			8	
Turn Type	Perm		Perm	Perm			Split			Split		
Protected Phases		2			2		4	4		8	8	
Permitted Phases	2		2	2								
Actuated Green, G (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Effective Green, g (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Actuated g/C Ratio		0.24	0.24		0.24		0.30	0.30			0.31	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Grp Cap (vph)		647	334		711		533	478			491	
v/s Ratio Prot							c0.27	0.25			c0.19	
v/s Ratio Perm		0.16	0.04		c0.20							
v/c Ratio		0.65	0.16		0.85		0.91	0.83			0.62	
Uniform Delay, d1		28.3	24.9		30.1		27.9	27.0			24.3	
Progression Factor		1.00	1.00		1.00		1.00	1.00			1.00	
Incremental Delay, d2		4.9	1.0		12.2		22.3	15.5			5.8	
Delay (s)		33.2	25.9		42.2		50.3	42.6			30.1	
Level of Service		C	C		D		D	D			C	
Approach Delay (s)		30.9			42.2			46.8			30.1	
Approach LOS		C			D			D			C	

Intersection Summary			
HCM Average Control Delay	39.3	HCM Level of Service	D
HCM Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	83.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	78.8%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL2	EBL	EBT	EBR	NBT	NBR	NBR2	SBL2	SBL	SBT
Lane Configurations										
Volume (vph)	43	595	141	82	131	155	57	326	130	295
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0	4.5	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor		0.91	0.91	1.00	0.95	1.00		1.00	1.00	1.00
Frpb, ped/bikes		1.00	1.00	0.86	1.00	0.93		1.00	1.00	1.00
Flpb, ped/bikes		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frt		1.00	1.00	0.85	1.00	0.85		1.00	1.00	1.00
Flt Protected		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (prot)		1610	3276	1369	3539	1478		1770	1770	1863
Flt Permitted		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (perm)		1610	3276	1369	3539	1478		1770	1770	1863
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	45	626	148	86	138	163	60	343	137	311
RTOR Reduction (vph)	0	0	0	65	0	20	0	0	0	0
Lane Group Flow (vph)	0	333	486	21	138	203	0	343	137	311
Confl. Peds. (#/hr)				50			50		50	
Confl. Bikes (#/hr)				10			10			
Turn Type	Perm	Perm		Perm		Perm		Prot	Prot	
Protected Phases			4		2			1	1	6
Permitted Phases	4	4		4		2				
Actuated Green, G (s)		17.4	17.4	17.4	18.3	18.3		25.8	25.8	47.6
Effective Green, g (s)		18.9	18.9	18.4	17.8	17.8		26.3	26.3	48.1
Actuated g/C Ratio		0.25	0.25	0.25	0.24	0.24		0.35	0.35	0.64
Clearance Time (s)		5.5	5.5	5.5	3.5	3.5		4.5	4.5	4.5
Vehicle Extension (s)		2.0	2.0	2.0	2.0	2.0		2.0	2.0	2.0
Lane Grp Cap (vph)		406	826	336	840	351		621	621	1195
v/s Ratio Prot					0.04			c0.19	0.08	0.17
v/s Ratio Perm		c0.21	0.15	0.02		c0.14				
v/c Ratio		0.82	0.59	0.06	0.16	0.58		0.55	0.22	0.26
Uniform Delay, d1		26.4	24.6	21.7	22.7	25.3		19.6	17.1	5.8
Progression Factor		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2		11.9	0.7	0.0	0.0	1.4		3.5	0.8	0.5
Delay (s)		38.4	25.3	21.7	22.7	26.7		23.1	18.0	6.3
Level of Service		D	C	C	C	C		C	B	A
Approach Delay (s)			29.8		25.2					15.6
Approach LOS			C		C					B

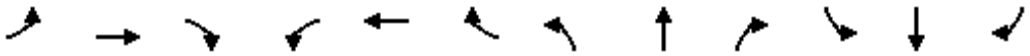
Intersection Summary			
HCM Average Control Delay	23.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.64		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	63.2%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group



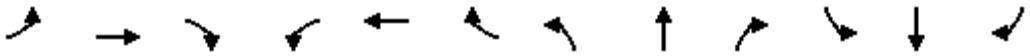
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	252	559	0	0	0	0	0	423	219
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0						4.0	4.0
Lane Util. Factor				0.86	0.86						0.86	0.86
Frpb, ped/bikes				1.00	1.00						1.00	1.00
Flpb, ped/bikes				1.00	1.00						1.00	1.00
Frt				1.00	1.00						0.98	0.85
Flt Protected				0.95	1.00						1.00	1.00
Satd. Flow (prot)				1522	4784						4685	1362
Flt Permitted				0.95	1.00						1.00	1.00
Satd. Flow (perm)				1522	4784						4685	1362
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	265	588	0	0	0	0	0	445	231
RTOR Reduction (vph)	0	0	0	155	14	0	0	0	0	0	29	92
Lane Group Flow (vph)	0	0	0	52	632	0	0	0	0	0	495	60
Confl. Bikes (#/hr)						9						10
Turn Type				Prot								Prot
Protected Phases				7	3						2	2
Permitted Phases												
Actuated Green, G (s)				20.0	40.0						31.0	31.0
Effective Green, g (s)				20.0	40.0						31.0	31.0
Actuated g/C Ratio				0.25	0.51						0.39	0.39
Clearance Time (s)				4.0	4.0						4.0	4.0
Lane Grp Cap (vph)				385	2422						1838	534
v/s Ratio Prot				0.03	c0.07						c0.11	0.04
v/s Ratio Perm					0.07							
v/c Ratio				0.14	0.26						0.27	0.11
Uniform Delay, d1				22.8	11.1						16.3	15.3
Progression Factor				1.00	1.00						1.00	1.00
Incremental Delay, d2				0.7	0.3						0.4	0.4
Delay (s)				23.6	11.4						16.7	15.7
Level of Service				C	B						B	B
Approach Delay (s)		0.0			14.3			0.0			16.4	
Approach LOS		A			B			A			B	

Intersection Summary			
HCM Average Control Delay	15.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.26		
Actuated Cycle Length (s)	79.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	28.4%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



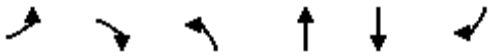
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	63	279	0	0	0	0	0	941	1712	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0						4.0	4.0			
Lane Util. Factor		0.91						0.91	0.88			
Frpb, ped/bikes		1.00						1.00	1.00			
Flpb, ped/bikes		1.00						1.00	1.00			
Frt		1.00						1.00	0.85			
Flt Protected		0.99						1.00	1.00			
Satd. Flow (prot)		5032						5085	2787			
Flt Permitted		0.99						1.00	1.00			
Satd. Flow (perm)		5032						5085	2787			
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	66	294	0	0	0	0	0	991	1802	0	0	0
RTOR Reduction (vph)	0	15	0	0	0	0	0	0	440	0	0	0
Lane Group Flow (vph)	0	345	0	0	0	0	0	991	1362	0	0	0
Confl. Peds. (#/hr)	12		21	21		12	42		29	29		42
Confl. Bikes (#/hr)			2			1						
Turn Type	Perm								custom			
Protected Phases		4						2	2			
Permitted Phases	4								7			
Actuated Green, G (s)		27.0						23.0	23.0			
Effective Green, g (s)		27.0						24.0	24.0			
Actuated g/C Ratio		0.45						0.40	0.40			
Clearance Time (s)		5.0						5.0	5.0			
Vehicle Extension (s)		3.0						3.0	3.0			
Lane Grp Cap (vph)		2264						2034	1115			
v/s Ratio Prot								0.19	c0.49			
v/s Ratio Perm		0.07										
v/c Ratio		0.15						0.49	1.22			
Uniform Delay, d1		9.7						13.4	18.0			
Progression Factor		1.00						1.00	1.00			
Incremental Delay, d2		0.1						0.2	108.0			
Delay (s)		9.9						13.6	126.0			
Level of Service		A						B	F			
Approach Delay (s)		9.9			0.0			86.1			0.0	
Approach LOS		A			A			F			A	

Intersection Summary			
HCM Average Control Delay	77.4	HCM Level of Service	E
HCM Volume to Capacity ratio	0.66		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	92.5%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	42	683	1234	0	0	0	0	253	89	36	309	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0					4.0			4.0	
Lane Util. Factor		0.86	0.86					1.00			1.00	
Frpb, ped/bikes		0.96	0.97					0.98			1.00	
Flpb, ped/bikes		1.00	1.00					1.00			1.00	
Frt		0.93	0.85					0.96			1.00	
Flt Protected		1.00	1.00					1.00			0.99	
Satd. Flow (prot)		4271	1315					1755			1846	
Flt Permitted		1.00	1.00					1.00			0.79	
Satd. Flow (perm)		4271	1315					1755			1464	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	44	719	1299	0	0	0	0	266	94	38	325	0
RTOR Reduction (vph)	0	82	0	0	0	0	0	22	0	0	0	0
Lane Group Flow (vph)	0	1331	649	0	0	0	0	338	0	0	363	0
Confl. Peds. (#/hr)	51		75	75		51	29		79	79		29
Confl. Bikes (#/hr)												3
Turn Type	Perm		Free							Perm		
Protected Phases		2						4			8	
Permitted Phases	2		Free							8		
Actuated Green, G (s)		34.9	60.0					16.1			16.1	
Effective Green, g (s)		35.9	60.0					16.1			16.1	
Actuated g/C Ratio		0.60	1.00					0.27			0.27	
Clearance Time (s)		5.0						4.0			4.0	
Vehicle Extension (s)		2.0						2.0			2.0	
Lane Grp Cap (vph)		2555	1315					471			393	
v/s Ratio Prot								0.19				
v/s Ratio Perm		0.31	c0.49								c0.25	
v/c Ratio		0.52	0.49					0.72			0.92	
Uniform Delay, d1		7.0	0.0					19.9			21.4	
Progression Factor		0.70	1.00					1.00			1.00	
Incremental Delay, d2		0.1	0.1					4.3			26.7	
Delay (s)		5.0	0.1					24.2			48.0	
Level of Service		A	A					C			D	
Approach Delay (s)		3.5			0.0			24.2			48.0	
Approach LOS		A			A			C			D	

Intersection Summary			
HCM Average Control Delay	12.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	4.0
Intersection Capacity Utilization	75.7%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

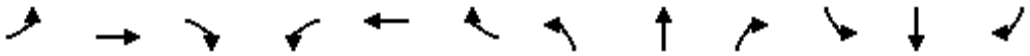


Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	283	80	61	716	1177	477
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	1.00	1.00	0.95	0.91	0.88
Frpb, ped/bikes	1.00	0.98	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3433	1550	1770	3539	5085	2787
Flt Permitted	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	3433	1550	1770	3539	5085	2787
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	301	85	65	762	1252	507
RTOR Reduction (vph)	0	0	0	0	0	355
Lane Group Flow (vph)	301	85	65	762	1252	152
Confl. Peds. (#/hr)	2	16	2			2
Turn Type		Perm	Prot			Prot
Protected Phases	4		5	2	6	6
Permitted Phases		4				
Actuated Green, G (s)	26.0	26.0	4.0	26.0	18.0	18.0
Effective Green, g (s)	26.0	26.0	4.0	26.0	18.0	18.0
Actuated g/C Ratio	0.43	0.43	0.07	0.43	0.30	0.30
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Grp Cap (vph)	1488	672	118	1534	1526	836
v/s Ratio Prot	c0.09		0.04	c0.22	c0.25	0.05
v/s Ratio Perm		0.05				
v/c Ratio	0.20	0.13	0.55	0.50	0.82	0.18
Uniform Delay, d1	10.6	10.2	27.1	12.3	19.5	15.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.3	0.4	17.2	1.2	5.1	0.5
Delay (s)	10.9	10.6	44.4	13.4	24.6	16.0
Level of Service	B	B	D	B	C	B
Approach Delay (s)	10.8			15.9	22.1	
Approach LOS	B			B	C	

Intersection Summary			
HCM Average Control Delay	18.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.47		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	62.0%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

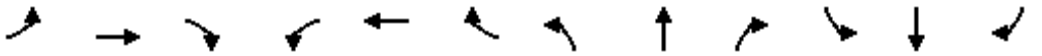
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	11	127	47	38	94	45	48	72	31	80	138	4
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95			0.95	1.00	1.00	0.95		0.91	0.91	
Frpb, ped/bikes		0.99			1.00	0.99	1.00	1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.96			1.00	0.85	1.00	0.95		1.00	1.00	
Flt Protected		1.00			0.99	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3371			3486	1563	1770	3365		1610	3368	
Flt Permitted		0.94			0.85	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		3179			2994	1563	1770	3365		1610	3368	
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	12	143	53	43	106	51	54	81	35	90	155	4
RTOR Reduction (vph)	0	34	0	0	0	0	0	29	0	0	2	0
Lane Group Flow (vph)	0	174	0	0	149	51	54	87	0	81	166	0
Confl. Peds. (#/hr)	2		4	4		2	4		2	2		4
Confl. Bikes (#/hr)			2			1						2
Turn Type	Perm			Perm		Free	Split			Split		
Protected Phases		2			6		3	3		4	4	
Permitted Phases	2			6		Free						
Actuated Green, G (s)		14.8			13.8	41.7	6.7	6.7		7.2	7.2	
Effective Green, g (s)		14.8			14.8	41.7	6.7	6.7		8.2	8.2	
Actuated g/C Ratio		0.35			0.35	1.00	0.16	0.16		0.20	0.20	
Clearance Time (s)		4.0			5.0		4.0	4.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		1128			1063	1563	284	541		317	662	
v/s Ratio Prot							c0.03	0.03		c0.05	0.05	
v/s Ratio Perm		c0.05			0.05	0.03						
v/c Ratio		0.15			0.14	0.03	0.19	0.16		0.26	0.25	
Uniform Delay, d1		9.2			9.1	0.0	15.2	15.1		14.2	14.2	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.1			0.1	0.0	0.3	0.1		0.4	0.2	
Delay (s)		9.2			9.2	0.0	15.5	15.2		14.6	14.4	
Level of Service		A			A	A	B	B		B	B	
Approach Delay (s)		9.2			6.9			15.3			14.4	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM Average Control Delay	11.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.19		
Actuated Cycle Length (s)	41.7	Sum of lost time (s)	12.0
Intersection Capacity Utilization	34.3%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



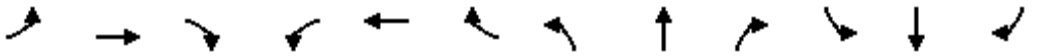
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	6	226	6	175	170	29	2	27	111	25	34	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			0.98			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	1.00		1.00	0.98			0.89			0.99	
Flt Protected	0.95	1.00		0.95	1.00			1.00			0.98	
Satd. Flow (prot)	1787	3561		1787	3480			1641			1815	
Flt Permitted	0.95	1.00		0.95	1.00			1.00			0.88	
Satd. Flow (perm)	1787	3561		1787	3480			1640			1634	
Peak-hour factor, PHF	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
Adj. Flow (vph)	7	269	7	208	202	35	2	32	132	30	40	6
RTOR Reduction (vph)	0	3	0	0	23	0	0	75	0	0	3	0
Lane Group Flow (vph)	7	273	0	208	214	0	0	91	0	0	73	0
Confl. Peds. (#/hr)	4					4	1		24	24		1
Confl. Bikes (#/hr)						2			1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Effective Green, g (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Actuated g/C Ratio	0.10	0.27		0.10	0.27			0.43			0.43	
Clearance Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Grp Cap (vph)	179	950		179	928			711			708	
v/s Ratio Prot	0.00	c0.08		c0.12	0.06							
v/s Ratio Perm								c0.06			0.04	
v/c Ratio	0.04	0.29		1.16	0.23			0.13			0.10	
Uniform Delay, d1	24.4	17.5		27.0	17.2			10.2			10.1	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	0.4	0.8		117.6	0.6			0.4			0.3	
Delay (s)	24.8	18.2		144.6	17.8			10.6			10.4	
Level of Service	C	B		F	B			B			B	
Approach Delay (s)		18.4			77.1			10.6			10.4	
Approach LOS		B			E			B			B	

Intersection Summary			
HCM Average Control Delay	43.3	HCM Level of Service	D
HCM Volume to Capacity ratio	0.31		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	50.0%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	223	199	66	68	249	51	89	503	77	108	827	322
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	11	12	11	11	12	12	12	12	12	12	12
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.97	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.94	1.00	0.99		1.00	0.99		1.00	1.00	0.91
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.97		1.00	0.98		1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	2884	3079	1340	1540	2963		1593	3099		1593	3185	1259
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (perm)	2884	3079	1340	1540	2963		1593	3099		1593	3185	1259
Peak-hour factor, PHF	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Adj. Flow (vph)	245	219	73	75	274	56	98	553	85	119	909	354
RTOR Reduction (vph)	0	0	61	0	16	0	0	9	0	0	0	216
Lane Group Flow (vph)	245	219	12	75	314	0	98	629	0	119	909	138
Confl. Peds. (#/hr)			47			60			42			75
Confl. Bikes (#/hr)						1						
Bus Blockages (#/hr)	0	0	0	0	0	2	0	0	0	0	0	8
Turn Type	Split		Perm	Split			Prot			Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			4									6
Actuated Green, G (s)	14.2	14.2	14.2	15.2	15.2		8.2	28.4		10.9	31.1	31.1
Effective Green, g (s)	14.2	14.2	14.2	15.2	15.2		8.2	29.4		10.9	32.1	32.1
Actuated g/C Ratio	0.17	0.17	0.17	0.18	0.18		0.10	0.34		0.13	0.37	0.37
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	5.0		4.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	478	510	222	273	526		152	1063		203	1193	472
v/s Ratio Prot	c0.08	0.07		0.05	c0.11		0.06	0.20		c0.07	c0.29	
v/s Ratio Perm			0.01									0.11
v/c Ratio	0.51	0.43	0.05	0.27	0.60		0.64	0.59		0.59	0.76	0.29
Uniform Delay, d1	32.6	32.1	30.1	30.5	32.4		37.3	23.2		35.3	23.5	18.8
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	0.9	0.6	0.1	0.5	1.8		9.0	0.9		4.3	2.9	0.3
Delay (s)	33.5	32.7	30.2	31.0	34.3		46.4	24.1		39.5	26.4	19.2
Level of Service	C	C	C	C	C		D	C		D	C	B
Approach Delay (s)		32.7			33.7			27.1			25.7	
Approach LOS		C			C			C			C	

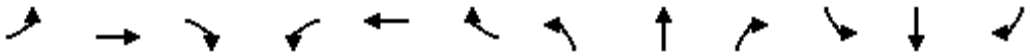
Intersection Summary			
HCM Average Control Delay	28.3	HCM Level of Service	C
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	85.7	Sum of lost time (s)	16.0
Intersection Capacity Utilization	70.7%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	98	149	95	40	110	107	95	459	32	129	1157	111
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.9	4.9		4.9	4.9		4.3	4.8	4.8	4.3	4.8	4.8
Lane Util. Factor	1.00	0.95		1.00	0.95		0.97	0.95	1.00	0.97	0.95	1.00
Frpb, ped/bikes	1.00	0.99		1.00	0.99		1.00	1.00	0.98	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.94		1.00	0.93		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1787	3343		1787	3270		3467	3574	1571	3467	3574	1576
Flt Permitted	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1787	3343		1787	3270		3467	3574	1571	3467	3574	1576
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	103	157	100	42	116	113	100	483	34	136	1218	117
RTOR Reduction (vph)	0	86	0	0	99	0	0	0	20	0	0	12
Lane Group Flow (vph)	103	171	0	42	130	0	100	483	14	136	1218	105
Confl. Peds. (#/hr)			7			14			8			3
Confl. Bikes (#/hr)						1						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Split			Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases									2			6
Actuated Green, G (s)	10.5	10.5		9.4	9.4		5.0	29.4	29.4	4.3	28.7	28.7
Effective Green, g (s)	9.6	9.6		8.5	8.5		4.7	29.6	29.6	4.0	28.9	28.9
Actuated g/C Ratio	0.14	0.14		0.12	0.12		0.07	0.42	0.42	0.06	0.41	0.41
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	5.0	5.0	4.0	5.0	5.0
Vehicle Extension (s)	2.0	2.0		2.0	2.0		2.0	2.0	2.0	2.0	2.0	2.0
Lane Grp Cap (vph)	243	455		215	394		231	1498	659	196	1463	645
v/s Ratio Prot	c0.06	0.05		0.02	c0.04		0.03	0.14		c0.04	c0.34	
v/s Ratio Perm									0.01			0.07
v/c Ratio	0.42	0.37		0.20	0.33		0.43	0.32	0.02	0.69	0.83	0.16
Uniform Delay, d1	28.0	27.8		28.0	28.4		31.7	13.8	12.0	32.7	18.7	13.2
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.4	0.2		0.2	0.2		0.5	0.0	0.0	8.3	4.0	0.0
Delay (s)	28.4	28.0		28.1	28.6		32.1	13.8	12.0	41.0	22.7	13.2
Level of Service	C	C		C	C		C	B	B	D	C	B
Approach Delay (s)		28.1			28.5			16.7			23.6	
Approach LOS		C			C			B			C	

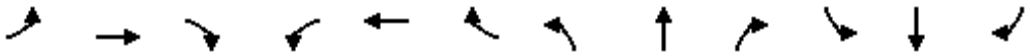
Intersection Summary			
HCM Average Control Delay	23.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	70.6	Sum of lost time (s)	18.9
Intersection Capacity Utilization	69.7%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



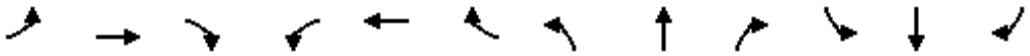
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	4	5	2	10	4	28	1	101	24	59	173	3
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frpb, ped/bikes		1.00			1.00	0.97	1.00	1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.98			1.00	0.85	1.00	0.97		1.00	1.00	
Flt Protected		0.98			0.96	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1776			1797	1536	1770	1802		1770	1858	
Flt Permitted		0.98			0.96	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		1776			1797	1536	1770	1802		1770	1858	
Peak-hour factor, PHF	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Adj. Flow (vph)	4	5	2	11	4	31	1	111	26	65	190	3
RTOR Reduction (vph)	0	2	0	0	0	30	0	9	0	0	1	0
Lane Group Flow (vph)	0	9	0	0	15	1	1	128	0	65	192	0
Confl. Peds. (#/hr)	2		6	6		2	8		2	2		8
Confl. Bikes (#/hr)						1						
Turn Type	Split			Split		Perm	Split			Split		
Protected Phases	2	2		1	1		4	4		3	3	
Permitted Phases						1						
Actuated Green, G (s)		1.5			1.9	1.9	11.2	11.2		12.0	12.0	
Effective Green, g (s)		1.5			1.9	1.9	11.2	11.2		12.0	12.0	
Actuated g/C Ratio		0.04			0.04	0.04	0.26	0.26		0.28	0.28	
Clearance Time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0	3.0	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		63			80	69	465	474		499	523	
v/s Ratio Prot		c0.01			c0.01		0.00	c0.07		0.04	c0.10	
v/s Ratio Perm						0.00						
v/c Ratio		0.14			0.19	0.02	0.00	0.27		0.13	0.37	
Uniform Delay, d1		19.9			19.6	19.5	11.6	12.5		11.4	12.3	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		1.1			1.1	0.1	0.0	0.3		0.1	0.4	
Delay (s)		21.0			20.7	19.6	11.6	12.8		11.5	12.7	
Level of Service		C			C	B	B	B		B	B	
Approach Delay (s)		21.0			20.0			12.8			12.4	
Approach LOS		C			B			B			B	

Intersection Summary			
HCM Average Control Delay	13.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.30		
Actuated Cycle Length (s)	42.6	Sum of lost time (s)	16.0
Intersection Capacity Utilization	30.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	142	119	34	49	129	30	8	403	31	37	607	85
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			0.95			0.95	
Frpb, ped/bikes	1.00	0.99		1.00	1.00			1.00			0.99	
Flpb, ped/bikes	0.99	1.00		0.98	1.00			1.00			1.00	
Frt	1.00	0.97		1.00	0.97			0.99			0.98	
Flt Protected	0.95	1.00		0.95	1.00			1.00			1.00	
Satd. Flow (prot)	1584	3058		1567	3085			3141			3099	
Flt Permitted	0.65	1.00		0.65	1.00			0.94			0.92	
Satd. Flow (perm)	1079	3058		1074	3085			2968			2844	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	148	124	35	51	134	31	8	420	32	39	632	89
RTOR Reduction (vph)	0	20	0	0	18	0	0	8	0	0	15	0
Lane Group Flow (vph)	148	139	0	51	147	0	0	452	0	0	745	0
Confl. Peds. (#/hr)	10		29	29		10	63		34	34		63
Confl. Bikes (#/hr)									1			
Parking (#/hr)							0					
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			4			2			2	
Permitted Phases	4			4			2			2		
Actuated Green, G (s)	30.0	30.0		30.0	30.0			32.0			32.0	
Effective Green, g (s)	29.0	29.0		29.0	29.0			31.0			31.0	
Actuated g/C Ratio	0.43	0.43		0.43	0.43			0.46			0.46	
Clearance Time (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	460	1304		458	1316			1353			1297	
v/s Ratio Prot		0.05			0.05							
v/s Ratio Perm	c0.14			0.05				0.15			c0.26	
v/c Ratio	0.32	0.11		0.11	0.11			0.33			0.57	
Uniform Delay, d1	13.0	11.7		11.7	11.7			11.9			13.6	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	1.8	0.2		0.5	0.2			0.7			1.9	
Delay (s)	14.8	11.9		12.2	11.9			12.5			15.5	
Level of Service	B	B		B	B			B			B	
Approach Delay (s)		13.3			12.0			12.5			15.5	
Approach LOS		B			B			B			B	

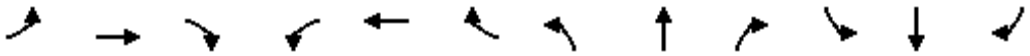
Intersection Summary			
HCM Average Control Delay	13.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.45		
Actuated Cycle Length (s)	68.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	94.6%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	11	155	22	12	152	126	13	395	36	522	530	28
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0			5.0		5.0	5.0	
Lane Util. Factor		0.95			0.95			0.95		0.97	1.00	
Frpb, ped/bikes		1.00			0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00			1.00		1.00	1.00	
Frt		0.98			0.93			0.99		1.00	0.99	
Flt Protected		1.00			1.00			1.00		0.95	1.00	
Satd. Flow (prot)		3491			3310			3520		3467	1865	
Flt Permitted		0.92			0.94			1.00		0.95	1.00	
Satd. Flow (perm)		3230			3106			3520		3467	1865	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	12	165	23	13	162	134	14	420	38	555	564	30
RTOR Reduction (vph)	0	14	0	0	113	0	0	9	0	0	2	0
Lane Group Flow (vph)	0	186	0	0	196	0	0	463	0	555	592	0
Confl. Peds. (#/hr)	2		6	6		2	11		10	10		11
Confl. Bikes (#/hr)						2						1
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm			Perm			Split			Split		
Protected Phases		4			4		2	2		3	3	
Permitted Phases	4			4								
Actuated Green, G (s)		11.0			11.0			13.6		26.5	26.5	
Effective Green, g (s)		10.0			10.0			12.6		25.5	25.5	
Actuated g/C Ratio		0.16			0.16			0.20		0.40	0.40	
Clearance Time (s)		4.0			4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		512			492			703		1401	754	
v/s Ratio Prot								c0.13		0.16	c0.32	
v/s Ratio Perm		0.06			c0.06							
v/c Ratio		0.36			0.40			0.66		0.40	0.79	
Uniform Delay, d1		23.7			23.8			23.3		13.3	16.4	
Progression Factor		1.00			1.00			1.00		1.00	1.00	
Incremental Delay, d2		0.4			0.5			2.2		0.2	5.4	
Delay (s)		24.1			24.4			25.5		13.5	21.8	
Level of Service		C			C			C		B	C	
Approach Delay (s)		24.1			24.4			25.5			17.8	
Approach LOS		C			C			C			B	

Intersection Summary			
HCM Average Control Delay	21.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	63.1	Sum of lost time (s)	15.0
Intersection Capacity Utilization	73.7%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	12	309	395	16	282	105	337	273	27	90	375	26
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Util. Factor		0.91	0.91		0.95		1.00	1.00			1.00	
Frpb, ped/bikes		0.99	0.96		0.99		1.00	1.00			1.00	
Flpb, ped/bikes		1.00	1.00		1.00		1.00	1.00			1.00	
Frt		0.95	0.85		0.96		1.00	0.99			0.99	
Flt Protected		1.00	1.00		1.00		0.95	1.00			0.99	
Satd. Flow (prot)		2974	1399		3159		1787	1592			1588	
Flt Permitted		0.94	1.00		0.93		0.95	1.00			0.99	
Satd. Flow (perm)		2804	1399		2931		1787	1592			1588	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	12	319	407	16	291	108	347	281	28	93	387	27
RTOR Reduction (vph)	0	74	176	0	43	0	0	4	0	0	3	0
Lane Group Flow (vph)	0	432	56	0	372	0	347	305	0	0	504	0
Confl. Peds. (#/hr)	17		21	21		17	30		15	15		30
Confl. Bikes (#/hr)			1			1						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Parking (#/hr)		8			8			8			8	
Turn Type	Perm		Perm	Perm			Split			Split		
Protected Phases		2			2		4	4		8	8	
Permitted Phases	2		2	2								
Actuated Green, G (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Effective Green, g (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Actuated g/C Ratio		0.24	0.24		0.24		0.30	0.30			0.31	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Grp Cap (vph)		676	337		706		538	480			497	
v/s Ratio Prot							c0.19	0.19			c0.32	
v/s Ratio Perm		c0.15	0.04		0.13							
v/c Ratio		0.64	0.17		0.53		0.64	0.64			1.01	
Uniform Delay, d1		28.3	24.9		27.4		25.2	25.1			28.5	
Progression Factor		1.00	1.00		1.00		1.00	1.00			1.00	
Incremental Delay, d2		4.6	1.1		2.8		5.9	6.3			44.1	
Delay (s)		32.9	26.0		30.2		31.0	31.3			72.6	
Level of Service		C	C		C		C	C			E	
Approach Delay (s)		30.7			30.2			31.2			72.6	
Approach LOS		C			C			C			E	

Intersection Summary			
HCM Average Control Delay	39.9	HCM Level of Service	D
HCM Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	83.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	79.4%	ICU Level of Service	D
Analysis Period (min)	15		

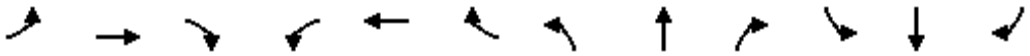
c Critical Lane Group

Movement	EBL2	EBL	EBT	EBR	NBT	NBR	NBR2	SBL2	SBL	SBT
Lane Configurations										
Volume (vph)	28	896	268	71	293	232	56	308	243	262
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0	4.5	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor		0.91	0.91	1.00	0.95	1.00		1.00	1.00	1.00
Frpb, ped/bikes		1.00	1.00	0.85	1.00	0.92		1.00	1.00	1.00
Flpb, ped/bikes		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frt		1.00	1.00	0.85	1.00	0.85		1.00	1.00	1.00
Flt Protected		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (prot)		1610	3286	1343	3539	1451		1770	1770	1863
Flt Permitted		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (perm)		1610	3286	1343	3539	1451		1770	1770	1863
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	29	943	282	75	308	244	59	324	256	276
RTOR Reduction (vph)	0	0	0	49	0	10	0	0	0	0
Lane Group Flow (vph)	0	482	772	26	308	293	0	324	256	276
Confl. Peds. (#/hr)				50			50		50	
Confl. Bikes (#/hr)				10			10			
Turn Type	Perm	Perm		Perm		Perm		Prot	Prot	
Protected Phases			4		2			1	1	6
Permitted Phases	4	4		4		2				
Actuated Green, G (s)		30.0	30.0	30.0	20.6	20.6		26.4	26.4	50.0
Effective Green, g (s)		31.5	31.5	31.0	20.1	20.1		26.4	26.4	50.5
Actuated g/C Ratio		0.35	0.35	0.34	0.22	0.22		0.29	0.29	0.56
Clearance Time (s)		5.5	5.5	5.5	3.5	3.5		4.0	4.0	4.5
Vehicle Extension (s)		2.0	2.0	2.0	2.0	2.0		2.0	2.0	2.0
Lane Grp Cap (vph)		564	1150	463	790	324		519	519	1045
v/s Ratio Prot					0.09			c0.18	0.14	0.15
v/s Ratio Perm		c0.30	0.23	0.02		c0.20				
v/c Ratio		0.85	0.67	0.06	0.39	0.90		0.62	0.49	0.26
Uniform Delay, d1		27.1	24.9	19.7	29.7	34.0		27.5	26.3	10.2
Progression Factor		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2		11.6	1.2	0.0	0.1	26.6		5.6	3.3	0.6
Delay (s)		38.8	26.1	19.7	29.8	60.6		33.1	29.6	10.8
Level of Service		D	C	B	C	E		C	C	B
Approach Delay (s)			30.3		45.1					24.9
Approach LOS			C		D					C

Intersection Summary			
HCM Average Control Delay	31.9	HCM Level of Service	C
HCM Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	69.7%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

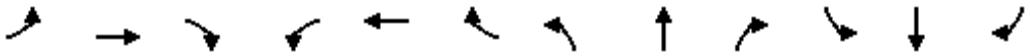
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	315	439	0	0	0	0	0	860	259
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0						4.0	4.0
Lane Util. Factor				0.86	0.86						0.86	0.86
Frpb, ped/bikes				1.00	1.00						1.00	1.00
Flpb, ped/bikes				1.00	1.00						1.00	1.00
Frt				1.00	1.00						1.00	0.85
Flt Protected				0.95	0.99						1.00	1.00
Satd. Flow (prot)				1522	4751						4783	1362
Flt Permitted				0.95	0.99						1.00	1.00
Satd. Flow (perm)				1522	4751						4783	1362
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	332	462	0	0	0	0	0	905	273
RTOR Reduction (vph)	0	0	0	144	24	0	0	0	0	0	4	149
Lane Group Flow (vph)	0	0	0	49	577	0	0	0	0	0	928	97
Confl. Bikes (#/hr)						5						9
Turn Type				Prot								Prot
Protected Phases				7	3						2	2
Permitted Phases												
Actuated Green, G (s)				20.0	40.0						31.0	31.0
Effective Green, g (s)				20.0	40.0						31.0	31.0
Actuated g/C Ratio				0.25	0.51						0.39	0.39
Clearance Time (s)				4.0	4.0						4.0	4.0
Lane Grp Cap (vph)				385	2406						1877	534
v/s Ratio Prot				0.03	c0.06						c0.19	0.07
v/s Ratio Perm					0.06							
v/c Ratio				0.13	0.24						0.49	0.18
Uniform Delay, d1				22.8	11.0						18.1	15.7
Progression Factor				1.00	1.00						1.00	1.00
Incremental Delay, d2				0.7	0.2						0.9	0.7
Delay (s)				23.4	11.2						19.0	16.4
Level of Service				C	B						B	B
Approach Delay (s)		0.0			14.2			0.0			18.5	
Approach LOS		A			B			A			B	

Intersection Summary			
HCM Average Control Delay	16.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.35		
Actuated Cycle Length (s)	79.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	36.4%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	148	611	0	0	0	0	0	685	1561	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0						4.0	4.0			
Lane Util. Factor		0.91						0.91	0.88			
Frpb, ped/bikes		1.00						1.00	1.00			
Flpb, ped/bikes		1.00						1.00	1.00			
Frt		1.00						1.00	0.85			
Flt Protected		0.99						1.00	1.00			
Satd. Flow (prot)		5022						5085	2787			
Flt Permitted		0.99						1.00	1.00			
Satd. Flow (perm)		5022						5085	2787			
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	156	643	0	0	0	0	0	721	1643	0	0	0
RTOR Reduction (vph)	0	5	0	0	0	0	0	0	317	0	0	0
Lane Group Flow (vph)	0	794	0	0	0	0	0	721	1326	0	0	0
Confl. Peds. (#/hr)	28		7	7		28	99		3	3		99
Confl. Bikes (#/hr)			1			2			1			
Turn Type	Perm								custom			
Protected Phases		4						2	2			
Permitted Phases	4								7			
Actuated Green, G (s)		34.0						16.0	16.0			
Effective Green, g (s)		35.0						17.0	17.0			
Actuated g/C Ratio		0.58						0.28	0.28			
Clearance Time (s)		5.0						5.0	5.0			
Vehicle Extension (s)		3.0						3.0	3.0			
Lane Grp Cap (vph)		2930						1441	790			
v/s Ratio Prot								0.14	c0.48			
v/s Ratio Perm		0.16										
v/c Ratio		0.27						0.50	1.68			
Uniform Delay, d1		6.2						18.0	21.5			
Progression Factor		1.00						1.00	1.00			
Incremental Delay, d2		0.2						0.3	310.6			
Delay (s)		6.4						18.2	332.1			
Level of Service		A						B	F			
Approach Delay (s)		6.4			0.0			236.4			0.0	
Approach LOS		A			A			F			A	

Intersection Summary			
HCM Average Control Delay	178.3	HCM Level of Service	F
HCM Volume to Capacity ratio	0.73		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	89.9%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

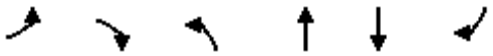


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	33	1021	1127	0	0	0	0	168	170	57	322	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0					4.0			4.0	
Lane Util. Factor		0.86	0.86					1.00			1.00	
Frpb, ped/bikes		0.98	0.97					0.98			1.00	
Flpb, ped/bikes		1.00	1.00					1.00			1.00	
Frt		0.95	0.85					0.93			1.00	
Flt Protected		1.00	1.00					1.00			0.99	
Satd. Flow (prot)		4432	1323					1703			1845	
Flt Permitted		1.00	1.00					1.00			0.76	
Satd. Flow (perm)		4432	1323					1703			1405	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	35	1075	1186	0	0	0	0	177	179	60	339	0
RTOR Reduction (vph)	0	76	0	0	0	0	0	46	0	0	0	0
Lane Group Flow (vph)	0	1627	593	0	0	0	0	310	0	0	399	0
Confl. Peds. (#/hr)	52		55	55		52	39		25	25		39
Confl. Bikes (#/hr)			1						2			2
Turn Type	Perm		Free							Perm		
Protected Phases		2						4			8	
Permitted Phases	2		Free							8		
Actuated Green, G (s)		33.2	60.0					17.8			17.8	
Effective Green, g (s)		34.2	60.0					17.8			17.8	
Actuated g/C Ratio		0.57	1.00					0.30			0.30	
Clearance Time (s)		5.0						4.0			4.0	
Vehicle Extension (s)		2.0						2.0			2.0	
Lane Grp Cap (vph)		2526	1323					505			417	
v/s Ratio Prot								0.18				
v/s Ratio Perm		0.37	0.45								c0.28	
v/c Ratio		0.64	0.45					0.61			0.96	
Uniform Delay, d1		8.8	0.0					18.1			20.7	
Progression Factor		0.58	1.00					1.00			1.00	
Incremental Delay, d2		0.1	0.1					1.6			32.5	
Delay (s)		5.2	0.1					19.7			53.3	
Level of Service		A	A					B			D	
Approach Delay (s)		3.9			0.0			19.7			53.3	
Approach LOS		A			A			B			D	

Intersection Summary			
HCM Average Control Delay	12.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	82.6%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Near-Term (2018) No Project Conditions

FEHR PEERS



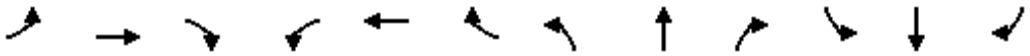
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	410	60	40	1210	850	530
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	1.00	1.00	0.95	0.91	0.88
Frpb, ped/bikes	1.00	0.98	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3400	1535	1752	3505	5036	2760
Flt Permitted	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	3400	1535	1752	3505	5036	2760
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	446	65	43	1315	924	576
RTOR Reduction (vph)	0	0	0	0	0	403
Lane Group Flow (vph)	446	65	43	1315	924	173
Confl. Peds. (#/hr)	3	11	4			4
Confl. Bikes (#/hr)		5				5
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%
Turn Type		Perm	Prot			Prot
Protected Phases	4		5	2	6	6
Permitted Phases		4				
Actuated Green, G (s)	26.0	26.0	4.0	26.0	18.0	18.0
Effective Green, g (s)	26.0	26.0	4.0	26.0	18.0	18.0
Actuated g/C Ratio	0.43	0.43	0.07	0.43	0.30	0.30
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Grp Cap (vph)	1473	665	117	1519	1511	828
v/s Ratio Prot	c0.13		0.02	c0.38	0.18	0.06
v/s Ratio Perm		0.04				
v/c Ratio	0.30	0.10	0.37	0.87	0.61	0.21
Uniform Delay, d1	11.1	10.1	26.8	15.4	18.0	15.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.5	0.3	8.7	6.9	1.9	0.6
Delay (s)	11.6	10.4	35.5	22.3	19.9	16.3
Level of Service	B	B	D	C	B	B
Approach Delay (s)	11.5			22.7	18.5	
Approach LOS	B			C	B	

Intersection Summary			
HCM Average Control Delay	19.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.58		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	65.9%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	50	30	100	100	110	60	190	70	40	90	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95			0.95	1.00	1.00	0.95		0.91	0.91	
Frpb, ped/bikes		0.99			1.00	0.98	1.00	0.99		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.95			1.00	0.85	1.00	0.96		1.00	0.97	
Flt Protected		0.99			0.98	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3183			3310	1500	1703	3244		1550	3158	
Flt Permitted		0.92			0.78	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		2947			2652	1500	1703	3244		1550	3158	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	54	33	109	109	120	65	207	76	43	98	22
RTOR Reduction (vph)	0	23	0	0	0	0	0	51	0	0	18	0
Lane Group Flow (vph)	0	75	0	0	218	120	65	232	0	39	106	0
Confl. Peds. (#/hr)	9		8	8		9	12		17	17		12
Confl. Bikes (#/hr)						3			5			2
Heavy Vehicles (%)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
Turn Type	Perm			Perm		Free	Split			Split		
Protected Phases		2			6		3	3		4	4	
Permitted Phases	2			6		Free						
Actuated Green, G (s)		12.7			11.7	41.9	9.5	9.5		6.7	6.7	
Effective Green, g (s)		12.7			12.7	41.9	9.5	9.5		7.7	7.7	
Actuated g/C Ratio		0.30			0.30	1.00	0.23	0.23		0.18	0.18	
Clearance Time (s)		4.0			5.0		4.0	4.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		893			804	1500	386	736		285	580	
v/s Ratio Prot							0.04	c0.07		0.03	c0.03	
v/s Ratio Perm		0.03			c0.08	0.08						
v/c Ratio		0.08			0.27	0.08	0.17	0.32		0.14	0.18	
Uniform Delay, d1		10.4			11.1	0.0	13.0	13.5		14.3	14.4	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.0			0.2	0.1	0.2	0.2		0.2	0.2	
Delay (s)		10.5			11.3	0.1	13.2	13.7		14.5	14.6	
Level of Service		B			B	A	B	B		B	B	
Approach Delay (s)		10.5			7.3			13.6			14.6	
Approach LOS		B			A			B			B	

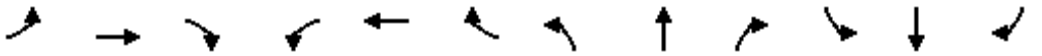
Intersection Summary			
HCM Average Control Delay	11.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.26		
Actuated Cycle Length (s)	41.9	Sum of lost time (s)	12.0
Intersection Capacity Utilization	42.0%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	130	10	140	270	30	20	90	230	40	80	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			0.97			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	0.99		1.00	0.98			0.91			0.98	
Flt Protected	0.95	1.00		0.95	1.00			1.00			0.99	
Satd. Flow (prot)	1736	3422		1736	3404			1607			1752	
Flt Permitted	0.95	1.00		0.95	1.00			0.98			0.85	
Satd. Flow (perm)	1736	3422		1736	3404			1582			1515	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	141	11	152	293	33	22	98	250	43	87	22
RTOR Reduction (vph)	0	8	0	0	14	0	0	125	0	0	10	0
Lane Group Flow (vph)	11	144	0	152	312	0	0	245	0	0	142	0
Confl. Peds. (#/hr)	11		13	13		11	22		48	48		22
Confl. Bikes (#/hr)			1			2			1			
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Effective Green, g (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Actuated g/C Ratio	0.10	0.27		0.10	0.27			0.43			0.43	
Clearance Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Grp Cap (vph)	174	913		174	908			686			657	
v/s Ratio Prot	0.01	0.04		c0.09	c0.09							
v/s Ratio Perm								c0.15			0.09	
v/c Ratio	0.06	0.16		0.87	0.34			0.36			0.22	
Uniform Delay, d1	24.5	16.8		26.6	17.8			11.4			10.6	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	0.7	0.4		41.4	1.0			1.4			0.8	
Delay (s)	25.2	17.2		68.0	18.8			12.8			11.4	
Level of Service	C	B		E	B			B			B	
Approach Delay (s)		17.7			34.4			12.8			11.4	
Approach LOS		B			C			B			B	

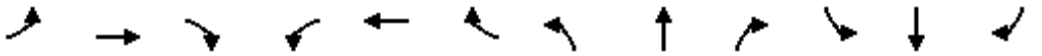
Intersection Summary			
HCM Average Control Delay	22.2	HCM Level of Service	C
HCM Volume to Capacity ratio	0.42		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	54.5%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	310	260	120	40	320	70	140	890	70	100	480	340
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	11	12	11	11	12	12	12	12	12	12	12
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.97	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.97	1.00	0.98		1.00	1.00		1.00	1.00	0.95
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.97		1.00	0.99		1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	2828	3020	1356	1510	2882		1562	3081		1562	3124	1280
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (perm)	2828	3020	1356	1510	2882		1562	3081		1562	3124	1280
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	337	283	130	43	348	76	152	967	76	109	522	370
RTOR Reduction (vph)	0	0	105	0	16	0	0	5	0	0	0	252
Lane Group Flow (vph)	337	283	25	43	408	0	152	1038	0	109	522	118
Confl. Peds. (#/hr)			16			85			25			37
Confl. Bikes (#/hr)						1			1			1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Bus Blockages (#/hr)	0	0	0	0	0	2	0	0	0	0	0	8
Turn Type	Split		Perm	Split			Prot			Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			4									6
Actuated Green, G (s)	17.8	17.8	17.8	18.4	18.4		12.2	30.5		10.7	29.0	29.0
Effective Green, g (s)	17.8	17.8	17.8	18.4	18.4		12.2	31.5		10.7	30.0	30.0
Actuated g/C Ratio	0.19	0.19	0.19	0.19	0.19		0.13	0.33		0.11	0.32	0.32
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	5.0		4.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	533	569	256	294	562		202	1028		177	993	407
v/s Ratio Prot	c0.12	0.09		0.03	c0.14		c0.10	c0.34		0.07	0.17	
v/s Ratio Perm			0.02									0.09
v/c Ratio	0.63	0.50	0.10	0.15	0.73		0.75	1.01		0.62	0.53	0.29
Uniform Delay, d1	35.3	34.3	31.6	31.5	35.6		39.6	31.5		39.9	26.4	24.2
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	2.4	0.7	0.2	0.2	4.6		14.6	30.6		6.2	0.5	0.4
Delay (s)	37.7	35.0	31.8	31.7	40.3		54.3	62.0		46.1	26.9	24.6
Level of Service	D	C	C	C	D		D	E		D	C	C
Approach Delay (s)		35.7			39.5			61.0			28.1	
Approach LOS		D			D			E			C	

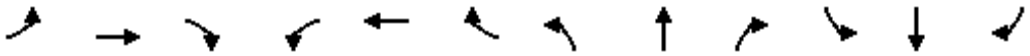
Intersection Summary			
HCM Average Control Delay	42.9	HCM Level of Service	D
HCM Volume to Capacity ratio	0.80		
Actuated Cycle Length (s)	94.4	Sum of lost time (s)	12.0
Intersection Capacity Utilization	79.7%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group



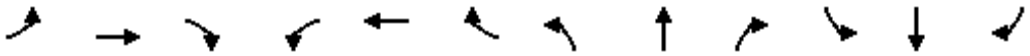
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	80	200	90	50	180	100	140	790	50	90	350	70
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.9	4.9		4.9	4.9		4.3	4.8	4.8	4.3	4.8	4.8
Lane Util. Factor	1.00	0.95		1.00	0.95		0.97	0.95	1.00	0.97	0.95	1.00
Frpb, ped/bikes	1.00	0.99		1.00	0.99		1.00	1.00	0.98	1.00	1.00	0.98
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.95		1.00	0.95		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	3357		1770	3321		3433	3539	1558	3433	3539	1550
Flt Permitted	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	3357		1770	3321		3433	3539	1558	3433	3539	1550
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	86	215	97	54	194	108	151	849	54	97	376	75
RTOR Reduction (vph)	0	54	0	0	80	0	0	0	37	0	0	32
Lane Group Flow (vph)	86	258	0	54	222	0	151	849	17	97	376	43
Confl. Peds. (#/hr)			7			13			6			11
Confl. Bikes (#/hr)						2						
Turn Type	Split			Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases									2			6
Actuated Green, G (s)	11.7	11.7		11.1	11.1		7.1	20.8	20.8	4.3	18.0	18.0
Effective Green, g (s)	10.8	10.8		10.2	10.2		6.8	21.0	21.0	4.0	18.2	18.2
Actuated g/C Ratio	0.17	0.17		0.16	0.16		0.10	0.32	0.32	0.06	0.28	0.28
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	5.0	5.0	4.0	5.0	5.0
Vehicle Extension (s)	2.0	2.0		2.0	2.0		2.0	2.0	2.0	2.0	2.0	2.0
Lane Grp Cap (vph)	295	559		278	522		360	1145	504	212	992	435
v/s Ratio Prot	0.05	c0.08		0.03	c0.07		c0.04	c0.24		0.03	0.11	
v/s Ratio Perm									0.01			0.03
v/c Ratio	0.29	0.46		0.19	0.43		0.42	0.74	0.03	0.46	0.38	0.10
Uniform Delay, d1	23.7	24.4		23.8	24.7		27.2	19.5	15.0	29.4	18.8	17.3
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.2	0.2		0.1	0.2		0.3	2.3	0.0	0.6	0.1	0.0
Delay (s)	23.9	24.6		23.9	24.9		27.5	21.8	15.0	30.0	18.9	17.3
Level of Service	C	C		C	C		C	C	B	C	B	B
Approach Delay (s)		24.5			24.8			22.3			20.6	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	22.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	64.9	Sum of lost time (s)	18.9
Intersection Capacity Utilization	59.7%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



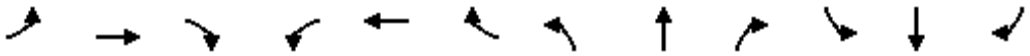
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	10	10	80	20	110	10	220	40	50	190	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frpb, ped/bikes		0.99			1.00	0.98	1.00	0.99		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.95			1.00	0.85	1.00	0.98		1.00	0.99	
Flt Protected		0.98			0.96	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1737			1791	1554	1770	1806		1770	1845	
Flt Permitted		0.98			0.96	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		1737			1791	1554	1770	1806		1770	1845	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	11	11	87	22	120	11	239	43	54	207	11
RTOR Reduction (vph)	0	10	0	0	0	105	0	7	0	0	2	0
Lane Group Flow (vph)	0	23	0	0	109	15	11	275	0	54	216	0
Confl. Peds. (#/hr)	2		1	1		2	13		20	20		13
Confl. Bikes (#/hr)						1			5			
Turn Type	Split			Split		Perm	Split			Split		
Protected Phases	2	2		1	1		4	4		3	3	
Permitted Phases						1						
Actuated Green, G (s)		4.5			7.0	7.0	15.5	15.5		13.8	13.8	
Effective Green, g (s)		4.5			7.0	7.0	15.5	15.5		13.8	13.8	
Actuated g/C Ratio		0.08			0.12	0.12	0.27	0.27		0.24	0.24	
Clearance Time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0	3.0	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		138			221	192	483	493		430	448	
v/s Ratio Prot		c0.01			c0.06		0.01	c0.15		0.03	c0.12	
v/s Ratio Perm						0.01						
v/c Ratio		0.17			0.49	0.08	0.02	0.56		0.13	0.48	
Uniform Delay, d1		24.4			23.2	22.0	15.1	17.7		16.8	18.4	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.6			1.7	0.2	0.0	1.4		0.1	0.8	
Delay (s)		25.0			25.0	22.2	15.1	19.1		16.9	19.3	
Level of Service		C			C	C	B	B		B	B	
Approach Delay (s)		25.0			23.5			18.9			18.8	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	20.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.48		
Actuated Cycle Length (s)	56.8	Sum of lost time (s)	16.0
Intersection Capacity Utilization	42.2%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	250	220	50	50	280	50	60	610	30	30	330	90
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			0.95			0.95	
Frpb, ped/bikes	1.00	0.99		1.00	0.99			1.00			0.99	
Flpb, ped/bikes	0.98	1.00		0.99	1.00			1.00			1.00	
Frt	1.00	0.97		1.00	0.98			0.99			0.97	
Flt Protected	0.95	1.00		0.95	1.00			1.00			1.00	
Satd. Flow (prot)	1540	3052		1561	3059			3112			3027	
Flt Permitted	0.53	1.00		0.57	1.00			0.87			0.88	
Satd. Flow (perm)	855	3052		941	3059			2728			2683	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	272	239	54	54	304	54	65	663	33	33	359	98
RTOR Reduction (vph)	0	29	0	0	21	0	0	5	0	0	33	0
Lane Group Flow (vph)	272	264	0	54	337	0	0	756	0	0	457	0
Confl. Peds. (#/hr)	56		22	22		56	31		42	42		31
Confl. Bikes (#/hr)						2			5			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			4			2			2	
Permitted Phases	4			4			2			2		
Actuated Green, G (s)	30.0	30.0		30.0	30.0			32.0			32.0	
Effective Green, g (s)	29.0	29.0		29.0	29.0			31.0			31.0	
Actuated g/C Ratio	0.43	0.43		0.43	0.43			0.46			0.46	
Clearance Time (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	365	1302		401	1305			1244			1223	
v/s Ratio Prot		0.09			0.11							
v/s Ratio Perm	c0.32			0.06				c0.28			0.17	
v/c Ratio	0.75	0.20		0.13	0.26			0.61			0.37	
Uniform Delay, d1	16.4	12.2		11.9	12.6			13.9			12.1	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	13.0	0.4		0.7	0.5			2.2			0.9	
Delay (s)	29.4	12.6		12.6	13.0			16.1			13.0	
Level of Service	C	B		B	B			B			B	
Approach Delay (s)		20.7			13.0			16.1			13.0	
Approach LOS		C			B			B			B	

Intersection Summary			
HCM Average Control Delay	16.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	68.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	101.2%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			



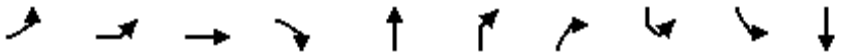
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	220	40	20	290	250	30	560	20	170	290	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0			5.0		5.0	5.0	
Lane Util. Factor		0.95			0.95			0.95		0.97	1.00	
Frpb, ped/bikes		0.99			0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00			1.00		1.00	1.00	
Frt		0.98			0.93			1.00		1.00	0.99	
Flt Protected		1.00			1.00			1.00		0.95	1.00	
Satd. Flow (prot)		3468			3305			3544		3467	1860	
Flt Permitted		0.88			0.93			1.00		0.95	1.00	
Satd. Flow (perm)		3047			3093			3544		3467	1860	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	239	43	22	315	272	33	609	22	185	315	22
RTOR Reduction (vph)	0	17	0	0	191	0	0	3	0	0	3	0
Lane Group Flow (vph)	0	287	0	0	418	0	0	661	0	185	334	0
Confl. Peds. (#/hr)	2		11	11		2	14		25	25		14
Confl. Bikes (#/hr)			1			2						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm			Perm			Split			Split		
Protected Phases		4			4		2	2		3	3	
Permitted Phases	4			4								
Actuated Green, G (s)		14.8			14.8			16.6		16.8	16.8	
Effective Green, g (s)		13.8			13.8			15.6		15.8	15.8	
Actuated g/C Ratio		0.23			0.23			0.26		0.26	0.26	
Clearance Time (s)		4.0			4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		698			709			918		910	488	
v/s Ratio Prot								c0.19		0.05	c0.18	
v/s Ratio Perm		0.09			c0.14							
v/c Ratio		0.41			0.59			0.72		0.20	0.68	
Uniform Delay, d1		19.7			20.7			20.3		17.3	20.0	
Progression Factor		1.00			1.00			1.00		1.00	1.00	
Incremental Delay, d2		0.4			1.3			2.8		0.1	4.0	
Delay (s)		20.1			21.9			23.1		17.4	23.9	
Level of Service		C			C			C		B	C	
Approach Delay (s)		20.1			21.9			23.1			21.6	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	22.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	60.2	Sum of lost time (s)	15.0
Intersection Capacity Utilization	79.7%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	280	330	20	410	150	420	330	30	80	210	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Util. Factor		0.91	0.91		0.95		1.00	1.00			1.00	
Frpb, ped/bikes		0.99	0.96		0.99		1.00	1.00			1.00	
Flpb, ped/bikes		1.00	1.00		1.00		1.00	1.00			1.00	
Frt		0.95	0.85		0.96		1.00	0.99			0.99	
Flt Protected		1.00	1.00		1.00		0.95	1.00			0.99	
Satd. Flow (prot)		2968	1385		3130		1770	1578			1564	
Flt Permitted		0.85	1.00		0.93		0.95	1.00			0.99	
Satd. Flow (perm)		2533	1385		2906		1770	1578			1564	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	304	359	22	446	163	457	359	33	87	228	22
RTOR Reduction (vph)	0	52	166	0	42	0	0	4	0	0	3	0
Lane Group Flow (vph)	0	414	53	0	589	0	457	388	0	0	334	0
Confl. Peds. (#/hr)	16		21	21		16	20		16	16		20
Confl. Bikes (#/hr)			1			2			1			
Parking (#/hr)		8			8			8			8	
Turn Type	Perm		Perm	Perm			Split			Split		
Protected Phases		2			2		4	4		8	8	
Permitted Phases	2		2	2								
Actuated Green, G (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Effective Green, g (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Actuated g/C Ratio		0.24	0.24		0.24		0.30	0.30			0.31	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Grp Cap (vph)		610	334		700		533	475			490	
v/s Ratio Prot							c0.26	0.25			c0.21	
v/s Ratio Perm		0.16	0.04		c0.20							
v/c Ratio		0.68	0.16		0.84		0.86	0.82			0.68	
Uniform Delay, d1		28.6	24.9		30.0		27.3	26.9			24.9	
Progression Factor		1.00	1.00		1.00		1.00	1.00			1.00	
Incremental Delay, d2		6.0	1.0		11.7		16.2	14.4			7.5	
Delay (s)		34.5	25.9		41.7		43.5	41.2			32.4	
Level of Service		C	C		D		D	D			C	
Approach Delay (s)		31.8			41.7			42.5			32.4	
Approach LOS		C			D			D			C	

Intersection Summary			
HCM Average Control Delay	38.0	HCM Level of Service	D
HCM Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	83.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	86.6%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

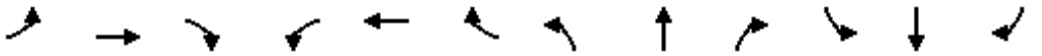


Movement	EBL2	EBL	EBT	EBR	NBT	NBR	NBR2	SBL2	SBL	SBT
Lane Configurations										
Volume (vph)	70	660	150	100	200	190	70	360	150	330
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0	4.5	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor		0.91	0.91	1.00	0.95	1.00		1.00	1.00	1.00
Frpb, ped/bikes		1.00	1.00	0.87	1.00	0.93		1.00	1.00	1.00
Flpb, ped/bikes		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frt		1.00	1.00	0.85	1.00	0.85		1.00	1.00	1.00
Flt Protected		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (prot)		1610	3274	1370	3539	1479		1770	1770	1863
Flt Permitted		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (perm)		1610	3274	1370	3539	1479		1770	1770	1863
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	74	695	158	105	211	200	74	379	158	347
RTOR Reduction (vph)	0	0	0	78	0	20	0	0	0	0
Lane Group Flow (vph)	0	387	540	27	211	254	0	379	158	347
Confl. Peds. (#/hr)				50			50		50	
Confl. Bikes (#/hr)				10			10			
Turn Type	Perm	Perm		Perm		Perm		Prot	Prot	
Protected Phases			4		2			1	1	6
Permitted Phases	4	4		4		2				
Actuated Green, G (s)		18.5	18.5	18.5	19.1	19.1		23.9	23.9	46.5
Effective Green, g (s)		20.0	20.0	19.5	18.6	18.6		24.4	24.4	47.0
Actuated g/C Ratio		0.27	0.27	0.26	0.25	0.25		0.33	0.33	0.63
Clearance Time (s)		5.5	5.5	5.5	3.5	3.5		4.5	4.5	4.5
Vehicle Extension (s)		2.0	2.0	2.0	2.0	2.0		2.0	2.0	2.0
Lane Grp Cap (vph)		429	873	356	878	367		576	576	1167
v/s Ratio Prot					0.06			c0.21	0.09	0.19
v/s Ratio Perm		c0.24	0.16	0.02		c0.17				
v/c Ratio		0.90	0.85dl	0.08	0.24	0.69		0.66	0.27	0.30
Uniform Delay, d1		26.6	24.2	21.0	22.6	25.6		21.7	18.7	6.4
Progression Factor		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2		21.4	0.9	0.0	0.1	4.5		5.8	1.2	0.7
Delay (s)		47.9	25.1	21.0	22.6	30.1		27.5	19.9	7.1
Level of Service		D	C	C	C	C		C	B	A
Approach Delay (s)			33.2		26.9					18.1
Approach LOS			C		C					B

Intersection Summary			
HCM Average Control Delay	26.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	67.5%	ICU Level of Service	C
Analysis Period (min)	15		

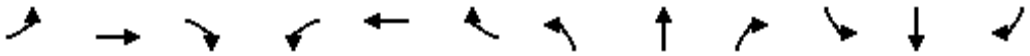
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

c Critical Lane Group



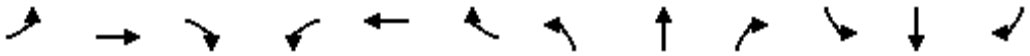
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	330	790	0	0	0	0	0	480	320
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0						4.0	4.0
Lane Util. Factor				0.86	0.86						0.86	0.86
Frpb, ped/bikes				1.00	1.00						1.00	1.00
Flpb, ped/bikes				1.00	1.00						1.00	1.00
Frt				1.00	1.00						0.97	0.85
Flt Protected				0.95	1.00						1.00	1.00
Satd. Flow (prot)				1522	4789						4627	1362
Flt Permitted				0.95	1.00						1.00	1.00
Satd. Flow (perm)				1522	4789						4627	1362
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	347	832	0	0	0	0	0	505	337
RTOR Reduction (vph)	0	0	0	213	10	0	0	0	0	0	62	81
Lane Group Flow (vph)	0	0	0	72	884	0	0	0	0	0	588	111
Confl. Bikes (#/hr)						9						10
Turn Type				Prot								Prot
Protected Phases				7	3						2	2
Permitted Phases												
Actuated Green, G (s)				20.0	40.0						31.0	31.0
Effective Green, g (s)				20.0	40.0						31.0	31.0
Actuated g/C Ratio				0.25	0.51						0.39	0.39
Clearance Time (s)				4.0	4.0						4.0	4.0
Lane Grp Cap (vph)				385	2425						1816	534
v/s Ratio Prot				0.05	c0.09						c0.13	0.08
v/s Ratio Perm					0.09							
v/c Ratio				0.19	0.36						0.32	0.21
Uniform Delay, d1				23.1	11.8						16.7	15.9
Progression Factor				1.00	1.00						1.00	1.00
Incremental Delay, d2				1.1	0.4						0.5	0.9
Delay (s)				24.2	12.2						17.2	16.8
Level of Service				C	B						B	B
Approach Delay (s)		0.0			15.1			0.0			17.1	
Approach LOS		A			B			A			B	

Intersection Summary			
HCM Average Control Delay	15.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.35		
Actuated Cycle Length (s)	79.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	36.3%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



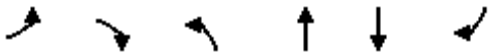
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	130	330	0	0	0	0	0	1030	1770	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0						4.0	4.0			
Lane Util. Factor		0.91						0.91	0.88			
Frpb, ped/bikes		1.00						1.00	1.00			
Flpb, ped/bikes		1.00						1.00	1.00			
Frt		1.00						1.00	0.85			
Flt Protected		0.99						1.00	1.00			
Satd. Flow (prot)		5003						5085	2787			
Flt Permitted		0.99						1.00	1.00			
Satd. Flow (perm)		5003						5085	2787			
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	137	347	0	0	0	0	0	1084	1863	0	0	0
RTOR Reduction (vph)	0	11	0	0	0	0	0	0	376	0	0	0
Lane Group Flow (vph)	0	473	0	0	0	0	0	1084	1487	0	0	0
Confl. Peds. (#/hr)	12		21	21		12	42		29	29		42
Confl. Bikes (#/hr)			2			1						1
Turn Type	Perm								custom			
Protected Phases		4						2	2			
Permitted Phases	4								7			
Actuated Green, G (s)		27.0						23.0	23.0			
Effective Green, g (s)		27.0						24.0	24.0			
Actuated g/C Ratio		0.45						0.40	0.40			
Clearance Time (s)		5.0						5.0	5.0			
Vehicle Extension (s)		3.0						3.0	3.0			
Lane Grp Cap (vph)		2251						2034	1115			
v/s Ratio Prot								0.21	c0.53			
v/s Ratio Perm		0.09										
v/c Ratio		0.21						0.53	1.33			
Uniform Delay, d1		10.0						13.7	18.0			
Progression Factor		1.00						1.00	1.00			
Incremental Delay, d2		0.2						0.3	156.3			
Delay (s)		10.2						14.0	174.3			
Level of Service		B						B	F			
Approach Delay (s)		10.2			0.0			115.3			0.0	
Approach LOS		B			A			F			A	

Intersection Summary			
HCM Average Control Delay	100.5	HCM Level of Service	F
HCM Volume to Capacity ratio	0.74		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	94.6%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	50	730	1310	0	0	0	0	270	100	60	320	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0					4.0			4.0	
Lane Util. Factor		0.86	0.86					1.00			1.00	
Frpb, ped/bikes		0.96	0.97					0.98			1.00	
Flpb, ped/bikes		1.00	1.00					1.00			0.99	
Frt		0.93	0.85					0.96			1.00	
Flt Protected		1.00	1.00					1.00			0.99	
Satd. Flow (prot)		4272	1315					1752			1838	
Flt Permitted		1.00	1.00					1.00			0.69	
Satd. Flow (perm)		4272	1315					1752			1270	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	53	768	1379	0	0	0	0	284	105	63	337	0
RTOR Reduction (vph)	0	84	0	0	0	0	0	22	0	0	0	0
Lane Group Flow (vph)	0	1427	689	0	0	0	0	367	0	0	400	0
Confl. Peds. (#/hr)	51		75	75		51	29		79	79		29
Confl. Bikes (#/hr)											1	1
Turn Type	Perm		Free							Perm		
Protected Phases		2						4			8	
Permitted Phases	2		Free							8		
Actuated Green, G (s)		33.0	60.0					18.0			18.0	
Effective Green, g (s)		34.0	60.0					18.0			18.0	
Actuated g/C Ratio		0.57	1.00					0.30			0.30	
Clearance Time (s)		5.0						4.0			4.0	
Vehicle Extension (s)		2.0						2.0			2.0	
Lane Grp Cap (vph)		2421	1315					526			381	
v/s Ratio Prot								0.21				
v/s Ratio Perm		0.33	0.52								c0.31	
v/c Ratio		0.59	0.52					0.70			1.05	
Uniform Delay, d1		8.5	0.0					18.6			21.0	
Progression Factor		0.71	1.00					1.00			1.00	
Incremental Delay, d2		0.1	0.1					3.2			59.8	
Delay (s)		6.1	0.1					21.8			80.8	
Level of Service		A	A					C			F	
Approach Delay (s)		4.3			0.0			21.8			80.8	
Approach LOS		A			A			C			F	

Intersection Summary			
HCM Average Control Delay	16.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	80.8%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

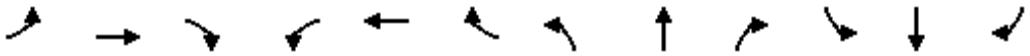


Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	390	100	70	780	1210	580
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	1.00	1.00	0.95	0.91	0.88
Frpb, ped/bikes	1.00	0.98	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3433	1550	1770	3539	5085	2787
Flt Permitted	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	3433	1550	1770	3539	5085	2787
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	415	106	74	830	1287	617
RTOR Reduction (vph)	0	0	0	0	0	432
Lane Group Flow (vph)	415	106	74	830	1287	185
Confl. Peds. (#/hr)	2	16	2			2
Turn Type		Perm	Prot			Prot
Protected Phases	4		5	2	6	6
Permitted Phases		4				
Actuated Green, G (s)	26.0	26.0	4.0	26.0	18.0	18.0
Effective Green, g (s)	26.0	26.0	4.0	26.0	18.0	18.0
Actuated g/C Ratio	0.43	0.43	0.07	0.43	0.30	0.30
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Grp Cap (vph)	1488	672	118	1534	1526	836
v/s Ratio Prot	c0.12		0.04	c0.23	c0.25	0.07
v/s Ratio Perm		0.07				
v/c Ratio	0.28	0.16	0.63	0.54	0.84	0.22
Uniform Delay, d1	11.0	10.3	27.3	12.6	19.7	15.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.5	0.5	22.6	1.4	5.9	0.6
Delay (s)	11.4	10.8	49.9	14.0	25.5	16.4
Level of Service	B	B	D	B	C	B
Approach Delay (s)	11.3			16.9	22.6	
Approach LOS	B			B	C	

Intersection Summary			
HCM Average Control Delay	19.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.53		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	63.1%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

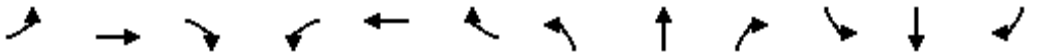
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	150	60	50	100	60	60	90	50	90	150	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95			0.95	1.00	1.00	0.95		0.91	0.91	
Frpb, ped/bikes		0.99			1.00	0.99	1.00	1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.96			1.00	0.85	1.00	0.95		1.00	0.99	
Flt Protected		1.00			0.98	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3363			3478	1563	1770	3335		1610	3347	
Flt Permitted		0.93			0.82	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		3133			2889	1563	1770	3335		1610	3347	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	163	65	54	109	65	65	98	54	98	163	11
RTOR Reduction (vph)	0	42	0	0	0	0	0	45	0	0	6	0
Lane Group Flow (vph)	0	208	0	0	163	65	65	107	0	88	178	0
Confl. Peds. (#/hr)	2		4	4		2	4		2	2		4
Confl. Bikes (#/hr)			2			1						2
Turn Type	Perm			Perm		Free	Split			Split		
Protected Phases		2			6		3	3		4	4	
Permitted Phases	2			6		Free						
Actuated Green, G (s)		15.1			14.1	42.2	6.8	6.8		7.3	7.3	
Effective Green, g (s)		15.1			15.1	42.2	6.8	6.8		8.3	8.3	
Actuated g/C Ratio		0.36			0.36	1.00	0.16	0.16		0.20	0.20	
Clearance Time (s)		4.0			5.0		4.0	4.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		1121			1034	1563	285	537		317	658	
v/s Ratio Prot							c0.04	0.03		c0.05	0.05	
v/s Ratio Perm		c0.07			0.06	0.04						
v/c Ratio		0.19			0.16	0.04	0.23	0.20		0.28	0.27	
Uniform Delay, d1		9.3			9.2	0.0	15.4	15.3		14.4	14.4	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.1			0.1	0.0	0.4	0.2		0.5	0.2	
Delay (s)		9.4			9.3	0.0	15.8	15.5		14.9	14.6	
Level of Service		A			A	A	B	B		B	B	
Approach Delay (s)		9.4			6.7			15.6			14.7	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM Average Control Delay	11.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.22		
Actuated Cycle Length (s)	42.2	Sum of lost time (s)	12.0
Intersection Capacity Utilization	37.2%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



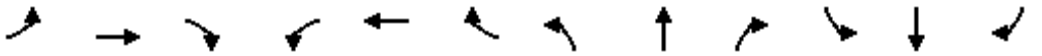
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	260	10	190	200	40	10	40	130	30	40	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			0.98			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	0.99		1.00	0.98			0.90			0.98	
Flt Protected	0.95	1.00		0.95	1.00			1.00			0.98	
Satd. Flow (prot)	1787	3554		1787	3468			1659			1804	
Flt Permitted	0.95	1.00		0.95	1.00			0.99			0.88	
Satd. Flow (perm)	1787	3554		1787	3468			1645			1610	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	283	11	207	217	43	11	43	141	33	43	11
RTOR Reduction (vph)	0	4	0	0	27	0	0	80	0	0	6	0
Lane Group Flow (vph)	11	290	0	207	233	0	0	115	0	0	81	0
Confl. Peds. (#/hr)	4					4	1		24	24		1
Confl. Bikes (#/hr)						2			1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Effective Green, g (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Actuated g/C Ratio	0.10	0.27		0.10	0.27			0.43			0.43	
Clearance Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Grp Cap (vph)	179	948		179	925			713			698	
v/s Ratio Prot	0.01	c0.08		c0.12	0.07							
v/s Ratio Perm								c0.07			0.05	
v/c Ratio	0.06	0.31		1.16	0.25			0.16			0.12	
Uniform Delay, d1	24.5	17.6		27.0	17.3			10.4			10.1	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	0.7	0.8		115.6	0.7			0.5			0.3	
Delay (s)	25.1	18.4		142.6	17.9			10.8			10.5	
Level of Service	C	B		F	B			B			B	
Approach Delay (s)		18.6			73.2			10.8			10.5	
Approach LOS		B			E			B			B	

Intersection Summary			
HCM Average Control Delay	40.7	HCM Level of Service	D
HCM Volume to Capacity ratio	0.33		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	51.4%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	260	220	80	90	280	70	100	530	100	120	840	350
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	11	12	11	11	12	12	12	12	12	12	12
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.97	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.94	1.00	0.98		1.00	0.99		1.00	1.00	0.91
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.97		1.00	0.98		1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	2884	3079	1337	1540	2941		1593	3081		1593	3185	1253
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (perm)	2884	3079	1337	1540	2941		1593	3081		1593	3185	1253
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	283	239	87	98	304	76	109	576	109	130	913	380
RTOR Reduction (vph)	0	0	72	0	20	0	0	12	0	0	0	239
Lane Group Flow (vph)	283	239	15	98	360	0	109	673	0	130	913	141
Confl. Peds. (#/hr)			47			60			42			75
Confl. Bikes (#/hr)						1						
Bus Blockages (#/hr)	0	0	0	0	0	2	0	0	0	0	0	8
Turn Type	Split		Perm	Split			Prot			Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			4									6
Actuated Green, G (s)	15.5	15.5	15.5	16.6	16.6		10.6	29.7		11.4	30.5	30.5
Effective Green, g (s)	15.5	15.5	15.5	16.6	16.6		10.6	30.7		11.4	31.5	31.5
Actuated g/C Ratio	0.17	0.17	0.17	0.18	0.18		0.12	0.34		0.13	0.35	0.35
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	5.0		4.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	496	529	230	283	541		187	1049		201	1112	438
v/s Ratio Prot	c0.10	0.08		0.06	c0.12		0.07	0.22		c0.08	c0.29	
v/s Ratio Perm			0.01									0.11
v/c Ratio	0.57	0.45	0.07	0.35	0.67		0.58	0.64		0.65	0.82	0.32
Uniform Delay, d1	34.3	33.5	31.3	32.1	34.2		37.7	25.1		37.5	26.8	21.5
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	1.6	0.6	0.1	0.7	3.1		4.6	1.4		7.0	5.0	0.4
Delay (s)	35.9	34.2	31.4	32.8	37.3		42.3	26.5		44.5	31.8	21.9
Level of Service	D	C	C	C	D		D	C		D	C	C
Approach Delay (s)		34.6			36.4			28.6			30.3	
Approach LOS		C			D			C			C	

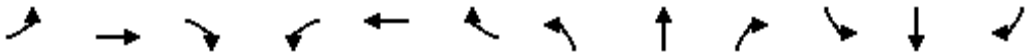
Intersection Summary			
HCM Average Control Delay	31.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	90.2	Sum of lost time (s)	12.0
Intersection Capacity Utilization	73.2%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	120	180	110	50	140	120	110	480	40	140	1200	140
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.9	4.9		4.9	4.9		4.3	4.8	4.8	4.3	4.8	4.8
Lane Util. Factor	1.00	0.95		1.00	0.95		0.97	0.95	1.00	0.97	0.95	1.00
Frpb, ped/bikes	1.00	0.99		1.00	0.99		1.00	1.00	0.98	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.94		1.00	0.93		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1787	3348		1787	3289		3467	3574	1571	3467	3574	1576
Flt Permitted	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1787	3348		1787	3289		3467	3574	1571	3467	3574	1576
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	126	189	116	53	147	126	116	505	42	147	1263	147
RTOR Reduction (vph)	0	99	0	0	110	0	0	0	25	0	0	16
Lane Group Flow (vph)	126	206	0	53	163	0	116	505	17	147	1263	131
Confl. Peds. (#/hr)			7			14			8			3
Confl. Bikes (#/hr)						1						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Split			Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases									2			6
Actuated Green, G (s)	11.3	11.3		10.0	10.0		5.1	29.5	29.5	4.2	28.6	28.6
Effective Green, g (s)	10.4	10.4		9.1	9.1		4.8	29.7	29.7	3.9	28.8	28.8
Actuated g/C Ratio	0.14	0.14		0.13	0.13		0.07	0.41	0.41	0.05	0.40	0.40
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	5.0	5.0	4.0	5.0	5.0
Vehicle Extension (s)	2.0	2.0		2.0	2.0		2.0	2.0	2.0	2.0	2.0	2.0
Lane Grp Cap (vph)	258	484		226	416		231	1474	648	188	1430	630
v/s Ratio Prot	c0.07	0.06		0.03	c0.05		0.03	0.14		c0.04	c0.35	
v/s Ratio Perm									0.01			0.08
v/c Ratio	0.49	0.43		0.23	0.39		0.50	0.34	0.03	0.78	0.88	0.21
Uniform Delay, d1	28.4	28.1		28.3	28.9		32.4	14.5	12.6	33.6	20.0	14.1
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.5	0.2		0.2	0.2		0.6	0.1	0.0	17.5	6.6	0.1
Delay (s)	28.9	28.3		28.5	29.1		33.1	14.5	12.6	51.1	26.7	14.2
Level of Service	C	C		C	C		C	B	B	D	C	B
Approach Delay (s)		28.5			29.0			17.6			27.8	
Approach LOS		C			C			B			C	

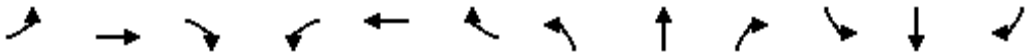
Intersection Summary			
HCM Average Control Delay	25.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	72.0	Sum of lost time (s)	18.9
Intersection Capacity Utilization	72.9%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	10	10	20	10	40	10	130	30	70	200	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frpb, ped/bikes		0.99			1.00	0.98	1.00	1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.95			1.00	0.85	1.00	0.97		1.00	0.99	
Flt Protected		0.98			0.97	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1733			1803	1547	1770	1802		1770	1847	
Flt Permitted		0.98			0.97	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		1733			1803	1547	1770	1802		1770	1847	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	11	11	22	11	43	11	141	33	76	217	11
RTOR Reduction (vph)	0	10	0	0	0	40	0	9	0	0	2	0
Lane Group Flow (vph)	0	23	0	0	33	3	11	165	0	76	226	0
Confl. Peds. (#/hr)	2		6	6		2	8		2	2		8
Confl. Bikes (#/hr)						1						
Turn Type	Split			Split		Perm	Split			Split		
Protected Phases	2	2		1	1		4	4		3	3	
Permitted Phases						1						
Actuated Green, G (s)		2.9			3.6	3.6	12.4	12.4		13.5	13.5	
Effective Green, g (s)		2.9			3.6	3.6	12.4	12.4		13.5	13.5	
Actuated g/C Ratio		0.06			0.07	0.07	0.26	0.26		0.28	0.28	
Clearance Time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0	3.0	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		104			134	115	453	462		494	515	
v/s Ratio Prot		c0.01			c0.02		0.01	c0.09		0.04	c0.12	
v/s Ratio Perm						0.00						
v/c Ratio		0.22			0.25	0.03	0.02	0.36		0.15	0.44	
Uniform Delay, d1		21.7			21.1	20.8	13.5	14.7		13.1	14.3	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		1.1			1.0	0.1	0.0	0.5		0.1	0.6	
Delay (s)		22.7			22.1	20.9	13.5	15.2		13.3	14.9	
Level of Service		C			C	C	B	B		B	B	
Approach Delay (s)		22.7			21.4			15.1			14.5	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	16.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.37		
Actuated Cycle Length (s)	48.4	Sum of lost time (s)	16.0
Intersection Capacity Utilization	35.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	160	140	40	60	150	40	20	430	40	50	630	100
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			0.95			0.95	
Frpb, ped/bikes	1.00	0.99		1.00	1.00			1.00			0.99	
Flpb, ped/bikes	0.99	1.00		0.98	1.00			1.00			1.00	
Frt	1.00	0.97		1.00	0.97			0.99			0.98	
Flt Protected	0.95	1.00		0.95	1.00			1.00			1.00	
Satd. Flow (prot)	1584	3057		1568	3072			3129			3090	
Flt Permitted	0.63	1.00		0.63	1.00			0.91			0.89	
Satd. Flow (perm)	1046	3057		1045	3072			2867			2773	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	167	146	42	62	156	42	21	448	42	52	656	104
RTOR Reduction (vph)	0	24	0	0	24	0	0	10	0	0	17	0
Lane Group Flow (vph)	167	164	0	62	174	0	0	501	0	0	795	0
Confl. Peds. (#/hr)	10		29	29		10	63		34	34		63
Confl. Bikes (#/hr)									1			
Parking (#/hr)							0					
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			4			2			2	
Permitted Phases	4			4			2			2		
Actuated Green, G (s)	30.0	30.0		30.0	30.0			32.0			32.0	
Effective Green, g (s)	29.0	29.0		29.0	29.0			31.0			31.0	
Actuated g/C Ratio	0.43	0.43		0.43	0.43			0.46			0.46	
Clearance Time (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	446	1304		446	1310			1307			1264	
v/s Ratio Prot		0.05			0.06							
v/s Ratio Perm	c0.16			0.06				0.17			c0.29	
v/c Ratio	0.37	0.13		0.14	0.13			0.38			0.63	
Uniform Delay, d1	13.3	11.8		11.9	11.9			12.2			14.1	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	2.4	0.2		0.7	0.2			0.9			2.4	
Delay (s)	15.7	12.0		12.5	12.1			13.1			16.5	
Level of Service	B	B		B	B			B			B	
Approach Delay (s)		13.8			12.2			13.1			16.5	
Approach LOS		B			B			B			B	

Intersection Summary			
HCM Average Control Delay	14.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.51		
Actuated Cycle Length (s)	68.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	96.6%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	170	30	20	170	140	20	420	40	550	550	40
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0			5.0		5.0	5.0	
Lane Util. Factor		0.95			0.95			0.95		0.97	1.00	
Frpb, ped/bikes		1.00			0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00			1.00		1.00	1.00	
Frt		0.98			0.94			0.99		1.00	0.99	
Flt Protected		1.00			1.00			1.00		0.95	1.00	
Satd. Flow (prot)		3472			3312			3516		3467	1859	
Flt Permitted		0.90			0.92			1.00		0.95	1.00	
Satd. Flow (perm)		3125			3067			3516		3467	1859	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	21	181	32	21	181	149	21	447	43	585	585	43
RTOR Reduction (vph)	0	18	0	0	125	0	0	9	0	0	3	0
Lane Group Flow (vph)	0	216	0	0	226	0	0	502	0	585	625	0
Confl. Peds. (#/hr)	2		6	6		2	11		10	10		11
Confl. Bikes (#/hr)						2						1
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm			Perm			Split			Split		
Protected Phases		4			4		2	2		3	3	
Permitted Phases	4			4								
Actuated Green, G (s)		11.5			11.5			14.2		26.5	26.5	
Effective Green, g (s)		10.5			10.5			13.2		25.5	25.5	
Actuated g/C Ratio		0.16			0.16			0.21		0.40	0.40	
Clearance Time (s)		4.0			4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		511			502			723		1377	738	
v/s Ratio Prot								c0.14		0.17	c0.34	
v/s Ratio Perm		0.07			c0.07							
v/c Ratio		0.42			0.45			0.69		0.42	0.85	
Uniform Delay, d1		24.1			24.2			23.6		14.0	17.6	
Progression Factor		1.00			1.00			1.00		1.00	1.00	
Incremental Delay, d2		0.6			0.6			2.9		0.2	8.9	
Delay (s)		24.7			24.9			26.5		14.2	26.5	
Level of Service		C			C			C		B	C	
Approach Delay (s)		24.7			24.9			26.5			20.6	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	23.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	64.2	Sum of lost time (s)	15.0
Intersection Capacity Utilization	81.7%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	330	410	20	300	120	350	290	40	100	390	30
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Util. Factor		0.91	0.91		0.95		1.00	1.00			1.00	
Frpb, ped/bikes		0.99	0.96		0.99		1.00	1.00			1.00	
Flpb, ped/bikes		1.00	1.00		1.00		1.00	1.00			1.00	
Frt		0.95	0.85		0.96		1.00	0.98			0.99	
Flt Protected		1.00	1.00		1.00		0.95	1.00			0.99	
Satd. Flow (prot)		2981	1399		3150		1787	1583			1586	
Flt Permitted		0.93	1.00		0.90		0.95	1.00			0.99	
Satd. Flow (perm)		2767	1399		2848		1787	1583			1586	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	21	340	423	21	309	124	361	299	41	103	402	31
RTOR Reduction (vph)	0	65	186	0	47	0	0	6	0	0	3	0
Lane Group Flow (vph)	0	474	59	0	407	0	361	334	0	0	533	0
Confl. Peds. (#/hr)	17		21	21		17	30		15	15		30
Confl. Bikes (#/hr)			1			1						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Parking (#/hr)		8			8			8			8	
Turn Type	Perm		Perm	Perm			Split			Split		
Protected Phases		2			2		4	4		8	8	
Permitted Phases	2		2	2								
Actuated Green, G (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Effective Green, g (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Actuated g/C Ratio		0.24	0.24		0.24		0.30	0.30			0.31	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Grp Cap (vph)		667	337		686		538	477			497	
v/s Ratio Prot							0.20	c0.21			c0.34	
v/s Ratio Perm		c0.17	0.04		0.14							
v/c Ratio		0.71	0.18		0.59		0.67	0.70			1.07	
Uniform Delay, d1		28.8	25.0		27.9		25.4	25.7			28.5	
Progression Factor		1.00	1.00		1.00		1.00	1.00			1.00	
Incremental Delay, d2		6.3	1.1		3.7		6.5	8.3			61.3	
Delay (s)		35.2	26.1		31.6		31.9	34.0			89.8	
Level of Service		D	C		C		C	C			F	
Approach Delay (s)		32.3			31.6			32.9			89.8	
Approach LOS		C			C			C			F	

Intersection Summary			
HCM Average Control Delay	44.8	HCM Level of Service	D
HCM Volume to Capacity ratio	0.84		
Actuated Cycle Length (s)	83.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	86.8%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL2	EBL	EBT	EBR	NBT	NBR	NBR2	SBL2	SBL	SBT
Lane Configurations										
Volume (vph)	30	950	310	100	380	270	70	330	270	340
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0	4.5	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor		0.91	0.91	1.00	0.95	1.00		1.00	1.00	1.00
Frpb, ped/bikes		1.00	1.00	0.85	1.00	0.92		1.00	1.00	1.00
Flpb, ped/bikes		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frt		1.00	1.00	0.85	1.00	0.85		1.00	1.00	1.00
Flt Protected		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (prot)		1610	3289	1343	3539	1452		1770	1770	1863
Flt Permitted		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (perm)		1610	3289	1343	3539	1452		1770	1770	1863
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	32	1000	326	105	400	284	74	347	284	358
RTOR Reduction (vph)	0	0	0	68	0	11	0	0	0	0
Lane Group Flow (vph)	0	512	846	37	400	347	0	347	284	358
Confl. Peds. (#/hr)				50			50		50	
Confl. Bikes (#/hr)				10			10			
Turn Type	Perm	Perm		Perm		Perm		Prot	Prot	
Protected Phases			4		2			1	1	6
Permitted Phases	4	4		4		2				
Actuated Green, G (s)		30.7	30.7	30.7	22.5	22.5		23.8	23.8	49.3
Effective Green, g (s)		32.2	32.2	31.7	22.0	22.0		23.8	23.8	49.8
Actuated g/C Ratio		0.36	0.36	0.35	0.24	0.24		0.26	0.26	0.55
Clearance Time (s)		5.5	5.5	5.5	3.5	3.5		4.0	4.0	4.5
Vehicle Extension (s)		2.0	2.0	2.0	2.0	2.0		2.0	2.0	2.0
Lane Grp Cap (vph)		576	1177	473	865	355		468	468	1031
v/s Ratio Prot					0.11			c0.20	0.16	0.19
v/s Ratio Perm		c0.32	0.26	0.03		c0.24				
v/c Ratio		0.89	0.86dl	0.08	0.46	0.98		0.74	0.61	0.35
Uniform Delay, d1		27.2	25.0	19.4	29.0	33.8		30.3	29.0	11.1
Progression Factor		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2		15.1	1.8	0.0	0.1	41.4		10.1	5.7	0.9
Delay (s)		42.3	26.8	19.4	29.1	75.2		40.4	34.8	12.0
Level of Service		D	C	B	C	E		D	C	B
Approach Delay (s)			31.7		50.9					28.5
Approach LOS			C		D					C

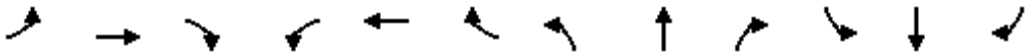
Intersection Summary			
HCM Average Control Delay	35.2	HCM Level of Service	D
HCM Volume to Capacity ratio	0.87		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	75.7%	ICU Level of Service	D
Analysis Period (min)	15		

dl Defacto Left Lane. Recode with 1 though lane as a left lane.

c Critical Lane Group

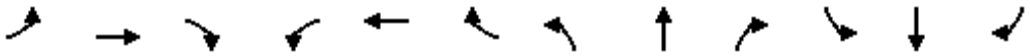
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	360	660	0	0	0	0	0	890	350
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0						4.0	4.0
Lane Util. Factor				0.86	0.86						0.86	0.86
Frpb, ped/bikes				1.00	1.00						1.00	1.00
Flpb, ped/bikes				1.00	1.00						1.00	1.00
Frt				1.00	1.00						0.99	0.85
Flt Protected				0.95	0.99						1.00	1.00
Satd. Flow (prot)				1522	4772						4745	1362
Flt Permitted				0.95	0.99						1.00	1.00
Satd. Flow (perm)				1522	4772						4745	1362
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	379	695	0	0	0	0	0	937	368
RTOR Reduction (vph)	0	0	0	196	22	0	0	0	0	0	11	114
Lane Group Flow (vph)	0	0	0	66	790	0	0	0	0	0	1003	177
Confl. Bikes (#/hr)						5						9
Turn Type				Prot								Prot
Protected Phases				7	3						2	2
Permitted Phases												
Actuated Green, G (s)				20.0	40.0						31.0	31.0
Effective Green, g (s)				20.0	40.0						31.0	31.0
Actuated g/C Ratio				0.25	0.51						0.39	0.39
Clearance Time (s)				4.0	4.0						4.0	4.0
Lane Grp Cap (vph)				385	2416						1862	534
v/s Ratio Prot				0.04	c0.08						c0.21	0.13
v/s Ratio Perm					0.08							
v/c Ratio				0.17	0.33						0.54	0.33
Uniform Delay, d1				23.0	11.5						18.5	16.8
Progression Factor				1.00	1.00						1.00	1.00
Incremental Delay, d2				1.0	0.4						1.1	1.7
Delay (s)				24.0	11.9						19.6	18.4
Level of Service				C	B						B	B
Approach Delay (s)		0.0			14.9			0.0			19.3	
Approach LOS		A			B			A			B	

Intersection Summary			
HCM Average Control Delay	17.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.42		
Actuated Cycle Length (s)	79.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	41.5%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	210	740	0	0	0	0	0	800	1670	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0						4.0	4.0			
Lane Util. Factor		0.91						0.91	0.88			
Frpb, ped/bikes		1.00						1.00	1.00			
Flpb, ped/bikes		1.00						1.00	1.00			
Frt		1.00						1.00	0.85			
Flt Protected		0.99						1.00	1.00			
Satd. Flow (prot)		5013						5085	2787			
Flt Permitted		0.99						1.00	1.00			
Satd. Flow (perm)		5013						5085	2787			
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	221	779	0	0	0	0	0	842	1758	0	0	0
RTOR Reduction (vph)	0	3	0	0	0	0	0	0	231	0	0	0
Lane Group Flow (vph)	0	998	0	0	0	0	0	842	1527	0	0	0
Confl. Peds. (#/hr)	28		7	7		28	99		3	3		99
Confl. Bikes (#/hr)			1			2			1			
Turn Type	Perm								custom			
Protected Phases		4						2	2			
Permitted Phases	4								7			
Actuated Green, G (s)		34.0						16.0	16.0			
Effective Green, g (s)		35.0						17.0	17.0			
Actuated g/C Ratio		0.58						0.28	0.28			
Clearance Time (s)		5.0						5.0	5.0			
Vehicle Extension (s)		3.0						3.0	3.0			
Lane Grp Cap (vph)		2924						1441	790			
v/s Ratio Prot								0.17	c0.55			
v/s Ratio Perm		0.20										
v/c Ratio		0.34						0.58	1.93			
Uniform Delay, d1		6.5						18.5	21.5			
Progression Factor		1.00						1.00	1.00			
Incremental Delay, d2		0.3						0.6	424.2			
Delay (s)		6.8						19.1	445.7			
Level of Service		A						B	F			
Approach Delay (s)		6.8			0.0			307.5			0.0	
Approach LOS		A			A			F			A	

Intersection Summary			
HCM Average Control Delay	224.0	HCM Level of Service	F
HCM Volume to Capacity ratio	0.86		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	93.7%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	50	1150	1230	0	0	0	0	230	240	80	340	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0					4.0			4.0	
Lane Util. Factor		0.86	0.86					1.00			1.00	
Frpb, ped/bikes		0.98	0.97					0.98			1.00	
Flpb, ped/bikes		1.00	1.00					1.00			1.00	
Frt		0.95	0.85					0.93			1.00	
Flt Protected		1.00	1.00					1.00			0.99	
Satd. Flow (prot)		4437	1323					1701			1842	
Flt Permitted		1.00	1.00					1.00			0.39	
Satd. Flow (perm)		4437	1323					1701			733	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	53	1211	1295	0	0	0	0	242	253	84	358	0
RTOR Reduction (vph)	0	70	0	0	0	0	0	33	0	0	0	0
Lane Group Flow (vph)	0	1842	647	0	0	0	0	462	0	0	442	0
Confl. Peds. (#/hr)	52		55	55		52	39		25	25		39
Confl. Bikes (#/hr)			1						2		1	2
Turn Type	Perm		Free							Perm		
Protected Phases		2						4			8	
Permitted Phases	2		Free							8		
Actuated Green, G (s)		33.0	60.0					18.0			18.0	
Effective Green, g (s)		34.0	60.0					18.0			18.0	
Actuated g/C Ratio		0.57	1.00					0.30			0.30	
Clearance Time (s)		5.0						4.0			4.0	
Vehicle Extension (s)		2.0						2.0			2.0	
Lane Grp Cap (vph)		2514	1323					510			220	
v/s Ratio Prot								0.27				
v/s Ratio Perm		0.42	0.49								c0.60	
v/c Ratio		0.73	0.49					0.91			2.01	
Uniform Delay, d1		9.6	0.0					20.2			21.0	
Progression Factor		0.59	1.00					1.00			1.00	
Incremental Delay, d2		0.2	0.1					19.2			469.8	
Delay (s)		5.9	0.1					39.4			490.8	
Level of Service		A	A					D			F	
Approach Delay (s)		4.4			0.0			39.4			490.8	
Approach LOS		A			A			D			F	

Intersection Summary			
HCM Average Control Delay	70.9	HCM Level of Service	E
HCM Volume to Capacity ratio	1.17		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	96.0%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			

Near-Term (2018) Plus Phase 1 Project Conditions

FEHR PEERS

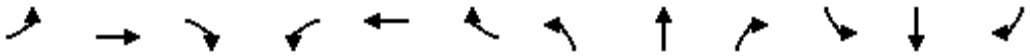
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	410	60	40	1227	954	530
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	1.00	1.00	0.95	0.91	0.88
Frpb, ped/bikes	1.00	0.98	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3400	1535	1752	3505	5036	2760
Flt Permitted	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	3400	1535	1752	3505	5036	2760
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	446	65	43	1334	1037	576
RTOR Reduction (vph)	0	0	0	0	0	403
Lane Group Flow (vph)	446	65	43	1334	1037	173
Confl. Peds. (#/hr)	3	11	4			4
Confl. Bikes (#/hr)		5				5
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%
Turn Type		Perm	Prot			Prot
Protected Phases	4		5	2	6	6
Permitted Phases		4				
Actuated Green, G (s)	26.0	26.0	4.0	26.0	18.0	18.0
Effective Green, g (s)	26.0	26.0	4.0	26.0	18.0	18.0
Actuated g/C Ratio	0.43	0.43	0.07	0.43	0.30	0.30
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Grp Cap (vph)	1473	665	117	1519	1511	828
v/s Ratio Prot	c0.13		0.02	c0.38	0.21	0.06
v/s Ratio Perm		0.04				
v/c Ratio	0.30	0.10	0.37	0.88	0.69	0.21
Uniform Delay, d1	11.1	10.1	26.8	15.6	18.5	15.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.5	0.3	8.7	7.5	2.6	0.6
Delay (s)	11.6	10.4	35.5	23.1	21.1	16.3
Level of Service	B	B	D	C	C	B
Approach Delay (s)	11.5			23.5	19.4	
Approach LOS	B			C	B	

Intersection Summary			
HCM Average Control Delay	19.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	66.4%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	62	32	160	175	110	75	190	80	40	92	22
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95			0.95	1.00	1.00	0.95		0.91	0.91	
Frpb, ped/bikes		0.99			1.00	0.98	1.00	0.99		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.95			1.00	0.85	1.00	0.96		1.00	0.97	
Flt Protected		1.00			0.98	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3201			3314	1500	1703	3227		1550	3152	
Flt Permitted		0.92			0.78	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		2948			2635	1500	1703	3227		1550	3152	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	67	35	174	190	120	82	207	87	43	100	24
RTOR Reduction (vph)	0	24	0	0	0	0	0	63	0	0	20	0
Lane Group Flow (vph)	0	89	0	0	364	120	82	231	0	39	108	0
Confl. Peds. (#/hr)	9		8	8		9	12		17	17		12
Confl. Bikes (#/hr)						3			5			2
Heavy Vehicles (%)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
Turn Type	Perm			Perm		Free	Split			Split		
Protected Phases		2			6		3	3		4	4	
Permitted Phases	2			6		Free						
Actuated Green, G (s)		14.3			13.3	43.8	9.7	9.7		6.8	6.8	
Effective Green, g (s)		14.3			14.3	43.8	9.7	9.7		7.8	7.8	
Actuated g/C Ratio		0.33			0.33	1.00	0.22	0.22		0.18	0.18	
Clearance Time (s)		4.0			5.0		4.0	4.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		962			860	1500	377	715		276	561	
v/s Ratio Prot							0.05	c0.07		0.03	c0.03	
v/s Ratio Perm		0.03			c0.14	0.08						
v/c Ratio		0.09			0.42	0.08	0.22	0.32		0.14	0.19	
Uniform Delay, d1		10.2			11.5	0.0	13.9	14.3		15.2	15.3	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.0			0.3	0.1	0.3	0.3		0.2	0.2	
Delay (s)		10.3			11.9	0.1	14.2	14.6		15.4	15.5	
Level of Service		B			B	A	B	B		B	B	
Approach Delay (s)		10.3			8.9			14.5			15.5	
Approach LOS		B			A			B			B	

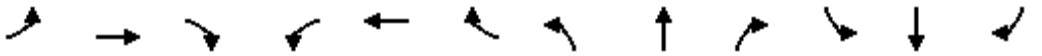
Intersection Summary			
HCM Average Control Delay	11.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.34		
Actuated Cycle Length (s)	43.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	44.6%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	151	10	140	405	30	20	90	230	40	80	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			0.97			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	0.99		1.00	0.99			0.91			0.98	
Flt Protected	0.95	1.00		0.95	1.00			1.00			0.99	
Satd. Flow (prot)	1736	3429		1736	3425			1607			1752	
Flt Permitted	0.95	1.00		0.95	1.00			0.98			0.85	
Satd. Flow (perm)	1736	3429		1736	3425			1582			1515	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	164	11	152	440	33	22	98	250	43	87	22
RTOR Reduction (vph)	0	8	0	0	9	0	0	125	0	0	10	0
Lane Group Flow (vph)	11	167	0	152	464	0	0	245	0	0	142	0
Confl. Peds. (#/hr)	11		13	13		11	22		48	48		22
Confl. Bikes (#/hr)			1			2			1			
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Effective Green, g (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Actuated g/C Ratio	0.10	0.27		0.10	0.27			0.43			0.43	
Clearance Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Grp Cap (vph)	174	914		174	913			686			657	
v/s Ratio Prot	0.01	0.05		c0.09	c0.14							
v/s Ratio Perm								c0.15			0.09	
v/c Ratio	0.06	0.18		0.87	0.51			0.36			0.22	
Uniform Delay, d1	24.5	17.0		26.6	18.7			11.4			10.6	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	0.7	0.4		41.4	2.0			1.4			0.8	
Delay (s)	25.2	17.4		68.0	20.7			12.8			11.4	
Level of Service	C	B		E	C			B			B	
Approach Delay (s)		17.9			32.2			12.8			11.4	
Approach LOS		B			C			B			B	

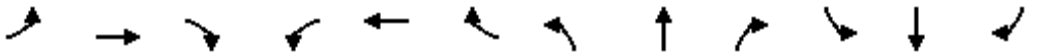
Intersection Summary			
HCM Average Control Delay	22.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.47		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	54.5%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	327	265	120	40	351	70	140	890	70	100	480	444
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	11	12	11	11	12	12	12	12	12	12	12
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.97	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.97	1.00	0.98		1.00	1.00		1.00	1.00	0.95
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.98		1.00	0.99		1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	2828	3020	1356	1510	2891		1562	3081		1562	3124	1279
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (perm)	2828	3020	1356	1510	2891		1562	3081		1562	3124	1279
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	355	288	130	43	382	76	152	967	76	109	522	483
RTOR Reduction (vph)	0	0	105	0	14	0	0	5	0	0	0	333
Lane Group Flow (vph)	355	288	25	43	444	0	152	1038	0	109	522	150
Confl. Peds. (#/hr)			16			85			25			37
Confl. Bikes (#/hr)						1			1			1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Bus Blockages (#/hr)	0	0	0	0	0	2	0	0	0	0	0	8
Turn Type	Split		Perm	Split			Prot			Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			4									6
Actuated Green, G (s)	18.6	18.6	18.6	19.5	19.5		12.2	30.4		10.8	29.0	29.0
Effective Green, g (s)	18.6	18.6	18.6	19.5	19.5		12.2	31.4		10.8	30.0	30.0
Actuated g/C Ratio	0.19	0.19	0.19	0.20	0.20		0.13	0.33		0.11	0.31	0.31
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	5.0		4.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	546	583	262	306	585		198	1005		175	973	398
v/s Ratio Prot	c0.13	0.10		0.03	c0.15		c0.10	c0.34		0.07	0.17	
v/s Ratio Perm			0.02									0.12
v/c Ratio	0.65	0.49	0.10	0.14	0.76		0.77	1.03		0.62	0.54	0.38
Uniform Delay, d1	35.8	34.7	31.9	31.5	36.2		40.7	32.5		40.8	27.4	25.9
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	2.8	0.7	0.2	0.2	5.6		16.2	37.3		6.7	0.6	0.6
Delay (s)	38.6	35.3	32.1	31.7	41.8		56.9	69.7		47.5	28.0	26.5
Level of Service	D	D	C	C	D		E	E		D	C	C
Approach Delay (s)		36.3			40.9			68.1			29.2	
Approach LOS		D			D			E			C	

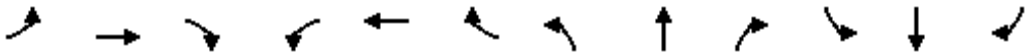
Intersection Summary			
HCM Average Control Delay	45.3	HCM Level of Service	D
HCM Volume to Capacity ratio	0.81		
Actuated Cycle Length (s)	96.3	Sum of lost time (s)	12.0
Intersection Capacity Utilization	80.3%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group



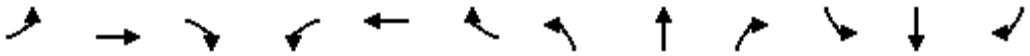
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	80	203	92	50	196	100	155	790	50	90	350	70
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.9	4.9		4.9	4.9		4.3	4.8	4.8	4.3	4.8	4.8
Lane Util. Factor	1.00	0.95		1.00	0.95		0.97	0.95	1.00	0.97	0.95	1.00
Frpb, ped/bikes	1.00	0.99		1.00	0.99		1.00	1.00	0.98	1.00	1.00	0.98
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.95		1.00	0.95		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	3356		1770	3333		3433	3539	1558	3433	3539	1550
Flt Permitted	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	3356		1770	3333		3433	3539	1558	3433	3539	1550
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	86	218	99	54	211	108	167	849	54	97	376	75
RTOR Reduction (vph)	0	55	0	0	68	0	0	0	37	0	0	32
Lane Group Flow (vph)	86	262	0	54	251	0	167	849	17	97	376	43
Confl. Peds. (#/hr)			7			13			6			11
Confl. Bikes (#/hr)						2						
Turn Type	Split			Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases									2			6
Actuated Green, G (s)	11.8	11.8		11.6	11.6		7.3	21.1	21.1	4.3	18.1	18.1
Effective Green, g (s)	10.9	10.9		10.7	10.7		7.0	21.3	21.3	4.0	18.3	18.3
Actuated g/C Ratio	0.17	0.17		0.16	0.16		0.11	0.32	0.32	0.06	0.28	0.28
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	5.0	5.0	4.0	5.0	5.0
Vehicle Extension (s)	2.0	2.0		2.0	2.0		2.0	2.0	2.0	2.0	2.0	2.0
Lane Grp Cap (vph)	293	556		288	542		365	1146	504	209	984	431
v/s Ratio Prot	0.05	c0.08		0.03	c0.08		c0.05	c0.24		0.03	0.11	
v/s Ratio Perm									0.01			0.03
v/c Ratio	0.29	0.47		0.19	0.46		0.46	0.74	0.03	0.46	0.38	0.10
Uniform Delay, d1	24.1	24.8		23.8	25.0		27.6	19.8	15.2	29.9	19.2	17.6
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.2	0.2		0.1	0.2		0.3	2.3	0.0	0.6	0.1	0.0
Delay (s)	24.3	25.1		23.9	25.2		27.9	22.1	15.2	30.5	19.3	17.7
Level of Service	C	C		C	C		C	C	B	C	B	B
Approach Delay (s)		24.9			25.0			22.7			21.0	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	23.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	65.8	Sum of lost time (s)	18.9
Intersection Capacity Utilization	60.0%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



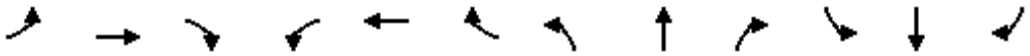
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	12	12	80	35	110	25	235	40	50	192	72
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frpb, ped/bikes		0.99			1.00	0.98	1.00	0.99		1.00	0.99	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.96			1.00	0.85	1.00	0.98		1.00	0.96	
Flt Protected		0.98			0.97	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1744			1800	1556	1770	1809		1770	1768	
Flt Permitted		0.98			0.97	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		1744			1800	1556	1770	1809		1770	1768	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	13	13	87	38	120	27	255	43	54	209	78
RTOR Reduction (vph)	0	12	0	0	0	101	0	7	0	0	15	0
Lane Group Flow (vph)	0	36	0	0	125	19	27	291	0	54	272	0
Confl. Peds. (#/hr)	2		1	1		2	13		20	20		13
Confl. Bikes (#/hr)						1			5			
Turn Type	Split			Split		Perm	Split			Split		
Protected Phases	2	2		1	1		4	4		3	3	
Permitted Phases						1						
Actuated Green, G (s)		4.9			9.8	9.8	15.8	15.8		15.8	15.8	
Effective Green, g (s)		4.9			9.8	9.8	15.8	15.8		15.8	15.8	
Actuated g/C Ratio		0.08			0.16	0.16	0.25	0.25		0.25	0.25	
Clearance Time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0	3.0	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		137			283	245	449	459		449	448	
v/s Ratio Prot		c0.02			c0.07		0.02	c0.16		0.03	c0.15	
v/s Ratio Perm						0.01						
v/c Ratio		0.26			0.44	0.08	0.06	0.63		0.12	0.61	
Uniform Delay, d1		27.0			23.8	22.4	17.6	20.7		17.9	20.5	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		1.0			1.1	0.1	0.1	2.9		0.1	2.3	
Delay (s)		28.0			24.9	22.5	17.7	23.5		18.0	22.8	
Level of Service		C			C	C	B	C		B	C	
Approach Delay (s)		28.0			23.7			23.1			22.1	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	23.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	62.3	Sum of lost time (s)	16.0
Intersection Capacity Utilization	40.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	250	222	50	50	295	50	60	610	30	30	330	90
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			0.95			0.95	
Frpb, ped/bikes	1.00	1.00		1.00	0.99			1.00			0.99	
Flpb, ped/bikes	0.98	1.00		0.99	1.00			1.00			1.00	
Frt	1.00	0.97		1.00	0.98			0.99			0.97	
Flt Protected	0.95	1.00		0.95	1.00			1.00			1.00	
Satd. Flow (prot)	1541	3053		1561	3063			3112			3027	
Flt Permitted	0.51	1.00		0.57	1.00			0.87			0.88	
Satd. Flow (perm)	834	3053		939	3063			2728			2683	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	272	241	54	54	321	54	65	663	33	33	359	98
RTOR Reduction (vph)	0	28	0	0	20	0	0	5	0	0	33	0
Lane Group Flow (vph)	272	267	0	54	355	0	0	756	0	0	457	0
Confl. Peds. (#/hr)	56		22	22		56	31		42	42		31
Confl. Bikes (#/hr)						2			5			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			4			2			2	
Permitted Phases	4			4			2			2		
Actuated Green, G (s)	30.0	30.0		30.0	30.0			32.0			32.0	
Effective Green, g (s)	29.0	29.0		29.0	29.0			31.0			31.0	
Actuated g/C Ratio	0.43	0.43		0.43	0.43			0.46			0.46	
Clearance Time (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	356	1302		400	1306			1244			1223	
v/s Ratio Prot		0.09			0.12							
v/s Ratio Perm	c0.33			0.06				c0.28			0.17	
v/c Ratio	0.76	0.20		0.14	0.27			0.61			0.37	
Uniform Delay, d1	16.6	12.3		11.9	12.6			13.9			12.1	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	14.4	0.4		0.7	0.5			2.2			0.9	
Delay (s)	31.0	12.6		12.6	13.2			16.1			13.0	
Level of Service	C	B		B	B			B			B	
Approach Delay (s)		21.4			13.1			16.1			13.0	
Approach LOS		C			B			B			B	

Intersection Summary			
HCM Average Control Delay	16.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	68.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	101.2%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	222	40	20	305	265	30	560	20	172	290	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0			5.0		5.0	5.0	
Lane Util. Factor		0.95			0.95			0.95		0.97	1.00	
Frpb, ped/bikes		0.99			0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00			1.00		1.00	1.00	
Frt		0.98			0.93			1.00		1.00	0.99	
Flt Protected		1.00			1.00			1.00		0.95	1.00	
Satd. Flow (prot)		3469			3304			3544		3467	1860	
Flt Permitted		0.86			0.94			1.00		0.95	1.00	
Satd. Flow (perm)		3004			3095			3544		3467	1860	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	241	43	22	332	288	33	609	22	187	315	22
RTOR Reduction (vph)	0	17	0	0	192	0	0	3	0	0	3	0
Lane Group Flow (vph)	0	289	0	0	450	0	0	661	0	187	334	0
Confl. Peds. (#/hr)	2		11	11		2	14		25	25		14
Confl. Bikes (#/hr)			1			2						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm			Perm			Split			Split		
Protected Phases		4			4		2	2		3	3	
Permitted Phases	4			4								
Actuated Green, G (s)		15.4			15.4			16.7		17.0	17.0	
Effective Green, g (s)		14.4			14.4			15.7		16.0	16.0	
Actuated g/C Ratio		0.24			0.24			0.26		0.26	0.26	
Clearance Time (s)		4.0			4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		708			729			911		908	487	
v/s Ratio Prot								c0.19		0.05	c0.18	
v/s Ratio Perm		0.10			c0.15							
v/c Ratio		0.41			0.62			0.73		0.21	0.69	
Uniform Delay, d1		19.7			20.9			20.7		17.6	20.3	
Progression Factor		1.00			1.00			1.00		1.00	1.00	
Incremental Delay, d2		0.4			1.6			2.9		0.1	4.0	
Delay (s)		20.1			22.5			23.6		17.7	24.3	
Level of Service		C			C			C		B	C	
Approach Delay (s)		20.1			22.5			23.6			21.9	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	22.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	61.1	Sum of lost time (s)	15.0
Intersection Capacity Utilization	80.6%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	284	331	20	434	150	425	330	30	80	210	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Util. Factor		0.91	0.91		0.95		1.00	1.00			1.00	
Frpb, ped/bikes		0.99	0.96		0.99		1.00	1.00			1.00	
Flpb, ped/bikes		1.00	1.00		1.00		1.00	1.00			1.00	
Frt		0.96	0.85		0.96		1.00	0.99			0.99	
Flt Protected		1.00	1.00		1.00		0.95	1.00			0.99	
Satd. Flow (prot)		2970	1385		3136		1770	1578			1564	
Flt Permitted		0.83	1.00		0.93		0.95	1.00			0.99	
Satd. Flow (perm)		2485	1385		2914		1770	1578			1564	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	309	360	22	472	163	462	359	33	87	228	22
RTOR Reduction (vph)	0	51	167	0	39	0	0	4	0	0	3	0
Lane Group Flow (vph)	0	420	53	0	618	0	462	388	0	0	334	0
Confl. Peds. (#/hr)	16		21	21		16	20		16	16		20
Confl. Bikes (#/hr)			1			2			1			
Parking (#/hr)		8			8			8			8	
Turn Type	Perm		Perm	Perm			Split			Split		
Protected Phases		2			2		4	4		8	8	
Permitted Phases	2		2	2								
Actuated Green, G (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Effective Green, g (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Actuated g/C Ratio		0.24	0.24		0.24		0.30	0.30			0.31	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Grp Cap (vph)		599	334		702		533	475			490	
v/s Ratio Prot							c0.26	0.25			c0.21	
v/s Ratio Perm		0.17	0.04		c0.21							
v/c Ratio		0.70	0.16		0.88		0.87	0.82			0.68	
Uniform Delay, d1		28.8	24.9		30.4		27.4	26.9			24.9	
Progression Factor		1.00	1.00		1.00		1.00	1.00			1.00	
Incremental Delay, d2		6.7	1.0		14.8		17.1	14.4			7.5	
Delay (s)		35.5	25.9		45.2		44.5	41.2			32.4	
Level of Service		D	C		D		D	D			C	
Approach Delay (s)		32.4			45.2			43.0			32.4	
Approach LOS		C			D			D			C	

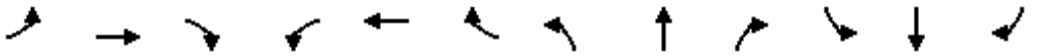
Intersection Summary			
HCM Average Control Delay	39.3	HCM Level of Service	D
HCM Volume to Capacity ratio	0.80		
Actuated Cycle Length (s)	83.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	87.5%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL2	EBL	EBT	EBR	NBT	NBR	NBR2	SBL2	SBL	SBT
Lane Configurations										
Volume (vph)	70	691	150	100	200	192	70	375	150	330
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0	4.5	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor		0.91	0.91	1.00	0.95	1.00		1.00	1.00	1.00
Frpb, ped/bikes		1.00	1.00	0.87	1.00	0.93		1.00	1.00	1.00
Flpb, ped/bikes		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frt		1.00	1.00	0.85	1.00	0.85		1.00	1.00	1.00
Flt Protected		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (prot)		1610	3273	1370	3539	1479		1770	1770	1863
Flt Permitted		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (perm)		1610	3273	1370	3539	1479		1770	1770	1863
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	74	727	158	105	211	202	74	395	158	347
RTOR Reduction (vph)	0	0	0	77	0	20	0	0	0	0
Lane Group Flow (vph)	0	401	558	28	211	256	0	395	158	347
Confl. Peds. (#/hr)				50			50		50	
Confl. Bikes (#/hr)				10			10			
Turn Type	Perm	Perm		Perm		Perm		Prot	Prot	
Protected Phases			4		2			1	1	6
Permitted Phases	4	4		4		2				
Actuated Green, G (s)		18.7	18.7	18.7	19.2	19.2		23.6	23.6	46.3
Effective Green, g (s)		20.2	20.2	19.7	18.7	18.7		24.1	24.1	46.8
Actuated g/C Ratio		0.27	0.27	0.26	0.25	0.25		0.32	0.32	0.62
Clearance Time (s)		5.5	5.5	5.5	3.5	3.5		4.5	4.5	4.5
Vehicle Extension (s)		2.0	2.0	2.0	2.0	2.0		2.0	2.0	2.0
Lane Grp Cap (vph)		434	882	360	882	369		569	569	1163
v/s Ratio Prot					0.06			c0.22	0.09	0.19
v/s Ratio Perm		c0.25	0.17	0.02		c0.17				
v/c Ratio		0.92	0.88dl	0.08	0.24	0.70		0.69	0.28	0.30
Uniform Delay, d1		26.7	24.1	20.8	22.5	25.6		22.2	19.0	6.5
Progression Factor		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2		24.9	1.1	0.0	0.1	4.5		6.8	1.2	0.7
Delay (s)		51.6	25.2	20.8	22.5	30.1		29.1	20.2	7.2
Level of Service		D	C	C	C	C		C	C	A
Approach Delay (s)			34.7		26.8					19.1
Approach LOS			C		C					B

Intersection Summary			
HCM Average Control Delay	27.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.77		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	69.2%	ICU Level of Service	C
Analysis Period (min)	15		

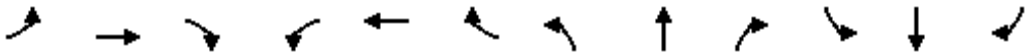
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

c Critical Lane Group



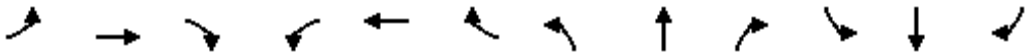
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	363	791	0	0	0	0	0	487	320
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0						4.0	4.0
Lane Util. Factor				0.86	0.86						0.86	0.86
Frpb, ped/bikes				1.00	1.00						1.00	1.00
Flpb, ped/bikes				1.00	1.00						1.00	1.00
Frt				1.00	1.00						0.97	0.85
Flt Protected				0.95	1.00						1.00	1.00
Satd. Flow (prot)				1522	4783						4629	1362
Flt Permitted				0.95	1.00						1.00	1.00
Satd. Flow (perm)				1522	4783						4629	1362
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	382	833	0	0	0	0	0	513	337
RTOR Reduction (vph)	0	0	0	220	15	0	0	0	0	0	60	81
Lane Group Flow (vph)	0	0	0	74	906	0	0	0	0	0	598	111
Confl. Bikes (#/hr)						9						10
Turn Type				Prot								Prot
Protected Phases				7	3						2	2
Permitted Phases												
Actuated Green, G (s)				20.0	40.0						31.0	31.0
Effective Green, g (s)				20.0	40.0						31.0	31.0
Actuated g/C Ratio				0.25	0.51						0.39	0.39
Clearance Time (s)				4.0	4.0						4.0	4.0
Lane Grp Cap (vph)				385	2422						1816	534
v/s Ratio Prot				0.05	c0.09						c0.13	0.08
v/s Ratio Perm					0.09							
v/c Ratio				0.19	0.37						0.33	0.21
Uniform Delay, d1				23.2	11.9						16.7	15.9
Progression Factor				1.00	1.00						1.00	1.00
Incremental Delay, d2				1.1	0.4						0.5	0.9
Delay (s)				24.3	12.3						17.2	16.8
Level of Service				C	B						B	B
Approach Delay (s)		0.0			15.2			0.0			17.1	
Approach LOS		A			B			A			B	

Intersection Summary			
HCM Average Control Delay	16.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.35		
Actuated Cycle Length (s)	79.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	36.9%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



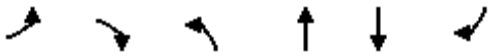
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	130	330	0	0	0	0	0	1032	1785	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0						4.0	4.0			
Lane Util. Factor		0.91						0.91	0.88			
Frpb, ped/bikes		1.00						1.00	1.00			
Flpb, ped/bikes		1.00						1.00	1.00			
Frt		1.00						1.00	0.85			
Flt Protected		0.99						1.00	1.00			
Satd. Flow (prot)		5003						5085	2787			
Flt Permitted		0.99						1.00	1.00			
Satd. Flow (perm)		5003						5085	2787			
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	137	347	0	0	0	0	0	1086	1879	0	0	0
RTOR Reduction (vph)	0	11	0	0	0	0	0	0	376	0	0	0
Lane Group Flow (vph)	0	473	0	0	0	0	0	1086	1503	0	0	0
Confl. Peds. (#/hr)	12		21	21		12	42		29	29		42
Confl. Bikes (#/hr)			2			1						1
Turn Type	Perm								custom			
Protected Phases		4						2	2			
Permitted Phases	4								7			
Actuated Green, G (s)		27.0						23.0	23.0			
Effective Green, g (s)		27.0						24.0	24.0			
Actuated g/C Ratio		0.45						0.40	0.40			
Clearance Time (s)		5.0						5.0	5.0			
Vehicle Extension (s)		3.0						3.0	3.0			
Lane Grp Cap (vph)		2251						2034	1115			
v/s Ratio Prot								0.21	c0.54			
v/s Ratio Perm		0.09										
v/c Ratio		0.21						0.53	1.35			
Uniform Delay, d1		10.0						13.7	18.0			
Progression Factor		1.00						1.00	1.00			
Incremental Delay, d2		0.2						0.3	162.5			
Delay (s)		10.2						14.0	180.5			
Level of Service		B						B	F			
Approach Delay (s)		10.2			0.0			119.5			0.0	
Approach LOS		B			A			F			A	

Intersection Summary			
HCM Average Control Delay	104.2	HCM Level of Service	F
HCM Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	95.1%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			



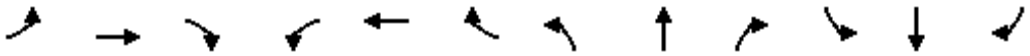
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	50	733	1322	0	0	0	0	270	100	60	320	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0					4.0			4.0	
Lane Util. Factor		0.86	0.86					1.00			1.00	
Frpb, ped/bikes		0.96	0.97					0.98			1.00	
Flpb, ped/bikes		1.00	1.00					1.00			0.99	
Frt		0.93	0.85					0.96			1.00	
Flt Protected		1.00	1.00					1.00			0.99	
Satd. Flow (prot)		4271	1315					1752			1838	
Flt Permitted		1.00	1.00					1.00			0.69	
Satd. Flow (perm)		4271	1315					1752			1270	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	53	772	1392	0	0	0	0	284	105	63	337	0
RTOR Reduction (vph)	0	84	0	0	0	0	0	22	0	0	0	0
Lane Group Flow (vph)	0	1437	696	0	0	0	0	367	0	0	400	0
Confl. Peds. (#/hr)	51		75	75		51	29		79	79		29
Confl. Bikes (#/hr)											1	1
Turn Type	Perm		Free							Perm		
Protected Phases		2						4			8	
Permitted Phases	2		Free							8		
Actuated Green, G (s)		33.0	60.0					18.0			18.0	
Effective Green, g (s)		34.0	60.0					18.0			18.0	
Actuated g/C Ratio		0.57	1.00					0.30			0.30	
Clearance Time (s)		5.0						4.0			4.0	
Vehicle Extension (s)		2.0						2.0			2.0	
Lane Grp Cap (vph)		2420	1315					526			381	
v/s Ratio Prot								0.21				
v/s Ratio Perm		0.34	0.53								c0.31	
v/c Ratio		0.59	0.53					0.70			1.05	
Uniform Delay, d1		8.5	0.0					18.6			21.0	
Progression Factor		0.72	1.00					1.00			1.00	
Incremental Delay, d2		0.1	0.1					3.2			59.8	
Delay (s)		6.2	0.1					21.8			80.8	
Level of Service		A	A					C			F	
Approach Delay (s)		4.3			0.0			21.8			80.8	
Approach LOS		A			A			C			F	

Intersection Summary			
HCM Average Control Delay	16.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	81.0%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



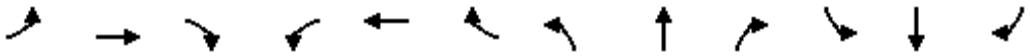
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	390	100	70	878	1225	580
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	1.00	1.00	0.95	0.91	0.88
Frpb, ped/bikes	1.00	0.98	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3433	1550	1770	3539	5085	2787
Flt Permitted	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	3433	1550	1770	3539	5085	2787
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	415	106	74	934	1303	617
RTOR Reduction (vph)	0	0	0	0	0	432
Lane Group Flow (vph)	415	106	74	934	1303	185
Confl. Peds. (#/hr)	2	16	2			2
Turn Type		Perm	Prot			Prot
Protected Phases	4		5	2	6	6
Permitted Phases		4				
Actuated Green, G (s)	26.0	26.0	4.0	26.0	18.0	18.0
Effective Green, g (s)	26.0	26.0	4.0	26.0	18.0	18.0
Actuated g/C Ratio	0.43	0.43	0.07	0.43	0.30	0.30
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Grp Cap (vph)	1488	672	118	1534	1526	836
v/s Ratio Prot	c0.12		0.04	c0.26	c0.26	0.07
v/s Ratio Perm		0.07				
v/c Ratio	0.28	0.16	0.63	0.61	0.85	0.22
Uniform Delay, d1	11.0	10.3	27.3	13.1	19.8	15.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.5	0.5	22.6	1.8	6.3	0.6
Delay (s)	11.4	10.8	49.9	14.9	26.1	16.4
Level of Service	B	B	D	B	C	B
Approach Delay (s)	11.3			17.5	22.9	
Approach LOS	B			B	C	

Intersection Summary			
HCM Average Control Delay	19.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	63.4%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	22	221	74	59	111	60	62	92	107	90	150	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95			0.95	1.00	1.00	0.95		0.91	0.91	
Frpb, ped/bikes		0.99			1.00	0.99	1.00	0.99		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.97			1.00	0.85	1.00	0.92		1.00	0.99	
Flt Protected		1.00			0.98	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3382			3476	1563	1770	3231		1610	3347	
Flt Permitted		0.93			0.77	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		3152			2723	1563	1770	3231		1610	3347	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	24	240	80	64	121	65	67	100	116	98	163	11
RTOR Reduction (vph)	0	38	0	0	0	0	0	91	0	0	6	0
Lane Group Flow (vph)	0	306	0	0	185	65	67	125	0	88	178	0
Confl. Peds. (#/hr)	2		4	4		2	4		2	2		4
Confl. Bikes (#/hr)			2			1						2
Turn Type	Perm			Perm		Free	Split			Split		
Protected Phases		2			6		3	3		4	4	
Permitted Phases	2			6		Free						
Actuated Green, G (s)		12.1			11.1	41.1	8.7	8.7		7.3	7.3	
Effective Green, g (s)		12.1			12.1	41.1	8.7	8.7		8.3	8.3	
Actuated g/C Ratio		0.29			0.29	1.00	0.21	0.21		0.20	0.20	
Clearance Time (s)		4.0			5.0		4.0	4.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		928			802	1563	375	684		325	676	
v/s Ratio Prot							0.04	c0.04		c0.05	0.05	
v/s Ratio Perm		c0.10			0.07	0.04						
v/c Ratio		0.33			0.23	0.04	0.18	0.18		0.27	0.26	
Uniform Delay, d1		11.3			11.0	0.0	13.3	13.3		13.8	13.8	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.2			0.1	0.0	0.2	0.1		0.5	0.2	
Delay (s)		11.5			11.1	0.0	13.5	13.4		14.3	14.0	
Level of Service		B			B	A	B	B		B	B	
Approach Delay (s)		11.5			8.2			13.4			14.1	
Approach LOS		B			A			B			B	

Intersection Summary			
HCM Average Control Delay	11.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.27		
Actuated Cycle Length (s)	41.1	Sum of lost time (s)	12.0
Intersection Capacity Utilization	41.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

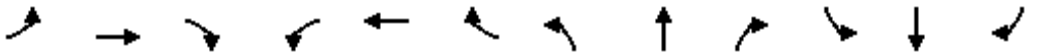


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	387	10	190	220	40	10	40	130	30	40	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			0.98			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	1.00		1.00	0.98			0.90			0.98	
Flt Protected	0.95	1.00		0.95	1.00			1.00			0.98	
Satd. Flow (prot)	1787	3561		1787	3476			1659			1804	
Flt Permitted	0.95	1.00		0.95	1.00			0.99			0.88	
Satd. Flow (perm)	1787	3561		1787	3476			1645			1610	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	421	11	207	239	43	11	43	141	33	43	11
RTOR Reduction (vph)	0	3	0	0	25	0	0	80	0	0	6	0
Lane Group Flow (vph)	11	429	0	207	257	0	0	115	0	0	81	0
Confl. Peds. (#/hr)	4					4	1		24	24		1
Confl. Bikes (#/hr)						2			1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Effective Green, g (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Actuated g/C Ratio	0.10	0.27		0.10	0.27			0.43			0.43	
Clearance Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Grp Cap (vph)	179	950		179	927			713			698	
v/s Ratio Prot	0.01	c0.12		c0.12	0.07							
v/s Ratio Perm								c0.07			0.05	
v/c Ratio	0.06	0.45		1.16	0.28			0.16			0.12	
Uniform Delay, d1	24.5	18.3		27.0	17.4			10.4			10.1	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	0.7	1.6		115.6	0.7			0.5			0.3	
Delay (s)	25.1	19.9		142.6	18.2			10.8			10.5	
Level of Service	C	B		F	B			B			B	
Approach Delay (s)		20.0			70.9			10.8			10.5	
Approach LOS		C			E			B			B	

Intersection Summary			
HCM Average Control Delay	38.3	HCM Level of Service	D
HCM Volume to Capacity ratio	0.38		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	54.9%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	358	249	80	90	285	70	100	530	100	120	840	365
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	11	12	11	11	12	12	12	12	12	12	12
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.97	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.94	1.00	0.98		1.00	0.99		1.00	1.00	0.90
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.97		1.00	0.98		1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	2884	3079	1333	1540	2941		1593	3080		1593	3185	1248
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (perm)	2884	3079	1333	1540	2941		1593	3080		1593	3185	1248
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	389	271	87	98	310	76	109	576	109	130	913	397
RTOR Reduction (vph)	0	0	69	0	20	0	0	12	0	0	0	257
Lane Group Flow (vph)	389	271	18	98	366	0	109	673	0	130	913	140
Confl. Peds. (#/hr)			47			60			42			75
Confl. Bikes (#/hr)						1						
Bus Blockages (#/hr)	0	0	0	0	0	2	0	0	0	0	0	8
Turn Type	Split		Perm	Split			Prot			Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			4									6
Actuated Green, G (s)	19.3	19.3	19.3	17.2	17.2		10.7	29.8		11.4	30.5	30.5
Effective Green, g (s)	19.3	19.3	19.3	17.2	17.2		10.7	30.8		11.4	31.5	31.5
Actuated g/C Ratio	0.20	0.20	0.20	0.18	0.18		0.11	0.33		0.12	0.33	0.33
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	5.0		4.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	588	628	272	280	534		180	1002		192	1059	415
v/s Ratio Prot	c0.13	0.09		0.06	c0.12		0.07	0.22		c0.08	c0.29	
v/s Ratio Perm			0.01									0.11
v/c Ratio	0.66	0.43	0.07	0.35	0.69		0.61	0.67		0.68	0.86	0.34
Uniform Delay, d1	34.7	32.9	30.4	33.9	36.2		40.0	27.6		39.9	29.6	23.8
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	2.8	0.5	0.1	0.8	3.6		5.7	1.8		9.1	7.4	0.5
Delay (s)	37.5	33.4	30.5	34.6	39.9		45.6	29.4		49.0	36.9	24.2
Level of Service	D	C	C	C	D		D	C		D	D	C
Approach Delay (s)		35.2			38.8			31.6			34.5	
Approach LOS		D			D			C			C	

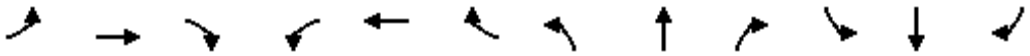
Intersection Summary			
HCM Average Control Delay	34.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	94.7	Sum of lost time (s)	12.0
Intersection Capacity Utilization	76.3%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	120	195	124	50	142	120	112	480	40	140	1200	140
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.9	4.9		4.9	4.9		4.3	4.8	4.8	4.3	4.8	4.8
Lane Util. Factor	1.00	0.95		1.00	0.95		0.97	0.95	1.00	0.97	0.95	1.00
Frpb, ped/bikes	1.00	0.99		1.00	0.99		1.00	1.00	0.98	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.94		1.00	0.93		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1787	3343		1787	3292		3467	3574	1571	3467	3574	1576
Flt Permitted	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1787	3343		1787	3292		3467	3574	1571	3467	3574	1576
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	126	205	131	53	149	126	118	505	42	147	1263	147
RTOR Reduction (vph)	0	110	0	0	110	0	0	0	25	0	0	16
Lane Group Flow (vph)	126	226	0	53	165	0	118	505	17	147	1263	131
Confl. Peds. (#/hr)			7			14			8			3
Confl. Bikes (#/hr)						1						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Split			Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases									2			6
Actuated Green, G (s)	11.3	11.3		10.1	10.1		5.2	29.6	29.6	4.2	28.6	28.6
Effective Green, g (s)	10.4	10.4		9.2	9.2		4.9	29.8	29.8	3.9	28.8	28.8
Actuated g/C Ratio	0.14	0.14		0.13	0.13		0.07	0.41	0.41	0.05	0.40	0.40
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	5.0	5.0	4.0	5.0	5.0
Vehicle Extension (s)	2.0	2.0		2.0	2.0		2.0	2.0	2.0	2.0	2.0	2.0
Lane Grp Cap (vph)	257	482		228	419		235	1475	648	187	1426	629
v/s Ratio Prot	c0.07	0.07		0.03	c0.05		0.03	0.14		c0.04	c0.35	
v/s Ratio Perm									0.01			0.08
v/c Ratio	0.49	0.47		0.23	0.39		0.50	0.34	0.03	0.79	0.89	0.21
Uniform Delay, d1	28.5	28.4		28.3	28.9		32.5	14.5	12.6	33.7	20.2	14.2
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.5	0.3		0.2	0.2		0.6	0.1	0.0	17.9	6.8	0.1
Delay (s)	29.0	28.6		28.5	29.2		33.1	14.5	12.6	51.6	26.9	14.3
Level of Service	C	C		C	C		C	B	B	D	C	B
Approach Delay (s)		28.7			29.1			17.7			28.1	
Approach LOS		C			C			B			C	

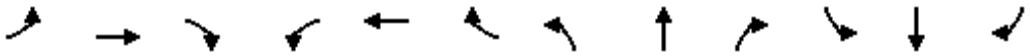
Intersection Summary			
HCM Average Control Delay	26.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	72.2	Sum of lost time (s)	18.9
Intersection Capacity Utilization	72.9%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



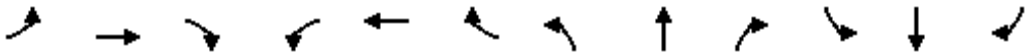
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	68	24	24	20	12	40	12	132	30	70	214	19
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frpb, ped/bikes		0.99			1.00	0.98	1.00	1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.97			1.00	0.85	1.00	0.97		1.00	0.99	
Flt Protected		0.97			0.97	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1748			1806	1545	1770	1803		1770	1835	
Flt Permitted		0.97			0.97	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		1748			1806	1545	1770	1803		1770	1835	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	74	26	26	22	13	43	13	143	33	76	233	21
RTOR Reduction (vph)	0	10	0	0	0	40	0	9	0	0	4	0
Lane Group Flow (vph)	0	116	0	0	35	3	13	167	0	76	250	0
Confl. Peds. (#/hr)	2		6	6		2	8		2	2		8
Confl. Bikes (#/hr)						1						
Turn Type	Split			Split		Perm	Split			Split		
Protected Phases	2	2		1	1		4	4		3	3	
Permitted Phases						1						
Actuated Green, G (s)		7.9			3.7	3.7	12.9	12.9		14.8	14.8	
Effective Green, g (s)		7.9			3.7	3.7	12.9	12.9		14.8	14.8	
Actuated g/C Ratio		0.14			0.07	0.07	0.23	0.23		0.27	0.27	
Clearance Time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0	3.0	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		250			121	103	413	421		474	491	
v/s Ratio Prot		c0.07			c0.02		0.01	c0.09		0.04	c0.14	
v/s Ratio Perm						0.00						
v/c Ratio		0.46			0.29	0.03	0.03	0.40		0.16	0.51	
Uniform Delay, d1		21.8			24.5	24.1	16.4	17.9		15.5	17.2	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		1.4			1.3	0.1	0.0	0.6		0.2	0.8	
Delay (s)		23.1			25.9	24.2	16.4	18.5		15.7	18.0	
Level of Service		C			C	C	B	B		B	B	
Approach Delay (s)		23.1			25.0			18.4			17.5	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	19.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.44		
Actuated Cycle Length (s)	55.3	Sum of lost time (s)	16.0
Intersection Capacity Utilization	40.6%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	160	154	40	60	152	40	20	430	40	50	630	100
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			0.95			0.95	
Frpb, ped/bikes	1.00	0.99		1.00	1.00			1.00			0.99	
Flpb, ped/bikes	0.99	1.00		0.98	1.00			1.00			1.00	
Frt	1.00	0.97		1.00	0.97			0.99			0.98	
Flt Protected	0.95	1.00		0.95	1.00			1.00			1.00	
Satd. Flow (prot)	1584	3065		1568	3073			3129			3090	
Flt Permitted	0.63	1.00		0.62	1.00			0.91			0.89	
Satd. Flow (perm)	1044	3065		1032	3073			2867			2773	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	167	160	42	62	158	42	21	448	42	52	656	104
RTOR Reduction (vph)	0	24	0	0	24	0	0	10	0	0	17	0
Lane Group Flow (vph)	167	178	0	62	176	0	0	501	0	0	795	0
Confl. Peds. (#/hr)	10		29	29		10	63		34	34		63
Confl. Bikes (#/hr)									1			
Parking (#/hr)							0					
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			4			2			2	
Permitted Phases	4			4			2			2		
Actuated Green, G (s)	30.0	30.0		30.0	30.0			32.0			32.0	
Effective Green, g (s)	29.0	29.0		29.0	29.0			31.0			31.0	
Actuated g/C Ratio	0.43	0.43		0.43	0.43			0.46			0.46	
Clearance Time (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	445	1307		440	1311			1307			1264	
v/s Ratio Prot		0.06			0.06							
v/s Ratio Perm	c0.16			0.06				0.17			c0.29	
v/c Ratio	0.38	0.14		0.14	0.13			0.38			0.63	
Uniform Delay, d1	13.3	11.9		11.9	11.9			12.2			14.1	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	2.4	0.2		0.7	0.2			0.9			2.4	
Delay (s)	15.7	12.1		12.6	12.1			13.1			16.5	
Level of Service	B	B		B	B			B			B	
Approach Delay (s)		13.7			12.2			13.1			16.5	
Approach LOS		B			B			B			B	

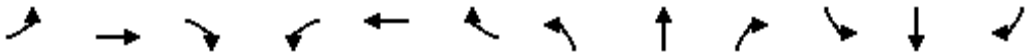
Intersection Summary			
HCM Average Control Delay	14.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.51		
Actuated Cycle Length (s)	68.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	96.6%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	184	30	20	172	142	20	420	40	564	550	40
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0			5.0		5.0	5.0	
Lane Util. Factor		0.95			0.95			0.95		0.97	1.00	
Frpb, ped/bikes		1.00			0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00			1.00		1.00	1.00	
Frt		0.98			0.94			0.99		1.00	0.99	
Flt Protected		1.00			1.00			1.00		0.95	1.00	
Satd. Flow (prot)		3478			3312			3516		3467	1859	
Flt Permitted		0.90			0.92			1.00		0.95	1.00	
Satd. Flow (perm)		3140			3064			3516		3467	1859	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	21	196	32	21	183	151	21	447	43	600	585	43
RTOR Reduction (vph)	0	17	0	0	126	0	0	9	0	0	3	0
Lane Group Flow (vph)	0	232	0	0	229	0	0	502	0	600	625	0
Confl. Peds. (#/hr)	2		6	6		2	11		10	10		11
Confl. Bikes (#/hr)						2						1
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm			Perm			Split			Split		
Protected Phases		4			4		2	2		3	3	
Permitted Phases	4			4								
Actuated Green, G (s)		11.7			11.7			14.2		26.5	26.5	
Effective Green, g (s)		10.7			10.7			13.2		25.5	25.5	
Actuated g/C Ratio		0.17			0.17			0.20		0.40	0.40	
Clearance Time (s)		4.0			4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		522			509			721		1373	736	
v/s Ratio Prot								c0.14		0.17	c0.34	
v/s Ratio Perm		0.07			c0.07							
v/c Ratio		0.45			0.45			0.70		0.44	0.85	
Uniform Delay, d1		24.2			24.2			23.7		14.2	17.7	
Progression Factor		1.00			1.00			1.00		1.00	1.00	
Incremental Delay, d2		0.6			0.6			2.9		0.2	9.0	
Delay (s)		24.8			24.8			26.7		14.4	26.7	
Level of Service		C			C			C		B	C	
Approach Delay (s)		24.8			24.8			26.7			20.7	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	23.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	64.4	Sum of lost time (s)	15.0
Intersection Capacity Utilization	82.1%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	352	415	20	304	120	351	290	40	100	390	30
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Util. Factor		0.91	0.91		0.95		1.00	1.00			1.00	
Frpb, ped/bikes		0.99	0.96		0.99		1.00	1.00			1.00	
Flpb, ped/bikes		1.00	1.00		1.00		1.00	1.00			1.00	
Frt		0.95	0.85		0.96		1.00	0.98			0.99	
Flt Protected		1.00	1.00		1.00		0.95	1.00			0.99	
Satd. Flow (prot)		2994	1399		3151		1787	1583			1586	
Flt Permitted		0.93	1.00		0.89		0.95	1.00			0.99	
Satd. Flow (perm)		2780	1399		2816		1787	1583			1586	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	21	363	428	21	313	124	362	299	41	103	402	31
RTOR Reduction (vph)	0	55	195	0	46	0	0	6	0	0	3	0
Lane Group Flow (vph)	0	500	62	0	412	0	362	334	0	0	533	0
Confl. Peds. (#/hr)	17		21	21		17	30		15	15		30
Confl. Bikes (#/hr)			1			1						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Parking (#/hr)		8			8			8			8	
Turn Type	Perm		Perm	Perm			Split			Split		
Protected Phases		2			2		4	4		8	8	
Permitted Phases	2		2	2								
Actuated Green, G (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Effective Green, g (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Actuated g/C Ratio		0.24	0.24		0.24		0.30	0.30			0.31	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Grp Cap (vph)		670	337		679		538	477			497	
v/s Ratio Prot							0.20	c0.21			c0.34	
v/s Ratio Perm		c0.18	0.04		0.15							
v/c Ratio		0.75	0.18		0.61		0.67	0.70			1.07	
Uniform Delay, d1		29.1	25.0		28.0		25.4	25.7			28.5	
Progression Factor		1.00	1.00		1.00		1.00	1.00			1.00	
Incremental Delay, d2		7.4	1.2		4.0		6.6	8.3			61.3	
Delay (s)		36.5	26.2		32.0		32.0	34.0			89.8	
Level of Service		D	C		C		C	C			F	
Approach Delay (s)		33.3			32.0			32.9			89.8	
Approach LOS		C			C			C			F	

Intersection Summary			
HCM Average Control Delay	45.0	HCM Level of Service	D
HCM Volume to Capacity ratio	0.85		
Actuated Cycle Length (s)	83.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	87.4%	ICU Level of Service	E
Analysis Period (min)	15		

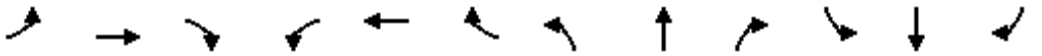
c Critical Lane Group

Movement	EBL2	EBL	EBT	EBR	NBT	NBR	NBR2	SBL2	SBL	SBT
Lane Configurations										
Volume (vph)	30	955	310	100	380	270	70	332	270	342
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0	4.5	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor		0.91	0.91	1.00	0.95	1.00		1.00	1.00	1.00
Frpb, ped/bikes		1.00	1.00	0.85	1.00	0.92		1.00	1.00	1.00
Flpb, ped/bikes		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frt		1.00	1.00	0.85	1.00	0.85		1.00	1.00	1.00
Flt Protected		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (prot)		1610	3289	1343	3539	1452		1770	1770	1863
Flt Permitted		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (perm)		1610	3289	1343	3539	1452		1770	1770	1863
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	32	1005	326	105	400	284	74	349	284	360
RTOR Reduction (vph)	0	0	0	68	0	11	0	0	0	0
Lane Group Flow (vph)	0	514	849	37	400	347	0	349	284	360
Confl. Peds. (#/hr)				50			50		50	
Confl. Bikes (#/hr)				10			10			
Turn Type	Perm	Perm		Perm		Perm		Prot	Prot	
Protected Phases			4		2			1	1	6
Permitted Phases	4	4		4		2				
Actuated Green, G (s)		30.8	30.8	30.8	22.5	22.5		23.7	23.7	49.2
Effective Green, g (s)		32.3	32.3	31.8	22.0	22.0		23.7	23.7	49.7
Actuated g/C Ratio		0.36	0.36	0.35	0.24	0.24		0.26	0.26	0.55
Clearance Time (s)		5.5	5.5	5.5	3.5	3.5		4.0	4.0	4.5
Vehicle Extension (s)		2.0	2.0	2.0	2.0	2.0		2.0	2.0	2.0
Lane Grp Cap (vph)		578	1180	475	865	355		466	466	1029
v/s Ratio Prot					0.11			c0.20	0.16	0.19
v/s Ratio Perm		c0.32	0.26	0.03		c0.24				
v/c Ratio		0.89	0.87dl	0.08	0.46	0.98		0.75	0.61	0.35
Uniform Delay, d1		27.2	24.9	19.4	29.0	33.8		30.4	29.1	11.2
Progression Factor		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2		15.1	1.8	0.0	0.1	41.4		10.5	5.8	0.9
Delay (s)		42.2	26.7	19.4	29.1	75.2		41.0	34.9	12.1
Level of Service		D	C	B	C	E		D	C	B
Approach Delay (s)			31.6		50.9					28.8
Approach LOS			C		D					C

Intersection Summary			
HCM Average Control Delay	35.3	HCM Level of Service	D
HCM Volume to Capacity ratio	0.87		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	75.9%	ICU Level of Service	D
Analysis Period (min)	15		

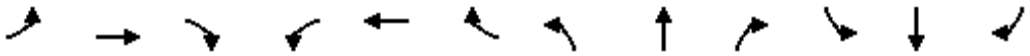
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

c Critical Lane Group



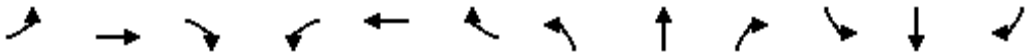
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	365	664	0	0	0	0	0	891	350
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0						4.0	4.0
Lane Util. Factor				0.86	0.86						0.86	0.86
Frpb, ped/bikes				1.00	1.00						1.00	1.00
Flpb, ped/bikes				1.00	1.00						1.00	1.00
Frt				1.00	1.00						0.99	0.85
Flt Protected				0.95	0.99						1.00	1.00
Satd. Flow (prot)				1522	4770						4745	1362
Flt Permitted				0.95	0.99						1.00	1.00
Satd. Flow (perm)				1522	4770						4745	1362
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	384	699	0	0	0	0	0	938	368
RTOR Reduction (vph)	0	0	0	195	22	0	0	0	0	0	11	113
Lane Group Flow (vph)	0	0	0	66	800	0	0	0	0	0	1004	178
Confl. Bikes (#/hr)						5						9
Turn Type				Prot								Prot
Protected Phases				7	3						2	2
Permitted Phases												
Actuated Green, G (s)				20.0	40.0						31.0	31.0
Effective Green, g (s)				20.0	40.0						31.0	31.0
Actuated g/C Ratio				0.25	0.51						0.39	0.39
Clearance Time (s)				4.0	4.0						4.0	4.0
Lane Grp Cap (vph)				385	2415						1862	534
v/s Ratio Prot				0.04	c0.08						c0.21	0.13
v/s Ratio Perm					0.08							
v/c Ratio				0.17	0.33						0.54	0.33
Uniform Delay, d1				23.0	11.6						18.5	16.8
Progression Factor				1.00	1.00						1.00	1.00
Incremental Delay, d2				1.0	0.4						1.1	1.7
Delay (s)				24.0	11.9						19.6	18.5
Level of Service				C	B						B	B
Approach Delay (s)		0.0			14.8			0.0			19.4	
Approach LOS		A			B			A			B	

Intersection Summary			
HCM Average Control Delay	17.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.42		
Actuated Cycle Length (s)	79.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	41.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



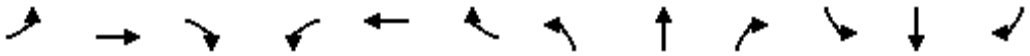
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	210	740	0	0	0	0	0	811	1757	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0						4.0	4.0			
Lane Util. Factor		0.91						0.91	0.88			
Frpb, ped/bikes		1.00						1.00	1.00			
Flpb, ped/bikes		1.00						1.00	1.00			
Frt		1.00						1.00	0.85			
Flt Protected		0.99						1.00	1.00			
Satd. Flow (prot)		5013						5085	2787			
Flt Permitted		0.99						1.00	1.00			
Satd. Flow (perm)		5013						5085	2787			
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	221	779	0	0	0	0	0	854	1849	0	0	0
RTOR Reduction (vph)	0	3	0	0	0	0	0	0	231	0	0	0
Lane Group Flow (vph)	0	998	0	0	0	0	0	854	1618	0	0	0
Confl. Peds. (#/hr)	28		7	7		28	99		3	3		99
Confl. Bikes (#/hr)			1			2			1			
Turn Type	Perm								custom			
Protected Phases		4						2	2			
Permitted Phases	4								7			
Actuated Green, G (s)		34.0						16.0	16.0			
Effective Green, g (s)		35.0						17.0	17.0			
Actuated g/C Ratio		0.58						0.28	0.28			
Clearance Time (s)		5.0						5.0	5.0			
Vehicle Extension (s)		3.0						3.0	3.0			
Lane Grp Cap (vph)		2924						1441	790			
v/s Ratio Prot								0.17	c0.58			
v/s Ratio Perm		0.20										
v/c Ratio		0.34						0.59	2.05			
Uniform Delay, d1		6.5						18.5	21.5			
Progression Factor		1.00						1.00	1.00			
Incremental Delay, d2		0.3						0.7	475.8			
Delay (s)		6.8						19.2	497.3			
Level of Service		A						B	F			
Approach Delay (s)		6.8			0.0			346.2			0.0	
Approach LOS		A			A			F			A	

Intersection Summary			
HCM Average Control Delay	254.6	HCM Level of Service	F
HCM Volume to Capacity ratio	0.90		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	96.8%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			



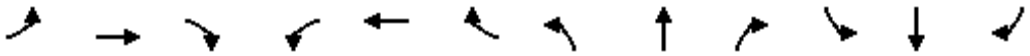
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	50	1165	1302	0	0	0	0	230	240	80	340	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0					4.0			4.0	
Lane Util. Factor		0.86	0.86					1.00			1.00	
Frpb, ped/bikes		0.98	0.97					0.98			1.00	
Flpb, ped/bikes		1.00	1.00					1.00			1.00	
Frt		0.95	0.85					0.93			1.00	
Flt Protected		1.00	1.00					1.00			0.99	
Satd. Flow (prot)		4427	1323					1701			1842	
Flt Permitted		1.00	1.00					1.00			0.39	
Satd. Flow (perm)		4427	1323					1701			733	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	53	1226	1371	0	0	0	0	242	253	84	358	0
RTOR Reduction (vph)	0	70	0	0	0	0	0	32	0	0	0	0
Lane Group Flow (vph)	0	1895	685	0	0	0	0	463	0	0	442	0
Confl. Peds. (#/hr)	52		55	55		52	39		25	25		39
Confl. Bikes (#/hr)			1						2		1	2
Turn Type	Perm		Free							Perm		
Protected Phases		2						4			8	
Permitted Phases	2		Free							8		
Actuated Green, G (s)		33.0	60.0					18.0			18.0	
Effective Green, g (s)		34.0	60.0					18.0			18.0	
Actuated g/C Ratio		0.57	1.00					0.30			0.30	
Clearance Time (s)		5.0						4.0			4.0	
Vehicle Extension (s)		2.0						2.0			2.0	
Lane Grp Cap (vph)		2509	1323					510			220	
v/s Ratio Prot								0.27				
v/s Ratio Perm		0.43	0.52								c0.60	
v/c Ratio		0.76	0.52					0.91			2.01	
Uniform Delay, d1		9.8	0.0					20.2			21.0	
Progression Factor		0.61	1.00					1.00			1.00	
Incremental Delay, d2		0.2	0.1					19.4			469.8	
Delay (s)		6.2	0.1					39.6			490.8	
Level of Service		A	A					D			F	
Approach Delay (s)		4.6			0.0			39.6			490.8	
Approach LOS		A			A			D			F	

Intersection Summary			
HCM Average Control Delay	69.4	HCM Level of Service	E
HCM Volume to Capacity ratio	1.19		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	96.9%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	130	330	0	0	0	0	0	1032	1785	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0						4.0	4.0			
Lane Util. Factor		0.91						0.91	0.88			
Frpb, ped/bikes		1.00						1.00	1.00			
Flpb, ped/bikes		1.00						1.00	1.00			
Frt		1.00						1.00	0.85			
Flt Protected		0.99						1.00	1.00			
Satd. Flow (prot)		4999						5085	2787			
Flt Permitted		0.99						1.00	1.00			
Satd. Flow (perm)		4999						5085	2787			
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	137	347	0	0	0	0	0	1086	1879	0	0	0
RTOR Reduction (vph)	0	12	0	0	0	0	0	0	392	0	0	0
Lane Group Flow (vph)	0	472	0	0	0	0	0	1086	1487	0	0	0
Confl. Peds. (#/hr)	12		21	21		12	42		29	29		42
Confl. Bikes (#/hr)			2			1						1
Turn Type	Perm								custom			
Protected Phases		4						2	2			
Permitted Phases	4								7			
Actuated Green, G (s)		38.0						32.0	32.0			
Effective Green, g (s)		38.0						33.0	33.0			
Actuated g/C Ratio		0.48						0.41	0.41			
Clearance Time (s)		5.0						5.0	5.0			
Vehicle Extension (s)		3.0						3.0	3.0			
Lane Grp Cap (vph)		2375						2098	1150			
v/s Ratio Prot								0.21	c0.53			
v/s Ratio Perm		0.09										
v/c Ratio		0.20						0.52	1.29			
Uniform Delay, d1		12.2						17.6	23.5			
Progression Factor		1.00						1.00	1.00			
Incremental Delay, d2		0.2						0.2	138.5			
Delay (s)		12.4						17.8	162.0			
Level of Service		B						B	F			
Approach Delay (s)		12.4			0.0			109.2			0.0	
Approach LOS		B			A			F			A	

Intersection Summary			
HCM Average Control Delay	95.6	HCM Level of Service	F
HCM Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	80.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	95.1%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			

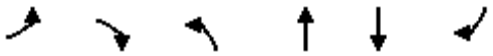


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	210	740	0	0	0	0	0	811	1757	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0						4.0	4.0			
Lane Util. Factor		0.91						0.91	0.88			
Frpb, ped/bikes		1.00						1.00	1.00			
Flpb, ped/bikes		1.00						1.00	1.00			
Frt		1.00						1.00	0.85			
Flt Protected		0.99						1.00	1.00			
Satd. Flow (prot)		5008						5085	2787			
Flt Permitted		0.99						1.00	1.00			
Satd. Flow (perm)		5008						5085	2787			
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	221	779	0	0	0	0	0	854	1849	0	0	0
RTOR Reduction (vph)	0	3	0	0	0	0	0	0	238	0	0	0
Lane Group Flow (vph)	0	997	0	0	0	0	0	854	1611	0	0	0
Confl. Peds. (#/hr)	28		7	7		28	99		3	3		99
Confl. Bikes (#/hr)			1			2			1			
Turn Type	Perm								custom			
Protected Phases		4						2	2			
Permitted Phases	4								7			
Actuated Green, G (s)		47.0						23.0	23.0			
Effective Green, g (s)		48.0						24.0	24.0			
Actuated g/C Ratio		0.60						0.30	0.30			
Clearance Time (s)		5.0						5.0	5.0			
Vehicle Extension (s)		3.0						3.0	3.0			
Lane Grp Cap (vph)		3005						1526	836			
v/s Ratio Prot								0.17	c0.58			
v/s Ratio Perm		0.20										
v/c Ratio		0.33						0.56	1.93			
Uniform Delay, d1		8.0						23.6	28.0			
Progression Factor		1.00						1.00	1.00			
Incremental Delay, d2		0.3						0.4	421.6			
Delay (s)		8.3						24.0	449.6			
Level of Service		A						C	F			
Approach Delay (s)		8.3			0.0			315.1			0.0	
Approach LOS		A			A			F			A	

Intersection Summary			
HCM Average Control Delay	232.3	HCM Level of Service	F
HCM Volume to Capacity ratio	0.86		
Actuated Cycle Length (s)	80.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	96.8%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			

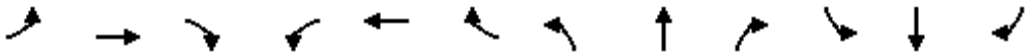
Cumulative (2035) No Project Conditions

FEHR PEERS



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	560	90	50	1300	1050	770
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	1.00	1.00	0.95	0.91	0.88
Frpb, ped/bikes	1.00	0.98	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3400	1535	1752	3505	5036	2760
Flt Permitted	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	3400	1535	1752	3505	5036	2760
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	609	98	54	1413	1141	837
RTOR Reduction (vph)	0	0	0	0	0	586
Lane Group Flow (vph)	609	98	54	1413	1141	251
Confl. Peds. (#/hr)	3	11	4			4
Confl. Bikes (#/hr)		5				5
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%
Turn Type		Perm	Prot			Prot
Protected Phases	4		5	2	6	6
Permitted Phases		4				
Actuated Green, G (s)	26.0	26.0	4.0	26.0	18.0	18.0
Effective Green, g (s)	26.0	26.0	4.0	26.0	18.0	18.0
Actuated g/C Ratio	0.43	0.43	0.07	0.43	0.30	0.30
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Grp Cap (vph)	1473	665	117	1519	1511	828
v/s Ratio Prot	c0.18		0.03	c0.40	0.23	0.09
v/s Ratio Perm		0.06				
v/c Ratio	0.41	0.15	0.46	0.93	0.76	0.30
Uniform Delay, d1	11.7	10.3	27.0	16.1	19.0	16.2
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.9	0.5	12.5	11.5	3.6	0.9
Delay (s)	12.6	10.8	39.5	27.7	22.6	17.1
Level of Service	B	B	D	C	C	B
Approach Delay (s)	12.3			28.1	20.3	
Approach LOS	B			C	C	

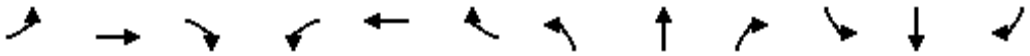
Intersection Summary			
HCM Average Control Delay	21.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	68.4%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	60	40	180	120	130	80	220	90	80	100	30
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95			0.95	1.00	1.00	0.95		0.91	0.91	
Frpb, ped/bikes		0.99			1.00	0.98	1.00	0.99		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.95			1.00	0.85	1.00	0.96		1.00	0.97	
Flt Protected		0.99			0.97	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3176			3291	1500	1703	3230		1550	3130	
Flt Permitted		0.88			0.74	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		2829			2522	1500	1703	3230		1550	3130	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	65	43	196	130	141	87	239	98	87	109	33
RTOR Reduction (vph)	0	30	0	0	0	0	0	59	0	0	27	0
Lane Group Flow (vph)	0	100	0	0	326	141	87	278	0	76	126	0
Confl. Peds. (#/hr)	9		8	8		9	12		17	17		12
Confl. Bikes (#/hr)						3			5			2
Heavy Vehicles (%)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
Turn Type	Perm			Perm		Free	Split			Split		
Protected Phases		2			6		3	3		4	4	
Permitted Phases	2			6		Free						
Actuated Green, G (s)		13.4			12.4	44.1	10.5	10.5		7.2	7.2	
Effective Green, g (s)		13.4			13.4	44.1	10.5	10.5		8.2	8.2	
Actuated g/C Ratio		0.30			0.30	1.00	0.24	0.24		0.19	0.19	
Clearance Time (s)		4.0			5.0		4.0	4.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		860			766	1500	405	769		288	582	
v/s Ratio Prot							0.05	c0.09		c0.05	0.04	
v/s Ratio Perm		0.04			c0.13	0.09						
v/c Ratio		0.12			0.43	0.09	0.21	0.36		0.26	0.22	
Uniform Delay, d1		11.1			12.3	0.0	13.5	14.0		15.4	15.2	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.1			0.4	0.1	0.3	0.3		0.5	0.2	
Delay (s)		11.1			12.7	0.1	13.8	14.3		15.9	15.4	
Level of Service		B			B	A	B	B		B	B	
Approach Delay (s)		11.1			8.9			14.2			15.6	
Approach LOS		B			A			B			B	

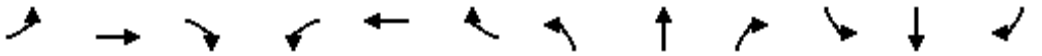
Intersection Summary			
HCM Average Control Delay	12.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.36		
Actuated Cycle Length (s)	44.1	Sum of lost time (s)	12.0
Intersection Capacity Utilization	46.9%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	190	20	200	370	70	30	100	270	40	90	30
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	0.99			0.97			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	0.99		1.00	0.98			0.91			0.97	
Flt Protected	0.95	1.00		0.95	1.00			1.00			0.99	
Satd. Flow (prot)	1736	3406		1736	3365			1606			1744	
Flt Permitted	0.95	1.00		0.95	1.00			0.97			0.85	
Satd. Flow (perm)	1736	3406		1736	3365			1566			1508	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	207	22	217	402	76	33	109	293	43	98	33
RTOR Reduction (vph)	0	13	0	0	26	0	0	124	0	0	14	0
Lane Group Flow (vph)	22	216	0	217	452	0	0	311	0	0	160	0
Confl. Peds. (#/hr)	11		13	13		11	22		48	48		22
Confl. Bikes (#/hr)			1			2			1			
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Effective Green, g (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Actuated g/C Ratio	0.10	0.27		0.10	0.27			0.43			0.43	
Clearance Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Grp Cap (vph)	174	908		174	897			679			653	
v/s Ratio Prot	0.01	0.06		c0.13	c0.13							
v/s Ratio Perm								c0.20			0.11	
v/c Ratio	0.13	0.24		1.25	0.50			0.46			0.24	
Uniform Delay, d1	24.6	17.2		27.0	18.6			12.0			10.8	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	1.5	0.6		149.9	2.0			2.2			0.9	
Delay (s)	26.1	17.8		176.9	20.7			14.2			11.7	
Level of Service	C	B		F	C			B			B	
Approach Delay (s)		18.6			69.5			14.2			11.7	
Approach LOS		B			E			B			B	

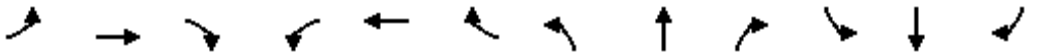
Intersection Summary			
HCM Average Control Delay	39.3	HCM Level of Service	D
HCM Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	62.2%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	350	340	130	60	470	90	160	940	100	170	610	370
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	11	12	11	11	12	12	12	12	12	12	12
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	3.0
Lane Util. Factor	0.97	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.97	1.00	0.98		1.00	1.00		1.00	1.00	0.96
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.98		1.00	0.99		1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	2828	3020	1353	1510	2890		1562	3064		1562	3124	1300
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (perm)	2828	3020	1353	1510	2890		1562	3064		1562	3124	1300
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	380	370	141	65	511	98	174	1022	109	185	663	402
RTOR Reduction (vph)	0	0	88	0	13	0	0	7	0	0	0	36
Lane Group Flow (vph)	380	370	53	65	596	0	174	1124	0	185	663	366
Confl. Peds. (#/hr)			16			85			25			37
Confl. Bikes (#/hr)						1			1			1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Bus Blockages (#/hr)	0	0	0	0	0	2	0	0	0	0	0	8
Turn Type	Prot		Perm	Prot			Prot			Prot		pm+ov
Protected Phases	7	4		3	8		5	2		1	6	7
Permitted Phases			4									6
Actuated Green, G (s)	17.0	36.6	36.6	8.2	27.8		17.7	43.0		15.0	40.3	57.3
Effective Green, g (s)	17.0	36.6	36.6	8.2	27.8		17.7	44.0		15.0	41.3	59.3
Actuated g/C Ratio	0.14	0.31	0.31	0.07	0.23		0.15	0.37		0.13	0.34	0.49
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	5.0		4.0	5.0	4.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	401	923	413	103	671		231	1125		196	1077	643
v/s Ratio Prot	c0.13	0.12		0.04	c0.21		0.11	c0.37		c0.12	0.21	0.09
v/s Ratio Perm			0.04									0.20
v/c Ratio	0.95	0.40	0.13	0.63	0.89		0.75	1.00		0.94	0.62	0.57
Uniform Delay, d1	51.0	32.9	30.1	54.3	44.5		49.0	37.9		52.0	32.6	21.3
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	31.5	0.3	0.1	11.9	13.6		13.0	26.4		48.1	1.1	1.2
Delay (s)	82.4	33.2	30.2	66.3	58.1		61.9	64.3		100.1	33.7	22.4
Level of Service	F	C	C	E	E		E	E		F	C	C
Approach Delay (s)		53.7			58.8			64.0			39.9	
Approach LOS		D			E			E			D	

Intersection Summary			
HCM Average Control Delay	53.6	HCM Level of Service	D
HCM Volume to Capacity ratio	0.95		
Actuated Cycle Length (s)	119.8	Sum of lost time (s)	16.0
Intersection Capacity Utilization	90.6%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group



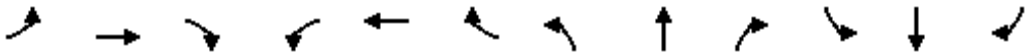
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	100	320	130	60	280	120	170	830	60	120	510	140
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.9	4.9		4.9	4.9		4.3	4.8	4.8	4.3	4.8	4.8
Lane Util. Factor	1.00	0.95		1.00	0.95		0.97	0.95	1.00	0.97	0.95	1.00
Frpb, ped/bikes	1.00	0.99		1.00	0.99		1.00	1.00	0.98	1.00	1.00	0.98
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.96		1.00	0.95		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	3368		1770	3355		3433	3539	1557	3433	3539	1548
Flt Permitted	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	3368		1770	3355		3433	3539	1557	3433	3539	1548
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	108	344	140	65	301	129	183	892	65	129	548	151
RTOR Reduction (vph)	0	44	0	0	49	0	0	0	44	0	0	44
Lane Group Flow (vph)	108	440	0	65	381	0	183	892	21	129	548	107
Confl. Peds. (#/hr)			7			13			6			11
Confl. Bikes (#/hr)						2						
Turn Type	Split			Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases									2			6
Actuated Green, G (s)	15.8	15.8		14.7	14.7		7.3	24.6	24.6	4.2	21.5	21.5
Effective Green, g (s)	14.9	14.9		13.8	13.8		7.0	24.8	24.8	3.9	21.7	21.7
Actuated g/C Ratio	0.20	0.20		0.18	0.18		0.09	0.33	0.33	0.05	0.28	0.28
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	5.0	5.0	4.0	5.0	5.0
Vehicle Extension (s)	2.0	2.0		2.0	2.0		2.0	2.0	2.0	2.0	2.0	2.0
Lane Grp Cap (vph)	346	658		320	607		315	1150	506	175	1007	440
v/s Ratio Prot	0.06	c0.13		0.04	c0.11		c0.05	c0.25		0.04	0.15	
v/s Ratio Perm									0.01			0.07
v/c Ratio	0.31	0.67		0.20	0.63		0.58	0.78	0.04	0.74	0.54	0.24
Uniform Delay, d1	26.3	28.4		26.6	28.9		33.2	23.2	17.6	35.7	23.1	21.0
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.2	2.0		0.1	1.5		1.8	3.0	0.0	13.0	0.3	0.1
Delay (s)	26.5	30.4		26.7	30.3		35.0	26.3	17.6	48.7	23.4	21.1
Level of Service	C	C		C	C		D	C	B	D	C	C
Approach Delay (s)		29.7			29.9			27.2			26.9	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	28.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	76.3	Sum of lost time (s)	18.9
Intersection Capacity Utilization	64.0%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	20	20	90	30	130	10	270	50	60	270	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frpb, ped/bikes		0.99			1.00	0.98	1.00	0.99		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.95			1.00	0.85	1.00	0.98		1.00	0.99	
Flt Protected		0.98			0.96	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1737			1796	1556	1770	1804		1770	1838	
Flt Permitted		0.98			0.96	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		1737			1796	1556	1770	1804		1770	1838	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	22	22	98	33	141	11	293	54	65	293	22
RTOR Reduction (vph)	0	20	0	0	0	120	0	7	0	0	3	0
Lane Group Flow (vph)	0	46	0	0	131	21	11	340	0	65	312	0
Confl. Peds. (#/hr)	2		1	1		2	13		20	20		13
Confl. Bikes (#/hr)						1			5			
Turn Type	Split			Split		Perm	Split			Split		
Protected Phases	2	2		1	1		4	4		3	3	
Permitted Phases						1						
Actuated Green, G (s)		6.8			10.1	10.1	18.4	18.4		17.4	17.4	
Effective Green, g (s)		6.8			10.1	10.1	18.4	18.4		17.4	17.4	
Actuated g/C Ratio		0.10			0.15	0.15	0.27	0.27		0.25	0.25	
Clearance Time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0	3.0	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		172			264	229	474	483		448	466	
v/s Ratio Prot		c0.03			c0.07		0.01	c0.19		0.04	c0.17	
v/s Ratio Perm						0.01						
v/c Ratio		0.27			0.50	0.09	0.02	0.70		0.15	0.67	
Uniform Delay, d1		28.6			27.0	25.3	18.5	22.7		19.9	23.1	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.8			1.5	0.2	0.0	4.6		0.1	3.6	
Delay (s)		29.5			28.4	25.5	18.5	27.3		20.0	26.7	
Level of Service		C			C	C	B	C		C	C	
Approach Delay (s)		29.5			26.9			27.1			25.6	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	26.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	68.7	Sum of lost time (s)	16.0
Intersection Capacity Utilization	45.3%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



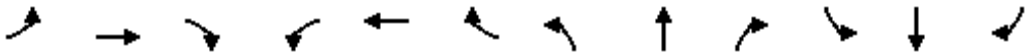
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	280	250	60	60	320	70	70	650	30	60	410	100
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			0.95			0.95	
Frpb, ped/bikes	1.00	0.99		1.00	0.99			1.00			0.99	
Flpb, ped/bikes	0.98	1.00		0.99	1.00			1.00			1.00	
Frt	1.00	0.97		1.00	0.97			0.99			0.97	
Flt Protected	0.95	1.00		0.95	1.00			1.00			0.99	
Satd. Flow (prot)	1544	3047		1562	3041			3113			3034	
Flt Permitted	0.48	1.00		0.54	1.00			0.84			0.81	
Satd. Flow (perm)	777	3047		894	3041			2629			2466	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	304	272	65	65	348	76	76	707	33	65	446	109
RTOR Reduction (vph)	0	31	0	0	28	0	0	4	0	0	27	0
Lane Group Flow (vph)	304	306	0	65	396	0	0	812	0	0	593	0
Confl. Peds. (#/hr)	56		22	22		56	31		42	42		31
Confl. Bikes (#/hr)						2			5			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			4			2			2	
Permitted Phases	4			4			2			2		
Actuated Green, G (s)	30.0	30.0		30.0	30.0			32.0			32.0	
Effective Green, g (s)	29.0	29.0		29.0	29.0			31.0			31.0	
Actuated g/C Ratio	0.43	0.43		0.43	0.43			0.46			0.46	
Clearance Time (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	331	1299		381	1297			1199			1124	
v/s Ratio Prot		0.10			0.13							
v/s Ratio Perm	c0.39			0.07				c0.31			0.24	
v/c Ratio	0.92	0.24		0.17	0.31			0.68			0.53	
Uniform Delay, d1	18.4	12.4		12.1	12.9			14.6			13.3	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	32.5	0.4		1.0	0.6			3.1			1.8	
Delay (s)	50.9	12.9		13.0	13.5			17.6			15.0	
Level of Service	D	B		B	B			B			B	
Approach Delay (s)		30.9			13.4			17.6			15.0	
Approach LOS		C			B			B			B	

Intersection Summary			
HCM Average Control Delay	19.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	68.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	103.1%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	260	40	20	350	300	40	580	20	270	390	30
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0			5.0		5.0	5.0	
Lane Util. Factor		0.95			0.95			0.95		0.97	1.00	
Frpb, ped/bikes		1.00			0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00			1.00		1.00	1.00	
Frt		0.98			0.93			1.00		1.00	0.99	
Flt Protected		1.00			1.00			1.00		0.95	1.00	
Satd. Flow (prot)		3480			3305			3542		3467	1858	
Flt Permitted		0.82			0.94			1.00		0.95	1.00	
Satd. Flow (perm)		2864			3098			3542		3467	1858	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	283	43	22	380	326	43	630	22	293	424	33
RTOR Reduction (vph)	0	14	0	0	187	0	0	3	0	0	4	0
Lane Group Flow (vph)	0	334	0	0	541	0	0	692	0	293	453	0
Confl. Peds. (#/hr)	2		11	11		2	14		25	25		14
Confl. Bikes (#/hr)			1			2						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm			Perm			Split			Split		
Protected Phases		4			4		2	2		3	3	
Permitted Phases	4			4								
Actuated Green, G (s)		18.5			18.5			17.9		22.0	22.0	
Effective Green, g (s)		17.5			17.5			16.9		21.0	21.0	
Actuated g/C Ratio		0.25			0.25			0.24		0.30	0.30	
Clearance Time (s)		4.0			4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		712			770			850		1034	554	
v/s Ratio Prot								c0.20		0.08	c0.24	
v/s Ratio Perm		0.12			c0.17							
v/c Ratio		0.47			0.70			0.81		0.28	0.82	
Uniform Delay, d1		22.5			24.1			25.3		18.9	22.9	
Progression Factor		1.00			1.00			1.00		1.00	1.00	
Incremental Delay, d2		0.5			2.9			6.0		0.2	9.2	
Delay (s)		23.0			27.0			31.3		19.1	32.1	
Level of Service		C			C			C		B	C	
Approach Delay (s)		23.0			27.0			31.3			27.0	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	27.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	70.4	Sum of lost time (s)	15.0
Intersection Capacity Utilization	87.7%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	300	380	20	450	160	440	340	30	90	280	30
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Util. Factor		0.91	0.91		0.95		1.00	1.00			1.00	
Frpb, ped/bikes		0.99	0.96		0.99		1.00	1.00			1.00	
Flpb, ped/bikes		1.00	1.00		1.00		1.00	1.00			1.00	
Frt		0.95	0.85		0.96		1.00	0.99			0.99	
Flt Protected		1.00	1.00		1.00		0.95	1.00			0.99	
Satd. Flow (prot)		2954	1385		3133		1770	1578			1564	
Flt Permitted		0.82	1.00		0.92		0.95	1.00			0.99	
Satd. Flow (perm)		2424	1385		2894		1770	1578			1564	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	326	413	22	489	174	478	370	33	98	304	33
RTOR Reduction (vph)	0	64	185	0	40	0	0	4	0	0	3	0
Lane Group Flow (vph)	0	453	59	0	645	0	478	399	0	0	432	0
Confl. Peds. (#/hr)	16		21	21		16	20		16	16		20
Confl. Bikes (#/hr)			1			2			1			
Parking (#/hr)		8			8			8			8	
Turn Type	Perm		Perm	Perm			Split			Split		
Protected Phases		2			2		4	4		8	8	
Permitted Phases	2		2	2								
Actuated Green, G (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Effective Green, g (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Actuated g/C Ratio		0.24	0.24		0.24		0.30	0.30			0.31	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Grp Cap (vph)		584	334		697		533	475			490	
v/s Ratio Prot							c0.27	0.25			c0.28	
v/s Ratio Perm		0.19	0.04		c0.22							
v/c Ratio		0.78	0.18		0.93		0.90	0.84			0.88	
Uniform Delay, d1		29.4	25.0		30.8		27.8	27.1			27.0	
Progression Factor		1.00	1.00		1.00		1.00	1.00			1.00	
Incremental Delay, d2		9.7	1.1		20.0		20.4	16.2			19.8	
Delay (s)		39.2	26.1		50.8		48.2	43.3			46.8	
Level of Service		D	C		D		D	D			D	
Approach Delay (s)		35.0			50.8			45.9			46.8	
Approach LOS		C			D			D			D	

Intersection Summary			
HCM Average Control Delay	44.3	HCM Level of Service	D
HCM Volume to Capacity ratio	0.90		
Actuated Cycle Length (s)	83.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	89.1%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL2	EBL	EBT	EBR	NBT	NBR	NBR2	SBL2	SBL	SBT
Lane Configurations										
Volume (vph)	140	840	170	140	380	270	90	420	170	400
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0	4.5	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor		0.91	0.91	1.00	0.95	1.00		1.00	1.00	1.00
Frpb, ped/bikes		1.00	1.00	0.87	1.00	0.93		1.00	1.00	1.00
Flpb, ped/bikes		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frt		1.00	1.00	0.85	1.00	0.85		1.00	1.00	1.00
Flt Protected		0.95	0.96	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (prot)		1610	3269	1370	3539	1480		1770	1770	1863
Flt Permitted		0.95	0.96	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (perm)		1610	3269	1370	3539	1480		1770	1770	1863
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	147	884	179	147	400	284	95	442	179	421
RTOR Reduction (vph)	0	0	0	108	0	17	0	0	0	0
Lane Group Flow (vph)	0	518	692	39	400	362	0	442	179	421
Confl. Peds. (#/hr)				50			50		50	
Confl. Bikes (#/hr)				10			10			
Turn Type	Perm	Perm		Perm		Perm		Prot	Prot	
Protected Phases			4		2			1	1	6
Permitted Phases	4	4		4		2				
Actuated Green, G (s)		19.0	19.0	19.0	21.3	21.3		21.2	21.2	46.0
Effective Green, g (s)		20.5	20.5	20.0	20.8	20.8		21.7	21.7	46.5
Actuated g/C Ratio		0.27	0.27	0.27	0.28	0.28		0.29	0.29	0.62
Clearance Time (s)		5.5	5.5	5.5	3.5	3.5		4.5	4.5	4.5
Vehicle Extension (s)		2.0	2.0	2.0	2.0	2.0		2.0	2.0	2.0
Lane Grp Cap (vph)		440	894	365	981	410		512	512	1155
v/s Ratio Prot					0.11			c0.25	0.10	0.23
v/s Ratio Perm		c0.32	0.21	0.03		c0.24				
v/c Ratio		1.18	1.12dl	0.11	0.41	0.88		0.86	0.35	0.36
Uniform Delay, d1		27.2	25.1	20.8	22.1	25.9		25.2	21.1	7.0
Progression Factor		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2		101.2	3.9	0.0	0.1	19.2		17.3	1.9	0.9
Delay (s)		128.4	29.0	20.8	22.2	45.1		42.6	22.9	7.9
Level of Service		F	C	C	C	D		D	C	A
Approach Delay (s)			66.1		33.3					25.2
Approach LOS			E		C					C

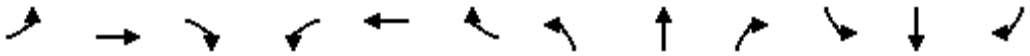
Intersection Summary			
HCM Average Control Delay	44.6	HCM Level of Service	D
HCM Volume to Capacity ratio	0.97		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	78.8%	ICU Level of Service	D
Analysis Period (min)	15		

dl Defacto Left Lane. Recode with 1 though lane as a left lane.

c Critical Lane Group

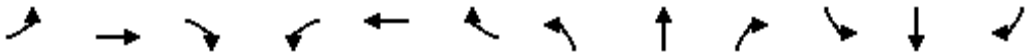
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	550	1430	0	0	0	0	0	640	570
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0						4.0	4.0
Lane Util. Factor				0.86	0.86						0.86	0.86
Frpb, ped/bikes				1.00	1.00						0.99	1.00
Flpb, ped/bikes				1.00	1.00						1.00	1.00
Frt				1.00	1.00						0.95	0.85
Flt Protected				0.95	1.00						1.00	1.00
Satd. Flow (prot)				1522	4795						4559	1362
Flt Permitted				0.95	1.00						1.00	1.00
Satd. Flow (perm)				1522	4795						4559	1362
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	579	1505	0	0	0	0	0	674	600
RTOR Reduction (vph)	0	0	0	333	6	0	0	0	0	0	16	16
Lane Group Flow (vph)	0	0	0	171	1574	0	0	0	0	0	958	284
Confl. Bikes (#/hr)						9						10
Turn Type				Prot								Prot
Protected Phases				7	3						2	2
Permitted Phases												
Actuated Green, G (s)				20.0	40.0						31.0	31.0
Effective Green, g (s)				20.0	40.0						31.0	31.0
Actuated g/C Ratio				0.25	0.51						0.39	0.39
Clearance Time (s)				4.0	4.0						4.0	4.0
Lane Grp Cap (vph)				385	2428						1789	534
v/s Ratio Prot				0.11	c0.16						c0.21	0.21
v/s Ratio Perm					0.16							
v/c Ratio				0.44	0.65						0.54	0.53
Uniform Delay, d1				24.8	14.3						18.5	18.4
Progression Factor				1.00	1.00						1.00	1.00
Incremental Delay, d2				3.7	1.4						1.2	3.8
Delay (s)				28.5	15.7						19.6	22.2
Level of Service				C	B						B	C
Approach Delay (s)		0.0			18.8			0.0			20.2	
Approach LOS		A			B			A			C	

Intersection Summary			
HCM Average Control Delay	19.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	79.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	59.3%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	300	470	0	0	0	0	0	1260	1930	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0						4.0	4.0			
Lane Util. Factor		0.91						0.91	0.88			
Frpb, ped/bikes		1.00						1.00	1.00			
Flpb, ped/bikes		1.00						1.00	1.00			
Frt		1.00						1.00	0.85			
Flt Protected		0.98						1.00	1.00			
Satd. Flow (prot)		4973						5085	2787			
Flt Permitted		0.98						1.00	1.00			
Satd. Flow (perm)		4973						5085	2787			
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	316	495	0	0	0	0	0	1326	2032	0	0	0
RTOR Reduction (vph)	0	4	0	0	0	0	0	0	242	0	0	0
Lane Group Flow (vph)	0	807	0	0	0	0	0	1326	1790	0	0	0
Confl. Peds. (#/hr)	12		21	21		12	42		29	29		42
Confl. Bikes (#/hr)			2			1						1
Turn Type	Perm								custom			
Protected Phases		4						2	2			
Permitted Phases	4								7			
Actuated Green, G (s)		27.0						23.0	23.0			
Effective Green, g (s)		27.0						24.0	24.0			
Actuated g/C Ratio		0.45						0.40	0.40			
Clearance Time (s)		5.0						5.0	5.0			
Vehicle Extension (s)		3.0						3.0	3.0			
Lane Grp Cap (vph)		2238						2034	1115			
v/s Ratio Prot								0.26	c0.64			
v/s Ratio Perm		0.16										
v/c Ratio		0.36						0.65	1.61			
Uniform Delay, d1		10.8						14.6	18.0			
Progression Factor		1.00						1.00	1.00			
Incremental Delay, d2		0.5						0.8	276.5			
Delay (s)		11.3						15.4	294.5			
Level of Service		B						B	F			
Approach Delay (s)		11.3			0.0			184.3			0.0	
Approach LOS		B			A			F			A	

Intersection Summary			
HCM Average Control Delay	150.6	HCM Level of Service	F
HCM Volume to Capacity ratio	0.95		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	100.2%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

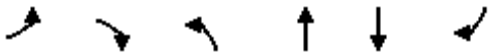


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	70	830	1500	0	0	0	0	290	110	110	350	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0					4.0			4.0	
Lane Util. Factor		0.86	0.86					1.00			1.00	
Frpb, ped/bikes		0.96	0.97					0.98			1.00	
Flpb, ped/bikes		1.00	1.00					1.00			0.99	
Frt		0.93	0.85					0.96			1.00	
Flt Protected		1.00	1.00					1.00			0.99	
Satd. Flow (prot)		4270	1315					1749			1826	
Flt Permitted		1.00	1.00					1.00			0.45	
Satd. Flow (perm)		4270	1315					1749			834	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	74	874	1579	0	0	0	0	305	116	116	368	0
RTOR Reduction (vph)	0	73	0	0	0	0	0	23	0	0	0	0
Lane Group Flow (vph)	0	1665	789	0	0	0	0	398	0	0	484	0
Confl. Peds. (#/hr)	51		75	75		51	29		79	79		29
Confl. Bikes (#/hr)											1	1
Turn Type	Perm		Free							Perm		
Protected Phases		2						4			8	
Permitted Phases	2		Free							8		
Actuated Green, G (s)		33.0	60.0					18.0			18.0	
Effective Green, g (s)		34.0	60.0					18.0			18.0	
Actuated g/C Ratio		0.57	1.00					0.30			0.30	
Clearance Time (s)		5.0						4.0			4.0	
Vehicle Extension (s)		2.0						2.0			2.0	
Lane Grp Cap (vph)		2420	1315					525			250	
v/s Ratio Prot								0.23				
v/s Ratio Perm		0.39	0.60								c0.58	
v/c Ratio		0.89dr	0.60					0.76			1.94	
Uniform Delay, d1		9.2	0.0					19.0			21.0	
Progression Factor		0.71	1.00					1.00			1.00	
Incremental Delay, d2		0.1	0.2					5.5			435.6	
Delay (s)		6.7	0.2					24.5			456.6	
Level of Service		A	A					C			F	
Approach Delay (s)		4.7			0.0			24.5			456.6	
Approach LOS		A			A			C			F	

Intersection Summary			
HCM Average Control Delay	70.9	HCM Level of Service	E
HCM Volume to Capacity ratio	1.12		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	90.6%	ICU Level of Service	E
Analysis Period (min)	15		

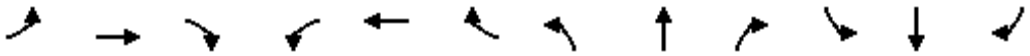
dr Defacto Right Lane. Recode with 1 though lane as a right lane.

c Critical Lane Group



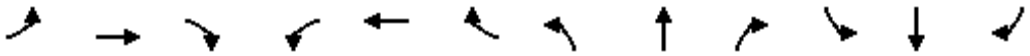
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	690	130	90	940	1290	850
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	1.00	1.00	0.95	0.91	0.88
Frpb, ped/bikes	1.00	0.98	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3433	1550	1770	3539	5085	2787
Flt Permitted	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	3433	1550	1770	3539	5085	2787
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	734	138	96	1000	1372	904
RTOR Reduction (vph)	0	0	0	0	0	633
Lane Group Flow (vph)	734	138	96	1000	1372	271
Confl. Peds. (#/hr)	2	16	2			2
Turn Type		Perm	Prot			Prot
Protected Phases	4		5	2	6	6
Permitted Phases		4				
Actuated Green, G (s)	26.0	26.0	4.0	26.0	18.0	18.0
Effective Green, g (s)	26.0	26.0	4.0	26.0	18.0	18.0
Actuated g/C Ratio	0.43	0.43	0.07	0.43	0.30	0.30
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Grp Cap (vph)	1488	672	118	1534	1526	836
v/s Ratio Prot	c0.21		0.05	c0.28	c0.27	0.10
v/s Ratio Perm		0.09				
v/c Ratio	0.49	0.21	0.81	0.65	0.90	0.32
Uniform Delay, d1	12.3	10.6	27.6	13.4	20.1	16.3
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.2	0.7	43.7	2.2	8.8	1.0
Delay (s)	13.4	11.3	71.4	15.6	28.9	17.3
Level of Service	B	B	E	B	C	B
Approach Delay (s)	13.1			20.5	24.3	
Approach LOS	B			C	C	

Intersection Summary			
HCM Average Control Delay	21.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	65.7%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	30	180	70	80	110	90	70	120	70	110	180	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95			0.95	1.00	1.00	0.95		0.91	0.91	
Frpb, ped/bikes		0.99			1.00	0.99	1.00	1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.96			1.00	0.85	1.00	0.94		1.00	0.99	
Flt Protected		0.99			0.98	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3366			3462	1563	1770	3327		1610	3328	
Flt Permitted		0.91			0.74	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		3078			2622	1563	1770	3327		1610	3328	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	33	196	76	87	120	98	76	130	76	120	196	22
RTOR Reduction (vph)	0	43	0	0	0	0	0	63	0	0	10	0
Lane Group Flow (vph)	0	262	0	0	207	98	76	143	0	108	220	0
Confl. Peds. (#/hr)	2		4	4		2	4		2	2		4
Confl. Bikes (#/hr)			2			1						2
Turn Type	Perm			Perm		Free	Split			Split		
Protected Phases		2			6		3	3		4	4	
Permitted Phases	2			6		Free						
Actuated Green, G (s)		12.5			11.5	42.1	7.0	7.0		9.6	9.6	
Effective Green, g (s)		12.5			12.5	42.1	7.0	7.0		10.6	10.6	
Actuated g/C Ratio		0.30			0.30	1.00	0.17	0.17		0.25	0.25	
Clearance Time (s)		4.0			5.0		4.0	4.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		914			779	1563	294	553		405	838	
v/s Ratio Prot							c0.04	0.04		c0.07	0.07	
v/s Ratio Perm		c0.09			0.08	0.06						
v/c Ratio		0.29			0.27	0.06	0.26	0.26		0.27	0.26	
Uniform Delay, d1		11.4			11.3	0.0	15.3	15.3		12.6	12.6	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.2			0.2	0.1	0.5	0.2		0.4	0.2	
Delay (s)		11.5			11.5	0.1	15.8	15.5		13.0	12.8	
Level of Service		B			B	A	B	B		B	B	
Approach Delay (s)		11.5			7.8			15.6			12.9	
Approach LOS		B			A			B			B	

Intersection Summary			
HCM Average Control Delay	11.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.27		
Actuated Cycle Length (s)	42.1	Sum of lost time (s)	12.0
Intersection Capacity Utilization	42.0%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

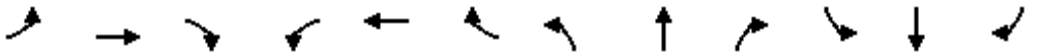


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	320	20	210	250	50	20	50	170	40	50	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			0.98			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	0.99		1.00	0.98			0.90			0.98	
Flt Protected	0.95	1.00		0.95	1.00			1.00			0.98	
Satd. Flow (prot)	1787	3542		1787	3468			1661			1791	
Flt Permitted	0.95	1.00		0.95	1.00			0.98			0.85	
Satd. Flow (perm)	1787	3542		1787	3468			1629			1553	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	348	22	228	272	54	22	54	185	43	54	22
RTOR Reduction (vph)	0	7	0	0	27	0	0	105	0	0	12	0
Lane Group Flow (vph)	22	363	0	228	299	0	0	156	0	0	107	0
Confl. Peds. (#/hr)	4					4	1		24	24		1
Confl. Bikes (#/hr)						2			1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Effective Green, g (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Actuated g/C Ratio	0.10	0.27		0.10	0.27			0.43			0.43	
Clearance Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Grp Cap (vph)	179	945		179	925			706			673	
v/s Ratio Prot	0.01	c0.10		c0.13	0.09							
v/s Ratio Perm								c0.10			0.07	
v/c Ratio	0.12	0.38		1.27	0.32			0.22			0.16	
Uniform Delay, d1	24.6	18.0		27.0	17.7			10.7			10.3	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	1.4	1.2		159.4	0.9			0.7			0.5	
Delay (s)	26.0	19.2		186.4	18.6			11.4			10.8	
Level of Service	C	B		F	B			B			B	
Approach Delay (s)		19.5			87.6			11.4			10.8	
Approach LOS		B			F			B			B	

Intersection Summary			
HCM Average Control Delay	45.6	HCM Level of Service	D
HCM Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	54.4%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	350	270	90	140	350	100	110	580	150	150	870	400
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	11	12	11	11	12	12	12	12	12	12	12
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.97	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.93	1.00	0.98		1.00	0.99		1.00	1.00	0.90
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.97		1.00	0.97		1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	2884	3079	1330	1540	2921		1593	3049		1593	3185	1243
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (perm)	2884	3079	1330	1540	2921		1593	3049		1593	3185	1243
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	380	293	98	152	380	109	120	630	163	163	946	435
RTOR Reduction (vph)	0	0	79	0	23	0	0	19	0	0	0	277
Lane Group Flow (vph)	380	293	19	152	466	0	120	774	0	163	946	158
Confl. Peds. (#/hr)			47			60			42			75
Confl. Bikes (#/hr)						1						
Bus Blockages (#/hr)	0	0	0	0	0	2	0	0	0	0	0	8
Turn Type	Split		Perm	Split			Prot			Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			4									6
Actuated Green, G (s)	19.5	19.5	19.5	20.6	20.6		11.1	29.5		12.1	30.5	30.5
Effective Green, g (s)	19.5	19.5	19.5	20.6	20.6		11.1	30.5		12.1	31.5	31.5
Actuated g/C Ratio	0.20	0.20	0.20	0.21	0.21		0.11	0.31		0.12	0.32	0.32
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	5.0		4.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	570	608	263	321	610		179	942		195	1016	397
v/s Ratio Prot	c0.13	0.10		0.10	c0.16		0.08	0.25		c0.10	c0.30	
v/s Ratio Perm			0.01									0.13
v/c Ratio	0.67	0.48	0.07	0.47	0.76		0.67	0.82		0.84	0.93	0.40
Uniform Delay, d1	36.6	35.1	32.2	34.3	36.8		42.0	31.6		42.3	32.5	26.2
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	2.9	0.6	0.1	1.1	5.7		9.5	5.9		25.5	14.5	0.7
Delay (s)	39.5	35.7	32.4	35.4	42.4		51.5	37.4		67.8	47.0	26.9
Level of Service	D	D	C	D	D		D	D		E	D	C
Approach Delay (s)		37.2			40.8			39.3			43.5	
Approach LOS		D			D			D			D	

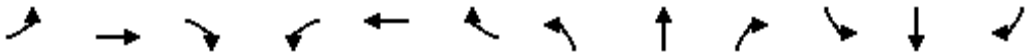
Intersection Summary			
HCM Average Control Delay	40.8	HCM Level of Service	D
HCM Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	98.7	Sum of lost time (s)	12.0
Intersection Capacity Utilization	78.0%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	150	260	120	60	220	140	130	520	50	170	1310	190
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.9	4.9		4.9	4.9		4.3	4.8	4.8	4.3	4.8	4.8
Lane Util. Factor	1.00	0.95		1.00	0.95		0.97	0.95	1.00	0.97	0.95	1.00
Frpb, ped/bikes	1.00	0.99		1.00	0.99		1.00	1.00	0.98	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.95		1.00	0.94		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1787	3386		1787	3334		3467	3574	1570	3467	3574	1575
Flt Permitted	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1787	3386		1787	3334		3467	3574	1570	3467	3574	1575
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	158	274	126	63	232	147	137	547	53	179	1379	200
RTOR Reduction (vph)	0	56	0	0	108	0	0	0	32	0	0	20
Lane Group Flow (vph)	158	344	0	63	271	0	137	547	21	179	1379	180
Confl. Peds. (#/hr)			7			14			8			3
Confl. Bikes (#/hr)						1						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Split			Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases									2			6
Actuated Green, G (s)	13.5	13.5		12.2	12.2		6.7	30.5	30.5	4.1	27.9	27.9
Effective Green, g (s)	12.6	12.6		11.3	11.3		6.4	30.7	30.7	3.8	28.1	28.1
Actuated g/C Ratio	0.16	0.16		0.15	0.15		0.08	0.40	0.40	0.05	0.36	0.36
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	5.0	5.0	4.0	5.0	5.0
Vehicle Extension (s)	2.0	2.0		2.0	2.0		2.0	2.0	2.0	2.0	2.0	2.0
Lane Grp Cap (vph)	291	552		261	487		287	1419	624	170	1299	573
v/s Ratio Prot	0.09	c0.10		0.04	c0.08		0.04	c0.15		c0.05	c0.39	
v/s Ratio Perm									0.01			0.11
v/c Ratio	0.54	0.62		0.24	0.56		0.48	0.39	0.03	1.05	1.06	0.31
Uniform Delay, d1	29.7	30.1		29.2	30.7		33.9	16.6	14.2	36.8	24.6	17.7
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.1	1.6		0.2	0.8		0.5	0.1	0.0	83.7	43.1	0.1
Delay (s)	30.8	31.7		29.4	31.4		34.3	16.6	14.2	120.5	67.7	17.8
Level of Service	C	C		C	C		C	B	B	F	E	B
Approach Delay (s)		31.5			31.2			19.8			67.4	
Approach LOS		C			C			B			E	

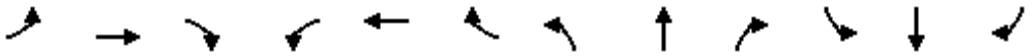
Intersection Summary			
HCM Average Control Delay	47.0	HCM Level of Service	D
HCM Volume to Capacity ratio	0.90		
Actuated Cycle Length (s)	77.3	Sum of lost time (s)	23.7
Intersection Capacity Utilization	79.7%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group



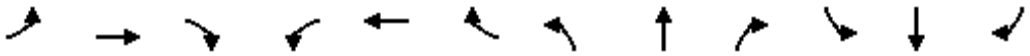
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	20	20	30	20	40	20	180	40	80	250	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frpb, ped/bikes		0.99			1.00	0.98	1.00	1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.95			1.00	0.85	1.00	0.97		1.00	0.99	
Flt Protected		0.98			0.97	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1732			1808	1552	1770	1805		1770	1838	
Flt Permitted		0.98			0.97	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		1732			1808	1552	1770	1805		1770	1838	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	22	22	33	22	43	22	196	43	87	272	22
RTOR Reduction (vph)	0	20	0	0	0	39	0	8	0	0	3	0
Lane Group Flow (vph)	0	46	0	0	55	4	22	231	0	87	291	0
Confl. Peds. (#/hr)	2		6	6		2	8		2	2		8
Confl. Bikes (#/hr)						1						
Turn Type	Split			Split		Perm	Split			Split		
Protected Phases	2	2		1	1		4	4		3	3	
Permitted Phases						1						
Actuated Green, G (s)		4.8			6.0	6.0	14.6	14.6		16.2	16.2	
Effective Green, g (s)		4.8			6.0	6.0	14.6	14.6		16.2	16.2	
Actuated g/C Ratio		0.08			0.10	0.10	0.25	0.25		0.28	0.28	
Clearance Time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0	3.0	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		144			188	162	449	458		498	517	
v/s Ratio Prot		c0.03			c0.03		0.01	c0.13		0.05	c0.16	
v/s Ratio Perm						0.00						
v/c Ratio		0.32			0.29	0.03	0.05	0.50		0.17	0.56	
Uniform Delay, d1		24.9			23.8	23.2	16.3	18.4		15.6	17.7	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		1.3			0.9	0.1	0.0	0.9		0.2	1.4	
Delay (s)		26.1			24.7	23.2	16.3	19.3		15.8	19.1	
Level of Service		C			C	C	B	B		B	B	
Approach Delay (s)		26.1			24.1			19.0			18.3	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	19.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.48		
Actuated Cycle Length (s)	57.6	Sum of lost time (s)	16.0
Intersection Capacity Utilization	39.6%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	190	170	50	60	180	50	20	480	40	50	670	120
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			0.95			0.95	
Frpb, ped/bikes	1.00	0.99		1.00	1.00			1.00			0.99	
Flpb, ped/bikes	0.99	1.00		0.99	1.00			1.00			1.00	
Frt	1.00	0.97		1.00	0.97			0.99			0.98	
Flt Protected	0.95	1.00		0.95	1.00			1.00			1.00	
Satd. Flow (prot)	1585	3054		1569	3069			3134			3081	
Flt Permitted	0.60	1.00		0.61	1.00			0.91			0.89	
Satd. Flow (perm)	1005	3054		1006	3069			2871			2760	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	198	177	52	62	188	52	21	500	42	52	698	125
RTOR Reduction (vph)	0	30	0	0	30	0	0	9	0	0	20	0
Lane Group Flow (vph)	198	199	0	62	210	0	0	554	0	0	855	0
Confl. Peds. (#/hr)	10		29	29		10	63		34	34		63
Confl. Bikes (#/hr)									1			
Parking (#/hr)							0					
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			4			2			2	
Permitted Phases	4			4			2			2		
Actuated Green, G (s)	30.0	30.0		30.0	30.0			32.0			32.0	
Effective Green, g (s)	29.0	29.0		29.0	29.0			31.0			31.0	
Actuated g/C Ratio	0.43	0.43		0.43	0.43			0.46			0.46	
Clearance Time (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	429	1302		429	1309			1309			1258	
v/s Ratio Prot		0.07			0.07							
v/s Ratio Perm	c0.20			0.06				0.19			c0.31	
v/c Ratio	0.46	0.15		0.14	0.16			0.42			0.68	
Uniform Delay, d1	13.9	12.0		11.9	12.0			12.5			14.6	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	3.5	0.2		0.7	0.3			1.0			3.0	
Delay (s)	17.5	12.2		12.6	12.3			13.5			17.6	
Level of Service	B	B		B	B			B			B	
Approach Delay (s)		14.7			12.3			13.5			17.6	
Approach LOS		B			B			B			B	

Intersection Summary			
HCM Average Control Delay	15.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	68.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	100.5%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	200	40	30	200	150	30	470	50	620	580	40
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0			5.0		5.0	5.0	
Lane Util. Factor		0.95			0.95			0.95		0.97	1.00	
Frpb, ped/bikes		1.00			0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00			1.00		1.00	1.00	
Frt		0.98			0.94			0.99		1.00	0.99	
Flt Protected		1.00			1.00			1.00		0.95	1.00	
Satd. Flow (prot)		3462			3326			3509		3467	1860	
Flt Permitted		0.90			0.90			1.00		0.95	1.00	
Satd. Flow (perm)		3128			3019			3509		3467	1860	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	21	213	43	32	213	160	32	500	53	660	617	43
RTOR Reduction (vph)	0	21	0	0	132	0	0	9	0	0	2	0
Lane Group Flow (vph)	0	256	0	0	273	0	0	576	0	660	658	0
Confl. Peds. (#/hr)	2		6	6		2	11		10	10		11
Confl. Bikes (#/hr)						2						1
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm			Perm			Split			Split		
Protected Phases		4			4		2	2		3	3	
Permitted Phases	4			4								
Actuated Green, G (s)		12.6			12.6			15.8		26.4	26.4	
Effective Green, g (s)		11.6			11.6			14.8		25.4	25.4	
Actuated g/C Ratio		0.17			0.17			0.22		0.38	0.38	
Clearance Time (s)		4.0			4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		543			524			777		1318	707	
v/s Ratio Prot								c0.16		0.19	c0.35	
v/s Ratio Perm		0.08			c0.09							
v/c Ratio		0.47			0.52			0.74		0.50	0.93	
Uniform Delay, d1		24.8			25.1			24.2		15.8	19.8	
Progression Factor		1.00			1.00			1.00		1.00	1.00	
Incremental Delay, d2		0.7			0.9			3.8		0.3	18.8	
Delay (s)		25.5			26.0			28.0		16.1	38.7	
Level of Service		C			C			C		B	D	
Approach Delay (s)		25.5			26.0			28.0			27.4	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	27.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	66.8	Sum of lost time (s)	15.0
Intersection Capacity Utilization	87.0%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	360	440	20	350	130	380	330	40	120	400	40
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Util. Factor		0.91	0.91		0.95		1.00	1.00			1.00	
Frpb, ped/bikes		0.99	0.96		0.99		1.00	1.00			1.00	
Flpb, ped/bikes		1.00	1.00		1.00		1.00	1.00			1.00	
Frt		0.95	0.85		0.96		1.00	0.98			0.99	
Flt Protected		1.00	1.00		1.00		0.95	1.00			0.99	
Satd. Flow (prot)		2987	1399		3159		1787	1587			1581	
Flt Permitted		0.92	1.00		0.88		0.95	1.00			0.99	
Satd. Flow (perm)		2767	1399		2784		1787	1587			1581	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	21	371	454	21	361	134	392	340	41	124	412	41
RTOR Reduction (vph)	0	61	203	0	42	0	0	5	0	0	3	0
Lane Group Flow (vph)	0	517	65	0	474	0	392	376	0	0	574	0
Confl. Peds. (#/hr)	17		21	21		17	30		15	15		30
Confl. Bikes (#/hr)			1			1						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Parking (#/hr)		8			8			8			8	
Turn Type	Perm		Perm	Perm			Split			Split		
Protected Phases		2			2		4	4		8	8	
Permitted Phases	2		2	2								
Actuated Green, G (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Effective Green, g (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Actuated g/C Ratio		0.24	0.24		0.24		0.30	0.30			0.31	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Grp Cap (vph)		667	337		671		538	478			495	
v/s Ratio Prot							0.22	c0.24			c0.36	
v/s Ratio Perm		c0.19	0.05		0.17							
v/c Ratio		0.77	0.19		0.71		0.73	0.79			1.16	
Uniform Delay, d1		29.4	25.1		28.8		26.0	26.6			28.5	
Progression Factor		1.00	1.00		1.00		1.00	1.00			1.00	
Incremental Delay, d2		8.5	1.3		6.2		8.4	12.3			92.0	
Delay (s)		37.9	26.3		35.0		34.4	38.9			120.5	
Level of Service		D	C		C		C	D			F	
Approach Delay (s)		34.3			35.0			36.6			120.5	
Approach LOS		C			C			D			F	

Intersection Summary			
HCM Average Control Delay	53.4	HCM Level of Service	D
HCM Volume to Capacity ratio	0.92		
Actuated Cycle Length (s)	83.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	91.8%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL2	EBL	EBT	EBR	NBT	NBR	NBR2	SBL2	SBL	SBT
Lane Configurations										
Volume (vph)	40	1100	400	150	620	370	110	390	320	540
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0	4.5	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor		0.91	0.91	1.00	0.95	1.00		1.00	1.00	1.00
Frpb, ped/bikes		1.00	1.00	0.85	1.00	0.92		1.00	1.00	1.00
Flpb, ped/bikes		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frt		1.00	1.00	0.85	1.00	0.85		1.00	1.00	1.00
Flt Protected		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (prot)		1610	3293	1344	3539	1452		1770	1770	1863
Flt Permitted		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (perm)		1610	3293	1344	3539	1452		1770	1770	1863
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	42	1158	421	158	653	389	116	411	337	568
RTOR Reduction (vph)	0	0	0	99	0	12	0	0	0	0
Lane Group Flow (vph)	0	598	1023	59	653	493	0	411	337	568
Confl. Peds. (#/hr)				50			50		50	
Confl. Bikes (#/hr)				10			10			
Turn Type	Perm	Perm		Perm		Perm		Prot	Prot	
Protected Phases			4		2			1	1	6
Permitted Phases	4	4		4		2				
Actuated Green, G (s)		32.5	32.5	32.5	22.5	22.5		22.0	22.0	47.5
Effective Green, g (s)		34.0	34.0	33.5	22.0	22.0		22.0	22.0	48.0
Actuated g/C Ratio		0.38	0.38	0.37	0.24	0.24		0.24	0.24	0.53
Clearance Time (s)		5.5	5.5	5.5	3.5	3.5		4.0	4.0	4.5
Vehicle Extension (s)		2.0	2.0	2.0	2.0	2.0		2.0	2.0	2.0
Lane Grp Cap (vph)		608	1244	500	865	355		433	433	994
v/s Ratio Prot					0.18			c0.23	0.19	0.30
v/s Ratio Perm		c0.37	0.31	0.04		c0.34				
v/c Ratio		0.98	0.95dl	0.12	0.75	1.39		0.95	0.78	0.57
Uniform Delay, d1		27.7	25.3	18.5	31.5	34.0		33.5	31.7	14.1
Progression Factor		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2		32.0	4.3	0.0	3.4	191.4		32.2	12.9	2.4
Delay (s)		59.8	29.6	18.6	34.9	225.4		65.7	44.6	16.5
Level of Service		E	C	B	C	F		E	D	B
Approach Delay (s)			38.7		117.9					39.1
Approach LOS			D		F					D

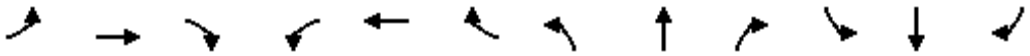
Intersection Summary			
HCM Average Control Delay	60.4	HCM Level of Service	E
HCM Volume to Capacity ratio	1.09		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	91.8%	ICU Level of Service	F
Analysis Period (min)	15		

dl Defacto Left Lane. Recode with 1 though lane as a left lane.

c Critical Lane Group

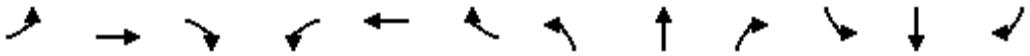
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	450	1280	0	0	0	0	0	970	580
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0						4.0	4.0
Lane Util. Factor				0.86	0.86						0.86	0.86
Frpb, ped/bikes				1.00	1.00						1.00	1.00
Flpb, ped/bikes				1.00	1.00						1.00	1.00
Frt				1.00	1.00						0.97	0.85
Flt Protected				0.95	1.00						1.00	1.00
Satd. Flow (prot)				1522	4798						4651	1362
Flt Permitted				0.95	1.00						1.00	1.00
Satd. Flow (perm)				1522	4798						4651	1362
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	474	1347	0	0	0	0	0	1021	611
RTOR Reduction (vph)	0	0	0	294	4	0	0	0	0	0	24	24
Lane Group Flow (vph)	0	0	0	133	1390	0	0	0	0	0	1241	343
Confl. Bikes (#/hr)						5						9
Turn Type				Prot								Prot
Protected Phases				7	3						2	2
Permitted Phases												
Actuated Green, G (s)				20.0	40.0						31.0	31.0
Effective Green, g (s)				20.0	40.0						31.0	31.0
Actuated g/C Ratio				0.25	0.51						0.39	0.39
Clearance Time (s)				4.0	4.0						4.0	4.0
Lane Grp Cap (vph)				385	2429						1825	534
v/s Ratio Prot				0.09	c0.14						c0.27	0.25
v/s Ratio Perm					0.14							
v/c Ratio				0.35	0.57						0.68	0.64
Uniform Delay, d1				24.2	13.6						19.9	19.5
Progression Factor				1.00	1.00						1.00	1.00
Incremental Delay, d2				2.5	1.0						2.1	5.9
Delay (s)				26.6	14.5						22.0	25.4
Level of Service				C	B						C	C
Approach Delay (s)		0.0			17.4			0.0			22.7	
Approach LOS		A			B			A			C	

Intersection Summary			
HCM Average Control Delay	19.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	79.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	56.0%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	350	1090	0	0	0	0	0	1120	1970	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0						4.0	4.0			
Lane Util. Factor		0.91						0.91	0.88			
Frpb, ped/bikes		1.00						1.00	1.00			
Flpb, ped/bikes		1.00						1.00	1.00			
Frt		1.00						1.00	0.85			
Flt Protected		0.99						1.00	1.00			
Satd. Flow (prot)		5006						5085	2787			
Flt Permitted		0.99						1.00	1.00			
Satd. Flow (perm)		5006						5085	2787			
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	368	1147	0	0	0	0	0	1179	2074	0	0	0
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	97	0	0	0
Lane Group Flow (vph)	0	1515	0	0	0	0	0	1179	1977	0	0	0
Confl. Peds. (#/hr)	28		7	7		28	99		3	3		99
Confl. Bikes (#/hr)			1			2			1			
Turn Type	Perm								custom			
Protected Phases		4						2	2			
Permitted Phases	4								7			
Actuated Green, G (s)		34.0						16.0	16.0			
Effective Green, g (s)		35.0						17.0	17.0			
Actuated g/C Ratio		0.58						0.28	0.28			
Clearance Time (s)		5.0						5.0	5.0			
Vehicle Extension (s)		3.0						3.0	3.0			
Lane Grp Cap (vph)		2920						1441	790			
v/s Ratio Prot								0.23	c0.71			
v/s Ratio Perm		0.30										
v/c Ratio		0.52						0.82	2.50			
Uniform Delay, d1		7.5						20.1	21.5			
Progression Factor		1.00						1.00	1.00			
Incremental Delay, d2		0.7						3.7	679.6			
Delay (s)		8.1						23.8	701.1			
Level of Service		A						C	F			
Approach Delay (s)		8.1			0.0			455.7			0.0	
Approach LOS		A			A			F			A	

Intersection Summary			
HCM Average Control Delay	313.5	HCM Level of Service	F
HCM Volume to Capacity ratio	1.17		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	104.2%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

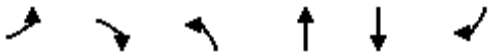


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	70	1500	1490	0	0	0	0	380	430	130	360	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0					4.0			4.0	
Lane Util. Factor		0.86	0.86					1.00			1.00	
Frpb, ped/bikes		0.98	0.97					0.98			1.00	
Flpb, ped/bikes		1.00	1.00					1.00			1.00	
Frt		0.95	0.85					0.93			1.00	
Flt Protected		1.00	1.00					1.00			0.99	
Satd. Flow (prot)		4453	1323					1694			1836	
Flt Permitted		1.00	1.00					1.00			0.14	
Satd. Flow (perm)		4453	1323					1694			262	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	74	1579	1568	0	0	0	0	400	453	137	379	0
RTOR Reduction (vph)	0	64	0	0	0	0	0	13	0	0	0	0
Lane Group Flow (vph)	0	2373	784	0	0	0	0	840	0	0	516	0
Confl. Peds. (#/hr)	52		55	55		52	39		25	25		39
Confl. Bikes (#/hr)			1						2		1	2
Turn Type	Perm		Free							Perm		
Protected Phases		2						4			8	
Permitted Phases	2		Free							8		
Actuated Green, G (s)		33.0	60.0					18.0			18.0	
Effective Green, g (s)		34.0	60.0					18.0			18.0	
Actuated g/C Ratio		0.57	1.00					0.30			0.30	
Clearance Time (s)		5.0						4.0			4.0	
Vehicle Extension (s)		2.0						2.0			2.0	
Lane Grp Cap (vph)		2523	1323					508			79	
v/s Ratio Prot								0.50				
v/s Ratio Perm		0.53	0.59								c1.97	
v/c Ratio		0.94	0.59					1.65			6.53	
Uniform Delay, d1		12.1	0.0					21.0			21.0	
Progression Factor		0.62	1.00					1.00			1.00	
Incremental Delay, d2		1.0	0.2					302.5			2515.9	
Delay (s)		8.4	0.2					323.5			2536.9	
Level of Service		A	A					F			F	
Approach Delay (s)		6.4			0.0			323.5			2536.9	
Approach LOS		A			A			F			F	

Intersection Summary			
HCM Average Control Delay	349.8	HCM Level of Service	F
HCM Volume to Capacity ratio	2.89		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	128.4%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

Cumulative (2035) Plus Phase 1 Project Conditions

FEHR PEERS



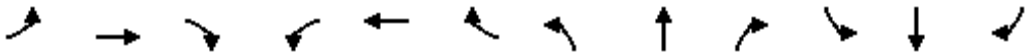
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	560	90	50	1317	1154	770
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	1.00	1.00	0.95	0.91	0.88
Frpb, ped/bikes	1.00	0.98	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3400	1535	1752	3505	5036	2760
Flt Permitted	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	3400	1535	1752	3505	5036	2760
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	609	98	54	1432	1254	837
RTOR Reduction (vph)	0	0	0	0	0	586
Lane Group Flow (vph)	609	98	54	1432	1254	251
Confl. Peds. (#/hr)	3	11	4			4
Confl. Bikes (#/hr)		5				5
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%
Turn Type		Perm	Prot			Prot
Protected Phases	4		5	2	6	6
Permitted Phases		4				
Actuated Green, G (s)	26.0	26.0	4.0	26.0	18.0	18.0
Effective Green, g (s)	26.0	26.0	4.0	26.0	18.0	18.0
Actuated g/C Ratio	0.43	0.43	0.07	0.43	0.30	0.30
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Grp Cap (vph)	1473	665	117	1519	1511	828
v/s Ratio Prot	c0.18		0.03	c0.41	0.25	0.09
v/s Ratio Perm		0.06				
v/c Ratio	0.41	0.15	0.46	0.94	0.83	0.30
Uniform Delay, d1	11.7	10.3	27.0	16.3	19.6	16.2
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.9	0.5	12.5	13.0	5.4	0.9
Delay (s)	12.6	10.8	39.5	29.3	25.0	17.1
Level of Service	B	B	D	C	C	B
Approach Delay (s)	12.3			29.6	21.8	
Approach LOS	B			C	C	

Intersection Summary			
HCM Average Control Delay	23.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	68.9%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	72	42	240	195	130	95	220	100	80	102	32
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95			0.95	1.00	1.00	0.95		0.91	0.91	
Frpb, ped/bikes		0.99			1.00	0.98	1.00	0.99		1.00	0.99	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.95			1.00	0.85	1.00	0.95		1.00	0.97	
Flt Protected		0.99			0.97	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3189			3299	1500	1703	3216		1550	3126	
Flt Permitted		0.88			0.74	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		2816			2522	1500	1703	3216		1550	3126	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	78	46	261	212	141	103	239	109	87	111	35
RTOR Reduction (vph)	0	30	0	0	0	0	0	72	0	0	29	0
Lane Group Flow (vph)	0	116	0	0	473	141	103	276	0	77	127	0
Confl. Peds. (#/hr)	9		8	8		9	12		17	17		12
Confl. Bikes (#/hr)						3			5			2
Heavy Vehicles (%)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
Turn Type	Perm			Perm		Free	Split			Split		
Protected Phases		2			6		3	3		4	4	
Permitted Phases	2			6		Free						
Actuated Green, G (s)		16.4			15.4	47.5	10.8	10.8		7.3	7.3	
Effective Green, g (s)		16.4			16.4	47.5	10.8	10.8		8.3	8.3	
Actuated g/C Ratio		0.35			0.35	1.00	0.23	0.23		0.17	0.17	
Clearance Time (s)		4.0			5.0		4.0	4.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		972			871	1500	387	731		271	546	
v/s Ratio Prot							0.06	c0.09		c0.05	0.04	
v/s Ratio Perm		0.04			c0.19	0.09						
v/c Ratio		0.12			0.54	0.09	0.27	0.38		0.28	0.23	
Uniform Delay, d1		10.6			12.5	0.0	15.1	15.5		17.0	16.9	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.1			0.7	0.1	0.4	0.3		0.6	0.2	
Delay (s)		10.7			13.2	0.1	15.5	15.8		17.6	17.1	
Level of Service		B			B	A	B	B		B	B	
Approach Delay (s)		10.7			10.2			15.8			17.3	
Approach LOS		B			B			B			B	

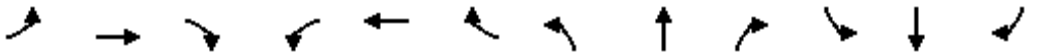
Intersection Summary			
HCM Average Control Delay	13.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.43		
Actuated Cycle Length (s)	47.5	Sum of lost time (s)	12.0
Intersection Capacity Utilization	50.5%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	211	20	200	505	70	30	100	270	40	90	30
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	0.99			0.97			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	0.99		1.00	0.98			0.91			0.97	
Flt Protected	0.95	1.00		0.95	1.00			1.00			0.99	
Satd. Flow (prot)	1736	3412		1736	3390			1606			1744	
Flt Permitted	0.95	1.00		0.95	1.00			0.97			0.85	
Satd. Flow (perm)	1736	3412		1736	3390			1566			1508	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	229	22	217	549	76	33	109	293	43	98	33
RTOR Reduction (vph)	0	12	0	0	18	0	0	124	0	0	14	0
Lane Group Flow (vph)	22	239	0	217	607	0	0	311	0	0	160	0
Confl. Peds. (#/hr)	11		13	13		11	22		48	48		22
Confl. Bikes (#/hr)			1			2			1			
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Effective Green, g (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Actuated g/C Ratio	0.10	0.27		0.10	0.27			0.43			0.43	
Clearance Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Grp Cap (vph)	174	910		174	904			679			653	
v/s Ratio Prot	0.01	0.07		c0.13	c0.18							
v/s Ratio Perm								c0.20			0.11	
v/c Ratio	0.13	0.26		1.25	0.67			0.46			0.24	
Uniform Delay, d1	24.6	17.3		27.0	19.6			12.0			10.8	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	1.5	0.7		149.9	4.0			2.2			0.9	
Delay (s)	26.1	18.1		176.9	23.6			14.2			11.7	
Level of Service	C	B		F	C			B			B	
Approach Delay (s)		18.7			63.1			14.2			11.7	
Approach LOS		B			E			B			B	

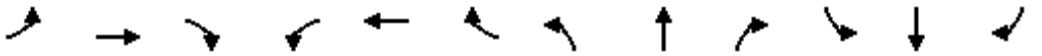
Intersection Summary			
HCM Average Control Delay	38.6	HCM Level of Service	D
HCM Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	62.2%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	367	345	130	60	501	90	160	940	100	170	610	474
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	11	12	11	11	12	12	12	12	12	12	12
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.97	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.97	1.00	0.98		1.00	1.00		1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.98		1.00	0.99		1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	2828	3020	1353	1510	2897		1562	3064		1562	3124	1353
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (perm)	2828	3020	1353	1510	2897		1562	3064		1562	3124	1353
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	399	375	141	65	545	98	174	1022	109	185	663	515
RTOR Reduction (vph)	0	0	87	0	12	0	0	7	0	0	0	37
Lane Group Flow (vph)	399	375	54	65	631	0	174	1124	0	185	663	478
Confl. Peds. (#/hr)			16			85			25			37
Confl. Bikes (#/hr)						1			1			1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Bus Blockages (#/hr)	0	0	0	0	0	2	0	0	0	0	0	8
Turn Type	Prot		Perm	Prot			Prot			Prot		pt+ov
Protected Phases	7	4		3	8		5	2		1	6	6 7
Permitted Phases			4									
Actuated Green, G (s)	18.0	38.2	38.2	8.2	28.4		18.0	44.0		13.0	39.0	62.0
Effective Green, g (s)	18.0	38.2	38.2	8.2	28.4		18.0	45.0		13.0	40.0	63.0
Actuated g/C Ratio	0.15	0.32	0.32	0.07	0.24		0.15	0.37		0.11	0.33	0.52
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	5.0		4.0	5.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	423	958	429	103	683		234	1145		169	1038	708
v/s Ratio Prot	c0.14	0.12		0.04	c0.22		c0.11	c0.37		c0.12	0.21	0.35
v/s Ratio Perm			0.04									
v/c Ratio	0.94	0.39	0.13	0.63	0.92		0.74	0.98		1.09	0.64	0.68
Uniform Delay, d1	50.7	32.0	29.2	54.6	44.9		49.0	37.3		53.7	34.1	21.2
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	29.6	0.3	0.1	11.9	18.2		12.0	22.1		96.8	1.3	2.6
Delay (s)	80.3	32.3	29.4	66.6	63.1		61.0	59.4		150.5	35.4	23.7
Level of Service	F	C	C	E	E		E	E		F	D	C
Approach Delay (s)		52.8			63.4			59.7			46.6	
Approach LOS		D			E			E			D	

Intersection Summary			
HCM Average Control Delay	54.7	HCM Level of Service	D
HCM Volume to Capacity ratio	0.94		
Actuated Cycle Length (s)	120.4	Sum of lost time (s)	12.0
Intersection Capacity Utilization	91.2%	ICU Level of Service	F
Analysis Period (min)	15		

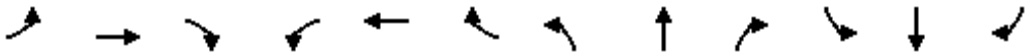
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	100	323	132	60	296	120	185	830	60	120	510	140
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.9	4.9		4.9	4.9		4.3	4.8	4.8	4.3	4.8	4.8
Lane Util. Factor	1.00	0.95		1.00	0.95		0.97	0.95	1.00	0.97	0.95	1.00
Frpb, ped/bikes	1.00	0.99		1.00	0.99		1.00	1.00	0.98	1.00	1.00	0.98
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.96		1.00	0.96		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	3368		1770	3362		3433	3539	1557	3433	3539	1548
Flt Permitted	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	3368		1770	3362		3433	3539	1557	3433	3539	1548
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	108	347	142	65	318	129	199	892	65	129	548	151
RTOR Reduction (vph)	0	45	0	0	45	0	0	0	44	0	0	44
Lane Group Flow (vph)	108	444	0	65	402	0	199	892	21	129	548	107
Confl. Peds. (#/hr)			7			13			6			11
Confl. Bikes (#/hr)						2						
Turn Type	Split			Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases									2			6
Actuated Green, G (s)	15.9	15.9		15.2	15.2		7.3	24.8	24.8	4.2	21.7	21.7
Effective Green, g (s)	15.0	15.0		14.3	14.3		7.0	25.0	25.0	3.9	21.9	21.9
Actuated g/C Ratio	0.19	0.19		0.19	0.19		0.09	0.32	0.32	0.05	0.28	0.28
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	5.0	5.0	4.0	5.0	5.0
Vehicle Extension (s)	2.0	2.0		2.0	2.0		2.0	2.0	2.0	2.0	2.0	2.0
Lane Grp Cap (vph)	344	655		328	624		312	1148	505	174	1005	440
v/s Ratio Prot	0.06	c0.13		0.04	c0.12		c0.06	c0.25		0.04	0.15	
v/s Ratio Perm									0.01			0.07
v/c Ratio	0.31	0.68		0.20	0.64		0.64	0.78	0.04	0.74	0.55	0.24
Uniform Delay, d1	26.6	28.8		26.6	29.0		33.8	23.5	17.8	36.1	23.4	21.2
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.2	2.2		0.1	1.7		3.1	3.1	0.0	13.8	0.3	0.1
Delay (s)	26.8	31.0		26.7	30.8		37.0	26.6	17.9	49.9	23.7	21.3
Level of Service	C	C		C	C		D	C	B	D	C	C
Approach Delay (s)		30.2			30.2			27.9			27.4	
Approach LOS		C			C			C			C	

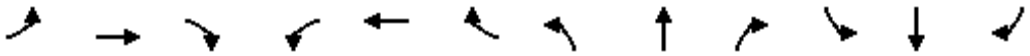
Intersection Summary			
HCM Average Control Delay	28.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.73		
Actuated Cycle Length (s)	77.1	Sum of lost time (s)	18.9
Intersection Capacity Utilization	64.3%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



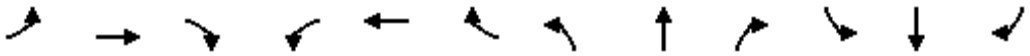
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	30	22	22	90	45	130	25	285	50	60	272	82
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frpb, ped/bikes		0.99			1.00	0.98	1.00	0.99		1.00	0.99	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.96			1.00	0.85	1.00	0.98		1.00	0.97	
Flt Protected		0.98			0.97	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1741			1803	1555	1770	1806		1770	1781	
Flt Permitted		0.98			0.97	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		1741			1803	1555	1770	1806		1770	1781	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	33	24	24	98	49	141	27	310	54	65	296	89
RTOR Reduction (vph)	0	18	0	0	0	121	0	7	0	0	12	0
Lane Group Flow (vph)	0	63	0	0	147	20	27	357	0	65	373	0
Confl. Peds. (#/hr)	2		1	1		2	13		20	20		13
Confl. Bikes (#/hr)						1			5			
Turn Type	Split			Split		Perm	Split			Split		
Protected Phases	2	2		1	1		4	4		3	3	
Permitted Phases						1						
Actuated Green, G (s)		7.4			10.4	10.4	19.6	19.6		20.6	20.6	
Effective Green, g (s)		7.4			10.4	10.4	19.6	19.6		20.6	20.6	
Actuated g/C Ratio		0.10			0.14	0.14	0.26	0.26		0.28	0.28	
Clearance Time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0	3.0	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		174			253	219	469	478		493	496	
v/s Ratio Prot		c0.04			c0.08		0.02	c0.20		0.04	c0.21	
v/s Ratio Perm						0.01						
v/c Ratio		0.36			0.58	0.09	0.06	0.75		0.13	0.75	
Uniform Delay, d1		31.1			29.8	27.7	20.3	24.9		20.0	24.4	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		1.3			3.4	0.2	0.1	6.3		0.1	6.4	
Delay (s)		32.4			33.1	27.9	20.4	31.2		20.1	30.8	
Level of Service		C			C	C	C	C		C	C	
Approach Delay (s)		32.4			30.6			30.5			29.2	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	30.2	HCM Level of Service	C
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	74.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	45.0%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	280	252	60	60	335	70	70	650	30	60	410	100
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			0.95			0.95	
Frpb, ped/bikes	1.00	0.99		1.00	0.99			1.00			0.99	
Flpb, ped/bikes	0.98	1.00		0.99	1.00			1.00			1.00	
Frt	1.00	0.97		1.00	0.97			0.99			0.97	
Flt Protected	0.95	1.00		0.95	1.00			1.00			0.99	
Satd. Flow (prot)	1544	3048		1562	3045			3113			3034	
Flt Permitted	0.47	1.00		0.54	1.00			0.84			0.81	
Satd. Flow (perm)	759	3048		892	3045			2629			2466	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	304	274	65	65	364	76	76	707	33	65	446	109
RTOR Reduction (vph)	0	30	0	0	26	0	0	4	0	0	27	0
Lane Group Flow (vph)	304	309	0	65	414	0	0	812	0	0	593	0
Confl. Peds. (#/hr)	56		22	22		56	31		42	42		31
Confl. Bikes (#/hr)						2			5			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			4			2			2	
Permitted Phases	4			4			2			2		
Actuated Green, G (s)	30.0	30.0		30.0	30.0			32.0			32.0	
Effective Green, g (s)	29.0	29.0		29.0	29.0			31.0			31.0	
Actuated g/C Ratio	0.43	0.43		0.43	0.43			0.46			0.46	
Clearance Time (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	324	1300		380	1299			1199			1124	
v/s Ratio Prot		0.10			0.14							
v/s Ratio Perm	c0.40			0.07				c0.31			0.24	
v/c Ratio	0.94	0.24		0.17	0.32			0.68			0.53	
Uniform Delay, d1	18.6	12.4		12.1	12.9			14.6			13.3	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	36.5	0.4		1.0	0.6			3.1			1.8	
Delay (s)	55.1	12.9		13.0	13.6			17.6			15.0	
Level of Service	E	B		B	B			B			B	
Approach Delay (s)		32.9			13.5			17.6			15.0	
Approach LOS		C			B			B			B	

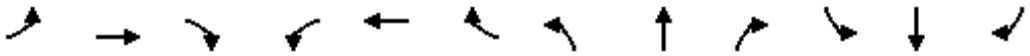
Intersection Summary			
HCM Average Control Delay	20.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.80		
Actuated Cycle Length (s)	68.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	103.1%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	262	40	20	365	315	40	580	20	272	390	30
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0			5.0		5.0	5.0	
Lane Util. Factor		0.95			0.95			0.95		0.97	1.00	
Frpb, ped/bikes		1.00			0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00			1.00		1.00	1.00	
Frt		0.98			0.93			1.00		1.00	0.99	
Flt Protected		1.00			1.00			1.00		0.95	1.00	
Satd. Flow (prot)		3481			3304			3542		3467	1858	
Flt Permitted		0.81			0.94			1.00		0.95	1.00	
Satd. Flow (perm)		2812			3100			3542		3467	1858	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	285	43	22	397	342	43	630	22	296	424	33
RTOR Reduction (vph)	0	14	0	0	188	0	0	3	0	0	4	0
Lane Group Flow (vph)	0	336	0	0	573	0	0	692	0	296	453	0
Confl. Peds. (#/hr)	2		11	11		2	14		25	25		14
Confl. Bikes (#/hr)			1			2						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm			Perm			Split			Split		
Protected Phases		4			4		2	2		3	3	
Permitted Phases	4			4								
Actuated Green, G (s)		18.9			18.9			18.0		22.1	22.1	
Effective Green, g (s)		17.9			17.9			17.0		21.1	21.1	
Actuated g/C Ratio		0.25			0.25			0.24		0.30	0.30	
Clearance Time (s)		4.0			4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		709			782			848		1030	552	
v/s Ratio Prot								c0.20		0.09	c0.24	
v/s Ratio Perm		0.12			c0.18							
v/c Ratio		0.47			0.73			0.82		0.29	0.82	
Uniform Delay, d1		22.5			24.4			25.5		19.2	23.2	
Progression Factor		1.00			1.00			1.00		1.00	1.00	
Incremental Delay, d2		0.5			3.6			6.1		0.2	9.6	
Delay (s)		23.1			27.9			31.6		19.3	32.8	
Level of Service		C			C			C		B	C	
Approach Delay (s)		23.1			27.9			31.6			27.5	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	28.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	71.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	88.6%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	304	381	20	474	160	445	340	30	90	280	30
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Util. Factor		0.91	0.91		0.95		1.00	1.00			1.00	
Frpb, ped/bikes		0.99	0.96		0.99		1.00	1.00			1.00	
Flpb, ped/bikes		1.00	1.00		1.00		1.00	1.00			1.00	
Frt		0.95	0.85		0.96		1.00	0.99			0.99	
Flt Protected		1.00	1.00		1.00		0.95	1.00			0.99	
Satd. Flow (prot)		2957	1385		3139		1770	1578			1564	
Flt Permitted		0.80	1.00		0.92		0.95	1.00			0.99	
Satd. Flow (perm)		2376	1385		2900		1770	1578			1564	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	330	414	22	515	174	484	370	33	98	304	33
RTOR Reduction (vph)	0	61	188	0	38	0	0	4	0	0	3	0
Lane Group Flow (vph)	0	457	60	0	673	0	484	399	0	0	432	0
Confl. Peds. (#/hr)	16		21	21		16	20		16	16		20
Confl. Bikes (#/hr)			1			2			1			
Parking (#/hr)		8			8			8			8	
Turn Type	Perm		Perm	Perm			Split			Split		
Protected Phases		2			2		4	4		8	8	
Permitted Phases	2		2	2								
Actuated Green, G (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Effective Green, g (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Actuated g/C Ratio		0.24	0.24		0.24		0.30	0.30			0.31	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Grp Cap (vph)		573	334		699		533	475			490	
v/s Ratio Prot							c0.27	0.25			c0.28	
v/s Ratio Perm		0.19	0.04		c0.23							
v/c Ratio		0.80	0.18		0.96		0.91	0.84			0.88	
Uniform Delay, d1		29.6	25.0		31.1		27.9	27.1			27.0	
Progression Factor		1.00	1.00		1.00		1.00	1.00			1.00	
Incremental Delay, d2		11.1	1.2		26.1		21.8	16.2			19.8	
Delay (s)		40.7	26.2		57.2		49.7	43.3			46.8	
Level of Service		D	C		E		D	D			D	
Approach Delay (s)		36.0			57.2			46.8			46.8	
Approach LOS		D			E			D			D	

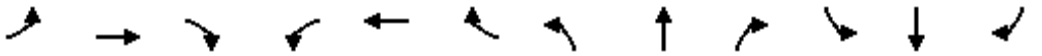
Intersection Summary			
HCM Average Control Delay	46.5	HCM Level of Service	D
HCM Volume to Capacity ratio	0.91		
Actuated Cycle Length (s)	83.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	89.9%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL2	EBL	EBT	EBR	NBT	NBR	NBR2	SBL2	SBL	SBT
Lane Configurations										
Volume (vph)	140	871	170	140	380	272	90	435	170	400
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0	4.5	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor		0.91	0.91	1.00	0.95	1.00		1.00	1.00	1.00
Frpb, ped/bikes		1.00	1.00	0.87	1.00	0.93		1.00	1.00	1.00
Flpb, ped/bikes		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frt		1.00	1.00	0.85	1.00	0.85		1.00	1.00	1.00
Flt Protected		0.95	0.96	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (prot)		1610	3268	1370	3539	1480		1770	1770	1863
Flt Permitted		0.95	0.96	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (perm)		1610	3268	1370	3539	1480		1770	1770	1863
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	147	917	179	147	400	286	95	458	179	421
RTOR Reduction (vph)	0	0	0	108	0	17	0	0	0	0
Lane Group Flow (vph)	0	532	711	39	400	364	0	458	179	421
Confl. Peds. (#/hr)				50			50		50	
Confl. Bikes (#/hr)				10			10			
Turn Type	Perm	Perm		Perm		Perm		Prot	Prot	
Protected Phases			4		2			1	1	6
Permitted Phases	4	4		4		2				
Actuated Green, G (s)		19.0	19.0	19.0	21.4	21.4		21.1	21.1	46.0
Effective Green, g (s)		20.5	20.5	20.0	20.9	20.9		21.6	21.6	46.5
Actuated g/C Ratio		0.27	0.27	0.27	0.28	0.28		0.29	0.29	0.62
Clearance Time (s)		5.5	5.5	5.5	3.5	3.5		4.5	4.5	4.5
Vehicle Extension (s)		2.0	2.0	2.0	2.0	2.0		2.0	2.0	2.0
Lane Grp Cap (vph)		440	893	365	986	412		510	510	1155
v/s Ratio Prot					0.11			c0.26	0.10	0.23
v/s Ratio Perm		c0.33	0.22	0.03		c0.25				
v/c Ratio		1.21	1.16dl	0.11	0.41	0.88		0.90	0.35	0.36
Uniform Delay, d1		27.2	25.3	20.8	22.0	25.9		25.6	21.1	7.0
Progression Factor		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2		113.7	4.6	0.0	0.1	19.2		21.2	1.9	0.9
Delay (s)		140.9	30.0	20.8	22.1	45.1		46.9	23.0	7.9
Level of Service		F	C	C	C	D		D	C	A
Approach Delay (s)			71.5		33.3					27.3
Approach LOS			E		C					C

Intersection Summary			
HCM Average Control Delay	47.8	HCM Level of Service	D
HCM Volume to Capacity ratio	0.99		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	80.6%	ICU Level of Service	D
Analysis Period (min)	15		

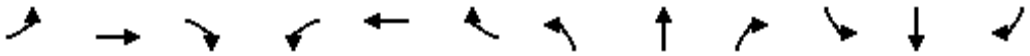
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

c Critical Lane Group



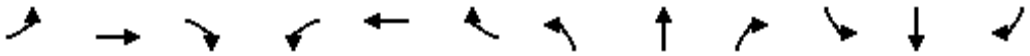
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	583	1431	0	0	0	0	0	647	570
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0						4.0	4.0
Lane Util. Factor				0.86	0.86						0.86	0.86
Frpb, ped/bikes				1.00	1.00						0.99	1.00
Flpb, ped/bikes				1.00	1.00						1.00	1.00
Frt				1.00	1.00						0.95	0.85
Flt Protected				0.95	1.00						1.00	1.00
Satd. Flow (prot)				1522	4790						4561	1362
Flt Permitted				0.95	1.00						1.00	1.00
Satd. Flow (perm)				1522	4790						4561	1362
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	614	1506	0	0	0	0	0	681	600
RTOR Reduction (vph)	0	0	0	332	9	0	0	0	0	0	16	16
Lane Group Flow (vph)	0	0	0	178	1601	0	0	0	0	0	965	284
Confl. Bikes (#/hr)						9						10
Turn Type				Prot								Prot
Protected Phases				7	3						2	2
Permitted Phases												
Actuated Green, G (s)				20.0	40.0						31.0	31.0
Effective Green, g (s)				20.0	40.0						31.0	31.0
Actuated g/C Ratio				0.25	0.51						0.39	0.39
Clearance Time (s)				4.0	4.0						4.0	4.0
Lane Grp Cap (vph)				385	2425						1790	534
v/s Ratio Prot				0.12	c0.17						c0.21	0.21
v/s Ratio Perm					0.17							
v/c Ratio				0.46	0.66						0.54	0.53
Uniform Delay, d1				25.0	14.5						18.5	18.4
Progression Factor				1.00	1.00						1.00	1.00
Incremental Delay, d2				4.0	1.4						1.2	3.8
Delay (s)				28.9	15.9						19.7	22.2
Level of Service				C	B						B	C
Approach Delay (s)		0.0			19.0			0.0			20.3	
Approach LOS		A			B			A			C	

Intersection Summary			
HCM Average Control Delay	19.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	79.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	59.8%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	300	470	0	0	0	0	0	1262	1945	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0						4.0	4.0			
Lane Util. Factor		0.91						0.91	0.88			
Frpb, ped/bikes		1.00						1.00	1.00			
Flpb, ped/bikes		1.00						1.00	1.00			
Frt		1.00						1.00	0.85			
Flt Protected		0.98						1.00	1.00			
Satd. Flow (prot)		4973						5085	2787			
Flt Permitted		0.98						1.00	1.00			
Satd. Flow (perm)		4973						5085	2787			
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	316	495	0	0	0	0	0	1328	2047	0	0	0
RTOR Reduction (vph)	0	4	0	0	0	0	0	0	242	0	0	0
Lane Group Flow (vph)	0	807	0	0	0	0	0	1328	1805	0	0	0
Confl. Peds. (#/hr)	12		21	21		12	42		29	29		42
Confl. Bikes (#/hr)			2			1						1
Turn Type	Perm								custom			
Protected Phases		4						2	2			
Permitted Phases	4								7			
Actuated Green, G (s)		27.0						23.0	23.0			
Effective Green, g (s)		27.0						24.0	24.0			
Actuated g/C Ratio		0.45						0.40	0.40			
Clearance Time (s)		5.0						5.0	5.0			
Vehicle Extension (s)		3.0						3.0	3.0			
Lane Grp Cap (vph)		2238						2034	1115			
v/s Ratio Prot								0.26	c0.65			
v/s Ratio Perm		0.16										
v/c Ratio		0.36						0.65	1.62			
Uniform Delay, d1		10.8						14.6	18.0			
Progression Factor		1.00						1.00	1.00			
Incremental Delay, d2		0.5						0.8	282.5			
Delay (s)		11.3						15.4	300.5			
Level of Service		B						B	F			
Approach Delay (s)		11.3			0.0			188.3			0.0	
Approach LOS		B			A			F			A	

Intersection Summary			
HCM Average Control Delay	154.0	HCM Level of Service	F
HCM Volume to Capacity ratio	0.95		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	100.7%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

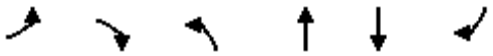


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	70	833	1512	0	0	0	0	290	110	110	350	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0					4.0			4.0	
Lane Util. Factor		0.86	0.86					1.00			1.00	
Frpb, ped/bikes		0.96	0.97					0.98			1.00	
Flpb, ped/bikes		1.00	1.00					1.00			0.99	
Frt		0.93	0.85					0.96			1.00	
Flt Protected		1.00	1.00					1.00			0.99	
Satd. Flow (prot)		4269	1315					1749			1826	
Flt Permitted		1.00	1.00					1.00			0.45	
Satd. Flow (perm)		4269	1315					1749			834	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	74	877	1592	0	0	0	0	305	116	116	368	0
RTOR Reduction (vph)	0	73	0	0	0	0	0	23	0	0	0	0
Lane Group Flow (vph)	0	1674	796	0	0	0	0	398	0	0	484	0
Confl. Peds. (#/hr)	51		75	75		51	29		79	79		29
Confl. Bikes (#/hr)											1	1
Turn Type	Perm		Free							Perm		
Protected Phases		2						4			8	
Permitted Phases	2		Free							8		
Actuated Green, G (s)		33.0	60.0					18.0			18.0	
Effective Green, g (s)		34.0	60.0					18.0			18.0	
Actuated g/C Ratio		0.57	1.00					0.30			0.30	
Clearance Time (s)		5.0						4.0			4.0	
Vehicle Extension (s)		2.0						2.0			2.0	
Lane Grp Cap (vph)		2419	1315					525			250	
v/s Ratio Prot								0.23				
v/s Ratio Perm		0.39	0.61								c0.58	
v/c Ratio		0.90dr	0.61					0.76			1.94	
Uniform Delay, d1		9.3	0.0					19.0			21.0	
Progression Factor		0.72	1.00					1.00			1.00	
Incremental Delay, d2		0.2	0.2					5.5			435.6	
Delay (s)		6.8	0.2					24.5			456.6	
Level of Service		A	A					C			F	
Approach Delay (s)		4.7			0.0			24.5			456.6	
Approach LOS		A			A			C			F	

Intersection Summary			
HCM Average Control Delay	70.6	HCM Level of Service	E
HCM Volume to Capacity ratio	1.12		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	90.8%	ICU Level of Service	E
Analysis Period (min)	15		

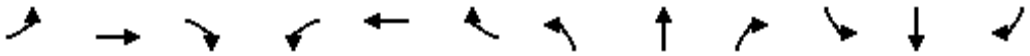
dr Defacto Right Lane. Recode with 1 though lane as a right lane.

c Critical Lane Group



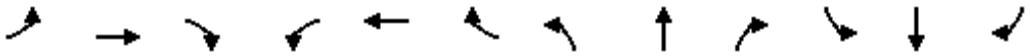
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	690	130	90	1038	1305	850
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	1.00	1.00	0.95	0.91	0.88
Frpb, ped/bikes	1.00	0.98	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3433	1550	1770	3539	5085	2787
Flt Permitted	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	3433	1550	1770	3539	5085	2787
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	734	138	96	1104	1388	904
RTOR Reduction (vph)	0	0	0	0	0	633
Lane Group Flow (vph)	734	138	96	1104	1388	271
Confl. Peds. (#/hr)	2	16	2			2
Turn Type		Perm	Prot			Prot
Protected Phases	4		5	2	6	6
Permitted Phases		4				
Actuated Green, G (s)	26.0	26.0	4.0	26.0	18.0	18.0
Effective Green, g (s)	26.0	26.0	4.0	26.0	18.0	18.0
Actuated g/C Ratio	0.43	0.43	0.07	0.43	0.30	0.30
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Grp Cap (vph)	1488	672	118	1534	1526	836
v/s Ratio Prot	c0.21		0.05	c0.31	c0.27	0.10
v/s Ratio Perm		0.09				
v/c Ratio	0.49	0.21	0.81	0.72	0.91	0.32
Uniform Delay, d1	12.3	10.6	27.6	14.0	20.2	16.3
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.2	0.7	43.7	2.9	9.6	1.0
Delay (s)	13.4	11.3	71.4	16.9	29.8	17.3
Level of Service	B	B	E	B	C	B
Approach Delay (s)	13.1			21.3	24.9	
Approach LOS	B			C	C	

Intersection Summary			
HCM Average Control Delay	21.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.69		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	66.0%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



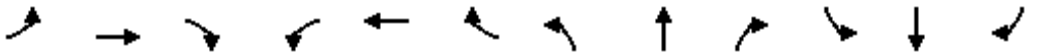
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	32	251	84	89	121	90	72	122	127	110	180	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95			0.95	1.00	1.00	0.95		0.91	0.91	
Frpb, ped/bikes		0.99			1.00	0.99	1.00	0.99		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.97			1.00	0.85	1.00	0.92		1.00	0.99	
Flt Protected		1.00			0.98	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3382			3462	1563	1770	3247		1610	3328	
Flt Permitted		0.91			0.70	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		3101			2461	1563	1770	3247		1610	3328	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	35	273	91	97	132	98	78	133	138	120	196	22
RTOR Reduction (vph)	0	38	0	0	0	0	0	110	0	0	10	0
Lane Group Flow (vph)	0	361	0	0	229	98	78	161	0	108	220	0
Confl. Peds. (#/hr)	2		4	4		2	4		2	2		4
Confl. Bikes (#/hr)			2			1						2
Turn Type	Perm			Perm		Free	Split			Split		
Protected Phases		2			6		3	3		4	4	
Permitted Phases	2			6		Free						
Actuated Green, G (s)		11.5			10.5	42.9	8.8	8.8		9.6	9.6	
Effective Green, g (s)		11.5			11.5	42.9	8.8	8.8		10.6	10.6	
Actuated g/C Ratio		0.27			0.27	1.00	0.21	0.21		0.25	0.25	
Clearance Time (s)		4.0			5.0		4.0	4.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		831			660	1563	363	666		398	822	
v/s Ratio Prot							0.04	c0.05		c0.07	0.07	
v/s Ratio Perm		c0.12			0.09	0.06						
v/c Ratio		0.43			0.35	0.06	0.21	0.24		0.27	0.27	
Uniform Delay, d1		13.0			12.7	0.0	14.2	14.3		13.0	13.0	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.4			0.3	0.1	0.3	0.2		0.4	0.2	
Delay (s)		13.4			13.0	0.1	14.5	14.5		13.4	13.2	
Level of Service		B			B	A	B	B		B	B	
Approach Delay (s)		13.4			9.1			14.5			13.3	
Approach LOS		B			A			B			B	

Intersection Summary			
HCM Average Control Delay	12.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.32		
Actuated Cycle Length (s)	42.9	Sum of lost time (s)	12.0
Intersection Capacity Utilization	46.4%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



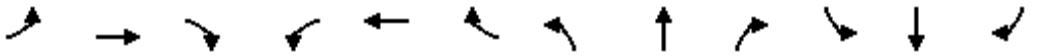
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	447	20	210	270	50	20	50	170	40	50	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			0.98			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	0.99		1.00	0.98			0.90			0.98	
Flt Protected	0.95	1.00		0.95	1.00			1.00			0.98	
Satd. Flow (prot)	1787	3551		1787	3474			1661			1791	
Flt Permitted	0.95	1.00		0.95	1.00			0.98			0.85	
Satd. Flow (perm)	1787	3551		1787	3474			1629			1553	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	486	22	228	293	54	22	54	185	43	54	22
RTOR Reduction (vph)	0	5	0	0	25	0	0	105	0	0	12	0
Lane Group Flow (vph)	22	503	0	228	322	0	0	156	0	0	107	0
Confl. Peds. (#/hr)	4					4	1		24	24		1
Confl. Bikes (#/hr)						2			1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Effective Green, g (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Actuated g/C Ratio	0.10	0.27		0.10	0.27			0.43			0.43	
Clearance Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Grp Cap (vph)	179	947		179	926			706			673	
v/s Ratio Prot	0.01	c0.14		c0.13	0.09							
v/s Ratio Perm								c0.10			0.07	
v/c Ratio	0.12	0.53		1.27	0.35			0.22			0.16	
Uniform Delay, d1	24.6	18.8		27.0	17.8			10.7			10.3	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	1.4	2.1		159.4	1.0			0.7			0.5	
Delay (s)	26.0	20.9		186.4	18.8			11.4			10.8	
Level of Service	C	C		F	B			B			B	
Approach Delay (s)		21.1			85.2			11.4			10.8	
Approach LOS		C			F			B			B	

Intersection Summary			
HCM Average Control Delay	43.4	HCM Level of Service	D
HCM Volume to Capacity ratio	0.46		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	58.0%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	448	299	90	140	355	100	110	580	150	150	870	415
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	11	12	11	11	12	12	12	12	12	12	12
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.97	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.93	1.00	0.98		1.00	0.99		1.00	1.00	0.90
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.97		1.00	0.97		1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	2884	3079	1326	1540	2921		1593	3047		1593	3185	1237
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (perm)	2884	3079	1326	1540	2921		1593	3047		1593	3185	1237
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	487	325	98	152	386	109	120	630	163	163	946	451
RTOR Reduction (vph)	0	0	75	0	22	0	0	19	0	0	0	294
Lane Group Flow (vph)	487	325	23	152	473	0	120	774	0	163	946	157
Confl. Peds. (#/hr)			47			60			42			75
Confl. Bikes (#/hr)						1						
Bus Blockages (#/hr)	0	0	0	0	0	2	0	0	0	0	0	8
Turn Type	Split		Perm	Split			Prot			Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			4									6
Actuated Green, G (s)	24.0	24.0	24.0	21.2	21.2		11.1	29.5		12.1	30.5	30.5
Effective Green, g (s)	24.0	24.0	24.0	21.2	21.2		11.1	30.5		12.1	31.5	31.5
Actuated g/C Ratio	0.23	0.23	0.23	0.20	0.20		0.11	0.29		0.12	0.30	0.30
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	5.0		4.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	667	712	307	315	597		170	895		186	967	375
v/s Ratio Prot	c0.17	0.11		0.10	c0.16		0.08	0.25		c0.10	c0.30	
v/s Ratio Perm			0.02									0.13
v/c Ratio	0.73	0.46	0.07	0.48	0.79		0.71	0.86		0.88	0.98	0.42
Uniform Delay, d1	36.9	34.3	31.2	36.5	39.2		44.8	34.7		45.1	35.8	28.8
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	4.1	0.5	0.1	1.2	7.1		12.5	8.7		33.8	23.5	0.8
Delay (s)	41.0	34.8	31.3	37.6	46.3		57.3	43.4		78.9	59.3	29.6
Level of Service	D	C	C	D	D		E	D		E	E	C
Approach Delay (s)		37.7			44.3			45.2			52.8	
Approach LOS		D			D			D			D	

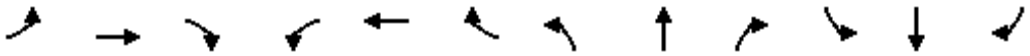
Intersection Summary			
HCM Average Control Delay	46.3	HCM Level of Service	D
HCM Volume to Capacity ratio	0.83		
Actuated Cycle Length (s)	103.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	81.1%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	150	275	134	60	222	140	132	520	50	170	1310	190
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.9	4.9		4.9	4.9		4.3	4.8	4.8	4.3	4.8	4.8
Lane Util. Factor	1.00	0.95		1.00	0.95		0.97	0.95	1.00	0.97	0.95	1.00
Frpb, ped/bikes	1.00	0.99		1.00	0.99		1.00	1.00	0.98	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.95		1.00	0.94		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1787	3379		1787	3335		3467	3574	1570	3467	3574	1575
Flt Permitted	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1787	3379		1787	3335		3467	3574	1570	3467	3574	1575
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	158	289	141	63	234	147	139	547	53	179	1379	200
RTOR Reduction (vph)	0	62	0	0	105	0	0	0	32	0	0	21
Lane Group Flow (vph)	158	368	0	63	276	0	139	547	21	179	1379	179
Confl. Peds. (#/hr)			7			14			8			3
Confl. Bikes (#/hr)						1						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Split			Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases									2			6
Actuated Green, G (s)	14.0	14.0		12.4	12.4		6.8	30.5	30.5	4.1	27.8	27.8
Effective Green, g (s)	13.1	13.1		11.5	11.5		6.5	30.7	30.7	3.8	28.0	28.0
Actuated g/C Ratio	0.17	0.17		0.15	0.15		0.08	0.39	0.39	0.05	0.36	0.36
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	5.0	5.0	4.0	5.0	5.0
Vehicle Extension (s)	2.0	2.0		2.0	2.0		2.0	2.0	2.0	2.0	2.0	2.0
Lane Grp Cap (vph)	300	567		263	492		289	1407	618	169	1283	565
v/s Ratio Prot	0.09	c0.11		0.04	c0.08		0.04	c0.15		c0.05	c0.39	
v/s Ratio Perm									0.01			0.11
v/c Ratio	0.53	0.65		0.24	0.56		0.48	0.39	0.03	1.06	1.07	0.32
Uniform Delay, d1	29.6	30.3		29.4	30.9		34.1	16.9	14.5	37.1	25.0	18.1
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.8	1.9		0.2	0.9		0.5	0.1	0.0	85.8	47.9	0.1
Delay (s)	30.4	32.2		29.6	31.8		34.6	17.0	14.5	122.9	72.9	18.2
Level of Service	C	C		C	C		C	B	B	F	E	B
Approach Delay (s)		31.7			31.5			20.1			71.7	
Approach LOS		C			C			C			E	

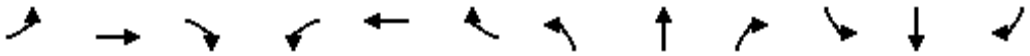
Intersection Summary			
HCM Average Control Delay	49.2	HCM Level of Service	D
HCM Volume to Capacity ratio	0.91		
Actuated Cycle Length (s)	78.0	Sum of lost time (s)	23.7
Intersection Capacity Utilization	79.7%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group



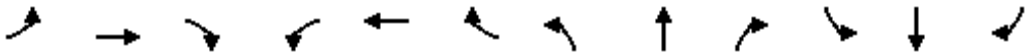
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	78	34	34	30	22	40	22	182	40	80	264	29
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frpb, ped/bikes		0.99			1.00	0.98	1.00	1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.97			1.00	0.85	1.00	0.97		1.00	0.98	
Flt Protected		0.97			0.97	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1745			1810	1550	1770	1806		1770	1829	
Flt Permitted		0.97			0.97	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		1745			1810	1550	1770	1806		1770	1829	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	85	37	37	33	24	43	24	198	43	87	287	32
RTOR Reduction (vph)	0	12	0	0	0	39	0	8	0	0	4	0
Lane Group Flow (vph)	0	147	0	0	57	4	24	233	0	87	315	0
Confl. Peds. (#/hr)	2		6	6		2	8		2	2		8
Confl. Bikes (#/hr)						1						
Turn Type	Split			Split		Perm	Split			Split		
Protected Phases	2	2		1	1		4	4		3	3	
Permitted Phases						1						
Actuated Green, G (s)		8.8			5.9	5.9	15.5	15.5		17.9	17.9	
Effective Green, g (s)		8.8			5.9	5.9	15.5	15.5		17.9	17.9	
Actuated g/C Ratio		0.14			0.09	0.09	0.24	0.24		0.28	0.28	
Clearance Time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0	3.0	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		240			167	143	428	437		494	511	
v/s Ratio Prot		c0.08			c0.03		0.01	c0.13		0.05	c0.17	
v/s Ratio Perm						0.00						
v/c Ratio		0.61			0.34	0.03	0.06	0.53		0.18	0.62	
Uniform Delay, d1		26.0			27.3	26.5	18.7	21.1		17.5	20.1	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		4.6			1.2	0.1	0.1	1.2		0.2	2.2	
Delay (s)		30.6			28.5	26.6	18.7	22.4		17.7	22.3	
Level of Service		C			C	C	B	C		B	C	
Approach Delay (s)		30.6			27.7			22.1			21.3	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	23.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.56		
Actuated Cycle Length (s)	64.1	Sum of lost time (s)	16.0
Intersection Capacity Utilization	44.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	190	184	50	60	182	50	20	480	40	50	670	120
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			0.95			0.95	
Frpb, ped/bikes	1.00	0.99		1.00	1.00			1.00			0.99	
Flpb, ped/bikes	0.99	1.00		0.99	1.00			1.00			1.00	
Frt	1.00	0.97		1.00	0.97			0.99			0.98	
Flt Protected	0.95	1.00		0.95	1.00			1.00			1.00	
Satd. Flow (prot)	1585	3062		1569	3070			3134			3081	
Flt Permitted	0.60	1.00		0.60	1.00			0.91			0.89	
Satd. Flow (perm)	1003	3062		992	3070			2871			2760	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	198	192	52	62	190	52	21	500	42	52	698	125
RTOR Reduction (vph)	0	30	0	0	30	0	0	9	0	0	20	0
Lane Group Flow (vph)	198	214	0	62	212	0	0	554	0	0	855	0
Confl. Peds. (#/hr)	10		29	29		10	63		34	34		63
Confl. Bikes (#/hr)									1			
Parking (#/hr)							0					
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			4			2			2	
Permitted Phases	4			4			2			2		
Actuated Green, G (s)	30.0	30.0		30.0	30.0			32.0			32.0	
Effective Green, g (s)	29.0	29.0		29.0	29.0			31.0			31.0	
Actuated g/C Ratio	0.43	0.43		0.43	0.43			0.46			0.46	
Clearance Time (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	428	1306		423	1309			1309			1258	
v/s Ratio Prot		0.07			0.07							
v/s Ratio Perm	c0.20			0.06				0.19			c0.31	
v/c Ratio	0.46	0.16		0.15	0.16			0.42			0.68	
Uniform Delay, d1	13.9	12.0		11.9	12.0			12.5			14.6	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	3.6	0.3		0.7	0.3			1.0			3.0	
Delay (s)	17.5	12.3		12.7	12.3			13.5			17.6	
Level of Service	B	B		B	B			B			B	
Approach Delay (s)		14.6			12.4			13.5			17.6	
Approach LOS		B			B			B			B	

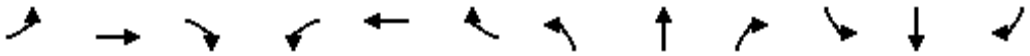
Intersection Summary			
HCM Average Control Delay	15.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	68.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	100.5%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	214	40	30	202	152	30	470	50	634	580	40
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0			5.0		5.0	5.0	
Lane Util. Factor		0.95			0.95			0.95		0.97	1.00	
Frpb, ped/bikes		1.00			0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00			1.00		1.00	1.00	
Frt		0.98			0.94			0.99		1.00	0.99	
Flt Protected		1.00			1.00			1.00		0.95	1.00	
Satd. Flow (prot)		3468			3326			3509		3467	1860	
Flt Permitted		0.90			0.90			1.00		0.95	1.00	
Satd. Flow (perm)		3142			3015			3509		3467	1860	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	21	228	43	32	215	162	32	500	53	674	617	43
RTOR Reduction (vph)	0	20	0	0	133	0	0	9	0	0	2	0
Lane Group Flow (vph)	0	272	0	0	276	0	0	576	0	674	658	0
Confl. Peds. (#/hr)	2		6	6		2	11		10	10		11
Confl. Bikes (#/hr)						2						1
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm			Perm			Split			Split		
Protected Phases		4			4		2	2		3	3	
Permitted Phases	4			4								
Actuated Green, G (s)		12.9			12.9			15.8		26.4	26.4	
Effective Green, g (s)		11.9			11.9			14.8		25.4	25.4	
Actuated g/C Ratio		0.18			0.18			0.22		0.38	0.38	
Clearance Time (s)		4.0			4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		557			535			774		1312	704	
v/s Ratio Prot								c0.16		0.19	c0.35	
v/s Ratio Perm		0.09			c0.09							
v/c Ratio		0.49			0.52			0.74		0.51	0.93	
Uniform Delay, d1		24.9			25.0			24.4		16.1	20.0	
Progression Factor		1.00			1.00			1.00		1.00	1.00	
Incremental Delay, d2		0.7			0.8			3.9		0.3	19.4	
Delay (s)		25.5			25.8			28.3		16.4	39.5	
Level of Service		C			C			C		B	D	
Approach Delay (s)		25.5			25.8			28.3			27.8	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	27.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	67.1	Sum of lost time (s)	15.0
Intersection Capacity Utilization	87.4%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	382	445	20	354	130	381	330	40	120	400	40
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Util. Factor		0.91	0.91		0.95		1.00	1.00			1.00	
Frpb, ped/bikes		0.99	0.96		0.99		1.00	1.00			1.00	
Flpb, ped/bikes		1.00	1.00		1.00		1.00	1.00			1.00	
Frt		0.95	0.85		0.96		1.00	0.98			0.99	
Flt Protected		1.00	1.00		1.00		0.95	1.00			0.99	
Satd. Flow (prot)		2995	1399		3160		1787	1587			1581	
Flt Permitted		0.93	1.00		0.87		0.95	1.00			0.99	
Satd. Flow (perm)		2777	1399		2741		1787	1587			1581	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	21	394	459	21	365	134	393	340	41	124	412	41
RTOR Reduction (vph)	0	55	209	0	42	0	0	5	0	0	3	0
Lane Group Flow (vph)	0	544	66	0	478	0	393	376	0	0	574	0
Confl. Peds. (#/hr)	17		21	21		17	30		15	15		30
Confl. Bikes (#/hr)			1			1						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Parking (#/hr)		8			8			8			8	
Turn Type	Perm		Perm	Perm			Split			Split		
Protected Phases		2			2		4	4		8	8	
Permitted Phases	2		2	2								
Actuated Green, G (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Effective Green, g (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Actuated g/C Ratio		0.24	0.24		0.24		0.30	0.30			0.31	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Grp Cap (vph)		669	337		660		538	478			495	
v/s Ratio Prot							0.22	c0.24			c0.36	
v/s Ratio Perm		c0.20	0.05		0.17							
v/c Ratio		0.81	0.20		0.72		0.73	0.79			1.16	
Uniform Delay, d1		29.7	25.1		29.0		26.0	26.6			28.5	
Progression Factor		1.00	1.00		1.00		1.00	1.00			1.00	
Incremental Delay, d2		10.4	1.3		6.8		8.5	12.3			92.0	
Delay (s)		40.1	26.4		35.8		34.5	38.9			120.5	
Level of Service		D	C		D		C	D			F	
Approach Delay (s)		35.8			35.8			36.6			120.5	
Approach LOS		D			D			D			F	

Intersection Summary			
HCM Average Control Delay	53.8	HCM Level of Service	D
HCM Volume to Capacity ratio	0.93		
Actuated Cycle Length (s)	83.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	92.4%	ICU Level of Service	F
Analysis Period (min)	15		

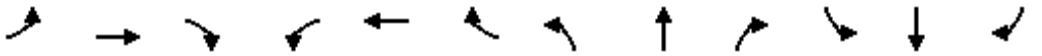
c Critical Lane Group

Movement	EBL2	EBL	EBT	EBR	NBT	NBR	NBR2	SBL2	SBL	SBT
Lane Configurations										
Volume (vph)	40	1105	400	150	620	370	110	392	320	542
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0	4.5	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor		0.91	0.91	1.00	0.95	1.00		1.00	1.00	1.00
Frpb, ped/bikes		1.00	1.00	0.85	1.00	0.92		1.00	1.00	1.00
Flpb, ped/bikes		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frt		1.00	1.00	0.85	1.00	0.85		1.00	1.00	1.00
Flt Protected		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (prot)		1610	3293	1344	3539	1452		1770	1770	1863
Flt Permitted		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (perm)		1610	3293	1344	3539	1452		1770	1770	1863
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	42	1163	421	158	653	389	116	413	337	571
RTOR Reduction (vph)	0	0	0	99	0	12	0	0	0	0
Lane Group Flow (vph)	0	600	1026	59	653	493	0	413	337	571
Confl. Peds. (#/hr)				50			50		50	
Confl. Bikes (#/hr)				10			10			
Turn Type	Perm	Perm		Perm		Perm		Prot	Prot	
Protected Phases			4		2			1	1	6
Permitted Phases	4	4		4		2				
Actuated Green, G (s)		32.5	32.5	32.5	22.5	22.5		22.0	22.0	47.5
Effective Green, g (s)		34.0	34.0	33.5	22.0	22.0		22.0	22.0	48.0
Actuated g/C Ratio		0.38	0.38	0.37	0.24	0.24		0.24	0.24	0.53
Clearance Time (s)		5.5	5.5	5.5	3.5	3.5		4.0	4.0	4.5
Vehicle Extension (s)		2.0	2.0	2.0	2.0	2.0		2.0	2.0	2.0
Lane Grp Cap (vph)		608	1244	500	865	355		433	433	994
v/s Ratio Prot					0.18			c0.23	0.19	0.31
v/s Ratio Perm		c0.37	0.31	0.04		c0.34				
v/c Ratio		0.99	0.95dl	0.12	0.75	1.39		0.95	0.78	0.57
Uniform Delay, d1		27.8	25.3	18.5	31.5	34.0		33.5	31.7	14.1
Progression Factor		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2		32.8	4.4	0.0	3.4	191.4		33.1	12.9	2.4
Delay (s)		60.5	29.7	18.6	34.9	225.4		66.6	44.6	16.5
Level of Service		E	C	B	C	F		E	D	B
Approach Delay (s)			39.1		117.9					39.4
Approach LOS			D		F					D

Intersection Summary			
HCM Average Control Delay	60.6	HCM Level of Service	E
HCM Volume to Capacity ratio	1.09		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	92.0%	ICU Level of Service	F
Analysis Period (min)	15		

dl Defacto Left Lane. Recode with 1 though lane as a left lane.

c Critical Lane Group

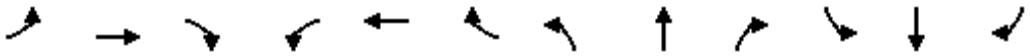


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	455	1284	0	0	0	0	0	971	580
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0						4.0	4.0
Lane Util. Factor				0.86	0.86						0.86	0.86
Frpb, ped/bikes				1.00	1.00						1.00	1.00
Flpb, ped/bikes				1.00	1.00						1.00	1.00
Frt				1.00	1.00						0.97	0.85
Flt Protected				0.95	1.00						1.00	1.00
Satd. Flow (prot)				1522	4798						4652	1362
Flt Permitted				0.95	1.00						1.00	1.00
Satd. Flow (perm)				1522	4798						4652	1362
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	479	1352	0	0	0	0	0	1022	611
RTOR Reduction (vph)	0	0	0	294	4	0	0	0	0	0	23	23
Lane Group Flow (vph)	0	0	0	137	1396	0	0	0	0	0	1243	344
Confl. Bikes (#/hr)						5						9
Turn Type				Prot								Prot
Protected Phases				7	3						2	2
Permitted Phases												
Actuated Green, G (s)				20.0	40.0						31.0	31.0
Effective Green, g (s)				20.0	40.0						31.0	31.0
Actuated g/C Ratio				0.25	0.51						0.39	0.39
Clearance Time (s)				4.0	4.0						4.0	4.0
Lane Grp Cap (vph)				385	2429						1825	534
v/s Ratio Prot				0.09	c0.15						c0.27	0.25
v/s Ratio Perm					0.15							
v/c Ratio				0.36	0.57						0.68	0.64
Uniform Delay, d1				24.2	13.6						19.9	19.5
Progression Factor				1.00	1.00						1.00	1.00
Incremental Delay, d2				2.6	1.0						2.1	5.9
Delay (s)				26.8	14.6						22.0	25.4
Level of Service				C	B						C	C
Approach Delay (s)		0.0			17.4			0.0			22.7	
Approach LOS		A			B			A			C	

Intersection Summary			
HCM Average Control Delay	19.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	79.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	56.1%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

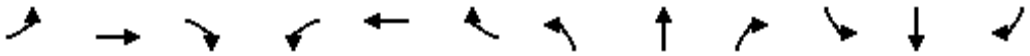
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	350	1090	0	0	0	0	0	1131	2057	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0						4.0	4.0			
Lane Util. Factor		0.91						0.91	0.88			
Frpb, ped/bikes		1.00						1.00	1.00			
Flpb, ped/bikes		1.00						1.00	1.00			
Frt		1.00						1.00	0.85			
Flt Protected		0.99						1.00	1.00			
Satd. Flow (prot)		5006						5085	2787			
Flt Permitted		0.99						1.00	1.00			
Satd. Flow (perm)		5006						5085	2787			
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	368	1147	0	0	0	0	0	1191	2165	0	0	0
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	97	0	0	0
Lane Group Flow (vph)	0	1515	0	0	0	0	0	1191	2068	0	0	0
Confl. Peds. (#/hr)	28		7	7		28	99		3	3		99
Confl. Bikes (#/hr)			1			2			1			
Turn Type	Perm								custom			
Protected Phases		4						2	2			
Permitted Phases	4								7			
Actuated Green, G (s)		34.0						16.0	16.0			
Effective Green, g (s)		35.0						17.0	17.0			
Actuated g/C Ratio		0.58						0.28	0.28			
Clearance Time (s)		5.0						5.0	5.0			
Vehicle Extension (s)		3.0						3.0	3.0			
Lane Grp Cap (vph)		2920						1441	790			
v/s Ratio Prot								0.23	c0.74			
v/s Ratio Perm		0.30										
v/c Ratio		0.52						0.83	2.62			
Uniform Delay, d1		7.5						20.1	21.5			
Progression Factor		1.00						1.00	1.00			
Incremental Delay, d2		0.7						4.0	731.4			
Delay (s)		8.1						24.1	752.9			
Level of Service		A						C	F			
Approach Delay (s)		8.1			0.0			494.3			0.0	
Approach LOS		A			A			F			A	

Intersection Summary			
HCM Average Control Delay	343.1	HCM Level of Service	F
HCM Volume to Capacity ratio	1.21		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	107.3%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			



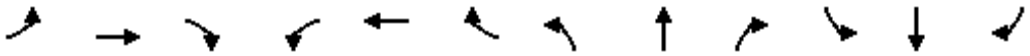
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	70	1515	1562	0	0	0	0	380	430	130	360	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0					4.0			4.0	
Lane Util. Factor		0.86	0.86					1.00			1.00	
Frpb, ped/bikes		0.98	0.97					0.98			1.00	
Flpb, ped/bikes		1.00	1.00					1.00			1.00	
Frt		0.95	0.85					0.93			1.00	
Flt Protected		1.00	1.00					1.00			0.99	
Satd. Flow (prot)		4445	1323					1694			1836	
Flt Permitted		1.00	1.00					1.00			0.14	
Satd. Flow (perm)		4445	1323					1694			262	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	74	1595	1644	0	0	0	0	400	453	137	379	0
RTOR Reduction (vph)	0	64	0	0	0	0	0	13	0	0	0	0
Lane Group Flow (vph)	0	2427	822	0	0	0	0	840	0	0	516	0
Confl. Peds. (#/hr)	52		55	55		52	39		25	25		39
Confl. Bikes (#/hr)			1						2		1	2
Turn Type	Perm		Free							Perm		
Protected Phases		2						4			8	
Permitted Phases	2		Free							8		
Actuated Green, G (s)		33.0	60.0					18.0			18.0	
Effective Green, g (s)		34.0	60.0					18.0			18.0	
Actuated g/C Ratio		0.57	1.00					0.30			0.30	
Clearance Time (s)		5.0						4.0			4.0	
Vehicle Extension (s)		2.0						2.0			2.0	
Lane Grp Cap (vph)		2519	1323					508			79	
v/s Ratio Prot								0.50				
v/s Ratio Perm		0.55	0.62								c1.97	
v/c Ratio		0.96	0.62					1.65			6.53	
Uniform Delay, d1		12.4	0.0					21.0			21.0	
Progression Factor		0.63	1.00					1.00			1.00	
Incremental Delay, d2		1.5	0.2					303.2			2515.9	
Delay (s)		9.4	0.2					324.2			2536.9	
Level of Service		A	A					F			F	
Approach Delay (s)		7.1			0.0			324.2			2536.9	
Approach LOS		A			A			F			F	

Intersection Summary			
HCM Average Control Delay	343.7	HCM Level of Service	F
HCM Volume to Capacity ratio	2.90		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	129.3%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	350	1090	0	0	0	0	0	1131	2057	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0						4.0	4.0			
Lane Util. Factor		0.91						0.91	0.88			
Frpb, ped/bikes		1.00						1.00	1.00			
Flpb, ped/bikes		1.00						1.00	1.00			
Frt		1.00						1.00	0.85			
Flt Protected		0.99						1.00	1.00			
Satd. Flow (prot)		5002						5085	2787			
Flt Permitted		0.99						1.00	1.00			
Satd. Flow (perm)		5002						5085	2787			
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	368	1147	0	0	0	0	0	1191	2165	0	0	0
RTOR Reduction (vph)	0	1	0	0	0	0	0	0	88	0	0	0
Lane Group Flow (vph)	0	1514	0	0	0	0	0	1191	2077	0	0	0
Confl. Peds. (#/hr)	28		7	7		28	99		3	3		99
Confl. Bikes (#/hr)			1			2			1			
Turn Type	Perm								custom			
Protected Phases		4						2	2			
Permitted Phases	4								7			
Actuated Green, G (s)		42.0						23.0	23.0			
Effective Green, g (s)		43.0						24.0	24.0			
Actuated g/C Ratio		0.57						0.32	0.32			
Clearance Time (s)		5.0						5.0	5.0			
Vehicle Extension (s)		3.0						3.0	3.0			
Lane Grp Cap (vph)		2868						1627	892			
v/s Ratio Prot								0.23	c0.75			
v/s Ratio Perm		0.30										
v/c Ratio		0.53						0.73	2.33			
Uniform Delay, d1		9.8						22.6	25.5			
Progression Factor		1.00						1.00	1.00			
Incremental Delay, d2		0.7						1.7	601.5			
Delay (s)		10.5						24.4	627.0			
Level of Service		B						C	F			
Approach Delay (s)		10.5			0.0			413.1			0.0	
Approach LOS		B			A			F			A	

Intersection Summary			
HCM Average Control Delay	287.9	HCM Level of Service	F
HCM Volume to Capacity ratio	1.17		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	107.3%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

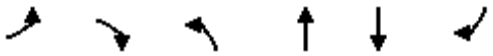


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	70	1515	1562	0	0	0	0	380	430	130	360	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0					4.0			4.0	
Lane Util. Factor		0.86	0.86					1.00			1.00	
Frpb, ped/bikes		0.97	0.97					0.98			1.00	
Flpb, ped/bikes		1.00	1.00					1.00			1.00	
Frt		0.95	0.85					0.93			1.00	
Flt Protected		1.00	1.00					1.00			0.99	
Satd. Flow (prot)		4420	1323					1689			1838	
Flt Permitted		1.00	1.00					1.00			0.28	
Satd. Flow (perm)		4420	1323					1689			531	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	74	1595	1644	0	0	0	0	400	453	137	379	0
RTOR Reduction (vph)	0	118	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	0	2373	822	0	0	0	0	853	0	0	516	0
Confl. Peds. (#/hr)	52		55	55		52	39		25	25		39
Confl. Bikes (#/hr)			1						2		1	2
Turn Type	Perm		Free							Perm		
Protected Phases		2						4			8	
Permitted Phases	2		Free							8		
Actuated Green, G (s)		26.0	75.0					40.0			40.0	
Effective Green, g (s)		27.0	75.0					40.0			40.0	
Actuated g/C Ratio		0.36	1.00					0.53			0.53	
Clearance Time (s)		5.0						4.0			4.0	
Vehicle Extension (s)		2.0						2.0			2.0	
Lane Grp Cap (vph)		1591	1323					901			283	
v/s Ratio Prot								0.50				
v/s Ratio Perm		0.54	0.62								c0.97	
v/c Ratio		1.49	0.62					0.95			1.82	
Uniform Delay, d1		24.0	0.0					16.5			17.5	
Progression Factor		1.11	1.00					1.00			1.00	
Incremental Delay, d2		221.4	0.2					18.0			384.1	
Delay (s)		248.1	0.2					34.5			401.6	
Level of Service		F	A					C			F	
Approach Delay (s)		186.6			0.0			34.5			401.6	
Approach LOS		F			A			C			F	

Intersection Summary			
HCM Average Control Delay	182.6	HCM Level of Service	F
HCM Volume to Capacity ratio	1.69		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	129.3%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

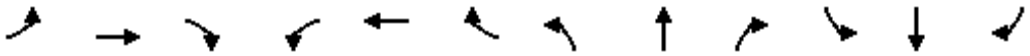
Near-Term (2018) Plus Additional Employment Alternative Conditions

FEHR PEERS



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	410	60	40	1238	1026	530
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	1.00	1.00	0.95	0.91	0.88
Frpb, ped/bikes	1.00	0.98	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3400	1535	1752	3505	5036	2760
Flt Permitted	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	3400	1535	1752	3505	5036	2760
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	446	65	43	1346	1115	576
RTOR Reduction (vph)	0	0	0	0	0	403
Lane Group Flow (vph)	446	65	43	1346	1115	173
Confl. Peds. (#/hr)	3	11	4			4
Confl. Bikes (#/hr)		5				5
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%
Turn Type		Perm	Prot			Prot
Protected Phases	4		5	2	6	6
Permitted Phases		4				
Actuated Green, G (s)	26.0	26.0	4.0	26.0	18.0	18.0
Effective Green, g (s)	26.0	26.0	4.0	26.0	18.0	18.0
Actuated g/C Ratio	0.43	0.43	0.07	0.43	0.30	0.30
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Grp Cap (vph)	1473	665	117	1519	1511	828
v/s Ratio Prot	c0.13		0.02	c0.38	0.22	0.06
v/s Ratio Perm		0.04				
v/c Ratio	0.30	0.10	0.37	0.89	0.74	0.21
Uniform Delay, d1	11.1	10.1	26.8	15.6	18.9	15.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.5	0.3	8.7	8.0	3.3	0.6
Delay (s)	11.6	10.4	35.5	23.6	22.1	16.3
Level of Service	B	B	D	C	C	B
Approach Delay (s)	11.5			24.0	20.1	
Approach LOS	B			C	C	

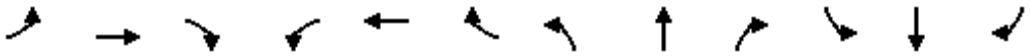
Intersection Summary			
HCM Average Control Delay	20.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	66.7%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	70	34	202	227	110	85	190	86	40	93	23
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95			0.95	1.00	1.00	0.95		0.91	0.91	
Frpb, ped/bikes		0.99			1.00	0.98	1.00	0.99		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.96			1.00	0.85	1.00	0.95		1.00	0.97	
Flt Protected		1.00			0.98	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3209			3315	1500	1703	3218		1550	3149	
Flt Permitted		0.91			0.77	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		2948			2618	1500	1703	3218		1550	3149	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	76	37	220	247	120	92	207	93	43	101	25
RTOR Reduction (vph)	0	24	0	0	0	0	0	70	0	0	21	0
Lane Group Flow (vph)	0	100	0	0	467	120	92	230	0	39	109	0
Confl. Peds. (#/hr)	9		8	8		9	12		17	17		12
Confl. Bikes (#/hr)						3			5			2
Heavy Vehicles (%)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
Turn Type	Perm			Perm		Free	Split			Split		
Protected Phases		2			6		3	3		4	4	
Permitted Phases	2			6		Free						
Actuated Green, G (s)		16.2			15.2	46.0	10.0	10.0		6.8	6.8	
Effective Green, g (s)		16.2			16.2	46.0	10.0	10.0		7.8	7.8	
Actuated g/C Ratio		0.35			0.35	1.00	0.22	0.22		0.17	0.17	
Clearance Time (s)		4.0			5.0		4.0	4.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		1038			922	1500	370	700		263	534	
v/s Ratio Prot							0.05	c0.07		0.03	c0.03	
v/s Ratio Perm		0.03			c0.18	0.08						
v/c Ratio		0.10			0.51	0.08	0.25	0.33		0.15	0.20	
Uniform Delay, d1		10.0			11.7	0.0	14.9	15.2		16.3	16.4	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.0			0.4	0.1	0.4	0.3		0.3	0.2	
Delay (s)		10.0			12.2	0.1	15.2	15.4		16.5	16.6	
Level of Service		B			B	A	B	B		B	B	
Approach Delay (s)		10.0			9.7			15.4			16.6	
Approach LOS		B			A			B			B	

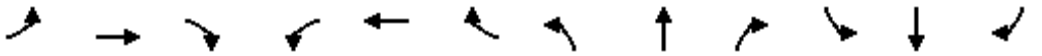
Intersection Summary			
HCM Average Control Delay	12.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.38		
Actuated Cycle Length (s)	46.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	47.0%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	166	10	140	499	30	20	90	230	40	80	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			0.97			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	0.99		1.00	0.99			0.91			0.98	
Flt Protected	0.95	1.00		0.95	1.00			1.00			0.99	
Satd. Flow (prot)	1736	3432		1736	3433			1607			1752	
Flt Permitted	0.95	1.00		0.95	1.00			0.98			0.85	
Satd. Flow (perm)	1736	3432		1736	3433			1582			1515	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	180	11	152	542	33	22	98	250	43	87	22
RTOR Reduction (vph)	0	7	0	0	7	0	0	125	0	0	10	0
Lane Group Flow (vph)	11	184	0	152	568	0	0	245	0	0	142	0
Confl. Peds. (#/hr)	11		13	13		11	22		48	48		22
Confl. Bikes (#/hr)			1			2			1			
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Effective Green, g (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Actuated g/C Ratio	0.10	0.27		0.10	0.27			0.43			0.43	
Clearance Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Grp Cap (vph)	174	915		174	915			686			657	
v/s Ratio Prot	0.01	0.05		c0.09	c0.17							
v/s Ratio Perm								c0.15			0.09	
v/c Ratio	0.06	0.20		0.87	0.62			0.36			0.22	
Uniform Delay, d1	24.5	17.0		26.6	19.3			11.4			10.6	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	0.7	0.5		41.4	3.2			1.4			0.8	
Delay (s)	25.2	17.5		68.0	22.5			12.8			11.4	
Level of Service	C	B		E	C			B			B	
Approach Delay (s)		18.0			32.0			12.8			11.4	
Approach LOS		B			C			B			B	

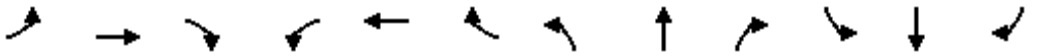
Intersection Summary			
HCM Average Control Delay	23.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.51		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	54.5%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	338	268	120	40	373	70	140	890	70	100	480	516
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	11	12	11	11	12	12	12	12	12	12	12
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.97	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.97	1.00	0.98		1.00	1.00		1.00	1.00	0.94
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.98		1.00	0.99		1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	2828	3020	1355	1510	2897		1562	3081		1562	3124	1278
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (perm)	2828	3020	1355	1510	2897		1562	3081		1562	3124	1278
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	367	291	130	43	405	76	152	967	76	109	522	561
RTOR Reduction (vph)	0	0	104	0	13	0	0	5	0	0	0	363
Lane Group Flow (vph)	367	291	26	43	468	0	152	1038	0	109	522	198
Confl. Peds. (#/hr)			16			85			25			37
Confl. Bikes (#/hr)						1			1			1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Bus Blockages (#/hr)	0	0	0	0	0	2	0	0	0	0	0	8
Turn Type	Split		Perm	Split			Prot			Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			4									6
Actuated Green, G (s)	19.2	19.2	19.2	20.4	20.4		12.2	30.4		10.8	29.0	29.0
Effective Green, g (s)	19.2	19.2	19.2	20.4	20.4		12.2	31.4		10.8	30.0	30.0
Actuated g/C Ratio	0.20	0.20	0.20	0.21	0.21		0.12	0.32		0.11	0.31	0.31
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	5.0		4.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	555	593	266	315	604		195	989		172	958	392
v/s Ratio Prot	c0.13	0.10		0.03	c0.16		c0.10	c0.34		0.07	0.17	
v/s Ratio Perm			0.02									0.15
v/c Ratio	0.66	0.49	0.10	0.14	0.77		0.78	1.05		0.63	0.54	0.50
Uniform Delay, d1	36.3	35.0	32.2	31.5	36.5		41.5	33.2		41.6	28.2	27.8
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	3.0	0.6	0.2	0.2	6.1		17.7	42.6		7.4	0.6	1.0
Delay (s)	39.3	35.6	32.3	31.7	42.7		59.2	75.8		49.0	28.9	28.8
Level of Service	D	D	C	C	D		E	E		D	C	C
Approach Delay (s)		36.8			41.8			73.7			30.7	
Approach LOS		D			D			E			C	

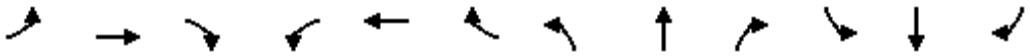
Intersection Summary			
HCM Average Control Delay	47.4	HCM Level of Service	D
HCM Volume to Capacity ratio	0.83		
Actuated Cycle Length (s)	97.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	80.7%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group



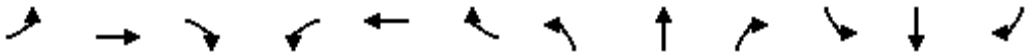
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	80	204	94	50	208	100	165	790	50	90	350	70
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.9	4.9		4.9	4.9		4.3	4.8	4.8	4.3	4.8	4.8
Lane Util. Factor	1.00	0.95		1.00	0.95		0.97	0.95	1.00	0.97	0.95	1.00
Frpb, ped/bikes	1.00	0.99		1.00	0.99		1.00	1.00	0.98	1.00	1.00	0.98
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.95		1.00	0.95		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	3354		1770	3341		3433	3539	1558	3433	3539	1550
Flt Permitted	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	3354		1770	3341		3433	3539	1558	3433	3539	1550
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	86	219	101	54	224	108	177	849	54	97	376	75
RTOR Reduction (vph)	0	57	0	0	61	0	0	0	37	0	0	32
Lane Group Flow (vph)	86	263	0	54	271	0	177	849	17	97	376	43
Confl. Peds. (#/hr)			7			13			6			11
Confl. Bikes (#/hr)						2						
Turn Type	Split			Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases									2			6
Actuated Green, G (s)	11.9	11.9		12.0	12.0		7.4	21.2	21.2	4.3	18.1	18.1
Effective Green, g (s)	11.0	11.0		11.1	11.1		7.1	21.4	21.4	4.0	18.3	18.3
Actuated g/C Ratio	0.17	0.17		0.17	0.17		0.11	0.32	0.32	0.06	0.28	0.28
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	5.0	5.0	4.0	5.0	5.0
Vehicle Extension (s)	2.0	2.0		2.0	2.0		2.0	2.0	2.0	2.0	2.0	2.0
Lane Grp Cap (vph)	293	556		296	559		367	1141	502	207	975	427
v/s Ratio Prot	0.05	c0.08		0.03	c0.08		c0.05	c0.24		0.03	0.11	
v/s Ratio Perm									0.01			0.03
v/c Ratio	0.29	0.47		0.18	0.49		0.48	0.74	0.03	0.47	0.39	0.10
Uniform Delay, d1	24.3	25.1		23.8	25.1		27.9	20.1	15.4	30.2	19.5	17.9
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.2	0.2		0.1	0.2		0.4	2.3	0.0	0.6	0.1	0.0
Delay (s)	24.5	25.3		23.9	25.3		28.3	22.4	15.4	30.8	19.6	18.0
Level of Service	C	C		C	C		C	C	B	C	B	B
Approach Delay (s)		25.1			25.1			23.0			21.3	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	23.3	HCM Level of Service	C
HCM Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	66.4	Sum of lost time (s)	18.9
Intersection Capacity Utilization	60.2%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



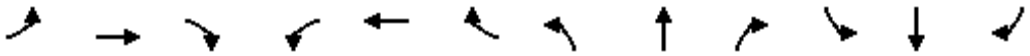
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	27	14	14	80	45	110	35	245	40	50	194	115
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frpb, ped/bikes		0.99			1.00	0.98	1.00	0.99		1.00	0.99	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.97			1.00	0.85	1.00	0.98		1.00	0.94	
Flt Protected		0.98			0.97	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1746			1805	1556	1770	1810		1770	1733	
Flt Permitted		0.98			0.97	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		1746			1805	1556	1770	1810		1770	1733	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	29	15	15	87	49	120	38	266	43	54	211	125
RTOR Reduction (vph)	0	14	0	0	0	101	0	6	0	0	23	0
Lane Group Flow (vph)	0	45	0	0	136	19	38	303	0	54	313	0
Confl. Peds. (#/hr)	2		1	1		2	13		20	20		13
Confl. Bikes (#/hr)						1			5			
Turn Type	Split			Split		Perm	Split			Split		
Protected Phases	2	2		1	1		4	4		3	3	
Permitted Phases						1						
Actuated Green, G (s)		5.2			10.3	10.3	16.9	16.9		17.8	17.8	
Effective Green, g (s)		5.2			10.3	10.3	16.9	16.9		17.8	17.8	
Actuated g/C Ratio		0.08			0.16	0.16	0.26	0.26		0.27	0.27	
Clearance Time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0	3.0	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		137			281	242	452	462		476	466	
v/s Ratio Prot		c0.03			c0.08		0.02	c0.17		0.03	c0.18	
v/s Ratio Perm						0.01						
v/c Ratio		0.33			0.48	0.08	0.08	0.66		0.11	0.67	
Uniform Delay, d1		28.9			25.5	23.9	18.8	22.0		18.2	21.6	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		1.4			1.3	0.1	0.1	3.3		0.1	3.8	
Delay (s)		30.3			26.8	24.0	18.8	25.4		18.4	25.4	
Level of Service		C			C	C	B	C		B	C	
Approach Delay (s)		30.3			25.5			24.7			24.4	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	25.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	66.2	Sum of lost time (s)	16.0
Intersection Capacity Utilization	41.2%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	250	224	50	50	305	50	60	610	30	30	330	90
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			0.95			0.95	
Frpb, ped/bikes	1.00	1.00		1.00	0.99			1.00			0.99	
Flpb, ped/bikes	0.98	1.00		0.99	1.00			1.00			1.00	
Frt	1.00	0.97		1.00	0.98			0.99			0.97	
Flt Protected	0.95	1.00		0.95	1.00			1.00			1.00	
Satd. Flow (prot)	1541	3053		1561	3066			3112			3027	
Flt Permitted	0.51	1.00		0.57	1.00			0.87			0.88	
Satd. Flow (perm)	821	3053		937	3066			2728			2683	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	272	243	54	54	332	54	65	663	33	33	359	98
RTOR Reduction (vph)	0	28	0	0	19	0	0	5	0	0	33	0
Lane Group Flow (vph)	272	269	0	54	367	0	0	756	0	0	457	0
Confl. Peds. (#/hr)	56		22	22		56	31		42	42		31
Confl. Bikes (#/hr)						2			5			1
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			4			2			2	
Permitted Phases	4			4			2			2		
Actuated Green, G (s)	30.0	30.0		30.0	30.0			32.0			32.0	
Effective Green, g (s)	29.0	29.0		29.0	29.0			31.0			31.0	
Actuated g/C Ratio	0.43	0.43		0.43	0.43			0.46			0.46	
Clearance Time (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	350	1302		400	1308			1244			1223	
v/s Ratio Prot		0.09			0.12							
v/s Ratio Perm	c0.33			0.06				c0.28			0.17	
v/c Ratio	0.78	0.21		0.14	0.28			0.61			0.37	
Uniform Delay, d1	16.7	12.3		11.9	12.7			13.9			12.1	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	15.5	0.4		0.7	0.5			2.2			0.9	
Delay (s)	32.3	12.6		12.6	13.2			16.1			13.0	
Level of Service	C	B		B	B			B			B	
Approach Delay (s)		22.0			13.2			16.1			13.0	
Approach LOS		C			B			B			B	

Intersection Summary			
HCM Average Control Delay	16.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.69		
Actuated Cycle Length (s)	68.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	101.2%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	224	40	20	315	275	30	560	20	174	290	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0			5.0		5.0	5.0	
Lane Util. Factor		0.95			0.95			0.95		0.97	1.00	
Frpb, ped/bikes		0.99			0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00			1.00		1.00	1.00	
Frt		0.98			0.93			1.00		1.00	0.99	
Flt Protected		1.00			1.00			1.00		0.95	1.00	
Satd. Flow (prot)		3469			3303			3544		3467	1860	
Flt Permitted		0.85			0.94			1.00		0.95	1.00	
Satd. Flow (perm)		2971			3096			3544		3467	1860	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	243	43	22	342	299	33	609	22	189	315	22
RTOR Reduction (vph)	0	17	0	0	193	0	0	3	0	0	3	0
Lane Group Flow (vph)	0	291	0	0	470	0	0	661	0	189	334	0
Confl. Peds. (#/hr)	2		11	11		2	14		25	25		14
Confl. Bikes (#/hr)			1			2						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm			Perm			Split			Split		
Protected Phases		4			4		2	2		3	3	
Permitted Phases	4			4								
Actuated Green, G (s)		15.7			15.7			16.8		17.1	17.1	
Effective Green, g (s)		14.7			14.7			15.8		16.1	16.1	
Actuated g/C Ratio		0.24			0.24			0.26		0.26	0.26	
Clearance Time (s)		4.0			4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		709			739			909		906	486	
v/s Ratio Prot								c0.19		0.05	c0.18	
v/s Ratio Perm		0.10			c0.15							
v/c Ratio		0.41			0.64			0.73		0.21	0.69	
Uniform Delay, d1		19.8			21.1			20.9		17.8	20.5	
Progression Factor		1.00			1.00			1.00		1.00	1.00	
Incremental Delay, d2		0.4			1.8			2.9		0.1	4.0	
Delay (s)		20.2			22.9			23.9		17.9	24.5	
Level of Service		C			C			C		B	C	
Approach Delay (s)		20.2			22.9			23.9			22.1	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	22.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	61.6	Sum of lost time (s)	15.0
Intersection Capacity Utilization	81.2%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	286	331	20	450	150	429	330	30	80	210	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Util. Factor		0.91	0.91		0.95		1.00	1.00			1.00	
Frpb, ped/bikes		0.99	0.96		0.99		1.00	1.00			1.00	
Flpb, ped/bikes		1.00	1.00		1.00		1.00	1.00			1.00	
Frt		0.96	0.85		0.96		1.00	0.99			0.99	
Flt Protected		1.00	1.00		1.00		0.95	1.00			0.99	
Satd. Flow (prot)		2973	1385		3140		1770	1578			1564	
Flt Permitted		0.82	1.00		0.93		0.95	1.00			0.99	
Satd. Flow (perm)		2455	1385		2920		1770	1578			1564	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	311	360	22	489	163	466	359	33	87	228	22
RTOR Reduction (vph)	0	49	169	0	37	0	0	4	0	0	3	0
Lane Group Flow (vph)	0	421	54	0	637	0	466	388	0	0	334	0
Confl. Peds. (#/hr)	16		21	21		16	20		16	16		20
Confl. Bikes (#/hr)			1			2			1			
Parking (#/hr)		8			8			8			8	
Turn Type	Perm		Perm	Perm			Split			Split		
Protected Phases		2			2		4	4		8	8	
Permitted Phases	2		2	2								
Actuated Green, G (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Effective Green, g (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Actuated g/C Ratio		0.24	0.24		0.24		0.30	0.30			0.31	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Grp Cap (vph)		592	334		704		533	475			490	
v/s Ratio Prot							c0.26	0.25			c0.21	
v/s Ratio Perm		0.17	0.04		c0.22							
v/c Ratio		0.71	0.16		0.90		0.87	0.82			0.68	
Uniform Delay, d1		28.8	24.9		30.6		27.5	26.9			24.9	
Progression Factor		1.00	1.00		1.00		1.00	1.00			1.00	
Incremental Delay, d2		7.1	1.0		17.3		17.9	14.4			7.5	
Delay (s)		35.9	25.9		47.9		45.4	41.2			32.4	
Level of Service		D	C		D		D	D			C	
Approach Delay (s)		32.7			47.9			43.5			32.4	
Approach LOS		C			D			D			C	

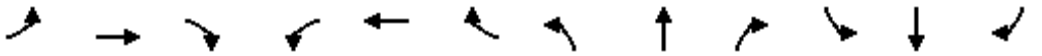
Intersection Summary			
HCM Average Control Delay	40.3	HCM Level of Service	D
HCM Volume to Capacity ratio	0.81		
Actuated Cycle Length (s)	83.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	88.1%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL2	EBL	EBT	EBR	NBT	NBR	NBR2	SBL2	SBL	SBT
Lane Configurations										
Volume (vph)	75	713	150	100	200	193	70	385	150	330
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0	4.5	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor		0.91	0.91	1.00	0.95	1.00		1.00	1.00	1.00
Frpb, ped/bikes		1.00	1.00	0.87	1.00	0.93		1.00	1.00	1.00
Flpb, ped/bikes		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frt		1.00	1.00	0.85	1.00	0.85		1.00	1.00	1.00
Flt Protected		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (prot)		1610	3272	1370	3539	1478		1770	1770	1863
Flt Permitted		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (perm)		1610	3272	1370	3539	1478		1770	1770	1863
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	79	751	158	105	211	203	74	405	158	347
RTOR Reduction (vph)	0	0	0	77	0	19	0	0	0	0
Lane Group Flow (vph)	0	417	571	28	211	258	0	405	158	347
Confl. Peds. (#/hr)				50			50		50	
Confl. Bikes (#/hr)				10			10			
Turn Type	Perm	Perm		Perm		Perm		Prot	Prot	
Protected Phases			4		2			1	1	6
Permitted Phases	4	4		4		2				
Actuated Green, G (s)		19.0	19.0	19.0	17.8	17.8		24.7	24.7	46.0
Effective Green, g (s)		20.5	20.5	20.0	17.3	17.3		25.2	25.2	46.5
Actuated g/C Ratio		0.27	0.27	0.27	0.23	0.23		0.34	0.34	0.62
Clearance Time (s)		5.5	5.5	5.5	3.5	3.5		4.5	4.5	4.5
Vehicle Extension (s)		2.0	2.0	2.0	2.0	2.0		2.0	2.0	2.0
Lane Grp Cap (vph)		440	894	365	816	341		595	595	1155
v/s Ratio Prot					0.06			c0.23	0.09	0.19
v/s Ratio Perm		c0.26	0.17	0.02		c0.17				
v/c Ratio		0.95	0.90dl	0.08	0.26	0.76		0.68	0.27	0.30
Uniform Delay, d1		26.7	24.0	20.6	23.6	26.9		21.4	18.2	6.7
Progression Factor		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2		29.4	1.1	0.0	0.1	8.2		6.2	1.1	0.7
Delay (s)		56.1	25.1	20.6	23.7	35.1		27.6	19.2	7.3
Level of Service		E	C	C	C	D		C	B	A
Approach Delay (s)			36.5		30.2					18.4
Approach LOS			D		C					B

Intersection Summary			
HCM Average Control Delay	28.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	70.4%	ICU Level of Service	C
Analysis Period (min)	15		

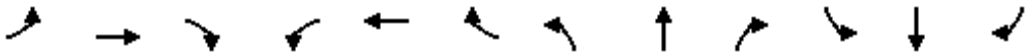
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

c Critical Lane Group



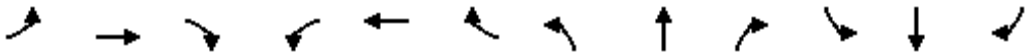
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	387	791	0	0	0	0	0	492	320
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0						4.0	4.0
Lane Util. Factor				0.86	0.86						0.86	0.86
Frpb, ped/bikes				1.00	1.00						1.00	1.00
Flpb, ped/bikes				1.00	1.00						1.00	1.00
Frt				1.00	1.00						0.97	0.85
Flt Protected				0.95	0.99						1.00	1.00
Satd. Flow (prot)				1522	4779						4633	1362
Flt Permitted				0.95	0.99						1.00	1.00
Satd. Flow (perm)				1522	4779						4633	1362
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	407	833	0	0	0	0	0	518	337
RTOR Reduction (vph)	0	0	0	225	19	0	0	0	0	0	57	81
Lane Group Flow (vph)	0	0	0	76	920	0	0	0	0	0	603	114
Confl. Bikes (#/hr)						9						10
Turn Type				Prot								Prot
Protected Phases				7	3						2	2
Permitted Phases												
Actuated Green, G (s)				20.0	40.0						31.0	31.0
Effective Green, g (s)				20.0	40.0						31.0	31.0
Actuated g/C Ratio				0.25	0.51						0.39	0.39
Clearance Time (s)				4.0	4.0						4.0	4.0
Lane Grp Cap (vph)				385	2420						1818	534
v/s Ratio Prot				0.05	c0.10						c0.13	0.08
v/s Ratio Perm					0.10							
v/c Ratio				0.20	0.38						0.33	0.21
Uniform Delay, d1				23.2	11.9						16.8	15.9
Progression Factor				1.00	1.00						1.00	1.00
Incremental Delay, d2				1.2	0.5						0.5	0.9
Delay (s)				24.3	12.4						17.3	16.8
Level of Service				C	B						B	B
Approach Delay (s)		0.0			15.3			0.0			17.2	
Approach LOS		A			B			A			B	

Intersection Summary			
HCM Average Control Delay	16.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.36		
Actuated Cycle Length (s)	79.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	37.2%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



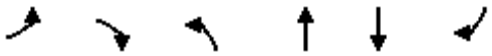
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	130	330	0	0	0	0	0	1033	1795	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0						4.0	4.0			
Lane Util. Factor		0.91						0.91	0.88			
Frpb, ped/bikes		1.00						1.00	1.00			
Flpb, ped/bikes		1.00						1.00	1.00			
Frt		1.00						1.00	0.85			
Flt Protected		0.99						1.00	1.00			
Satd. Flow (prot)		5003						5085	2787			
Flt Permitted		0.99						1.00	1.00			
Satd. Flow (perm)		5003						5085	2787			
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	137	347	0	0	0	0	0	1087	1889	0	0	0
RTOR Reduction (vph)	0	11	0	0	0	0	0	0	376	0	0	0
Lane Group Flow (vph)	0	473	0	0	0	0	0	1087	1513	0	0	0
Confl. Peds. (#/hr)	12		21	21		12	42		29	29		42
Confl. Bikes (#/hr)			2			1						1
Turn Type	Perm								custom			
Protected Phases		4						2	2			
Permitted Phases	4								7			
Actuated Green, G (s)		27.0						23.0	23.0			
Effective Green, g (s)		27.0						24.0	24.0			
Actuated g/C Ratio		0.45						0.40	0.40			
Clearance Time (s)		5.0						5.0	5.0			
Vehicle Extension (s)		3.0						3.0	3.0			
Lane Grp Cap (vph)		2251						2034	1115			
v/s Ratio Prot								0.21	c0.54			
v/s Ratio Perm		0.09										
v/c Ratio		0.21						0.53	1.36			
Uniform Delay, d1		10.0						13.7	18.0			
Progression Factor		1.00						1.00	1.00			
Incremental Delay, d2		0.2						0.3	166.5			
Delay (s)		10.2						14.0	184.5			
Level of Service		B						B	F			
Approach Delay (s)		10.2			0.0			122.2			0.0	
Approach LOS		B			A			F			A	

Intersection Summary			
HCM Average Control Delay	106.5	HCM Level of Service	F
HCM Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	95.4%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			



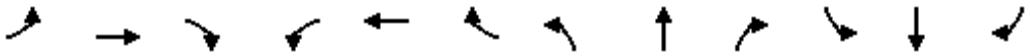
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	50	734	1331	0	0	0	0	270	100	60	320	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0					4.0			4.0	
Lane Util. Factor		0.86	0.86					1.00			1.00	
Frpb, ped/bikes		0.96	0.97					0.98			1.00	
Flpb, ped/bikes		1.00	1.00					1.00			0.99	
Frt		0.93	0.85					0.96			1.00	
Flt Protected		1.00	1.00					1.00			0.99	
Satd. Flow (prot)		4270	1315					1752			1838	
Flt Permitted		1.00	1.00					1.00			0.69	
Satd. Flow (perm)		4270	1315					1752			1270	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	53	773	1401	0	0	0	0	284	105	63	337	0
RTOR Reduction (vph)	0	84	0	0	0	0	0	22	0	0	0	0
Lane Group Flow (vph)	0	1443	700	0	0	0	0	367	0	0	400	0
Confl. Peds. (#/hr)	51		75	75		51	29		79	79		29
Confl. Bikes (#/hr)											1	1
Turn Type	Perm		Free							Perm		
Protected Phases		2						4			8	
Permitted Phases	2		Free							8		
Actuated Green, G (s)		33.0	60.0					18.0			18.0	
Effective Green, g (s)		34.0	60.0					18.0			18.0	
Actuated g/C Ratio		0.57	1.00					0.30			0.30	
Clearance Time (s)		5.0						4.0			4.0	
Vehicle Extension (s)		2.0						2.0			2.0	
Lane Grp Cap (vph)		2420	1315					526			381	
v/s Ratio Prot								0.21				
v/s Ratio Perm		0.34	0.53								c0.31	
v/c Ratio		0.60	0.53					0.70			1.05	
Uniform Delay, d1		8.5	0.0					18.6			21.0	
Progression Factor		0.72	1.00					1.00			1.00	
Incremental Delay, d2		0.1	0.1					3.2			59.8	
Delay (s)		6.2	0.1					21.8			80.8	
Level of Service		A	A					C			F	
Approach Delay (s)		4.3			0.0			21.8			80.8	
Approach LOS		A			A			C			F	

Intersection Summary			
HCM Average Control Delay	16.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	81.1%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



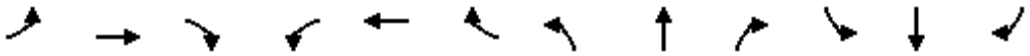
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	390	100	70	947	1236	580
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	1.00	1.00	0.95	0.91	0.88
Frpb, ped/bikes	1.00	0.98	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3433	1550	1770	3539	5085	2787
Flt Permitted	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	3433	1550	1770	3539	5085	2787
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	415	106	74	1007	1315	617
RTOR Reduction (vph)	0	0	0	0	0	432
Lane Group Flow (vph)	415	106	74	1007	1315	185
Confl. Peds. (#/hr)	2	16	2			2
Turn Type		Perm	Prot			Prot
Protected Phases	4		5	2	6	6
Permitted Phases		4				
Actuated Green, G (s)	26.0	26.0	4.0	26.0	18.0	18.0
Effective Green, g (s)	26.0	26.0	4.0	26.0	18.0	18.0
Actuated g/C Ratio	0.43	0.43	0.07	0.43	0.30	0.30
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Grp Cap (vph)	1488	672	118	1534	1526	836
v/s Ratio Prot	c0.12		0.04	c0.28	c0.26	0.07
v/s Ratio Perm		0.07				
v/c Ratio	0.28	0.16	0.63	0.66	0.86	0.22
Uniform Delay, d1	11.0	10.3	27.3	13.5	19.8	15.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.5	0.5	22.6	2.2	6.6	0.6
Delay (s)	11.4	10.8	49.9	15.7	26.5	16.4
Level of Service	B	B	D	B	C	B
Approach Delay (s)	11.3			18.0	23.2	
Approach LOS	B			B	C	

Intersection Summary			
HCM Average Control Delay	19.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	63.6%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	23	270	83	65	118	60	64	93	147	90	150	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95			0.95	1.00	1.00	0.95		0.91	0.91	
Frpb, ped/bikes		0.99			1.00	0.99	1.00	0.99		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.97			1.00	0.85	1.00	0.91		1.00	0.99	
Flt Protected		1.00			0.98	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3391			3474	1563	1770	3188		1610	3347	
Flt Permitted		0.93			0.74	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		3165			2631	1563	1770	3188		1610	3347	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	25	293	90	71	128	65	70	101	160	98	163	11
RTOR Reduction (vph)	0	35	0	0	0	0	0	126	0	0	6	0
Lane Group Flow (vph)	0	373	0	0	199	65	70	135	0	88	178	0
Confl. Peds. (#/hr)	2		4	4		2	4		2	2		4
Confl. Bikes (#/hr)			2			1						2
Turn Type	Perm			Perm		Free	Split			Split		
Protected Phases		2			6		3	3		4	4	
Permitted Phases	2			6		Free						
Actuated Green, G (s)		12.0			11.0	41.0	8.8	8.8		7.2	7.2	
Effective Green, g (s)		12.0			12.0	41.0	8.8	8.8		8.2	8.2	
Actuated g/C Ratio		0.29			0.29	1.00	0.21	0.21		0.20	0.20	
Clearance Time (s)		4.0			5.0		4.0	4.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		926			770	1563	380	684		322	669	
v/s Ratio Prot							0.04	c0.04		c0.05	0.05	
v/s Ratio Perm		c0.12			0.08	0.04						
v/c Ratio		0.40			0.26	0.04	0.18	0.20		0.27	0.27	
Uniform Delay, d1		11.6			11.1	0.0	13.2	13.2		13.9	13.9	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.3			0.2	0.0	0.2	0.1		0.5	0.2	
Delay (s)		11.9			11.3	0.0	13.4	13.3		14.3	14.1	
Level of Service		B			B	A	B	B		B	B	
Approach Delay (s)		11.9			8.5			13.4			14.2	
Approach LOS		B			A			B			B	

Intersection Summary			
HCM Average Control Delay	12.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.30		
Actuated Cycle Length (s)	41.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	44.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

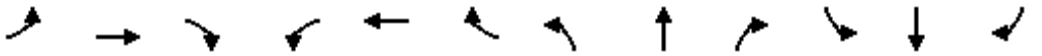


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	477	10	190	233	40	10	40	130	30	40	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			0.98			1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	1.00		1.00	0.98			0.90			0.98	
Flt Protected	0.95	1.00		0.95	1.00			1.00			0.98	
Satd. Flow (prot)	1787	3563		1787	3481			1659			1804	
Flt Permitted	0.95	1.00		0.95	1.00			0.99			0.88	
Satd. Flow (perm)	1787	3563		1787	3481			1645			1610	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	518	11	207	253	43	11	43	141	33	43	11
RTOR Reduction (vph)	0	2	0	0	23	0	0	80	0	0	6	0
Lane Group Flow (vph)	11	527	0	207	273	0	0	115	0	0	81	0
Confl. Peds. (#/hr)	4					4	1		24	24		1
Confl. Bikes (#/hr)						2			1			
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Effective Green, g (s)	6.0	16.0		6.0	16.0			26.0			26.0	
Actuated g/C Ratio	0.10	0.27		0.10	0.27			0.43			0.43	
Clearance Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Grp Cap (vph)	179	950		179	928			713			698	
v/s Ratio Prot	0.01	c0.15		c0.12	0.08							
v/s Ratio Perm								c0.07			0.05	
v/c Ratio	0.06	0.55		1.16	0.29			0.16			0.12	
Uniform Delay, d1	24.5	18.9		27.0	17.5			10.4			10.1	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	0.7	2.3		115.6	0.8			0.5			0.3	
Delay (s)	25.1	21.3		142.6	18.3			10.8			10.5	
Level of Service	C	C		F	B			B			B	
Approach Delay (s)		21.3			69.5			10.8			10.5	
Approach LOS		C			E			B			B	

Intersection Summary			
HCM Average Control Delay	37.4	HCM Level of Service	D
HCM Volume to Capacity ratio	0.42		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	57.4%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	427	270	80	90	288	70	100	530	100	120	840	376
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	11	12	11	11	12	12	12	12	12	12	12
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.97	0.95	1.00	1.00	0.95		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.93	1.00	0.98		1.00	0.99		1.00	1.00	0.90
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.97		1.00	0.98		1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	2884	3079	1331	1540	2941		1593	3079		1593	3185	1243
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (perm)	2884	3079	1331	1540	2941		1593	3079		1593	3185	1243
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	464	293	87	98	313	76	109	576	109	130	913	409
RTOR Reduction (vph)	0	0	67	0	19	0	0	12	0	0	0	269
Lane Group Flow (vph)	464	293	20	98	370	0	109	673	0	130	913	140
Confl. Peds. (#/hr)			47			60			42			75
Confl. Bikes (#/hr)						1						
Bus Blockages (#/hr)	0	0	0	0	0	2	0	0	0	0	0	8
Turn Type	Split		Perm	Split			Prot			Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			4									6
Actuated Green, G (s)	22.3	22.3	22.3	17.7	17.7		10.7	29.7		11.5	30.5	30.5
Effective Green, g (s)	22.3	22.3	22.3	17.7	17.7		10.7	30.7		11.5	31.5	31.5
Actuated g/C Ratio	0.23	0.23	0.23	0.18	0.18		0.11	0.31		0.12	0.32	0.32
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	5.0		4.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	655	699	302	278	530		174	963		187	1022	399
v/s Ratio Prot	c0.16	0.10		0.06	c0.13		0.07	0.22		c0.08	c0.29	
v/s Ratio Perm			0.01									0.11
v/c Ratio	0.71	0.42	0.07	0.35	0.70		0.63	0.70		0.70	0.89	0.35
Uniform Delay, d1	35.0	32.4	29.8	35.2	37.7		41.8	29.7		41.7	31.8	25.5
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	3.5	0.4	0.1	0.8	4.0		6.9	2.2		10.7	10.1	0.5
Delay (s)	38.5	32.8	29.9	36.0	41.7		48.7	31.9		52.3	41.8	26.1
Level of Service	D	C	C	D	D		D	C		D	D	C
Approach Delay (s)		35.6			40.6			34.2			38.3	
Approach LOS		D			D			C			D	

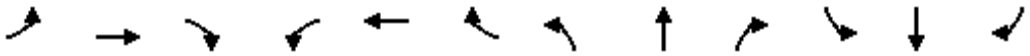
Intersection Summary			
HCM Average Control Delay	37.1	HCM Level of Service	D
HCM Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	98.2	Sum of lost time (s)	12.0
Intersection Capacity Utilization	78.5%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	120	206	133	50	144	120	114	480	40	140	1200	140
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.9	4.9		4.9	4.9		4.3	4.8	4.8	4.3	4.8	4.8
Lane Util. Factor	1.00	0.95		1.00	0.95		0.97	0.95	1.00	0.97	0.95	1.00
Frpb, ped/bikes	1.00	0.99		1.00	0.99		1.00	1.00	0.98	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.94		1.00	0.93		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1787	3341		1787	3295		3467	3574	1571	3467	3574	1576
Flt Permitted	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1787	3341		1787	3295		3467	3574	1571	3467	3574	1576
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	126	217	140	53	152	126	120	505	42	147	1263	147
RTOR Reduction (vph)	0	112	0	0	110	0	0	0	25	0	0	16
Lane Group Flow (vph)	126	245	0	53	168	0	120	505	17	147	1263	131
Confl. Peds. (#/hr)			7			14			8			3
Confl. Bikes (#/hr)						1						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Split			Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases									2			6
Actuated Green, G (s)	11.4	11.4		10.1	10.1		5.2	29.6	29.6	4.2	28.6	28.6
Effective Green, g (s)	10.5	10.5		9.2	9.2		4.9	29.8	29.8	3.9	28.8	28.8
Actuated g/C Ratio	0.15	0.15		0.13	0.13		0.07	0.41	0.41	0.05	0.40	0.40
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	5.0	5.0	4.0	5.0	5.0
Vehicle Extension (s)	2.0	2.0		2.0	2.0		2.0	2.0	2.0	2.0	2.0	2.0
Lane Grp Cap (vph)	260	485		227	419		235	1473	648	187	1424	628
v/s Ratio Prot	0.07	c0.07		0.03	c0.05		0.03	0.14		c0.04	c0.35	
v/s Ratio Perm									0.01			0.08
v/c Ratio	0.48	0.51		0.23	0.40		0.51	0.34	0.03	0.79	0.89	0.21
Uniform Delay, d1	28.4	28.5		28.4	29.0		32.5	14.5	12.6	33.8	20.2	14.3
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.5	0.3		0.2	0.2		0.8	0.1	0.0	17.9	6.9	0.1
Delay (s)	28.9	28.8		28.6	29.2		33.3	14.6	12.6	51.7	27.1	14.3
Level of Service	C	C		C	C		C	B	B	D	C	B
Approach Delay (s)		28.8			29.1			17.8			28.2	
Approach LOS		C			C			B			C	

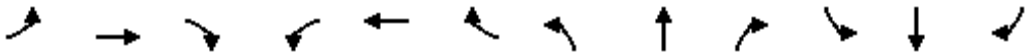
Intersection Summary			
HCM Average Control Delay	26.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	72.3	Sum of lost time (s)	18.9
Intersection Capacity Utilization	72.9%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



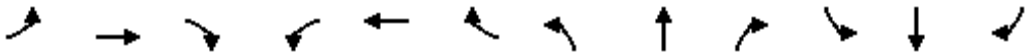
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	110	33	33	20	14	40	14	134	30	70	223	25
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frpb, ped/bikes		0.99			1.00	0.98	1.00	1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Frt		0.97			1.00	0.85	1.00	0.97		1.00	0.98	
Flt Protected		0.97			0.97	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1751			1809	1545	1770	1804		1770	1829	
Flt Permitted		0.97			0.97	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)		1751			1809	1545	1770	1804		1770	1829	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	120	36	36	22	15	43	15	146	33	76	242	27
RTOR Reduction (vph)	0	9	0	0	0	40	0	9	0	0	4	0
Lane Group Flow (vph)	0	183	0	0	37	3	15	170	0	76	265	0
Confl. Peds. (#/hr)	2		6	6		2	8		2	2		8
Confl. Bikes (#/hr)						1						
Turn Type	Split			Split		Perm	Split			Split		
Protected Phases	2	2		1	1		4	4		3	3	
Permitted Phases						1						
Actuated Green, G (s)		12.2			3.9	3.9	12.7	12.7		15.1	15.1	
Effective Green, g (s)		12.2			3.9	3.9	12.7	12.7		15.1	15.1	
Actuated g/C Ratio		0.20			0.07	0.07	0.21	0.21		0.25	0.25	
Clearance Time (s)		4.0			4.0	4.0	4.0	4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0	3.0	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		357			118	101	375	382		446	461	
v/s Ratio Prot		c0.10			c0.02		0.01	c0.09		0.04	c0.14	
v/s Ratio Perm						0.00						
v/c Ratio		0.51			0.31	0.03	0.04	0.44		0.17	0.57	
Uniform Delay, d1		21.2			26.7	26.2	18.8	20.5		17.5	19.6	
Progression Factor		1.00			1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2		1.2			1.5	0.1	0.0	0.8		0.2	1.7	
Delay (s)		22.5			28.2	26.3	18.8	21.4		17.7	21.3	
Level of Service		C			C	C	B	C		B	C	
Approach Delay (s)		22.5			27.2			21.2			20.5	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	21.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.50		
Actuated Cycle Length (s)	59.9	Sum of lost time (s)	16.0
Intersection Capacity Utilization	44.5%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	160	163	40	60	154	40	20	430	40	50	630	100
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			0.95			0.95	
Frpb, ped/bikes	1.00	0.99		1.00	1.00			1.00			0.99	
Flpb, ped/bikes	0.99	1.00		0.98	1.00			1.00			1.00	
Frt	1.00	0.97		1.00	0.97			0.99			0.98	
Flt Protected	0.95	1.00		0.95	1.00			1.00			1.00	
Satd. Flow (prot)	1584	3071		1568	3074			3129			3090	
Flt Permitted	0.62	1.00		0.62	1.00			0.91			0.89	
Satd. Flow (perm)	1042	3071		1022	3074			2867			2773	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	167	170	42	62	160	42	21	448	42	52	656	104
RTOR Reduction (vph)	0	24	0	0	24	0	0	10	0	0	17	0
Lane Group Flow (vph)	167	188	0	62	178	0	0	501	0	0	795	0
Confl. Peds. (#/hr)	10		29	29		10	63		34	34		63
Confl. Bikes (#/hr)									1			
Parking (#/hr)							0					
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			4			2			2	
Permitted Phases	4			4			2			2		
Actuated Green, G (s)	30.0	30.0		30.0	30.0			32.0			32.0	
Effective Green, g (s)	29.0	29.0		29.0	29.0			31.0			31.0	
Actuated g/C Ratio	0.43	0.43		0.43	0.43			0.46			0.46	
Clearance Time (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	444	1310		436	1311			1307			1264	
v/s Ratio Prot		0.06			0.06							
v/s Ratio Perm	c0.16			0.06				0.17			c0.29	
v/c Ratio	0.38	0.14		0.14	0.14			0.38			0.63	
Uniform Delay, d1	13.3	11.9		11.9	11.9			12.2			14.1	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	2.4	0.2		0.7	0.2			0.9			2.4	
Delay (s)	15.7	12.1		12.6	12.1			13.1			16.5	
Level of Service	B	B		B	B			B			B	
Approach Delay (s)		13.7			12.2			13.1			16.5	
Approach LOS		B			B			B			B	

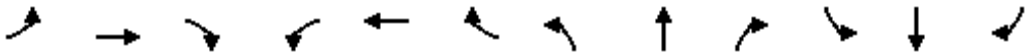
Intersection Summary			
HCM Average Control Delay	14.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.51		
Actuated Cycle Length (s)	68.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	96.6%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	193	30	20	174	144	20	420	40	573	550	40
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0			5.0		5.0	5.0	
Lane Util. Factor		0.95			0.95			0.95		0.97	1.00	
Frpb, ped/bikes		1.00			0.99			1.00		1.00	1.00	
Flpb, ped/bikes		1.00			1.00			1.00		1.00	1.00	
Frt		0.98			0.94			0.99		1.00	0.99	
Flt Protected		1.00			1.00			1.00		0.95	1.00	
Satd. Flow (prot)		3481			3312			3516		3467	1859	
Flt Permitted		0.90			0.92			1.00		0.95	1.00	
Satd. Flow (perm)		3149			3064			3516		3467	1859	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	21	205	32	21	185	153	21	447	43	610	585	43
RTOR Reduction (vph)	0	16	0	0	127	0	0	9	0	0	3	0
Lane Group Flow (vph)	0	242	0	0	232	0	0	502	0	610	625	0
Confl. Peds. (#/hr)	2		6	6		2	11		10	10		11
Confl. Bikes (#/hr)						2						1
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm			Perm			Split			Split		
Protected Phases		4			4		2	2		3	3	
Permitted Phases	4			4								
Actuated Green, G (s)		12.0			12.0			14.3		26.4	26.4	
Effective Green, g (s)		11.0			11.0			13.3		25.4	25.4	
Actuated g/C Ratio		0.17			0.17			0.21		0.39	0.39	
Clearance Time (s)		4.0			4.0			4.0		4.0	4.0	
Vehicle Extension (s)		3.0			3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		535			521			723		1361	730	
v/s Ratio Prot								c0.14		0.18	c0.34	
v/s Ratio Perm		c0.08			0.08							
v/c Ratio		0.45			0.45			0.69		0.45	0.86	
Uniform Delay, d1		24.1			24.1			23.8		14.5	18.0	
Progression Factor		1.00			1.00			1.00		1.00	1.00	
Incremental Delay, d2		0.6			0.6			2.9		0.2	9.7	
Delay (s)		24.8			24.7			26.7		14.7	27.7	
Level of Service		C			C			C		B	C	
Approach Delay (s)		24.8			24.7			26.7			21.3	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	23.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	64.7	Sum of lost time (s)	15.0
Intersection Capacity Utilization	82.4%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	368	419	20	306	120	351	290	40	100	390	30
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Util. Factor		0.91	0.91		0.95		1.00	1.00			1.00	
Frpb, ped/bikes		0.99	0.96		0.99		1.00	1.00			1.00	
Flpb, ped/bikes		1.00	1.00		1.00		1.00	1.00			1.00	
Frt		0.95	0.85		0.96		1.00	0.98			0.99	
Flt Protected		1.00	1.00		1.00		0.95	1.00			0.99	
Satd. Flow (prot)		2998	1399		3152		1787	1583			1586	
Flt Permitted		0.93	1.00		0.88		0.95	1.00			0.99	
Satd. Flow (perm)		2786	1399		2779		1787	1583			1586	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	21	379	432	21	315	124	362	299	41	103	402	31
RTOR Reduction (vph)	0	53	197	0	46	0	0	6	0	0	3	0
Lane Group Flow (vph)	0	520	62	0	414	0	362	334	0	0	533	0
Confl. Peds. (#/hr)	17		21	21		17	30		15	15		30
Confl. Bikes (#/hr)			1			1						
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Parking (#/hr)		8			8			8			8	
Turn Type	Perm		Perm	Perm			Split			Split		
Protected Phases		2			2		4	4		8	8	
Permitted Phases	2		2	2								
Actuated Green, G (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Effective Green, g (s)		20.0	20.0		20.0		25.0	25.0			26.0	
Actuated g/C Ratio		0.24	0.24		0.24		0.30	0.30			0.31	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0			4.0	
Lane Grp Cap (vph)		671	337		670		538	477			497	
v/s Ratio Prot							0.20	c0.21			c0.34	
v/s Ratio Perm		c0.19	0.04		0.15							
v/c Ratio		0.77	0.19		0.62		0.67	0.70			1.07	
Uniform Delay, d1		29.4	25.0		28.1		25.4	25.7			28.5	
Progression Factor		1.00	1.00		1.00		1.00	1.00			1.00	
Incremental Delay, d2		8.5	1.2		4.3		6.6	8.3			61.3	
Delay (s)		37.9	26.2		32.3		32.0	34.0			89.8	
Level of Service		D	C		C		C	C			F	
Approach Delay (s)		34.3			32.3			32.9			89.8	
Approach LOS		C			C			C			F	

Intersection Summary			
HCM Average Control Delay	45.3	HCM Level of Service	D
HCM Volume to Capacity ratio	0.86		
Actuated Cycle Length (s)	83.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	87.8%	ICU Level of Service	E
Analysis Period (min)	15		

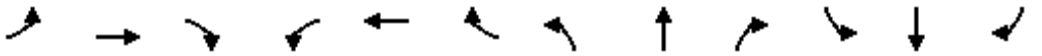
c Critical Lane Group

Movement	EBL2	EBL	EBT	EBR	NBT	NBR	NBR2	SBL2	SBL	SBT
Lane Configurations										
Volume (vph)	30	958	310	100	380	270	70	334	270	343
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0	4.5	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor		0.91	0.91	1.00	0.95	1.00		1.00	1.00	1.00
Frpb, ped/bikes		1.00	1.00	0.85	1.00	0.92		1.00	1.00	1.00
Flpb, ped/bikes		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frt		1.00	1.00	0.85	1.00	0.85		1.00	1.00	1.00
Flt Protected		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (prot)		1610	3289	1343	3539	1450		1770	1770	1863
Flt Permitted		0.95	0.97	1.00	1.00	1.00		0.95	0.95	1.00
Satd. Flow (perm)		1610	3289	1343	3539	1450		1770	1770	1863
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	32	1008	326	105	400	284	74	352	284	361
RTOR Reduction (vph)	0	0	0	68	0	11	0	0	0	0
Lane Group Flow (vph)	0	516	850	37	400	347	0	352	284	361
Confl. Peds. (#/hr)				50			50		50	
Confl. Bikes (#/hr)				10			10			
Turn Type	Perm	Perm		Perm		Perm		Prot	Prot	
Protected Phases			4		2			1	1	6
Permitted Phases	4	4		4		2				
Actuated Green, G (s)		30.9	30.9	30.9	20.4	20.4		25.7	25.7	49.1
Effective Green, g (s)		32.4	32.4	31.9	19.9	19.9		25.7	25.7	49.6
Actuated g/C Ratio		0.36	0.36	0.35	0.22	0.22		0.29	0.29	0.55
Clearance Time (s)		5.5	5.5	5.5	3.5	3.5		4.0	4.0	4.5
Vehicle Extension (s)		2.0	2.0	2.0	2.0	2.0		2.0	2.0	2.0
Lane Grp Cap (vph)		580	1184	476	783	321		505	505	1027
v/s Ratio Prot					0.11			c0.20	0.16	0.19
v/s Ratio Perm		c0.32	0.26	0.03		c0.24				
v/c Ratio		0.89	0.87dl	0.08	0.51	1.08		0.70	0.56	0.35
Uniform Delay, d1		27.1	24.9	19.3	30.8	35.0		28.7	27.4	11.2
Progression Factor		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2		15.1	1.8	0.0	0.2	73.6		7.8	4.5	0.9
Delay (s)		42.2	26.6	19.3	31.0	108.7		36.4	31.8	12.2
Level of Service		D	C	B	C	F		D	C	B
Approach Delay (s)			31.5		67.7					26.3
Approach LOS			C		E					C

Intersection Summary			
HCM Average Control Delay	38.4	HCM Level of Service	D
HCM Volume to Capacity ratio	0.88		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	76.1%	ICU Level of Service	D
Analysis Period (min)	15		

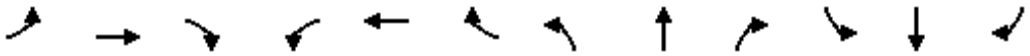
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

c Critical Lane Group



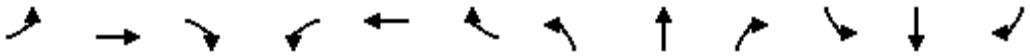
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	368	667	0	0	0	0	0	892	350
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0						4.0	4.0
Lane Util. Factor				0.86	0.86						0.86	0.86
Frpb, ped/bikes				1.00	1.00						1.00	1.00
Flpb, ped/bikes				1.00	1.00						1.00	1.00
Frt				1.00	1.00						0.99	0.85
Flt Protected				0.95	0.99						1.00	1.00
Satd. Flow (prot)				1522	4770						4745	1362
Flt Permitted				0.95	0.99						1.00	1.00
Satd. Flow (perm)				1522	4770						4745	1362
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	0	0	387	702	0	0	0	0	0	939	368
RTOR Reduction (vph)	0	0	0	196	22	0	0	0	0	0	11	112
Lane Group Flow (vph)	0	0	0	67	804	0	0	0	0	0	1005	179
Confl. Bikes (#/hr)						5						9
Turn Type				Prot								Prot
Protected Phases				7	3						2	2
Permitted Phases												
Actuated Green, G (s)				20.0	40.0						31.0	31.0
Effective Green, g (s)				20.0	40.0						31.0	31.0
Actuated g/C Ratio				0.25	0.51						0.39	0.39
Clearance Time (s)				4.0	4.0						4.0	4.0
Lane Grp Cap (vph)				385	2415						1862	534
v/s Ratio Prot				0.04	c0.08						c0.21	0.13
v/s Ratio Perm					0.08							
v/c Ratio				0.17	0.33						0.54	0.33
Uniform Delay, d1				23.0	11.6						18.5	16.8
Progression Factor				1.00	1.00						1.00	1.00
Incremental Delay, d2				1.0	0.4						1.1	1.7
Delay (s)				24.0	12.0						19.6	18.5
Level of Service				C	B						B	B
Approach Delay (s)		0.0			14.9			0.0			19.4	
Approach LOS		A			B			A			B	

Intersection Summary			
HCM Average Control Delay	17.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.42		
Actuated Cycle Length (s)	79.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	41.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	210	740	0	0	0	0	0	819	1818	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0						4.0	4.0			
Lane Util. Factor		0.91						0.91	0.88			
Frpb, ped/bikes		1.00						1.00	1.00			
Flpb, ped/bikes		1.00						1.00	1.00			
Frt		1.00						1.00	0.85			
Flt Protected		0.99						1.00	1.00			
Satd. Flow (prot)		5013						5085	2787			
Flt Permitted		0.99						1.00	1.00			
Satd. Flow (perm)		5013						5085	2787			
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	221	779	0	0	0	0	0	862	1914	0	0	0
RTOR Reduction (vph)	0	3	0	0	0	0	0	0	231	0	0	0
Lane Group Flow (vph)	0	998	0	0	0	0	0	862	1683	0	0	0
Confl. Peds. (#/hr)	28		7	7		28	99		3	3		99
Confl. Bikes (#/hr)			1			2			1			
Turn Type	Perm								custom			
Protected Phases		4						2	2			
Permitted Phases	4								7			
Actuated Green, G (s)		34.0						16.0	16.0			
Effective Green, g (s)		35.0						17.0	17.0			
Actuated g/C Ratio		0.58						0.28	0.28			
Clearance Time (s)		5.0						5.0	5.0			
Vehicle Extension (s)		3.0						3.0	3.0			
Lane Grp Cap (vph)		2924						1441	790			
v/s Ratio Prot								0.17	c0.60			
v/s Ratio Perm		0.20										
v/c Ratio		0.34						0.60	2.13			
Uniform Delay, d1		6.5						18.6	21.5			
Progression Factor		1.00						1.00	1.00			
Incremental Delay, d2		0.3						0.7	512.7			
Delay (s)		6.8						19.2	534.2			
Level of Service		A						B	F			
Approach Delay (s)		6.8			0.0			374.3			0.0	
Approach LOS		A			A			F			A	

Intersection Summary			
HCM Average Control Delay	277.0	HCM Level of Service	F
HCM Volume to Capacity ratio	0.93		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	98.9%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	50	1176	1353	0	0	0	0	230	240	80	340	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0					4.0			4.0	
Lane Util. Factor		0.86	0.86					1.00			1.00	
Frpb, ped/bikes		0.98	0.97					0.98			1.00	
Flpb, ped/bikes		1.00	1.00					1.00			1.00	
Frt		0.95	0.85					0.93			1.00	
Flt Protected		1.00	1.00					1.00			0.99	
Satd. Flow (prot)		4421	1323					1701			1842	
Flt Permitted		1.00	1.00					1.00			0.39	
Satd. Flow (perm)		4421	1323					1701			733	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	53	1238	1424	0	0	0	0	242	253	84	358	0
RTOR Reduction (vph)	0	70	0	0	0	0	0	31	0	0	0	0
Lane Group Flow (vph)	0	1933	712	0	0	0	0	464	0	0	442	0
Confl. Peds. (#/hr)	52		55	55		52	39		25	25		39
Confl. Bikes (#/hr)			1						2		1	2
Turn Type	Perm		Free							Perm		
Protected Phases		2						4			8	
Permitted Phases	2		Free							8		
Actuated Green, G (s)		33.0	60.0					18.0			18.0	
Effective Green, g (s)		34.0	60.0					18.0			18.0	
Actuated g/C Ratio		0.57	1.00					0.30			0.30	
Clearance Time (s)		5.0						4.0			4.0	
Vehicle Extension (s)		2.0						2.0			2.0	
Lane Grp Cap (vph)		2505	1323					510			220	
v/s Ratio Prot								0.27				
v/s Ratio Perm		0.44	0.54								c0.60	
v/c Ratio		0.77	0.54					0.91			2.01	
Uniform Delay, d1		10.0	0.0					20.2			21.0	
Progression Factor		0.62	1.00					1.00			1.00	
Incremental Delay, d2		0.2	0.1					20.0			469.8	
Delay (s)		6.4	0.1					40.3			490.8	
Level of Service		A	A					D			F	
Approach Delay (s)		4.8			0.0			40.3			490.8	
Approach LOS		A			A			D			F	

Intersection Summary			
HCM Average Control Delay	68.4	HCM Level of Service	E
HCM Volume to Capacity ratio	1.20		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	97.5%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			

Appendix F: Freeway LOS Calculations
Alameda Point

FEHR PEERS

Existing Conditions

FEHR PEERS

HCM 2000
Basic Freeway Segments
Capacity Analysis

Jurisdiction
Analysis Year Existing
Analyst TL

Agency or Company
Date
Project Description

General Information | *Flow Rate Calculation* | *Speed Calculation* | *Results*

	Freeway/ Direction	From/To	Analysis Time Period	Volume (vph)	PHF	Lanes	HOV Lane?	HOV Lane Volume	Terrain	Truck/ Bus %	RV %	E_T	E_R	f_{HV}	f_P	Flow Rate v_p (pcphpl)	Measured FFS (mph)	S (mph)	Density, D (pcplpm)	Level of Service
A-1	I-880 NB	I-880, west of SR 24	AM	7,490	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,859	65.0	-	**-**	**F**
A-2	I-880 NB	I-880, between SR 24 and Oak Street	AM	7,270	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,081	65.0	59.9	**34.7**	**D**
A-3	I-880 NB	I-880, south of Oak Street	AM	7,060	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,021	65.0	61.1	**33.1**	**D**
A-4	Posey Tube	Alameda to Oakland	AM	2,650	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,455	65.0	65.0	**22.4**	**C**
A-1	I-880 SB	I-880, west of SR 24	AM	7,630	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,912	65.0	-	**-**	**F**
A-2	I-880 SB	I-880, between SR 24 and Oak Street	AM	9,130	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,614	65.0	-	**-**	**F**
A-3	I-880 SB	I-880, south of Oak Street	AM	6,980	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	1,998	65.0	61.5	**32.5**	**D**
A-4	Webster Tube	Oakland to Alameda	AM	1,750	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	961	65.0	65.0	**14.8**	**B**
A-1	I-880 NB	I-880, west of SR 24	PM	7,150	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,729	65.0	-	**-**	**F**
A-2	I-880 NB	I-880, between SR 24 and Oak Street	PM	7,430	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,127	65.0	58.9	**36.1**	**E**
A-3	I-880 NB	I-880, south of Oak Street	PM	7,050	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,018	65.0	61.1	**33.0**	**D**
A-4	Posey Tube	Alameda to Oakland	PM	2,250	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,235	65.0	65.0	**19.0**	**C**
A-1	I-880 SB	I-880, west of SR 24	PM	8,090	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	3,088	65.0	-	**-**	**F**
A-2	I-880 SB	I-880, between SR 24 and Oak Street	PM	9,210	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,637	65.0	-	**-**	**F**
A-3	I-880 SB	I-880, south of Oak Street	PM	7,480	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,141	65.0	58.6	**36.6**	**E**
A-4	Webster Tube	Oakland to Alameda	PM	2,610	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,433	65.0	65.0	**22.0**	**C**

Near-Term (2018) No Project Conditions

FEHR PEERS

HCM 2000
Basic Freeway Segments
Capacity Analysis

Jurisdiction
Analysis Year Near-Term
Analyst TL
Agency or Company
Date
Project Description

General Information *Flow Rate Calculation* *Speed Calculation* *Results*

	Freeway/ Direction	From/To	Analysis Time Period	Volume (vph)	PHF	Lanes	HOV Lane?	HOV Lane Volume	Terrain	Truck/ Bus %	RV %	E_T	E_R	f_{HV}	f_P	Flow Rate v_p (pcphpl)	Measured FFS (mph)	S (mph)	Density, D (pcplpm)	Level of Service
A-1	I-880 NB	I-880, west of SR 24	AM	7,620	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,909	65.0	-	**-**	**F**
A-2	I-880 NB	I-880, between SR 24 and Oak Street	AM	7,380	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,113	65.0	59.2	**35.7**	**E**
A-3	I-880 NB	I-880, south of Oak Street	AM	7,200	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,061	65.0	60.3	**34.2**	**D**
A-4	Posey Tube	Alameda to Oakland	AM	2,770	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,520	65.0	65.0	**23.4**	**C**
A-1	I-880 SB	I-880, west of SR 24	AM	7,650	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,920	65.0	-	**-**	**F**
A-2	I-880 SB	I-880, between SR 24 and Oak Street	AM	9,320	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,668	65.0	-	**-**	**F**
A-3	I-880 SB	I-880, south of Oak Street	AM	7,180	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,055	65.0	60.4	**34.0**	**D**
A-4	Webster Tube	Oakland to Alameda	AM	2,010	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,103	65.0	65.0	**17.0**	**B**
A-1	I-880 NB	I-880, west of SR 24	PM	7,400	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,825	65.0	-	**-**	**F**
A-2	I-880 NB	I-880, between SR 24 and Oak Street	PM	7,710	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,207	65.0	56.8	**38.8**	**E**
A-3	I-880 NB	I-880, south of Oak Street	PM	7,390	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,116	65.0	59.2	**35.8**	**E**
A-4	Posey Tube	Alameda to Oakland	PM	2,450	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,345	65.0	65.0	**20.7**	**C**
A-1	I-880 SB	I-880, west of SR 24	PM	8,170	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	3,119	65.0	-	**-**	**F**
A-2	I-880 SB	I-880, between SR 24 and Oak Street	PM	9,390	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,688	65.0	-	**-**	**F**
A-3	I-880 SB	I-880, south of Oak Street	PM	7,700	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,204	65.0	56.9	**38.7**	**E**
A-4	Webster Tube	Oakland to Alameda	PM	2,810	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,542	65.0	65.0	**23.7**	**C**

Near-Term (2018) Plus Phase 1 Project Conditions

FEHR PEERS

HCM 2000
Basic Freeway Segments
Capacity Analysis

Jurisdiction
Analysis Year Near-Term + Project (Phase 1)
Analyst TL

Agency or Company
Date
Project Description

General Information | *Flow Rate Calculation* | *Speed Calculation* | *Results*

	Freeway/ Direction	From/To	Analysis Time Period	Volume (vph)	PHF	Lanes	HOV Lane?	HOV Lane Volume	Terrain	Truck/ Bus %	RV %	E_T	E_R	f_{HV}	f_P	Flow Rate v_p (pcphpl)	Measured FFS (mph)	S (mph)	Density, D (pcplpm)	Level of Service
A-1	I-880 NB	I-880, west of SR 24	AM	7,623	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,910	65.0	-	**-**	**F**
A-2	I-880 NB	I-880, between SR 24 and Oak Street	AM	7,387	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,115	65.0	59.2	**35.7**	**E**
A-3	I-880 NB	I-880, south of Oak Street	AM	7,240	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,073	65.0	60.1	**34.5**	**D**
A-4	Posey Tube	Alameda to Oakland	AM	2,787	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,530	65.0	65.0	**23.5**	**C**
A-1	I-880 SB	I-880, west of SR 24	AM	7,668	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,927	65.0	-	**-**	**F**
A-2	I-880 SB	I-880, between SR 24 and Oak Street	AM	9,320	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,668	65.0	-	**-**	**F**
A-3	I-880 SB	I-880, south of Oak Street	AM	7,187	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,057	65.0	60.4	**34.1**	**D**
A-4	Webster Tube	Oakland to Alameda	AM	2,114	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,160	65.0	65.0	**17.9**	**B**
A-1	I-880 NB	I-880, west of SR 24	PM	7,417	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,831	65.0	-	**-**	**F**
A-2	I-880 NB	I-880, between SR 24 and Oak Street	PM	7,751	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,219	65.0	56.5	**39.3**	**E**
A-3	I-880 NB	I-880, south of Oak Street	PM	7,396	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,117	65.0	59.1	**35.8**	**E**
A-4	Posey Tube	Alameda to Oakland	PM	2,548	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,399	65.0	65.0	**21.5**	**C**
A-1	I-880 SB	I-880, west of SR 24	PM	8,173	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	3,120	65.0	-	**-**	**F**
A-2	I-880 SB	I-880, between SR 24 and Oak Street	PM	9,390	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,688	65.0	-	**-**	**F**
A-3	I-880 SB	I-880, south of Oak Street	PM	7,738	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,215	65.0	56.6	**39.1**	**E**
A-4	Webster Tube	Oakland to Alameda	PM	2,825	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,551	65.0	65.0	**23.9**	**C**

Cumulative (2035) No Project Conditions

FEHR PEERS

HCM 2000
Basic Freeway Segments
Capacity Analysis

Jurisdiction
Analysis Year Cumulative
Analyst TL

Agency or Company
Date
Project Description

General Information | *Flow Rate Calculation* | *Speed Calculation* | *Results*

	Freeway/ Direction	From/To	Analysis Time Period	Volume (vph)	PHF	Lanes	HOV Lane?	HOV Lane Volume	Terrain	Truck/ Bus %	RV %	E_T	E_R	f_{HV}	f_P	Flow Rate v_p (pcphpl)	Measured FFS (mph)	S (mph)	Density, D (pcplpm)	Level of Service
A-1	I-880 NB	I-880, west of SR 24	AM	7,990	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	3,050	65.0	-	**-**	**F**
A-2	I-880 NB	I-880, between SR 24 and Oak Street	AM	7,710	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,207	65.0	56.8	**38.8**	**E**
A-3	I-880 NB	I-880, south of Oak Street	AM	7,610	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,179	65.0	57.6	**37.8**	**E**
A-4	Posey Tube	Alameda to Oakland	AM	3,120	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,713	65.0	64.5	**26.6**	**D**
A-1	I-880 SB	I-880, west of SR 24	AM	7,710	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,943	65.0	-	**-**	**F**
A-2	I-880 SB	I-880, between SR 24 and Oak Street	AM	9,870	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,826	65.0	-	**-**	**F**
A-3	I-880 SB	I-880, south of Oak Street	AM	7,750	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,219	65.0	56.5	**39.3**	**E**
A-4	Webster Tube	Oakland to Alameda	AM	2,730	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,499	65.0	65.0	**23.1**	**C**
A-1	I-880 NB	I-880, west of SR 24	PM	8,090	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	3,088	65.0	-	**-**	**F**
A-2	I-880 NB	I-880, between SR 24 and Oak Street	PM	8,510	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,436	65.0	-	**-**	**F**
A-3	I-880 NB	I-880, south of Oak Street	PM	8,340	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,388	65.0	-	**-**	**F**
A-4	Posey Tube	Alameda to Oakland	PM	3,030	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,663	65.0	64.7	**25.7**	**C**
A-1	I-880 SB	I-880, west of SR 24	PM	8,380	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	3,199	65.0	-	**-**	**F**
A-2	I-880 SB	I-880, between SR 24 and Oak Street	PM	9,910	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,837	65.0	-	**-**	**F**
A-3	I-880 SB	I-880, south of Oak Street	PM	8,330	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,385	65.0	-	**-**	**F**
A-4	Webster Tube	Oakland to Alameda	PM	3,370	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,850	65.0	63.5	**29.2**	**D**

Cumulative (2035) Plus Phase 1 Project Conditions

FEHR PEERS

HCM 2000
Basic Freeway Segments
Capacity Analysis

Jurisdiction
Analysis Year Cumulative + Project (Phase 1)
Analyst TL

Agency or Company
Date
Project Description

General Information | *Flow Rate Calculation* | *Speed Calculation* | *Results*

	Freeway/ Direction	From/To	Analysis Time Period	Volume (vph)	PHF	Lanes	HOV Lane?	HOV Lane Volume	Terrain	Truck/ Bus %	RV %	E_T	E_R	f_{HV}	f_P	Flow Rate v_p (pcphpl)	Measured FFS (mph)	S (mph)	Density, D (pcplpm)	Level of Service
A-1	I-880 NB	I-880, west of SR 24	AM	7,993	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	3,051	65.0	-	**-**	**F**
A-2	I-880 NB	I-880, between SR 24 and Oak Street	AM	7,717	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,209	65.0	56.8	**38.9**	**E**
A-3	I-880 NB	I-880, south of Oak Street	AM	7,650	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,190	65.0	57.3	**38.2**	**E**
A-4	Posey Tube	Alameda to Oakland	AM	3,137	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,722	65.0	64.4	**26.7**	**D**
A-1	I-880 SB	I-880, west of SR 24	AM	7,728	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,950	65.0	-	**-**	**F**
A-2	I-880 SB	I-880, between SR 24 and Oak Street	AM	9,870	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,826	65.0	-	**-**	**F**
A-3	I-880 SB	I-880, south of Oak Street	AM	7,757	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,221	65.0	56.5	**39.3**	**E**
A-4	Webster Tube	Oakland to Alameda	AM	2,834	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,556	65.0	65.0	**24.0**	**C**
A-1	I-880 NB	I-880, west of SR 24	PM	8,107	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	3,094	65.0	-	**-**	**F**
A-2	I-880 NB	I-880, between SR 24 and Oak Street	PM	8,551	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,448	65.0	-	**-**	**F**
A-3	I-880 NB	I-880, south of Oak Street	PM	8,346	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,389	65.0	-	**-**	**F**
A-4	Posey Tube	Alameda to Oakland	PM	3,128	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,717	65.0	64.5	**26.6**	**D**
A-1	I-880 SB	I-880, west of SR 24	PM	8,383	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	3,200	65.0	-	**-**	**F**
A-2	I-880 SB	I-880, between SR 24 and Oak Street	PM	9,910	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,837	65.0	-	**-**	**F**
A-3	I-880 SB	I-880, south of Oak Street	PM	8,368	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,396	65.0	-	**-**	**F**
A-4	Webster Tube	Oakland to Alameda	PM	3,385	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,858	65.0	63.4	**29.3**	**D**

Near-Term (2018) Plus Additional Employment Alternative Conditions

FEHR PEERS

HCM 2000
Basic Freeway Segments
Capacity Analysis

Jurisdiction
Analysis Year Near-Term + Phase 1 Alternative
Analyst SN
Agency or Company
Date
Project Description

General Information *Flow Rate Calculation* *Speed Calculation* *Results*

	Freeway/ Direction	From/To	Analysis Time Period	Volume (vph)	PHF	Lanes	HOV Lane?	HOV Lane Volume	Terrain	Truck/ Bus %	RV %	E_T	E_R	f_{HV}	f_P	Flow Rate v_p (pcphpl)	Measured FFS (mph)	S (mph)	Density, D (pcplpm)	Level of Service
A-1	I-880 NB	I-880, west of SR 24	AM	7,625	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,910	65.0	-	**-**	**F**
A-2	I-880 NB	I-880, between SR 24 and Oak Street	AM	7,392	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,116	65.0	59.2	**35.8**	**E**
A-3	I-880 NB	I-880, south of Oak Street	AM	7,268	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,081	65.0	59.9	**34.7**	**D**
A-4	Posey Tube	Alameda to Oakland	AM	2,798	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,536	65.0	65.0	**23.6**	**C**
A-1	I-880 SB	I-880, west of SR 24	AM	7,681	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,932	65.0	-	**-**	**F**
A-2	I-880 SB	I-880, between SR 24 and Oak Street	AM	9,320	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,668	65.0	-	**-**	**F**
A-3	I-880 SB	I-880, south of Oak Street	AM	7,191	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,059	65.0	60.4	**34.1**	**D**
A-4	Webster Tube	Oakland to Alameda	AM	2,186	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,200	65.0	65.0	**18.5**	**C**
A-1	I-880 NB	I-880, west of SR 24	PM	7,429	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,836	65.0	-	**-**	**F**
A-2	I-880 NB	I-880, between SR 24 and Oak Street	PM	7,780	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,227	65.0	56.3	**39.6**	**E**
A-3	I-880 NB	I-880, south of Oak Street	PM	7,400	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,118	65.0	59.1	**35.8**	**E**
A-4	Posey Tube	Alameda to Oakland	PM	2,617	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,437	65.0	65.0	**22.1**	**C**
A-1	I-880 SB	I-880, west of SR 24	PM	8,175	0.92	3	No		Level	11%	0%	1.5	1.2	0.949	1.00	3,120	65.0	-	**-**	**F**
A-2	I-880 SB	I-880, between SR 24 and Oak Street	PM	9,390	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,688	65.0	-	**-**	**F**
A-3	I-880 SB	I-880, south of Oak Street	PM	7,765	0.92	4	No		Level	11%	0%	1.5	1.2	0.949	1.00	2,223	65.0	56.4	**39.4**	**E**
A-4	Webster Tube	Oakland to Alameda	PM	2,836	0.92	2	No		Level	2%	0%	1.5	1.2	0.990	1.00	1,557	65.0	65.0	**24.0**	**C**

Appendix G: Intersection Count Data Sheets
LBNL

FEHR PEERS

Study Name University Ave/Shattuck Ave TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#1

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	3	0	0	1	1	0	0	0	0	0	0	1	0	0	0
7:15 AM	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
7:30 AM	0	2	1	0	1	0	0	0	0	0	0	0	1	2	0	0
7:45 AM	0	2	0	0	1	0	0	0	0	0	0	0	0	4	0	0
8:00 AM	0	3	0	0	0	0	0	0	0	0	0	0	0	2	0	0
8:15 AM	0	2	0	0	0	1	0	0	0	0	0	0	2	1	0	0
8:30 AM	0	7	1	0	2	1	0	0	0	0	0	0	1	2	0	0
8:45 AM	0	5	0	0	1	3	0	0	0	1	0	0	1	4	0	0
4:00 PM	0	3	0	0	0	2	0	0	0	0	0	0	1	2	0	0
4:15 PM	0	6	0	0	0	2	0	0	0	0	0	0	0	0	0	0
4:30 PM	1	3	0	0	0	5	1	0	0	0	0	0	0	0	0	0
4:45 PM	0	6	0	0	2	3	0	0	0	0	0	0	0	0	1	0
5:00 PM	0	8	0	0	1	5	0	0	0	0	0	0	1	4	0	0
5:15 PM	0	8	0	0	0	6	0	0	0	0	0	0	0	2	0	0
5:30 PM	0	3	0	0	3	0	1	0	0	0	0	0	0	4	0	0
5:45 PM	0	7	0	0	0	2	0	0	0	0	0	0	1	0	0	0

Study Name University Ave/Shattuck Ave TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#1

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	3	6	5	8	3	0	12	7
7:15 AM	4	4	6	18	5	2	18	18
7:30 AM	7	13	15	17	17	3	32	15
7:45 AM	8	17	11	23	30	2	30	22
8:00 AM	10	8	7	18	15	0	36	24
8:15 AM	6	17	15	20	10	5	45	21
8:30 AM	3	18	13	38	21	5	41	41
8:45 AM	11	21	24	34	28	5	56	43
4:00 PM	32	22	30	35	20	26	62	86
4:15 PM	33	21	20	29	22	23	59	61
4:30 PM	26	13	13	26	22	22	54	60
4:45 PM	36	17	25	21	33	29	81	74
5:00 PM	43	22	21	35	24	35	85	93
5:15 PM	48	23	16	27	26	41	77	91
5:30 PM	44	28	41	30	23	35	83	103
5:45 PM	43	30	27	45	19	23	61	88

Study Name University Ave/Shattuck Ave TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#1

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	15	67	0	0	16	51	3	0	0	0	0	0	23	52	10	1
7:15 AM	11	76	1	0	40	49	5	0	0	0	0	0	23	59	9	0
7:30 AM	14	109	9	0	33	65	9	0	0	0	0	0	30	88	11	0
7:45 AM	17	155	7	0	61	58	3	0	0	0	0	0	32	102	27	1
8:00 AM	28	176	9	0	36	68	3	0	0	0	0	0	41	90	16	0
8:15 AM	15	199	9	0	69	96	3	0	0	0	0	0	50	92	23	0
8:30 AM	23	155	6	0	59	82	8	0	0	0	0	0	33	96	25	0
8:45 AM	23	180	12	0	73	70	9	0	0	1	0	0	47	103	25	2
4:00 PM	24	137	7	0	74	144	13	0	0	0	0	0	46	67	27	0
4:15 PM	34	127	5	0	88	123	16	0	0	0	0	0	48	82	23	0
4:30 PM	26	114	9	0	96	156	14	0	0	0	0	0	38	83	22	0
4:45 PM	22	128	4	0	93	120	15	0	0	0	0	0	57	103	27	0
5:00 PM	27	131	2	0	112	140	12	0	0	0	0	0	51	87	31	0
5:15 PM	32	128	9	0	84	139	18	1	0	0	0	0	62	100	28	0
5:30 PM	31	125	10	0	123	129	20	0	0	0	0	0	52	104	22	0
5:45 PM	27	138	12	0	121	144	17	1	0	0	0	0	62	106	34	0

Totals

Study Name Hearst Ave/Shattuck Ave TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#2

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	2	0	0	0	3	0	0	0	1	0	0	0	3	0	0
7:15 AM	0	1	1	0	0	2	0	0	0	3	0	0	0	3	0	0
7:30 AM	0	4	3	0	0	0	0	0	0	0	0	0	0	5	0	0
7:45 AM	0	3	2	0	0	0	0	0	0	4	0	0	1	2	0	0
8:00 AM	0	3	4	0	0	0	0	0	0	0	0	0	2	5	0	0
8:15 AM	1	2	3	0	0	2	2	0	0	2	1	0	1	11	1	0
8:30 AM	0	8	1	0	0	3	1	0	1	0	0	0	2	17	0	0
8:45 AM	0	3	9	0	0	1	0	0	0	2	0	0	5	23	0	0
4:00 PM	0	2	0	0	0	8	0	0	0	3	0	0	2	1	0	0
4:15 PM	0	1	0	0	0	10	2	0	0	5	0	0	1	0	0	0
4:30 PM	0	4	2	0	0	11	0	0	0	7	2	0	0	0	0	0
4:45 PM	0	7	1	0	0	8	0	0	0	6	3	0	0	4	0	0
5:00 PM	0	4	0	0	1	29	3	0	0	4	1	0	1	4	0	0
5:15 PM	1	9	1	0	3	17	3	0	0	3	2	0	1	1	0	0
5:30 PM	1	4	1	0	2	23	2	0	0	7	0	0	1	2	0	0
5:45 PM	0	3	0	0	1	14	2	0	0	3	1	0	0	2	0	0

Study Name Hearst Ave/Shattuck Ave TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#2

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	0	0	1	3	3	1	12	1
7:15 AM	1	4	2	13	2	0	10	6
7:30 AM	3	7	2	14	10	0	29	4
7:45 AM	1	9	8	22	24	0	29	14
8:00 AM	5	12	3	18	7	2	28	7
8:15 AM	1	11	7	17	11	3	30	17
8:30 AM	1	15	6	31	12	3	34	19
8:45 AM	2	18	15	24	30	3	40	16
4:00 PM	13	1	22	14	3	9	25	39
4:15 PM	8	6	20	15	7	15	28	39
4:30 PM	5	4	28	17	8	11	22	31
4:45 PM	13	4	31	13	7	5	37	45
5:00 PM	38	8	22	15	0	5	39	45
5:15 PM	42	6	35	26	5	27	42	48
5:30 PM	20	3	34	27	5	26	47	48
5:45 PM	13	32	30	16	6	12	37	57

Study Name Hearst Ave/Shattuck Ave TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#2

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	2	81	9	0	0	11	4	0	3	17	0	0	3	20	3	0
7:15 AM	6	88	18	0	9	8	4	0	4	40	0	1	3	27	3	0
7:30 AM	4	121	38	0	6	12	13	0	4	34	1	0	8	29	2	0
7:45 AM	2	176	38	0	6	25	13	0	9	73	2	0	9	50	5	0
8:00 AM	15	209	32	0	7	51	16	0	8	52	3	0	9	50	4	0
8:15 AM	11	219	32	0	11	50	15	0	3	94	2	0	12	64	9	0
8:30 AM	10	184	40	0	11	42	12	0	6	84	0	0	7	62	9	0
8:45 AM	16	205	47	0	17	33	16	1	9	95	4	0	21	82	5	0
4:00 PM	12	131	13	0	20	56	26	0	5	125	9	0	11	28	6	0
4:15 PM	10	128	15	0	30	69	23	0	3	123	9	1	7	27	14	0
4:30 PM	6	103	15	0	18	90	19	0	6	120	7	1	8	25	14	0
4:45 PM	11	143	26	2	26	63	21	0	6	133	8	2	8	41	8	0
5:00 PM	14	122	16	1	36	107	30	0	8	126	12	1	12	42	10	0
5:15 PM	11	135	16	0	45	97	30	0	6	130	9	1	10	39	12	0
5:30 PM	8	124	15	1	36	102	27	0	9	155	6	0	17	46	14	0
5:45 PM	9	158	21	0	24	77	25	0	8	155	5	2	6	39	17	0

Totals

Study Name University Ave/Oxford St TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#3

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	3	2	0	0	0	0	0	0	2	0	0	0	0	0	0
7:15 AM	0	2	2	0	1	0	0	0	0	3	1	0	0	0	0	0
7:30 AM	0	7	2	0	0	0	0	0	0	3	1	0	1	0	0	0
7:45 AM	0	6	8	0	0	0	0	0	0	3	2	0	0	3	2	0
8:00 AM	1	8	3	0	0	0	0	0	4	2	1	0	0	4	0	0
8:15 AM	0	11	1	0	1	1	0	0	0	4	2	0	0	0	0	0
8:30 AM	1	8	10	0	0	2	0	0	0	0	0	0	3	2	0	0
8:45 AM	1	8	3	0	0	2	0	0	0	6	2	0	0	5	1	0
4:00 PM	0	5	0	0	4	4	0	0	0	4	2	0	0	1	1	0
4:15 PM	0	4	1	0	2	1	1	0	0	2	1	0	0	1	1	0
4:30 PM	0	7	0	0	1	6	0	0	0	4	2	0	0	0	0	0
4:45 PM	1	1	0	0	3	2	0	0	0	3	1	0	0	0	0	0
5:00 PM	0	10	0	0	0	1	0	0	0	3	2	0	1	1	1	0
5:15 PM	0	7	0	0	0	3	1	0	0	1	1	0	0	2	0	0
5:30 PM	1	7	2	0	0	0	2	0	0	5	2	0	1	1	0	0
5:45 PM	0	9	0	0	0	1	0	0	0	5	3	0	3	0	1	0

Study Name University Ave/Oxford St TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#3

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	1	1	0	0	5	0	5	6
7:15 AM	1	3	0	7	2	1	2	4
7:30 AM	0	20	0	2	9	0	7	15
7:45 AM	1	59	11	6	13	0	11	10
8:00 AM	3	26	14	7	9	2	7	11
8:15 AM	3	22	7	7	9	2	15	7
8:30 AM	2	23	8	12	12	4	20	12
8:45 AM	9	30	4	15	19	10	23	22
4:00 PM	37	14	7	8	22	24	24	22
4:15 PM	26	12	14	8	10	11	7	6
4:30 PM	17	11	8	10	5	10	14	15
4:45 PM	35	20	12	12	21	24	11	23
5:00 PM	54	14	9	32	8	41	23	43
5:15 PM	42	8	18	10	21	23	19	17
5:30 PM	36	17	10	18	8	27	18	10
5:45 PM	34	16	11	7	17	18	18	8

Study Name University Ave/Oxford St TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#3

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	13	72	3	0	0	2	0	0	0	35	15	0	24	1	48	0
7:15 AM	12	77	6	0	3	1	0	0	0	44	18	0	30	3	41	0
7:30 AM	13	136	3	0	2	5	0	0	0	50	18	0	53	10	48	0
7:45 AM	9	180	12	1	2	1	0	0	1	88	24	0	60	7	84	0
8:00 AM	13	212	6	0	4	5	1	0	4	86	19	0	48	9	74	0
8:15 AM	16	211	4	0	5	1	0	0	1	107	34	0	63	2	85	0
8:30 AM	18	165	15	0	2	4	1	0	0	90	28	1	48	5	77	0
8:45 AM	15	157	12	0	3	3	0	0	0	90	24	0	54	9	88	0
4:00 PM	21	129	0	1	9	6	1	0	0	134	56	1	54	4	46	1
4:15 PM	24	110	4	2	5	3	4	0	1	134	42	0	66	6	51	1
4:30 PM	31	118	3	0	4	7	1	0	1	112	51	0	52	4	54	0
4:45 PM	18	110	2	1	5	2	1	0	0	129	41	3	76	3	74	0
5:00 PM	35	158	9	0	4	8	1	0	1	165	52	0	57	6	54	0
5:15 PM	30	154	4	2	12	6	1	0	0	148	40	1	83	6	68	1
5:30 PM	36	152	6	0	2	4	3	0	5	181	45	2	58	6	62	0
5:45 PM	7	167	4	1	6	5	1	0	8	156	54	4	73	3	81	1

Totals

Study Name Hearst Ave/Oxford St TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#4

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	4	0	0	0	1	0	0	0	0	1	0	4	0	0	0
7:15 AM	0	4	1	0	0	2	0	0	0	2	0	0	1	2	1	0
7:30 AM	0	1	1	0	0	0	0	0	3	1	1	0	8	4	0	0
7:45 AM	0	5	0	0	0	1	1	0	0	0	0	0	12	12	0	0
8:00 AM	0	3	0	0	0	0	2	0	0	0	0	0	8	8	0	0
8:15 AM	0	5	0	0	0	0	0	0	0	0	0	0	5	14	0	0
8:30 AM	1	9	0	0	0	1	1	0	0	0	2	0	5	8	0	0
8:45 AM	0	1	1	0	0	1	2	0	0	0	1	0	9	26	0	0
4:00 PM	0	3	0	0	0	7	1	0	0	3	3	0	1	4	0	0
4:15 PM	0	1	0	0	1	11	1	0	1	2	1	0	0	0	0	0
4:30 PM	0	0	0	0	0	10	5	0	0	2	2	0	0	1	0	0
4:45 PM	0	0	0	0	0	9	0	0	0	1	0	0	2	1	0	0
5:00 PM	0	2	0	0	1	22	4	0	0	4	8	0	0	2	0	0
5:15 PM	0	3	0	0	1	17	2	0	1	1	8	0	3	1	0	0
5:30 PM	0	1	0	0	0	19	5	0	1	5	8	0	2	0	0	0
5:45 PM	0	2	0	0	0	17	1	0	0	2	2	0	2	2	0	0

Study Name Hearst Ave/Oxford St TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#4

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	2	5	1	4	2	1	4	5
7:15 AM	5	6	1	5	2	0	7	5
7:30 AM	3	7	0	13	7	0	13	5
7:45 AM	5	32	11	18	32	2	22	9
8:00 AM	11	13	2	13	27	1	20	2
8:15 AM	4	23	1	11	11	4	13	3
8:30 AM	9	17	0	21	17	4	16	2
8:45 AM	9	29	3	20	29	4	26	2
4:00 PM	30	8	27	8	2	12	8	10
4:15 PM	25	7	12	6	8	13	7	6
4:30 PM	23	11	15	4	3	10	6	11
4:45 PM	22	19	16	22	6	6	9	13
5:00 PM	73	11	29	8	8	15	11	15
5:15 PM	71	13	55	17	4	12	6	10
5:30 PM	46	11	25	4	6	5	12	10
5:45 PM	36	19	31	7	9	15	27	8

Study Name Hearst Ave/Oxford St TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#4

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	3	52	5	0	3	11	23	0	44	22	5	0	6	24	1	0
7:15 AM	0	62	2	0	1	15	25	0	54	23	7	2	5	42	1	0
7:30 AM	4	79	7	0	4	19	43	0	59	22	8	0	19	62	0	0
7:45 AM	4	124	10	0	1	23	39	0	63	66	8	0	23	75	2	0
8:00 AM	13	158	8	0	1	48	50	0	88	56	10	1	24	70	3	0
8:15 AM	6	128	8	0	4	54	75	0	100	66	8	0	21	73	5	0
8:30 AM	8	116	6	0	2	39	52	0	83	80	14	0	26	75	6	0
8:45 AM	12	112	4	0	7	44	51	0	83	60	12	0	25	111	5	0
4:00 PM	4	68	9	0	15	68	49	0	63	104	19	4	11	36	4	0
4:15 PM	6	60	6	0	12	91	62	0	46	113	22	1	15	31	7	0
4:30 PM	7	46	7	0	13	97	64	0	60	98	17	0	12	24	4	0
4:45 PM	1	69	2	0	11	82	49	0	78	103	18	1	20	51	8	0
5:00 PM	11	56	2	0	13	121	88	0	63	129	26	0	17	37	8	0
5:15 PM	9	81	1	0	15	132	81	0	78	158	29	0	19	41	8	0
5:30 PM	10	71	4	0	17	118	83	0	78	145	28	0	12	47	10	0
5:45 PM	4	85	6	0	16	97	81	0	80	147	24	2	27	43	8	0

Totals

Study Name Channing Way/Piedmont Ave Roundabout
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#10

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
7:15 AM	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0
7:30 AM	0	0	0	0	2	0	0	0	0	3	0	0	0	0	0	0
7:45 AM	0	0	0	0	2	2	0	0	0	2	0	0	0	0	0	0
8:00 AM	0	1	0	0	3	0	0	0	0	10	1	0	0	0	0	0
8:15 AM	0	2	0	0	0	1	0	0	0	5	0	0	0	0	0	0
8:30 AM	0	0	0	0	1	2	0	0	1	8	0	0	0	0	0	0
8:45 AM	0	0	0	0	1	0	0	0	0	3	0	0	0	1	0	0
4:00 PM	1	4	0	0	0	0	0	0	1	10	0	0	0	0	0	0
4:15 PM	4	8	2	0	0	0	0	0	0	3	0	0	0	0	0	0
4:30 PM	0	10	1	1	1	1	1	0	1	6	0	0	1	0	0	0
4:45 PM	1	10	1	0	1	0	1	0	0	5	0	0	0	0	0	0
5:00 PM	1	8	3	0	0	2	0	0	1	4	0	0	0	0	1	0
5:15 PM	0	9	0	0	0	0	0	0	0	2	0	0	0	1	0	0
5:30 PM	0	5	2	0	0	1	1	0	0	1	0	0	0	0	0	0
5:45 PM	1	10	0	0	1	0	0	0	0	1	0	0	0	0	0	0

Study Name Channing Way/Piedmont Ave Roundabout
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#10

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	1	2	0	0	0	0	0	4
7:15 AM	0	2	0	0	0	0	1	1
7:30 AM	0	1	0	0	0	0	0	5
7:45 AM	1	4	0	0	0	0	2	24
8:00 AM	0	0	0	0	0	0	2	15
8:15 AM	0	0	0	0	1	0	3	4
8:30 AM	2	2	1	0	1	0	2	6
8:45 AM	0	2	0	0	0	2	0	19
4:00 PM	11	2	0	1	9	3	25	10
4:15 PM	4	4	0	0	3	1	22	7
4:30 PM	3	4	0	0	3	0	14	4
4:45 PM	6	1	0	0	4	1	14	16
5:00 PM	17	3	0	2	8	5	42	16
5:15 PM	21	10	0	4	10	3	54	7
5:30 PM	22	6	0	0	14	8	19	8
5:45 PM	10	13	1	1	15	5	21	16

Study Name Channing Way/Piedmont Ave Roundabout
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#10

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	6	27	2	0	5	5	6	0	0	78	11	0	0	2	3	0
7:15 AM	2	45	2	0	5	11	3	0	4	87	14	0	1	0	2	0
7:30 AM	3	48	4	0	4	8	2	0	3	94	13	1	4	3	4	0
7:45 AM	7	72	3	0	3	13	6	0	2	103	17	0	1	1	7	0
8:00 AM	11	82	7	0	5	15	9	0	11	79	17	0	2	5	6	0
8:15 AM	9	65	8	0	4	11	10	0	1	101	12	0	2	4	7	0
8:30 AM	8	51	3	0	1	16	5	0	2	114	12	0	3	8	7	0
8:45 AM	4	78	0	1	2	8	5	0	3	100	13	0	1	7	6	0
4:00 PM	34	102	7	3	10	15	10	1	6	97	9	1	16	3	10	0
4:15 PM	31	99	11	2	3	13	8	0	4	82	5	0	19	7	3	1
4:30 PM	23	107	7	4	10	19	8	0	7	84	10	1	7	7	8	0
4:45 PM	9	108	14	1	12	17	16	0	1	98	9	2	5	15	13	0
5:00 PM	17	105	13	0	5	20	11	0	7	89	16	3	8	12	8	1
5:15 PM	25	104	19	0	5	30	19	1	7	74	20	2	16	10	6	2
5:30 PM	20	98	14	0	6	32	12	1	12	71	35	0	7	8	8	2
5:45 PM	14	100	14	2	4	24	12	0	5	87	28	0	15	15	6	0

Totals

Study Name Dwight Way/Piedmont Ave TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#11

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	0	0	0	1	0	0	0	0	3	0	0	0	0	1	0
7:15 AM	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0
7:30 AM	0	1	0	0	3	0	0	0	0	2	0	0	0	0	1	0
7:45 AM	0	0	0	0	3	0	0	0	0	9	0	0	1	0	5	0
8:00 AM	0	0	1	0	2	0	0	0	0	4	0	0	0	0	1	0
8:15 AM	0	0	0	0	2	0	0	0	0	1	0	0	0	1	5	0
8:30 AM	0	0	0	0	1	0	0	0	0	2	0	0	0	0	3	0
8:45 AM	0	0	0	0	0	0	0	0	0	4	0	0	0	0	4	0
4:00 PM	0	1	0	0	3	0	0	0	0	7	0	0	0	0	0	0
4:15 PM	1	4	0	0	0	0	0	0	0	1	0	0	0	0	0	0
4:30 PM	0	6	0	0	0	0	0	0	0	4	0	0	0	0	0	0
4:45 PM	0	2	1	0	1	0	0	0	0	1	0	0	0	0	1	0
5:00 PM	0	5	1	0	1	0	0	0	0	2	0	0	0	0	0	0
5:15 PM	0	2	0	0	0	0	0	0	0	1	0	0	0	1	1	0
5:30 PM	0	2	0	0	0	0	0	0	0	0	0	0	1	0	1	0
5:45 PM	0	3	0	0	0	0	0	0	0	8	0	0	0	2	2	0

Study Name Dwight Way/Piedmont Ave TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#11

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	3	1	0	0	1	1	3	0
7:15 AM	1	1	4	2	1	3	0	2
7:30 AM	9	0	18	3	0	7	0	9
7:45 AM	19	4	33	0	3	10	1	25
8:00 AM	3	4	5	2	4	1	4	6
8:15 AM	5	20	2	1	7	1	3	0
8:30 AM	6	5	14	5	5	4	4	2
8:45 AM	6	3	14	0	4	9	5	17
4:00 PM	7	15	7	11	13	6	19	5
4:15 PM	10	16	3	8	10	6	11	6
4:30 PM	10	7	3	5	9	26	10	4
4:45 PM	9	10	17	4	9	12	10	14
5:00 PM	8	14	12	17	31	6	27	5
5:15 PM	7	23	13	23	29	4	26	7
5:30 PM	8	15	25	15	10	7	15	4
5:45 PM	20	14	19	9	12	7	15	6

Study Name Dwight Way/Piedmont Ave TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#11

	Southbound Street Southbound				Westbound Street Westbound				Northbound Street Northbound				Eastbound Street Eastbound			
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn
7:00 AM	0	28	0	0	11	0	0	0	0	102	0	0	16	11	8	0
7:15 AM	0	44	0	0	12	0	3	0	0	105	0	0	17	10	12	0
7:30 AM	0	48	0	0	11	0	2	0	0	141	0	0	28	11	17	0
7:45 AM	0	68	4	0	17	0	5	0	0	132	0	0	24	22	24	0
8:00 AM	0	74	2	0	12	0	3	0	0	137	0	0	38	31	23	0
8:15 AM	0	51	1	0	14	0	5	0	0	153	0	0	31	28	24	0
8:30 AM	0	58	2	0	9	0	11	0	0	146	0	0	33	27	25	0
8:45 AM	0	64	1	0	6	0	2	0	0	152	0	0	35	28	26	0
4:00 PM	0	110	6	0	17	0	12	0	0	100	0	0	41	21	23	0
4:15 PM	1	111	2	0	16	0	5	0	0	85	0	0	57	22	21	0
4:30 PM	0	105	0	0	13	0	14	0	0	93	0	0	59	21	22	0
4:45 PM	0	99	2	0	12	0	13	0	0	108	0	0	44	28	24	0
5:00 PM	0	99	5	0	24	0	10	0	2	109	0	0	50	19	23	0
5:15 PM	0	89	1	0	23	0	7	0	1	93	0	0	62	25	30	0
5:30 PM	0	102	1	0	24	0	7	0	2	123	0	0	45	33	28	0
5:45 PM	0	96	3	0	26	0	6	0	0	147	0	0	42	33	27	0

Totals

Study Name Prospect St/Canyon Rd-Panoramic Way TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code Wc12-2953_#12

	Southbound Street Southbound			Northbound Street Northbound			Eastbound Street Eastbound		
Start Time	Right	Thru	U-Turn	Thru	Left	U-Turn	Right	Left	U-Turn
7:00 AM	2	0	0	0	2	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	3	0	0	0	0
7:45 AM	0	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	1	1	0	0	0	0
8:30 AM	0	0	0	0	0	0	0	1	0
8:45 AM	0	0	0	0	3	0	0	0	0
4:00 PM	0	0	0	0	0	0	0	0	0
4:15 PM	2	2	0	0	0	0	0	0	0
4:30 PM	2	0	0	0	0	0	1	0	0
4:45 PM	2	0	0	0	0	0	1	0	0
5:00 PM	1	0	0	0	0	0	0	0	0
5:15 PM	6	0	0	0	0	0	1	0	0
5:30 PM	3	0	0	0	0	0	1	0	0
5:45 PM	1	0	0	0	0	0	0	0	0

Study Name Prospect St/Canyon Rd-Panoramic Way TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code Wc12-2953_#12

	Southbound Street Southbound		Northbound Street Northbound		Eastbound Street Eastbound	
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW
7:00 AM	0	0	0	0	0	1
7:15 AM	0	0	0	0	0	1
7:30 AM	0	0	0	0	0	2
7:45 AM	0	0	0	0	1	0
8:00 AM	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	1
8:30 AM	0	0	0	0	0	0
8:45 AM	0	0	0	0	0	1
4:00 PM	0	0	0	0	0	0
4:15 PM	0	0	0	0	0	0
4:30 PM	1	0	0	0	0	0
4:45 PM	1	0	0	0	0	0
5:00 PM	0	0	0	0	0	2
5:15 PM	0	0	0	0	1	0
5:30 PM	0	0	0	0	2	0
5:45 PM	0	0	0	1	1	1

Study Name Prospect St/Canyon Rd-Panoramic Way TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code Wc12-2953_#12

	Southbound Street Southbound			Northbound Street Northbound			Eastbound Street Eastbound		
Start Time	Right	Thru	U-Turn	Thru	Left	U-Turn	Right	Left	U-Turn
7:00 AM	22	1	0	0	9	0	0	25	0
7:15 AM	15	0	0	0	4	0	3	44	0
7:30 AM	28	0	0	2	17	0	4	45	0
7:45 AM	22	0	0	3	5	0	2	40	0
8:00 AM	27	2	0	4	18	0	4	63	1
8:15 AM	24	4	0	3	9	0	6	48	1
8:30 AM	20	1	0	6	12	0	7	55	0
8:45 AM	20	1	0	3	13	0	5	40	0
4:00 PM	33	4	0	4	5	0	10	33	0
4:15 PM	38	5	0	1	8	0	5	33	0
4:30 PM	45	5	0	1	10	0	10	35	0
4:45 PM	40	1	0	4	7	0	8	42	0
5:00 PM	60	3	0	4	13	0	8	44	0
5:15 PM	51	4	0	5	7	0	9	42	0
5:30 PM	57	3	0	8	8	0	13	47	0
5:45 PM	37	2	0	5	12	0	10	31	1

Totals

Study Name Centennial Dr/Stadium Rim Way TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#13

	Southbound Street Southbound			Westbound Street Westbound			Northbound Street Northbound		
Start Time	Thru	Left	U-Turn	Right	Left	U-Turn	Right	Thru	U-Turn
7:00 AM	0	1	0	1	2	0	0	0	0
7:15 AM	0	0	0	0	0	0	0	0	0
7:30 AM	0	0	0	0	0	0	0	0	0
7:45 AM	0	1	0	1	1	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	0
8:15 AM	0	0	0	0	0	0	0	1	0
8:30 AM	0	1	0	1	0	0	1	0	0
8:45 AM	0	0	0	0	0	0	0	0	0
4:00 PM	0	1	0	0	0	0	1	0	0
4:15 PM	2	0	0	3	2	0	0	0	0
4:30 PM	0	0	0	1	2	0	0	0	0
4:45 PM	0	0	0	1	2	0	1	0	0
5:00 PM	0	0	0	1	1	0	0	0	0
5:15 PM	2	0	0	2	4	0	0	0	0
5:30 PM	0	0	0	2	2	0	1	0	0
5:45 PM	0	0	0	2	1	0	0	0	0

Study Name Centennial Dr/Stadium Rim Way TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#13

	Southbound Street Southbound		Westbound Street Westbound		Northbound Street Northbound			
Start Time	Peds CCW	Peds CW	Peds CCW	Peds CW	Peds CCW	Peds CW	Hourly Total	15-min Total
7:00 AM	0	1	0	0	0	1		
7:15 AM	0	1	0	0	3	0		
7:30 AM	1	1	1	1	1	1		
7:45 AM	0	4	0	0	4	1		
8:00 AM	0	0	0	0	1	1		
8:15 AM	1	0	0	1	0	4		
8:30 AM	0	1	0	0	1	1		
8:45 AM	0	1	1	0	1	0		
4:00 PM	1	3	0	0	4	2		
4:15 PM	3	5	2	0	2	2		
4:30 PM	1	0	0	2	3	4		
4:45 PM	1	1	0	3	5	3		
5:00 PM	3	2	1	0	6	1		
5:15 PM	6	1	4	5	6	7		
5:30 PM	4	2	2	0	4	9		
5:45 PM	3	7	1	0	1	4		

Study Name Centennial Dr/Stadium Rim Way TMC
Start Date 01/31/2013
Start Time 7:00 AM
Site Code WC12-2953_#13

	Southbound Street Southbound			Westbound Street Westbound			Northbound Street Northbound				
Start Time	Thru	Left	U-Turn	Right	Left	U-Turn	Right	Thru	U-Turn	Hourly Total	15-min Total
7:00 AM	1	4	0	5	21	0	23	1	0	316	55
7:15 AM	0	11	0	5	13	0	35	7	0	378	71
7:30 AM	1	10	0	12	25	0	32	15	0	416	95
7:45 AM	2	11	0	18	20	0	28	16	0	445	95
8:00 AM	5	14	0	13	21	0	43	21	0	462	117
8:15 AM	5	14	0	19	24	0	39	8	0		109
8:30 AM	1	24	0	20	19	0	50	10	0		124
8:45 AM	3	21	0	21	19	0	35	13	0		112
4:00 PM	7	19	0	10	31	0	20	15	0	483	102
4:15 PM	9	18	0	28	33	0	22	13	0	538	123
4:30 PM	10	21	0	18	40	0	24	10	0	560	123
4:45 PM	7	14	0	27	36	0	34	17	0	583	135
5:00 PM	9	29	0	20	53	0	28	18	0	550	157
5:15 PM	9	21	0	25	44	0	23	23	0		145
5:30 PM	10	12	0	20	47	0	32	25	0		146
5:45 PM	7	14	0	14	31	0	25	11	0		102

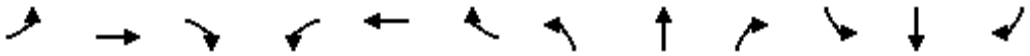
Totals

Appendix H: Intersection LOS Calculation
LBNL

FEHR PEERS

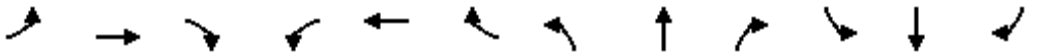
Existing Conditions

FEHR PEERS



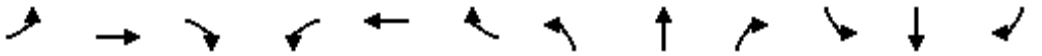
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	91	372	167	23	311	234	0	0	0	35	693	89
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Util. Factor	1.00	0.95			0.91	0.91					0.91	
Frpb, ped/bikes	1.00	0.97			0.99	0.90					0.97	
Flpb, ped/bikes	0.95	1.00			1.00	1.00					0.99	
Frt	1.00	0.95			0.98	0.85					0.98	
Flt Protected	0.95	1.00			1.00	1.00					1.00	
Satd. Flow (prot)	1624	3150			3131	1248					4622	
Flt Permitted	0.47	1.00			0.91	1.00					1.00	
Satd. Flow (perm)	800	3150			2844	1248					4622	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	99	404	182	25	338	254	0	0	0	38	753	97
RTOR Reduction (vph)	0	5	0	0	14	94	0	0	0	0	17	0
Lane Group Flow (vph)	99	581	0	0	410	99	0	0	0	0	871	0
Confl. Peds. (#/hr)	94		89	89		94	307		169	169		307
Confl. Bikes (#/hr)			9			5			1			17
Heavy Vehicles (%)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
Turn Type	Perm			Perm		Perm				Perm		
Protected Phases		4			8						6	
Permitted Phases	4			8		8				6		
Actuated Green, G (s)	46.0	46.0			46.0	46.0					36.0	
Effective Green, g (s)	46.0	46.0			46.0	46.0					36.0	
Actuated g/C Ratio	0.51	0.51			0.51	0.51					0.40	
Clearance Time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Grp Cap (vph)	409	1610			1454	638					1849	
v/s Ratio Prot		c0.18										
v/s Ratio Perm	0.12				0.14	0.08					0.19	
v/c Ratio	0.24	0.36			0.28	0.15					0.47	
Uniform Delay, d1	12.3	13.2			12.6	11.7					20.0	
Progression Factor	1.00	1.00			1.39	2.97					0.67	
Incremental Delay, d2	1.4	0.6			0.5	0.5					0.8	
Delay (s)	13.7	13.8			17.9	35.1					14.1	
Level of Service	B	B			B	D					B	
Approach Delay (s)		13.8			23.3			0.0			14.1	
Approach LOS		B			C			A			B	

Intersection Summary			
HCM Average Control Delay	16.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	83.3%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



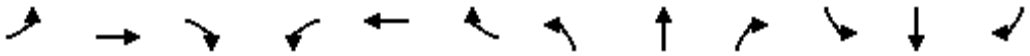
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	26	202	39	56	170	46	8	321	25	134	801	51
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95	1.00		0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes		1.00	0.90		0.99		1.00	0.99		1.00	0.99	
Flpb, ped/bikes		1.00	1.00		0.99		0.97	1.00		0.96	1.00	
Frt		1.00	0.85		0.97		1.00	0.99		1.00	0.99	
Flt Protected		0.99	1.00		0.99		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3471	1408		3314		1704	3446		1679	3447	
Flt Permitted		0.90	1.00		0.84		0.25	1.00		0.52	1.00	
Satd. Flow (perm)		3135	1408		2821		440	3446		921	3447	
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	28	217	42	60	183	49	9	345	27	144	861	55
RTOR Reduction (vph)	0	0	27	0	19	0	0	6	0	0	5	0
Lane Group Flow (vph)	0	245	15	0	273	0	9	366	0	144	911	0
Confl. Peds. (#/hr)	65		71	71		65	191		121	121		191
Confl. Bikes (#/hr)			56			6			4			16
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm		Perm	Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)		32.0	32.0		32.0		50.0	50.0		50.0	50.0	
Effective Green, g (s)		32.0	32.0		32.0		50.0	50.0		50.0	50.0	
Actuated g/C Ratio		0.36	0.36		0.36		0.56	0.56		0.56	0.56	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)		1115	501		1003		244	1914		512	1915	
v/s Ratio Prot								0.11			c0.26	
v/s Ratio Perm		0.08	0.01		c0.10		0.02			0.16		
v/c Ratio		0.22	0.03		0.27		0.04	0.19		0.28	0.48	
Uniform Delay, d1		20.3	18.9		20.7		9.1	9.9		10.5	12.1	
Progression Factor		1.00	1.00		0.86		2.01	1.97		1.00	1.00	
Incremental Delay, d2		0.5	0.1		0.6		0.3	0.2		1.4	0.8	
Delay (s)		20.7	19.0		18.4		18.5	19.8		11.9	12.9	
Level of Service		C	B		B		B	B		B	B	
Approach Delay (s)		20.5			18.4			19.7			12.8	
Approach LOS		C			B			B			B	

Intersection Summary			
HCM Average Control Delay	16.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.40		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	104.7%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			



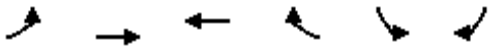
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	323	14	210	2	8	13	101	361	1	20	710	59
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.95	0.95			1.00		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	0.94			0.93		1.00	1.00		1.00	1.00	0.87
Flpb, ped/bikes	0.90	0.98			1.00		1.00	1.00		0.94	1.00	1.00
Frt	1.00	0.88			0.92		1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95	0.99			1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1480	1401			1559		1736	3469		1630	3471	1358
Flt Permitted	0.74	0.96			0.98		0.95	1.00		0.51	1.00	1.00
Satd. Flow (perm)	1153	1352			1539		1736	3469		880	3471	1358
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	363	16	236	2	9	15	113	406	1	22	798	66
RTOR Reduction (vph)	0	124	0	0	10	0	0	0	0	0	0	29
Lane Group Flow (vph)	319	172	0	0	16	0	113	407	0	22	798	37
Confl. Peds. (#/hr)	118		67	67		118	117		74	74		117
Confl. Bikes (#/hr)			11			5			12			35
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm			Perm			Prot			Perm		Perm
Protected Phases		4			8		5	2			6	
Permitted Phases	4			8						6		6
Actuated Green, G (s)	30.0	30.0			30.0		6.0	52.0		42.0	42.0	42.0
Effective Green, g (s)	30.0	30.0			30.0		6.0	52.0		42.0	42.0	42.0
Actuated g/C Ratio	0.33	0.33			0.33		0.07	0.58		0.47	0.47	0.47
Clearance Time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Grp Cap (vph)	384	451			513		116	2004		411	1620	634
v/s Ratio Prot							c0.07	0.12			c0.23	
v/s Ratio Perm	c0.28	0.13			0.01					0.03		0.03
v/c Ratio	0.83	0.38			0.03		0.97	0.20		0.05	0.49	0.06
Uniform Delay, d1	27.7	22.9			20.2		41.9	9.1		13.1	16.6	13.2
Progression Factor	0.70	0.43			1.00		1.00	1.00		0.46	0.45	0.30
Incremental Delay, d2	18.2	2.4			0.1		76.9	0.2		0.2	0.9	0.2
Delay (s)	37.4	12.2			20.3		118.8	9.3		6.2	8.4	4.2
Level of Service	D	B			C		F	A		A	A	A
Approach Delay (s)		25.3			20.3			33.1			8.1	
Approach LOS		C			C			C			A	

Intersection Summary			
HCM Average Control Delay	19.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.66		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	66.4%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	19	273	69	223	183	14	42	262	354	25	496	38
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.5	2.5		2.5	2.5		2.5	2.5	2.5		2.5	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.95	1.00		0.95	
Frpb, ped/bikes	1.00	0.98		1.00	0.99		1.00	1.00	0.91		0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		0.97	1.00	1.00		1.00	
Frt	1.00	0.97		1.00	0.99		1.00	1.00	0.85		0.99	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00		1.00	
Satd. Flow (prot)	1736	3282		1579	3229		1681	3471	1418		3394	
Flt Permitted	0.95	1.00		0.95	0.99		0.25	1.00	1.00		0.93	
Satd. Flow (perm)	1736	3282		1579	3229		436	3471	1418		3176	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	20	287	73	235	193	15	44	276	373	26	522	40
RTOR Reduction (vph)	0	25	0	0	4	0	0	0	267	0	6	0
Lane Group Flow (vph)	20	335	0	146	293	0	44	276	106	0	582	0
Confl. Peds. (#/hr)	115		97	97		115	84		71	71		84
Confl. Bikes (#/hr)			56			2						18
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Split			Split			Perm		Perm	Perm		
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2		2	6		
Actuated Green, G (s)	32.0	32.0		25.0	25.0		25.5	25.5	25.5		25.5	
Effective Green, g (s)	32.0	32.0		25.0	25.0		25.5	25.5	25.5		25.5	
Actuated g/C Ratio	0.36	0.36		0.28	0.28		0.28	0.28	0.28		0.28	
Clearance Time (s)	2.5	2.5		2.5	2.5		2.5	2.5	2.5		2.5	
Lane Grp Cap (vph)	617	1167		439	897		124	983	402		900	
v/s Ratio Prot	0.01	c0.10		c0.09	0.09			0.08				
v/s Ratio Perm							0.10		0.07		c0.18	
v/c Ratio	0.03	0.29		0.33	0.33		0.35	0.28	0.26		0.65	
Uniform Delay, d1	18.9	20.8		25.9	25.8		25.7	25.1	25.0		28.3	
Progression Factor	1.41	1.50		1.00	1.00		0.75	0.74	1.13		1.00	
Incremental Delay, d2	0.1	0.6		2.0	1.0		7.0	0.6	1.4		3.6	
Delay (s)	26.7	31.9		27.9	26.8		26.3	19.2	29.7		31.9	
Level of Service	C	C		C	C		C	B	C		C	
Approach Delay (s)		31.6			27.1			25.3			31.9	
Approach LOS		C			C			C			C	

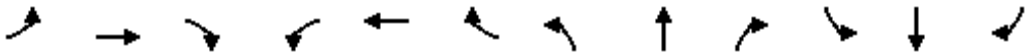
Intersection Summary			
HCM Average Control Delay	28.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	7.5
Intersection Capacity Utilization	92.4%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (vph)	79	423	190	13	41	118
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00	0.97		0.88	
Flpb, ped/bikes	1.00	1.00	1.00		1.00	
Frt	1.00	1.00	0.99		0.90	
Flt Protected	0.95	1.00	1.00		0.99	
Satd. Flow (prot)	1703	3406	1716		1401	
Flt Permitted	0.95	1.00	1.00		0.99	
Satd. Flow (perm)	1703	3406	1716		1401	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	83	445	200	14	43	124
RTOR Reduction (vph)	0	0	3	0	75	0
Lane Group Flow (vph)	83	445	211	0	92	0
Confl. Peds. (#/hr)				246	116	116
Confl. Bikes (#/hr)				4		
Heavy Vehicles (%)	6%	6%	6%	6%	6%	6%
Turn Type	Prot					
Protected Phases	7	4	8		6	
Permitted Phases						
Actuated Green, G (s)	6.2	31.8	21.6		26.0	
Effective Green, g (s)	6.2	31.8	21.6		26.0	
Actuated g/C Ratio	0.09	0.48	0.33		0.40	
Clearance Time (s)	4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	160	1646	563		554	
v/s Ratio Prot	c0.05	0.13	c0.12		c0.07	
v/s Ratio Perm						
v/c Ratio	0.52	0.27	0.37		0.17	
Uniform Delay, d1	28.4	10.1	16.9		12.9	
Progression Factor	1.00	1.00	1.00		1.00	
Incremental Delay, d2	2.8	0.4	1.9		0.6	
Delay (s)	31.2	10.5	18.8		13.5	
Level of Service	C	B	B		B	
Approach Delay (s)		13.8	18.8		13.5	
Approach LOS		B	B		B	

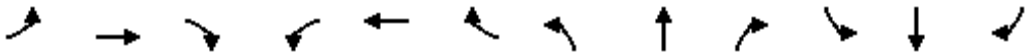
Intersection Summary			
HCM Average Control Delay	14.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.29		
Actuated Cycle Length (s)	65.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	41.2%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	13	184	207	17	40	0	82	146	175	15	195	19
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0			4.0			4.0	
Lane Util. Factor		1.00	1.00		1.00			1.00			1.00	
Frpb, ped/bikes		1.00	0.81		1.00			0.95			0.99	
Flpb, ped/bikes		0.99	1.00		0.96			0.99			1.00	
Frt		1.00	0.85		1.00			0.94			0.99	
Flt Protected		1.00	1.00		0.99			0.99			1.00	
Satd. Flow (prot)		1783	1250		1718			1578			1760	
Flt Permitted		0.98	1.00		0.90			0.89			0.97	
Satd. Flow (perm)		1762	1250		1578			1424			1711	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	14	192	216	18	42	0	85	152	182	16	203	20
RTOR Reduction (vph)	0	0	143	0	0	0	0	42	0	0	5	0
Lane Group Flow (vph)	0	206	73	0	60	0	0	377	0	0	234	0
Confl. Peds. (#/hr)	87		83	83		87	44		51	51		44
Confl. Bikes (#/hr)			2									16
Heavy Vehicles (%)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Turn Type	Perm		Perm	Perm		Perm	Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8		8	2			6		
Actuated Green, G (s)		21.5	21.5		21.5			34.5			34.5	
Effective Green, g (s)		22.0	22.0		22.0			35.0			35.0	
Actuated g/C Ratio		0.34	0.34		0.34			0.54			0.54	
Clearance Time (s)		4.5	4.5		4.5			4.5			4.5	
Lane Grp Cap (vph)		596	423		534			767			921	
v/s Ratio Prot												
v/s Ratio Perm		c0.12	0.06		0.04			c0.26			0.14	
v/c Ratio		0.35	0.17		0.11			0.49			0.25	
Uniform Delay, d1		16.1	15.1		14.8			9.4			8.0	
Progression Factor		1.00	1.00		1.00			1.00			1.00	
Incremental Delay, d2		1.6	0.9		0.4			2.2			0.7	
Delay (s)		17.7	16.0		15.2			11.7			8.7	
Level of Service		B	B		B			B			A	
Approach Delay (s)		16.8			15.2			11.7			8.7	
Approach LOS		B			B			B			A	

Intersection Summary			
HCM Average Control Delay	13.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.43		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	65.1%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	6	6	13	32	1	83	3	315	14	63	356	1
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Hourly flow rate (vph)	6	6	14	34	1	88	3	335	15	67	379	1

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	27	123	353	447
Volume Left (vph)	6	34	3	67
Volume Right (vph)	14	88	15	1
Hadj (s)	-0.15	-0.26	0.10	0.15
Departure Headway (s)	6.0	5.7	5.0	5.0
Degree Utilization, x	0.04	0.19	0.49	0.62
Capacity (veh/h)	491	558	693	706
Control Delay (s)	9.3	10.0	12.8	15.6
Approach Delay (s)	9.3	10.0	12.8	15.6
Approach LOS	A	B	B	C

Intersection Summary				
Delay		13.7		
HCM Level of Service		B		
Intersection Capacity Utilization		63.4%	ICU Level of Service	B
Analysis Period (min)		15		

Intersection 8 **Piedmont Avenue/Bancroft Way** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn	81	72	89.1%	49.1	16.1	E
	Through	442	394	89.2%	49.7	15.6	E
	Right Turn						
	Subtotal	**523**	**466**	**89.2%**	**49.6**	**15.7**	**E**
SB	Left Turn						
	Through	262	241	91.8%	12.2	1.6	B
	Right Turn	93	85	91.2%	10.2	0.7	B
	Subtotal	**355**	**325**	**91.7%**	**11.7**	**1.3**	**B**
EB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**878**	**792**	**90.2%**	**34.3**	**9.8**	**D**

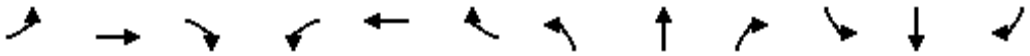
Intersection 9 **Piedmont Avenue/Durant Avenue** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn						
	Through	403	361	89.6%	22.8	8.8	C
	Right Turn						
	Subtotal	**403**	**361**	**89.6%**	**22.8**	**8.8**	**C**
SB	Left Turn						
	Through	257	241	93.9%	11.5	1.8	B
	Right Turn						
	Subtotal	**257**	**241**	**93.9%**	**11.5**	**1.8**	**B**
EB	Left Turn	111	97	87.6%	9.6	2.7	A
	Through						
	Right Turn	72	70	97.4%	6.6	0.9	A
	Subtotal	**183**	**167**	**91.4%**	**8.4**	**1.7**	**A**
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**843**	**770**	**91.3%**	**16.2**	**4.6**	**C**

Intersection	
Intersection Delay (sec/veh)	8.0
Intersection LOS	A

Approach	EB	WB	NB	SB
Entry Lanes	1	1	1	1
Conflicting Circle Lanes	1	1	1	1
Adjusted Approach Flow (vph)	59	86	455	336
Demand Flow Rate (pc/h)	61	89	473	349
Vehicles Circulating (pc/h)	346	483	73	139
Vehicles Exiting (pc/h)	142	63	334	433
Follow-Up Headway (s)	3.186	3.186	3.186	3.186
Ped Vol. Crossing Leg (#/hr)	1	51	6	4
Ped Capacity Adjustment	1.000	0.993	0.999	0.999
Approach Delay (sec/veh)	5.4	6.8	8.7	7.7
Approach LOS	A	A	A	A

Lane	Left	Left	Left	Left
Designated moves	LTR	LTR	LTR	LTR
Assumed Moves	LTR	LTR	LTR	LTR
Right Turn Channelized				
Lane Utilization	1.000	1.000	1.000	1.000
Critical Headway (s)	5.193	5.193	5.193	5.193
Entry Flow Rate (pc/h)	61	89	473	349
Capacity, Entry Lane (pc/h)	799	697	1050	983
Entry HV Adjustment Factor	0.968	0.967	0.961	0.962
Flow Rate, Entry (vph)	59	86	455	336
Capacity, Entry (vph)	774	669	1009	945
Volume to Capacity Ratio	0.076	0.129	0.451	0.355
Control Delay (sec/veh)	5.4	6.8	8.7	7.7
Level of Service	A	A	A	A
95th-Percentile Queue (veh)	0	0	2	2



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	85	113	137	21	0	36	0	577	0	5	247	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Util. Factor	1.00	1.00	1.00	1.00		1.00		*0.60			*0.60	
Frpb, ped/bikes	1.00	1.00	0.96	1.00		0.94		1.00			1.00	
Flpb, ped/bikes	0.96	1.00	1.00	0.97		1.00		1.00			1.00	
Frt	1.00	1.00	0.85	1.00		0.85		1.00			1.00	
Flt Protected	0.95	1.00	1.00	0.95		1.00		1.00			1.00	
Satd. Flow (prot)	1705	1863	1513	1720		1495		2235			2232	
Flt Permitted	0.95	1.00	1.00	0.68		1.00		1.00			0.94	
Satd. Flow (perm)	1705	1863	1513	1237		1495		2235			2107	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	87	115	140	21	0	37	0	589	0	5	252	0
RTOR Reduction (vph)	0	0	73	0	0	19	0	0	0	0	0	0
Lane Group Flow (vph)	87	115	67	21	0	18	0	589	0	0	257	0
Confl. Peds. (#/hr)	35		52	52		35	41		43	43		41
Confl. Bikes (#/hr)			1						11			
Turn Type	Perm		Perm	custom		custom				Perm		
Protected Phases		4						2			6	
Permitted Phases	4		4	8		8				6		
Actuated Green, G (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Effective Green, g (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Actuated g/C Ratio	0.48	0.48	0.48	0.48		0.48		0.43			0.43	
Clearance Time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Grp Cap (vph)	813	889	722	590		713		963			908	
v/s Ratio Prot		c0.06						c0.26				
v/s Ratio Perm	0.05		0.04	0.02		0.01					0.12	
v/c Ratio	0.11	0.13	0.09	0.04		0.02		0.61			0.28	
Uniform Delay, d1	9.4	9.5	9.3	9.0		9.0		14.3			12.0	
Progression Factor	1.00	1.00	1.00	1.00		1.00		1.00			1.00	
Incremental Delay, d2	0.3	0.3	0.3	0.1		0.1		2.9			0.8	
Delay (s)	9.6	9.8	9.6	9.2		9.1		17.2			12.8	
Level of Service	A	A	A	A		A		B			B	
Approach Delay (s)		9.7			9.1			17.2			12.8	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM Average Control Delay	13.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.36		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	60.5%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	207	22	8	91	48	15
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.82	0.82	0.82	0.82	0.82	0.82
Hourly flow rate (vph)	252	27	10	111	59	18
Pedestrians	2					
Lane Width (ft)	12.0					
Walking Speed (ft/s)	4.0					
Percent Blockage	0					
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			279		398	266
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			279		398	266
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			99		90	98
cM capacity (veh/h)			1283		602	773

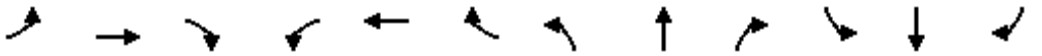
Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	279	121	77
Volume Left	0	10	59
Volume Right	27	0	18
cSH	1700	1283	635
Volume to Capacity	0.16	0.01	0.12
Queue Length 95th (ft)	0	1	10
Control Delay (s)	0.0	0.7	11.4
Lane LOS		A	B
Approach Delay (s)	0.0	0.7	11.4
Approach LOS			B

Intersection Summary			
Average Delay		2.0	
Intersection Capacity Utilization		22.5%	ICU Level of Service A
Analysis Period (min)		15	

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Sign Control	Stop		Stop			Stop
Volume (vph)	83	72	51	166	72	14
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	87	76	54	175	76	15

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total (vph)	163	228	91
Volume Left (vph)	87	0	76
Volume Right (vph)	76	175	0
Hadj (s)	-0.10	-0.39	0.24
Departure Headway (s)	4.5	4.0	4.8
Degree Utilization, x	0.20	0.25	0.12
Capacity (veh/h)	747	859	714
Control Delay (s)	8.6	8.4	8.4
Approach Delay (s)	8.6	8.4	8.4
Approach LOS	A	A	A

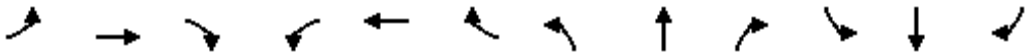
Intersection Summary			
Delay	8.5		
HCM Level of Service	A		
Intersection Capacity Utilization	37.4%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	2	109	99	156	71	8	21	12	18	7	50	2
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Hourly flow rate (vph)	2	124	112	177	81	9	24	14	20	8	57	2

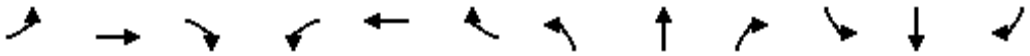
Direction, Lane #	EB 1	WB 1	NB 1	SB 1	SB 2
Volume Total (vph)	239	267	58	65	2
Volume Left (vph)	2	177	24	8	0
Volume Right (vph)	113	9	20	0	2
Hadj (s)	-0.26	0.13	-0.11	0.04	-0.58
Departure Headway (s)	4.3	4.6	5.0	5.2	3.2
Degree Utilization, x	0.28	0.34	0.08	0.09	0.00
Capacity (veh/h)	808	749	640	622	1121
Control Delay (s)	9.0	10.0	8.5	8.7	6.2
Approach Delay (s)	9.0	10.0	8.5	8.6	
Approach LOS	A	A	A	A	

Intersection Summary				
Delay	9.3			
HCM Level of Service	A			
Intersection Capacity Utilization	44.8%	ICU Level of Service		A
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	115	387	225	66	539	436	0	0	0	35	693	89
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Util. Factor	1.00	0.95			0.91	0.91					0.91	
Frpb, ped/bikes	1.00	0.92			0.96	0.73					0.96	
Flpb, ped/bikes	0.92	1.00			0.99	1.00					0.99	
Frt	1.00	0.94			0.98	0.85					0.98	
Flt Protected	0.95	1.00			1.00	1.00					1.00	
Satd. Flow (prot)	1617	3042			3122	1040					4697	
Flt Permitted	0.29	1.00			0.83	1.00					1.00	
Satd. Flow (perm)	491	3042			2590	1040					4697	
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	124	416	242	71	580	469	0	0	0	38	745	96
RTOR Reduction (vph)	0	0	0	0	14	168	0	0	0	0	17	0
Lane Group Flow (vph)	124	658	0	0	745	193	0	0	0	0	862	0
Confl. Peds. (#/hr)	281		226	226		281	681		242	242		681
Confl. Bikes (#/hr)			10			13						26
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm		Perm				Perm		
Protected Phases		4			8						6	
Permitted Phases	4			8		8				6		
Actuated Green, G (s)	48.0	48.0			48.0	48.0					34.0	
Effective Green, g (s)	48.0	48.0			48.0	48.0					34.0	
Actuated g/C Ratio	0.53	0.53			0.53	0.53					0.38	
Clearance Time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Grp Cap (vph)	262	1622			1381	555					1774	
v/s Ratio Prot		0.22										
v/s Ratio Perm	0.25				c0.29	0.19					0.18	
v/c Ratio	0.47	0.41			0.54	0.35					0.49	
Uniform Delay, d1	13.1	12.5			13.8	12.0					21.3	
Progression Factor	1.00	1.00			1.44	4.02					0.75	
Incremental Delay, d2	6.0	0.8			1.5	1.7					0.9	
Delay (s)	19.1	13.3			21.3	50.0					16.9	
Level of Service	B	B			C	D					B	
Approach Delay (s)		14.2			30.6			0.0			16.9	
Approach LOS		B			C			A			B	

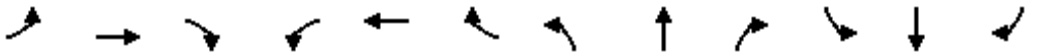
Intersection Summary			
HCM Average Control Delay	21.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.52		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	83.3%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	53	157	42	102	300	134	32	549	31	68	519	40
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95	1.00		0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes		1.00	0.91		0.95		1.00	0.99		1.00	0.98	
Flpb, ped/bikes		0.99	1.00		0.99		0.91	1.00		0.95	1.00	
Frt		1.00	0.85		0.96		1.00	0.99		1.00	0.99	
Flt Protected		0.99	1.00		0.99		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3445	1444		3186		1608	3485		1682	3445	
Flt Permitted		0.76	1.00		0.83		0.40	1.00		0.39	1.00	
Satd. Flow (perm)		2655	1444		2684		672	3485		682	3445	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	55	162	43	105	309	138	33	566	32	70	535	41
RTOR Reduction (vph)	0	0	27	0	36	0	0	5	0	0	6	0
Lane Group Flow (vph)	0	217	16	0	516	0	33	593	0	70	570	0
Confl. Peds. (#/hr)	162		86	86		162	363		205	205		363
Confl. Bikes (#/hr)			9			83			17			20
Turn Type	Perm		Perm	Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)		33.0	33.0		33.0		49.0	49.0		49.0	49.0	
Effective Green, g (s)		33.0	33.0		33.0		49.0	49.0		49.0	49.0	
Actuated g/C Ratio		0.37	0.37		0.37		0.54	0.54		0.54	0.54	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)		974	529		984		366	1897		371	1876	
v/s Ratio Prot								c0.17			0.17	
v/s Ratio Perm		0.08	0.01		c0.19		0.05			0.10		
v/c Ratio		0.22	0.03		0.52		0.09	0.31		0.19	0.30	
Uniform Delay, d1		19.7	18.2		22.3		9.8	11.3		10.4	11.2	
Progression Factor		1.00	1.00		1.48		1.73	1.72		1.00	1.00	
Incremental Delay, d2		0.5	0.1		1.7		0.4	0.4		1.1	0.4	
Delay (s)		20.2	18.4		34.6		17.4	19.7		11.5	11.6	
Level of Service		C	B		C		B	B		B	B	
Approach Delay (s)		19.9			34.6			19.6			11.6	
Approach LOS		B			C			B			B	

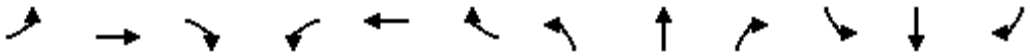
Intersection Summary			
HCM Average Control Delay	21.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.40		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	108.8%	ICU Level of Service	G
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	265	17	266	3	18	24	190	636	14	24	598	107
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.95	0.95			1.00		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	0.86			0.89		1.00	1.00		1.00	1.00	0.84
Flpb, ped/bikes	0.81	0.98			0.99		1.00	1.00		0.93	1.00	1.00
Frt	1.00	0.87			0.93		1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95	1.00			1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1354	1293			1508		1752	3480		1636	3505	1319
Flt Permitted	0.73	0.98			0.98		0.95	1.00		0.40	1.00	1.00
Satd. Flow (perm)	1037	1269			1487		1752	3480		688	3505	1319
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	270	17	271	3	18	24	194	649	14	24	610	109
RTOR Reduction (vph)	0	178	0	0	16	0	0	2	0	0	0	62
Lane Group Flow (vph)	243	137	0	0	29	0	194	661	0	24	610	47
Confl. Peds. (#/hr)	221		163	163		221	156		115	115		156
Confl. Bikes (#/hr)			4			5			14			33
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Prot			Perm		Perm
Protected Phases		4			8		5	2			6	
Permitted Phases	4			8						6		6
Actuated Green, G (s)	31.0	31.0			31.0		10.0	51.0		37.0	37.0	37.0
Effective Green, g (s)	31.0	31.0			31.0		10.0	51.0		37.0	37.0	37.0
Actuated g/C Ratio	0.34	0.34			0.34		0.11	0.57		0.41	0.41	0.41
Clearance Time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Grp Cap (vph)	357	437			512		195	1972		283	1441	542
v/s Ratio Prot							c0.11	0.19			c0.17	
v/s Ratio Perm	c0.23	0.11			0.02					0.03		0.04
v/c Ratio	0.68	0.31			0.06		0.99	0.34		0.08	0.42	0.09
Uniform Delay, d1	25.3	21.7			19.7		40.0	10.4		16.2	18.9	16.2
Progression Factor	0.68	0.34			1.00		1.00	1.00		0.44	0.49	0.40
Incremental Delay, d2	9.7	1.8			0.2		63.1	0.5		0.5	0.8	0.3
Delay (s)	26.8	9.2			19.9		103.1	10.9		7.6	10.1	6.8
Level of Service	C	A			B		F	B		A	B	A
Approach Delay (s)		16.9			19.9			31.8			9.5	
Approach LOS		B			B			C			A	

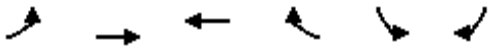
Intersection Summary			
HCM Average Control Delay	20.2	HCM Level of Service	C
HCM Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	72.5%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	34	163	68	321	393	59	83	567	297	13	285	34
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.0	2.0		2.0	2.0		2.0	2.0			2.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.95			0.95	
Frpb, ped/bikes	1.00	0.98		1.00	0.98		1.00	0.96			0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		0.95	1.00			1.00	
Frt	1.00	0.96		1.00	0.98		1.00	0.95			0.98	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00			1.00	
Satd. Flow (prot)	1770	3304		1610	3235		1689	3227			3441	
Flt Permitted	0.95	1.00		0.95	0.99		0.43	1.00			0.82	
Satd. Flow (perm)	1770	3304		1610	3235		762	3227			2815	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	36	173	72	341	418	63	88	603	316	14	303	36
RTOR Reduction (vph)	0	45	0	0	10	0	0	75	0	0	10	0
Lane Group Flow (vph)	36	200	0	269	543	0	88	844	0	0	343	0
Confl. Peds. (#/hr)	129		83	83		129	80		91	91		80
Confl. Bikes (#/hr)			5			75			12			8
Turn Type	Split			Split			Perm			Perm		
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	34.0	34.0		24.0	24.0		26.0	26.0			26.0	
Effective Green, g (s)	34.0	34.0		24.0	24.0		26.0	26.0			26.0	
Actuated g/C Ratio	0.38	0.38		0.27	0.27		0.29	0.29			0.29	
Clearance Time (s)	2.0	2.0		2.0	2.0		2.0	2.0			2.0	
Lane Grp Cap (vph)	669	1248		429	863		220	932			813	
v/s Ratio Prot	0.02	c0.06		0.17	c0.17			c0.26				
v/s Ratio Perm							0.12				0.12	
v/c Ratio	0.05	0.16		0.63	0.63		0.40	0.91			0.42	
Uniform Delay, d1	17.8	18.5		29.1	29.1		25.7	30.8			25.9	
Progression Factor	1.57	1.88		1.00	1.00		0.75	0.77			1.00	
Incremental Delay, d2	0.2	0.3		6.8	3.5		5.0	13.2			1.6	
Delay (s)	28.0	35.1		35.8	32.5		24.4	36.9			27.5	
Level of Service	C	D		D	C		C	D			C	
Approach Delay (s)		34.2			33.6			35.8			27.5	
Approach LOS		C			C			D			C	

Intersection Summary			
HCM Average Control Delay	33.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.51		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	110.5%	ICU Level of Service	H
Analysis Period (min)	15		

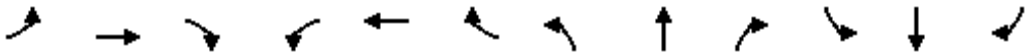
c Critical Lane Group



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (vph)	100	230	314	39	45	79
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00	0.93		0.85	
Flpb, ped/bikes	1.00	1.00	1.00		1.00	
Frt	1.00	1.00	0.99		0.91	
Flt Protected	0.95	1.00	1.00		0.98	
Satd. Flow (prot)	1719	3438	1666		1379	
Flt Permitted	0.95	1.00	1.00		0.98	
Satd. Flow (perm)	1719	3438	1666		1379	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	105	242	331	41	47	83
RTOR Reduction (vph)	0	0	6	0	53	0
Lane Group Flow (vph)	105	242	366	0	77	0
Confl. Peds. (#/hr)				365	162	162
Confl. Bikes (#/hr)				28		
Heavy Vehicles (%)	5%	5%	5%	5%	5%	5%
Turn Type	Prot					
Protected Phases	7	4	8		6	
Permitted Phases						
Actuated Green, G (s)	6.4	36.8	26.4		26.0	
Effective Green, g (s)	6.4	36.8	26.4		26.0	
Actuated g/C Ratio	0.09	0.52	0.37		0.37	
Clearance Time (s)	4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	155	1787	621		506	
v/s Ratio Prot	c0.06	0.07	c0.22		c0.06	
v/s Ratio Perm						
v/c Ratio	0.68	0.14	0.59		0.15	
Uniform Delay, d1	31.2	8.8	17.8		15.0	
Progression Factor	1.00	1.00	1.00		1.00	
Incremental Delay, d2	11.1	0.2	4.1		0.6	
Delay (s)	42.3	8.9	21.9		15.7	
Level of Service	D	A	C		B	
Approach Delay (s)		19.0	21.9		15.7	
Approach LOS		B	C		B	

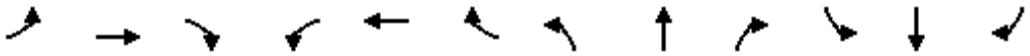
Intersection Summary			
HCM Average Control Delay	19.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	70.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	47.9%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	11	28	226	41	124	15	16	213	192	16	176	1
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0	4.0		4.0			4.0	
Lane Util. Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Frpb, ped/bikes		1.00	0.79		1.00	0.74		0.92			1.00	
Flpb, ped/bikes		0.95	1.00		0.95	1.00		1.00			1.00	
Frt		1.00	0.85		1.00	0.85		0.94			1.00	
Flt Protected		0.99	1.00		0.99	1.00		1.00			1.00	
Satd. Flow (prot)		1729	1235		1738	1161		1589			1826	
Flt Permitted		0.93	1.00		0.93	1.00		0.99			0.96	
Satd. Flow (perm)		1623	1235		1636	1161		1573			1757	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	12	30	246	45	135	16	17	232	209	17	191	1
RTOR Reduction (vph)	0	0	158	0	0	10	0	43	0	0	0	0
Lane Group Flow (vph)	0	42	88	0	180	6	0	415	0	0	209	0
Confl. Peds. (#/hr)	105		89	89		105	71		65	65		71
Confl. Bikes (#/hr)			2			18			15			5
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm		Perm	Perm		Perm	Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8		8	2			6		
Actuated Green, G (s)		24.5	24.5		24.5	24.5		36.5			36.5	
Effective Green, g (s)		25.0	25.0		25.0	25.0		37.0			37.0	
Actuated g/C Ratio		0.36	0.36		0.36	0.36		0.53			0.53	
Clearance Time (s)		4.5	4.5		4.5	4.5		4.5			4.5	
Lane Grp Cap (vph)		580	441		584	415		831			929	
v/s Ratio Prot												
v/s Ratio Perm		0.03	0.07		c0.11	0.00		c0.26			0.12	
v/c Ratio		0.07	0.20		0.31	0.01		0.50			0.22	
Uniform Delay, d1		14.8	15.6		16.3	14.5		10.6			8.8	
Progression Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Incremental Delay, d2		0.2	1.0		1.4	0.1		2.1			0.6	
Delay (s)		15.1	16.6		17.6	14.6		12.7			9.4	
Level of Service		B	B		B	B		B			A	
Approach Delay (s)		16.4			17.4			12.7			9.4	
Approach LOS		B			B			B			A	

Intersection Summary			
HCM Average Control Delay	13.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.42		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	62.6%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	21	8	9	40	1	114	2	278	26	83	366	1
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Hourly flow rate (vph)	21	8	9	41	1	116	2	284	27	85	373	1

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	39	158	312	459
Volume Left (vph)	21	41	2	85
Volume Right (vph)	9	116	27	1
Hadj (s)	0.02	-0.34	0.00	0.09
Departure Headway (s)	6.2	5.6	5.1	5.0
Degree Utilization, x	0.07	0.24	0.44	0.64
Capacity (veh/h)	476	571	673	699
Control Delay (s)	9.7	10.4	12.1	16.4
Approach Delay (s)	9.7	10.4	12.1	16.4
Approach LOS	A	B	B	C

Intersection Summary				
Delay		13.8		
HCM Level of Service		B		
Intersection Capacity Utilization		64.1%	ICU Level of Service	C
Analysis Period (min)		15		

SimTraffic Post-Processor **LBNL 2nd Campus**
Average Results from 10 Runs **Existing**
Volume and Delay by Movement **PM Peak Hour**

Intersection 8 **Piedmont Avenue/Bancroft Way** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn	118	112	95.3%	118.6	47.6	F
	Through	381	361	94.9%	119.8	48.2	F
	Right Turn						
	Subtotal	**499**	**474**	**94.9%**	**119.5**	**48.0**	**F**
SB	Left Turn						
	Through	333	336	101.0%	32.9	27.6	D
	Right Turn	116	114	98.6%	24.5	24.0	C
	Subtotal	**449**	**451**	**100.4%**	**30.8**	**26.7**	**D**
EB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**948**	**925**	**97.5%**	**76.4**	**33.0**	**F**

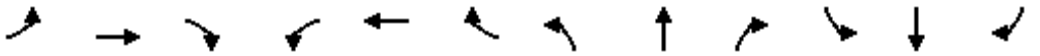
Intersection 9 **Piedmont Avenue/Durant Avenue** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn						
	Through	375	360	95.9%	86.2	42.9	F
	Right Turn						
	Subtotal	**375**	**360**	**95.9%**	**86.2**	**42.9**	**F**
SB	Left Turn						
	Through	324	331	102.3%	48.0	12.2	E
	Right Turn						
	Subtotal	**324**	**331**	**102.3%**	**48.0**	**12.2**	**E**
EB	Left Turn	112	106	95.0%	12.2	2.0	B
	Through						
	Right Turn	169	178	105.5%	19.9	4.4	C
	Subtotal	**281**	**285**	**101.3%**	**17.2**	**3.3**	**C**
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**980**	**976**	**99.6%**	**53.2**	**19.2**	**F**

Intersection	
Intersection Delay (sec/veh)	11.4
Intersection LOS	B

Approach	EB	WB	NB	SB
Entry Lanes	1	1	1	1
Conflicting Circle Lanes	1	1	1	1
Adjusted Approach Flow (vph)	122	184	465	531
Demand Flow Rate (pc/h)	125	187	475	542
Vehicles Circulating (pc/h)	519	471	135	273
Vehicles Exiting (pc/h)	296	139	509	385
Follow-Up Headway (s)	3.186	3.186	3.186	3.186
Ped Vol. Crossing Leg (#/hr)	183	8	102	68
Ped Capacity Adjustment	0.960	0.999	0.987	0.991
Approach Delay (sec/veh)	8.0	8.4	9.7	14.7
Approach LOS	A	A	A	B

Lane	Left	Left	Left	Left
Designated moves	LTR	LTR	LTR	LTR
Assumed Moves	LTR	LTR	LTR	LTR
Right Turn Channelized				
Lane Utilization	1.000	1.000	1.000	1.000
Critical Headway (s)	5.193	5.193	5.193	5.193
Entry Flow Rate (pc/h)	125	187	475	542
Capacity, Entry Lane (pc/h)	672	706	987	860
Entry HV Adjustment Factor	0.977	0.983	0.980	0.980
Flow Rate, Entry (vph)	122	184	465	531
Capacity, Entry (vph)	630	693	955	835
Volume to Capacity Ratio	0.194	0.265	0.488	0.636
Control Delay (sec/veh)	8.0	8.4	9.7	14.7
Level of Service	A	A	A	B
95th-Percentile Queue (veh)	1	1	3	5



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	104	107	198	30	0	96	0	461	5	9	374	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Util. Factor	1.00	1.00	1.00	1.00		1.00		*0.60			*0.60	
Frpb, ped/bikes	1.00	1.00	0.92	1.00		0.87		1.00			1.00	
Flpb, ped/bikes	0.89	1.00	1.00	0.94		1.00		1.00			1.00	
Frt	1.00	1.00	0.85	1.00		0.85		1.00			1.00	
Flt Protected	0.95	1.00	1.00	0.95		1.00		1.00			1.00	
Satd. Flow (prot)	1583	1881	1473	1685		1393		2249			2251	
Flt Permitted	0.95	1.00	1.00	0.68		1.00		1.00			0.94	
Satd. Flow (perm)	1583	1881	1473	1214		1393		2249			2120	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	109	113	208	32	0	101	0	485	5	9	394	0
RTOR Reduction (vph)	0	0	90	0	0	53	0	1	0	0	0	0
Lane Group Flow (vph)	109	113	118	32	0	48	0	489	0	0	403	0
Confl. Peds. (#/hr)	109		106	106		106	105		133	133		105
Confl. Bikes (#/hr)			4						11			12
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm		Perm	custom		custom				Perm		
Protected Phases		4						2			6	
Permitted Phases	4		4	8		8				6		
Actuated Green, G (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Effective Green, g (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Actuated g/C Ratio	0.48	0.48	0.48	0.48		0.48		0.43			0.43	
Clearance Time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Grp Cap (vph)	755	897	703	579		664		969			913	
v/s Ratio Prot		0.06						c0.22				
v/s Ratio Perm	0.07		c0.08	0.03		0.03					0.19	
v/c Ratio	0.14	0.13	0.17	0.06		0.07		0.51			0.44	
Uniform Delay, d1	9.5	9.5	9.7	9.1		9.2		13.5			13.0	
Progression Factor	1.00	1.00	1.00	1.00		1.00		1.00			1.00	
Incremental Delay, d2	0.4	0.3	0.5	0.2		0.2		1.9			1.5	
Delay (s)	10.0	9.7	10.2	9.3		9.4		15.3			14.6	
Level of Service	A	A	B	A		A		B			B	
Approach Delay (s)		10.0			9.4			15.3			14.6	
Approach LOS		B			A			B			B	

Intersection Summary			
HCM Average Control Delay	13.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.33		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	61.6%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	165	38	12	194	40	22
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.89	0.89	0.89	0.89	0.89	0.89
Hourly flow rate (vph)	185	43	13	218	45	25
Pedestrians	7			1		
Lane Width (ft)	12.0			12.0		
Walking Speed (ft/s)	4.0			4.0		
Percent Blockage	1			0		
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			228		459	208
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			228		459	208
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			99		92	97
cM capacity (veh/h)			1346		553	834

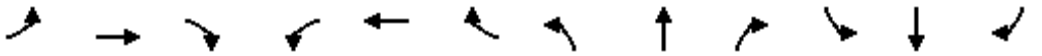
Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	228	231	70
Volume Left	0	13	45
Volume Right	43	0	25
cSH	1700	1346	628
Volume to Capacity	0.13	0.01	0.11
Queue Length 95th (ft)	0	1	9
Control Delay (s)	0.0	0.5	11.4
Lane LOS		A	B
Approach Delay (s)	0.0	0.5	11.4
Approach LOS			B

Intersection Summary			
Average Delay		1.7	
Intersection Capacity Utilization		30.3%	ICU Level of Service A
Analysis Period (min)		15	

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Sign Control	Stop		Stop			Stop
Volume (vph)	167	72	77	107	76	33
Peak Hour Factor	0.86	0.86	0.86	0.86	0.86	0.86
Hourly flow rate (vph)	194	84	90	124	88	38

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total (vph)	278	214	127
Volume Left (vph)	194	0	88
Volume Right (vph)	84	124	0
Hadj (s)	0.01	-0.30	0.19
Departure Headway (s)	4.7	4.5	5.1
Degree Utilization, x	0.36	0.27	0.18
Capacity (veh/h)	718	757	663
Control Delay (s)	10.4	9.1	9.2
Approach Delay (s)	10.4	9.1	9.2
Approach LOS	B	A	A

Intersection Summary			
Delay	9.7		
HCM Level of Service	A		
Intersection Capacity Utilization	42.6%	ICU Level of Service	A
Analysis Period (min)	15		



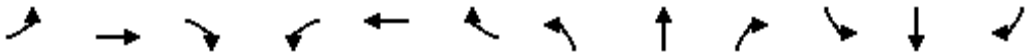
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	2	99	32	11	73	12	72	57	134	14	14	4
Peak Hour Factor	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Hourly flow rate (vph)	2	106	34	12	78	13	77	61	144	15	15	4

Direction, Lane #	EB 1	WB 1	NB 1	SB 1	SB 2
Volume Total (vph)	143	103	283	30	4
Volume Left (vph)	2	12	77	15	0
Volume Right (vph)	34	13	144	0	4
Hadj (s)	-0.12	-0.04	-0.23	0.12	-0.58
Departure Headway (s)	4.6	4.8	4.3	5.0	3.2
Degree Utilization, x	0.18	0.14	0.34	0.04	0.00
Capacity (veh/h)	725	697	798	669	1121
Control Delay (s)	8.7	8.5	9.5	8.2	6.2
Approach Delay (s)	8.7	8.5	9.5	7.9	
Approach LOS	A	A	A	A	

Intersection Summary				
Delay	9.0			
HCM Level of Service	A			
Intersection Capacity Utilization	39.9%	ICU Level of Service	A	
Analysis Period (min)	15			

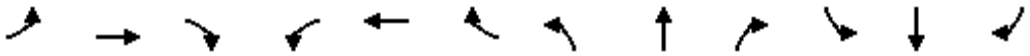
Near-Term (2018) No Project Conditions

FEHR PEERS



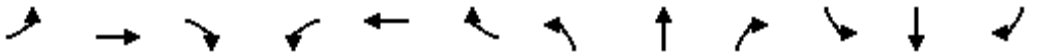
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	111	416	180	30	353	250	0	0	0	40	710	111
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Util. Factor	1.00	0.95			0.91	0.91					0.91	
Frpb, ped/bikes	1.00	0.97			0.99	0.89					0.96	
Flpb, ped/bikes	0.95	1.00			1.00	1.00					0.99	
Frt	1.00	0.95			0.98	0.85					0.98	
Flt Protected	0.95	1.00			1.00	1.00					1.00	
Satd. Flow (prot)	1619	3144			3146	1230					4556	
Flt Permitted	0.44	1.00			0.88	1.00					1.00	
Satd. Flow (perm)	746	3144			2789	1230					4556	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	121	452	196	33	384	272	0	0	0	43	772	121
RTOR Reduction (vph)	0	3	0	0	11	107	0	0	0	0	22	0
Lane Group Flow (vph)	121	645	0	0	460	111	0	0	0	0	914	0
Confl. Peds. (#/hr)	108		102	102		108	353		194	194		353
Confl. Bikes (#/hr)			10			6			1			20
Heavy Vehicles (%)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
Turn Type	Perm			Perm		Perm				Perm		
Protected Phases		4			8						6	
Permitted Phases	4			8		8				6		
Actuated Green, G (s)	46.0	46.0			46.0	46.0					36.0	
Effective Green, g (s)	46.0	46.0			46.0	46.0					36.0	
Actuated g/C Ratio	0.51	0.51			0.51	0.51					0.40	
Clearance Time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Grp Cap (vph)	381	1607			1425	629					1822	
v/s Ratio Prot		c0.21										
v/s Ratio Perm	0.16				0.17	0.09					0.20	
v/c Ratio	0.32	0.40			0.32	0.18					0.50	
Uniform Delay, d1	12.8	13.5			12.9	11.8					20.3	
Progression Factor	1.00	1.00			1.39	3.18					0.66	
Incremental Delay, d2	2.2	0.7			0.6	0.6					0.9	
Delay (s)	15.0	14.3			18.5	38.2					14.3	
Level of Service	B	B			B	D					B	
Approach Delay (s)		14.4			24.8			0.0			14.3	
Approach LOS		B			C			A			B	

Intersection Summary			
HCM Average Control Delay	17.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.45		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	83.3%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



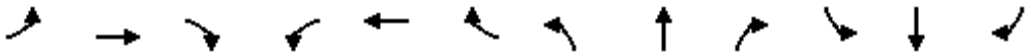
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	40	234	50	61	191	52	20	340	41	166	830	70
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95	1.00		0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes		1.00	0.88		0.99		1.00	0.99		1.00	0.99	
Flpb, ped/bikes		0.99	1.00		0.99		0.97	1.00		0.95	1.00	
Frt		1.00	0.85		0.97		1.00	0.98		1.00	0.99	
Flt Protected		0.99	1.00		0.99		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3460	1387		3305		1701	3414		1673	3425	
Flt Permitted		0.87	1.00		0.83		0.23	1.00		0.50	1.00	
Satd. Flow (perm)		3017	1387		2766		405	3414		874	3425	
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	43	252	54	66	205	56	22	366	44	178	892	75
RTOR Reduction (vph)	0	0	28	0	19	0	0	10	0	0	7	0
Lane Group Flow (vph)	0	295	26	0	308	0	22	400	0	178	960	0
Confl. Peds. (#/hr)	75		82	82		75	220		139	139		220
Confl. Bikes (#/hr)			64			7			5			18
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm		Perm	Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)		32.0	32.0		32.0		50.0	50.0		50.0	50.0	
Effective Green, g (s)		32.0	32.0		32.0		50.0	50.0		50.0	50.0	
Actuated g/C Ratio		0.36	0.36		0.36		0.56	0.56		0.56	0.56	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)		1073	493		983		225	1897		486	1903	
v/s Ratio Prot								0.12			c0.28	
v/s Ratio Perm		0.10	0.02		c0.11		0.05			0.20		
v/c Ratio		0.27	0.05		0.31		0.10	0.21		0.37	0.50	
Uniform Delay, d1		20.7	19.1		21.0		9.4	10.1		11.2	12.3	
Progression Factor		1.00	1.00		0.91		1.95	1.94		1.00	1.00	
Incremental Delay, d2		0.6	0.2		0.8		0.8	0.2		2.1	1.0	
Delay (s)		21.3	19.3		19.9		19.2	19.8		13.3	13.3	
Level of Service		C	B		B		B	B		B	B	
Approach Delay (s)		21.0			19.9			19.8			13.3	
Approach LOS		C			B			B			B	

Intersection Summary			
HCM Average Control Delay	16.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.43		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	110.9%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			



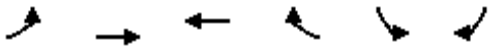
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	379	20	230	10	20	20	120	370	10	30	750	72
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.95	0.95			1.00		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	0.93			0.95		1.00	1.00		1.00	1.00	0.86
Flpb, ped/bikes	0.89	0.98			0.99		1.00	1.00		0.93	1.00	1.00
Frt	1.00	0.89			0.95		1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95	0.99			0.99		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1462	1395			1607		1736	3444		1617	3471	1332
Flt Permitted	0.78	0.94			0.93		0.95	1.00		0.50	1.00	1.00
Satd. Flow (perm)	1199	1322			1502		1736	3444		856	3471	1332
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	426	22	258	11	22	22	135	416	11	34	843	81
RTOR Reduction (vph)	0	117	0	0	15	0	0	2	0	0	0	34
Lane Group Flow (vph)	366	223	0	0	40	0	135	425	0	34	843	47
Confl. Peds. (#/hr)	136		77	77		136	135		85	85		135
Confl. Bikes (#/hr)			13			6			14			40
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm			Perm			Prot			Perm		Perm
Protected Phases		4			8		5	2			6	
Permitted Phases	4			8						6		6
Actuated Green, G (s)	30.0	30.0			30.0		6.0	52.0		42.0	42.0	42.0
Effective Green, g (s)	30.0	30.0			30.0		6.0	52.0		42.0	42.0	42.0
Actuated g/C Ratio	0.33	0.33			0.33		0.07	0.58		0.47	0.47	0.47
Clearance Time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Grp Cap (vph)	400	441			501		116	1990		399	1620	622
v/s Ratio Prot							c0.08	0.12			c0.24	
v/s Ratio Perm	c0.31	0.17			0.03					0.04		0.04
v/c Ratio	0.92	0.51			0.08		1.16	0.21		0.09	0.52	0.08
Uniform Delay, d1	28.8	24.1			20.6		42.0	9.2		13.3	16.9	13.3
Progression Factor	0.70	0.48			1.00		1.00	1.00		0.47	0.46	0.29
Incremental Delay, d2	27.4	4.0			0.3		134.2	0.2		0.4	1.0	0.2
Delay (s)	47.5	15.5			20.9		176.2	9.4		6.6	8.8	4.0
Level of Service	D	B			C		F	A		A	A	A
Approach Delay (s)		32.1			20.9			49.5			8.3	
Approach LOS		C			C			D			A	

Intersection Summary			
HCM Average Control Delay	26.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	69.1%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	30	331	80	242	205	21	50	280	399	42	530	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.5	2.5		2.5	2.5		2.5	2.5	2.5		2.5	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.95	1.00		0.95	
Frpb, ped/bikes	1.00	0.97		1.00	0.99		1.00	1.00	0.90		0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		0.97	1.00	1.00		1.00	
Frt	1.00	0.97		1.00	0.99		1.00	1.00	0.85		0.99	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00		1.00	
Satd. Flow (prot)	1736	3279		1579	3213		1681	3471	1399		3370	
Flt Permitted	0.95	1.00		0.95	0.99		0.20	1.00	1.00		0.91	
Satd. Flow (perm)	1736	3279		1579	3213		356	3471	1399		3088	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	32	348	84	255	216	22	53	295	420	44	558	53
RTOR Reduction (vph)	0	23	0	0	6	0	0	0	301	0	7	0
Lane Group Flow (vph)	32	409	0	161	326	0	53	295	119	0	648	0
Confl. Peds. (#/hr)	132		112	112		132	97		82	82		97
Confl. Bikes (#/hr)			64			2						21
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Split			Split			Perm		Perm	Perm		
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2		2	6		
Actuated Green, G (s)	32.0	32.0		25.0	25.0		25.5	25.5	25.5		25.5	
Effective Green, g (s)	32.0	32.0		25.0	25.0		25.5	25.5	25.5		25.5	
Actuated g/C Ratio	0.36	0.36		0.28	0.28		0.28	0.28	0.28		0.28	
Clearance Time (s)	2.5	2.5		2.5	2.5		2.5	2.5	2.5		2.5	
Lane Grp Cap (vph)	617	1166		439	893		101	983	396		875	
v/s Ratio Prot	0.02	c0.12		c0.10	0.10			0.08				
v/s Ratio Perm							0.15		0.09		c0.21	
v/c Ratio	0.05	0.35		0.37	0.37		0.52	0.30	0.30		0.74	
Uniform Delay, d1	19.0	21.4		26.1	26.1		27.1	25.3	25.3		29.2	
Progression Factor	1.33	1.41		1.00	1.00		0.78	0.74	1.47		1.00	
Incremental Delay, d2	0.2	0.8		2.4	1.2		15.7	0.7	1.7		5.6	
Delay (s)	25.5	31.0		28.5	27.3		37.0	19.3	38.8		34.8	
Level of Service	C	C		C	C		D	B	D		C	
Approach Delay (s)		30.6			27.7			31.2			34.8	
Approach LOS		C			C			C			C	

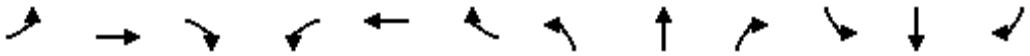
Intersection Summary			
HCM Average Control Delay	31.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.48		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	7.5
Intersection Capacity Utilization	102.5%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (vph)	90	531	218	22	65	130
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00	0.95		0.88	
Flpb, ped/bikes	1.00	1.00	1.00		1.00	
Frt	1.00	1.00	0.99		0.91	
Flt Protected	0.95	1.00	1.00		0.98	
Satd. Flow (prot)	1703	3406	1684		1407	
Flt Permitted	0.95	1.00	1.00		0.98	
Satd. Flow (perm)	1703	3406	1684		1407	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	95	559	229	23	68	137
RTOR Reduction (vph)	0	0	5	0	83	0
Lane Group Flow (vph)	95	559	247	0	122	0
Confl. Peds. (#/hr)				283	133	133
Confl. Bikes (#/hr)				5		
Heavy Vehicles (%)	6%	6%	6%	6%	6%	6%
Turn Type	Prot					
Protected Phases	7	4	8		6	
Permitted Phases						
Actuated Green, G (s)	6.3	31.8	21.5		26.0	
Effective Green, g (s)	6.3	31.8	21.5		26.0	
Actuated g/C Ratio	0.10	0.48	0.33		0.40	
Clearance Time (s)	4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	163	1646	550		556	
v/s Ratio Prot	c0.06	0.16	c0.15		c0.09	
v/s Ratio Perm						
v/c Ratio	0.58	0.34	0.45		0.22	
Uniform Delay, d1	28.5	10.5	17.5		13.2	
Progression Factor	1.00	1.00	1.00		1.00	
Incremental Delay, d2	5.2	0.6	2.6		0.9	
Delay (s)	33.7	11.1	20.1		14.1	
Level of Service	C	B	C		B	
Approach Delay (s)		14.4	20.1		14.1	
Approach LOS		B	C		B	

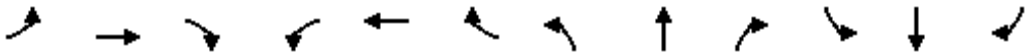
Intersection Summary			
HCM Average Control Delay	15.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.35		
Actuated Cycle Length (s)	65.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	44.7%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	205	311	22	42	10	97	161	191	21	217	30
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0	4.0		4.0			4.0	
Lane Util. Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Frpb, ped/bikes		1.00	0.79		1.00	0.78		0.94			0.99	
Flpb, ped/bikes		0.98	1.00		0.96	1.00		0.99			1.00	
Frt		1.00	0.85		1.00	0.85		0.94			0.98	
Flt Protected		1.00	1.00		0.98	1.00		0.99			1.00	
Satd. Flow (prot)		1772	1214		1700	1201		1567			1742	
Flt Permitted		0.98	1.00		0.88	1.00		0.87			0.96	
Satd. Flow (perm)		1738	1214		1520	1201		1381			1671	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	21	214	324	23	44	10	101	168	199	22	226	31
RTOR Reduction (vph)	0	0	214	0	0	7	0	41	0	0	7	0
Lane Group Flow (vph)	0	235	110	0	67	3	0	427	0	0	272	0
Confl. Peds. (#/hr)	100		95	95		100	51		59	59		51
Confl. Bikes (#/hr)			2									18
Heavy Vehicles (%)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Turn Type	Perm		Perm	Perm		Perm	Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8		8	2			6		
Actuated Green, G (s)		21.5	21.5		21.5	21.5		34.5			34.5	
Effective Green, g (s)		22.0	22.0		22.0	22.0		35.0			35.0	
Actuated g/C Ratio		0.34	0.34		0.34	0.34		0.54			0.54	
Clearance Time (s)		4.5	4.5		4.5	4.5		4.5			4.5	
Lane Grp Cap (vph)		588	411		514	406		744			900	
v/s Ratio Prot												
v/s Ratio Perm		c0.14	0.09		0.04	0.00		c0.31			0.16	
v/c Ratio		0.40	0.27		0.13	0.01		0.57			0.30	
Uniform Delay, d1		16.4	15.6		14.9	14.3		10.0			8.3	
Progression Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Incremental Delay, d2		2.0	1.6		0.5	0.0		3.2			0.9	
Delay (s)		18.5	17.2		15.4	14.3		13.2			9.1	
Level of Service		B	B		B	B		B			A	
Approach Delay (s)		17.7			15.3			13.2			9.1	
Approach LOS		B			B			B			A	

Intersection Summary			
HCM Average Control Delay	14.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.51		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	74.0%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	10	10	20	50	10	108	10	341	126	167	382	10
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Hourly flow rate (vph)	11	11	21	53	11	115	11	363	134	178	406	11

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	43	179	507	595
Volume Left (vph)	11	53	11	178
Volume Right (vph)	21	115	134	11
Hadj (s)	-0.13	-0.21	-0.04	0.17
Departure Headway (s)	7.4	6.7	5.6	5.7
Degree Utilization, x	0.09	0.33	0.79	0.94
Capacity (veh/h)	443	502	624	595
Control Delay (s)	11.1	13.1	26.8	46.1
Approach Delay (s)	11.1	13.1	26.8	46.1
Approach LOS	B	B	D	E

Intersection Summary				
Delay	33.1			
HCM Level of Service	D			
Intersection Capacity Utilization	83.2%	ICU Level of Service	E	
Analysis Period (min)	15			

Intersection 8 **Piedmont Avenue/Bancroft Way** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn	100	86	86.3%	55.0	19.1	F
	Through	587	500	85.1%	58.4	14.4	F
	Right Turn						
	Subtotal	**687**	**586**	**85.3%**	**57.9**	**14.9**	**F**
SB	Left Turn						
	Through	285	294	103.1%	14.0	1.7	B
	Right Turn	117	110	94.3%	11.2	1.0	B
	Subtotal	**402**	**404**	**100.5%**	**13.2**	**1.4**	**B**
EB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**1089**	**990**	**90.9%**	**39.7**	**8.9**	**E**

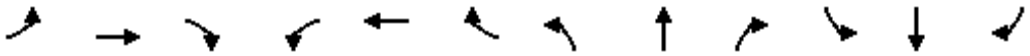
Intersection 9 **Piedmont Avenue/Durant Avenue** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn						
	Through	529	431	81.5%	484.4	185.1	F
	Right Turn						
	Subtotal	**529**	**431**	**81.5%**	**484.4**	**185.1**	**F**
SB	Left Turn						
	Through	275	294	106.9%	14.8	2.3	B
	Right Turn						
	Subtotal	**275**	**294**	**106.9%**	**14.8**	**2.3**	**B**
EB	Left Turn	150	150	99.9%	16.0	2.8	C
	Through						
	Right Turn	80	86	107.6%	8.0	0.6	A
	Subtotal	**230**	**236**	**102.6%**	**13.1**	**2.1**	**B**
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**1034**	**961**	**92.9%**	**223.9**	**81.2**	**F**

Intersection	
Intersection Delay (sec/veh)	10.1
Intersection LOS	B

Approach	EB	WB	NB	SB
Entry Lanes	1	1	1	1
Conflicting Circle Lanes	1	1	1	1
Adjusted Approach Flow (vph)	83	126	594	370
Demand Flow Rate (pc/h)	86	132	618	385
Vehicles Circulating (pc/h)	385	627	86	176
Vehicles Exiting (pc/h)	176	77	385	583
Follow-Up Headway (s)	3.186	3.186	3.186	3.186
Ped Vol. Crossing Leg (#/hr)	1	59	7	5
Ped Capacity Adjustment	1.000	0.992	0.999	0.999
Approach Delay (sec/veh)	6.0	9.1	11.8	8.7
Approach LOS	A	A	B	A

Lane	Left	Left	Left	Left
Designated moves	LTR	LTR	LTR	LTR
Assumed Moves	LTR	LTR	LTR	LTR
Right Turn Channelized				
Lane Utilization	1.000	1.000	1.000	1.000
Critical Headway (s)	5.193	5.193	5.193	5.193
Entry Flow Rate (pc/h)	86	132	618	385
Capacity, Entry Lane (pc/h)	769	604	1037	948
Entry HV Adjustment Factor	0.962	0.958	0.961	0.960
Flow Rate, Entry (vph)	83	126	594	370
Capacity, Entry (vph)	740	574	995	909
Volume to Capacity Ratio	0.112	0.220	0.597	0.407
Control Delay (sec/veh)	6.0	9.1	11.8	8.7
Level of Service	A	A	B	A
95th-Percentile Queue (veh)	0	1	4	2



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	153	131	150	30	0	50	0	647	11	10	274	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Util. Factor	1.00	1.00	1.00	1.00		1.00		*0.60			*0.60	
Frpb, ped/bikes	1.00	1.00	0.95	1.00		0.94		1.00			1.00	
Flpb, ped/bikes	0.96	1.00	1.00	0.97		1.00		1.00			1.00	
Frt	1.00	1.00	0.85	1.00		0.85		1.00			1.00	
Flt Protected	0.95	1.00	1.00	0.95		1.00		1.00			1.00	
Satd. Flow (prot)	1695	1863	1505	1714		1487		2226			2230	
Flt Permitted	0.95	1.00	1.00	0.67		1.00		1.00			0.92	
Satd. Flow (perm)	1695	1863	1505	1211		1487		2226			2063	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	156	134	153	31	0	51	0	660	11	10	280	0
RTOR Reduction (vph)	0	0	80	0	0	27	0	1	0	0	0	0
Lane Group Flow (vph)	156	134	73	31	0	24	0	670	0	0	290	0
Confl. Peds. (#/hr)	40		60	60		40	47		49	49		47
Confl. Bikes (#/hr)			1						13			
Turn Type	Perm		Perm	custom		custom				Perm		
Protected Phases		4						2			6	
Permitted Phases	4		4	8		8				6		
Actuated Green, G (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Effective Green, g (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Actuated g/C Ratio	0.48	0.48	0.48	0.48		0.48		0.43			0.43	
Clearance Time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Grp Cap (vph)	808	889	718	578		709		959			889	
v/s Ratio Prot		0.07						c0.30				
v/s Ratio Perm	c0.09		0.05	0.03		0.02					0.14	
v/c Ratio	0.19	0.15	0.10	0.05		0.03		0.70			0.33	
Uniform Delay, d1	9.8	9.6	9.3	9.1		9.0		15.1			12.3	
Progression Factor	1.00	1.00	1.00	1.00		1.00		1.00			1.00	
Incremental Delay, d2	0.5	0.4	0.3	0.2		0.1		4.2			1.0	
Delay (s)	10.3	9.9	9.6	9.3		9.1		19.3			13.2	
Level of Service	B	A	A	A		A		B			B	
Approach Delay (s)		10.0			9.2			19.3			13.2	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM Average Control Delay	14.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.43		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	64.3%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	224	30	10	100	50	20
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.82	0.82	0.82	0.82	0.82	0.82
Hourly flow rate (vph)	273	37	12	122	61	24
Pedestrians	2					
Lane Width (ft)	12.0					
Walking Speed (ft/s)	4.0					
Percent Blockage	0					
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			310		440	291
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			310		440	291
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			99		89	97
cM capacity (veh/h)			1251		568	748

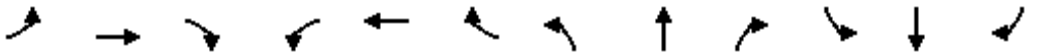
Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	310	134	85
Volume Left	0	12	61
Volume Right	37	0	24
cSH	1700	1251	610
Volume to Capacity	0.18	0.01	0.14
Queue Length 95th (ft)	0	1	12
Control Delay (s)	0.0	0.8	11.9
Lane LOS		A	B
Approach Delay (s)	0.0	0.8	11.9
Approach LOS			B

Intersection Summary			
Average Delay		2.1	
Intersection Capacity Utilization		24.3%	ICU Level of Service A
Analysis Period (min)		15	

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Sign Control	Stop		Stop			Stop
Volume (vph)	91	90	60	184	90	20
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	96	95	63	194	95	21

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total (vph)	191	257	116
Volume Left (vph)	96	0	95
Volume Right (vph)	95	194	0
Hadj (s)	-0.13	-0.38	0.23
Departure Headway (s)	4.6	4.1	4.9
Degree Utilization, x	0.24	0.29	0.16
Capacity (veh/h)	726	832	695
Control Delay (s)	9.1	8.9	8.8
Approach Delay (s)	9.1	8.9	8.8
Approach LOS	A	A	A

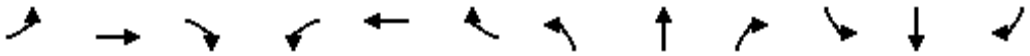
Intersection Summary			
Delay	8.9		
HCM Level of Service	A		
Intersection Capacity Utilization	41.7%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	10	120	123	201	80	20	31	20	34	20	60	10
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Hourly flow rate (vph)	11	136	140	228	91	23	35	23	39	23	68	11

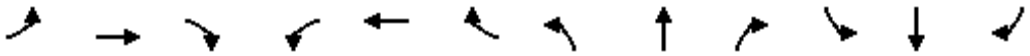
Direction, Lane #	EB 1	WB 1	NB 1	SB 1	SB 2
Volume Total (vph)	288	342	97	91	11
Volume Left (vph)	11	228	35	23	0
Volume Right (vph)	140	23	39	0	11
Hadj (s)	-0.27	0.11	-0.15	0.07	-0.58
Departure Headway (s)	4.6	4.9	5.4	5.7	3.2
Degree Utilization, x	0.37	0.47	0.15	0.14	0.01
Capacity (veh/h)	742	703	576	558	1121
Control Delay (s)	10.3	12.1	9.4	9.6	6.2
Approach Delay (s)	10.3	12.1	9.4	9.2	
Approach LOS	B	B	A	A	

Intersection Summary				
Delay	10.8			
HCM Level of Service	B			
Intersection Capacity Utilization	52.8%	ICU Level of Service		A
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	151	423	250	81	603	470	0	0	0	50	751	120
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Util. Factor	1.00	0.95			0.91	0.91					0.91	
Frpb, ped/bikes	1.00	0.91			0.96	0.69					0.95	
Flpb, ped/bikes	0.92	1.00			0.99	1.00					0.99	
Frt	1.00	0.94			0.98	0.85					0.98	
Flt Protected	0.95	1.00			0.99	1.00					1.00	
Satd. Flow (prot)	1617	2999			3131	986					4609	
Flt Permitted	0.25	1.00			0.78	1.00					1.00	
Satd. Flow (perm)	434	2999			2467	986					4609	
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	162	455	269	87	648	505	0	0	0	54	808	129
RTOR Reduction (vph)	0	0	0	0	11	189	0	0	0	0	22	0
Lane Group Flow (vph)	162	724	0	0	825	215	0	0	0	0	969	0
Confl. Peds. (#/hr)	323		260	260		323	783		278	278		783
Confl. Bikes (#/hr)			12			15						30
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm		Perm				Perm		
Protected Phases		4			8						6	
Permitted Phases	4			8		8				6		
Actuated Green, G (s)	48.0	48.0			48.0	48.0					34.0	
Effective Green, g (s)	48.0	48.0			48.0	48.0					34.0	
Actuated g/C Ratio	0.53	0.53			0.53	0.53					0.38	
Clearance Time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Grp Cap (vph)	231	1599			1316	526					1741	
v/s Ratio Prot		0.24										
v/s Ratio Perm	c0.37				0.33	0.22					0.21	
v/c Ratio	0.70	0.45			0.63	0.41					0.56	
Uniform Delay, d1	15.7	12.9			14.7	12.5					22.1	
Progression Factor	1.00	1.00			1.40	3.93					0.73	
Incremental Delay, d2	16.3	0.9			2.2	2.3					1.2	
Delay (s)	32.0	13.8			22.9	51.6					17.4	
Level of Service	C	B			C	D					B	
Approach Delay (s)		17.2			32.2			0.0			17.4	
Approach LOS		B			C			A			B	

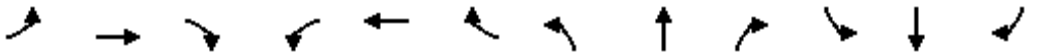
Intersection Summary			
HCM Average Control Delay	23.2	HCM Level of Service	C
HCM Volume to Capacity ratio	0.64		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	84.8%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	70	172	50	131	332	164	40	600	41	82	580	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95	1.00		0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes		1.00	0.90		0.95		1.00	0.99		1.00	0.98	
Flpb, ped/bikes		0.98	1.00		0.99		0.91	1.00		0.95	1.00	
Frt		1.00	0.85		0.96		1.00	0.99		1.00	0.99	
Flt Protected		0.99	1.00		0.99		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3434	1426		3143		1605	3471		1678	3425	
Flt Permitted		0.67	1.00		0.80		0.36	1.00		0.35	1.00	
Satd. Flow (perm)		2338	1426		2546		605	3471		623	3425	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	72	177	52	135	342	169	41	619	42	85	598	52
RTOR Reduction (vph)	0	0	20	0	39	0	0	5	0	0	7	0
Lane Group Flow (vph)	0	249	32	0	607	0	41	656	0	85	643	0
Confl. Peds. (#/hr)	186		99	99		186	417		236	236		417
Confl. Bikes (#/hr)			10			95			20			23
Turn Type	Perm		Perm	Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)		33.0	33.0		33.0		49.0	49.0		49.0	49.0	
Effective Green, g (s)		33.0	33.0		33.0		49.0	49.0		49.0	49.0	
Actuated g/C Ratio		0.37	0.37		0.37		0.54	0.54		0.54	0.54	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)		857	523		934		329	1890		339	1865	
v/s Ratio Prot								c0.19			0.19	
v/s Ratio Perm		0.11	0.02		c0.24		0.07			0.14		
v/c Ratio		0.29	0.06		0.65		0.12	0.35		0.25	0.34	
Uniform Delay, d1		20.2	18.5		23.7		10.0	11.5		10.8	11.5	
Progression Factor		1.00	1.00		1.55		1.63	1.65		1.00	1.00	
Incremental Delay, d2		0.9	0.2		2.5		0.6	0.4		1.8	0.5	
Delay (s)		21.1	18.7		39.2		17.0	19.4		12.6	12.0	
Level of Service		C	B		D		B	B		B	B	
Approach Delay (s)		20.7			39.2			19.2			12.1	
Approach LOS		C			D			B			B	

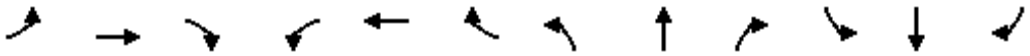
Intersection Summary			
HCM Average Control Delay	22.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.47		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	109.5%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	294	30	300	10	30	30	200	680	20	30	630	138
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.95	0.95			1.00		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	0.85			0.90		1.00	0.99		1.00	1.00	0.82
Flpb, ped/bikes	0.80	0.98			0.99		1.00	1.00		0.93	1.00	1.00
Frt	1.00	0.87			0.94		1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95	1.00			0.99		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1326	1277			1531		1752	3469		1628	3505	1286
Flt Permitted	0.75	0.98			0.94		0.95	1.00		0.38	1.00	1.00
Satd. Flow (perm)	1048	1251			1457		1752	3469		651	3505	1286
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	300	31	306	10	31	31	204	694	20	31	643	141
RTOR Reduction (vph)	0	174	0	0	20	0	0	2	0	0	0	75
Lane Group Flow (vph)	270	193	0	0	52	0	204	712	0	31	643	66
Confl. Peds. (#/hr)	254		187	187		254	179		132	132		179
Confl. Bikes (#/hr)			5			6			16			38
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Prot			Perm		Perm
Protected Phases		4			8		5	2			6	
Permitted Phases	4			8						6		6
Actuated Green, G (s)	31.0	31.0			31.0		10.0	51.0		37.0	37.0	37.0
Effective Green, g (s)	31.0	31.0			31.0		10.0	51.0		37.0	37.0	37.0
Actuated g/C Ratio	0.34	0.34			0.34		0.11	0.57		0.41	0.41	0.41
Clearance Time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Grp Cap (vph)	361	431			502		195	1966		268	1441	529
v/s Ratio Prot							c0.12	0.21			c0.18	
v/s Ratio Perm	c0.26	0.15			0.04					0.05		0.05
v/c Ratio	0.75	0.45			0.10		1.05	0.36		0.12	0.45	0.12
Uniform Delay, d1	26.0	22.9			20.0		40.0	10.6		16.4	19.1	16.4
Progression Factor	0.69	0.45			1.00		1.00	1.00		0.44	0.48	0.36
Incremental Delay, d2	12.6	3.2			0.4		77.1	0.5		0.7	0.8	0.4
Delay (s)	30.5	13.5			20.5		117.1	11.1		7.8	10.0	6.3
Level of Service	C	B			C		F	B		A	A	A
Approach Delay (s)		20.7			20.5			34.7			9.3	
Approach LOS		C			C			C			A	

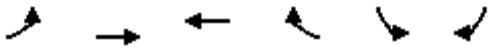
Intersection Summary			
HCM Average Control Delay	22.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.64		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	75.4%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	40	185	80	358	457	80	100	610	334	21	310	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.0	2.0		2.0	2.0		2.0	2.0			2.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.95			0.95	
Frpb, ped/bikes	1.00	0.97		1.00	0.97		1.00	0.95			0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		0.95	1.00			1.00	
Frt	1.00	0.95		1.00	0.98		1.00	0.95			0.98	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00			1.00	
Satd. Flow (prot)	1770	3289		1610	3205		1685	3200			3407	
Flt Permitted	0.95	1.00		0.95	0.99		0.38	1.00			0.72	
Satd. Flow (perm)	1770	3289		1610	3205		680	3200			2451	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	43	197	85	381	486	85	106	649	355	22	330	53
RTOR Reduction (vph)	0	53	0	0	12	0	0	82	0	0	14	0
Lane Group Flow (vph)	43	229	0	312	628	0	106	922	0	0	391	0
Confl. Peds. (#/hr)	148		95	95		148	92		105	105		92
Confl. Bikes (#/hr)			6			86			14			9
Turn Type	Split			Split			Perm			Perm		
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	34.0	34.0		24.0	24.0		26.0	26.0			26.0	
Effective Green, g (s)	34.0	34.0		24.0	24.0		26.0	26.0			26.0	
Actuated g/C Ratio	0.38	0.38		0.27	0.27		0.29	0.29			0.29	
Clearance Time (s)	2.0	2.0		2.0	2.0		2.0	2.0			2.0	
Lane Grp Cap (vph)	669	1243		429	855		196	924			708	
v/s Ratio Prot	0.02	c0.07		0.19	c0.20			c0.29				
v/s Ratio Perm							0.16				0.16	
v/c Ratio	0.06	0.18		0.73	0.73		0.54	1.00			0.55	
Uniform Delay, d1	17.9	18.7		30.0	30.1		27.0	32.0			27.1	
Progression Factor	1.48	1.76		1.00	1.00		0.78	0.78			1.00	
Incremental Delay, d2	0.2	0.3		10.3	5.6		9.5	27.9			3.1	
Delay (s)	26.6	33.3		40.3	35.6		30.4	52.9			30.2	
Level of Service	C	C		D	D		C	D			C	
Approach Delay (s)		32.4			37.2			50.7			30.2	
Approach LOS		C			D			D			C	

Intersection Summary			
HCM Average Control Delay	41.0	HCM Level of Service	D
HCM Volume to Capacity ratio	0.58		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	113.1%	ICU Level of Service	H
Analysis Period (min)	15		

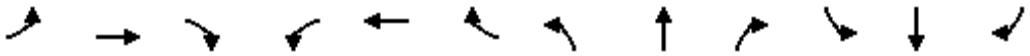
c Critical Lane Group



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (vph)	120	270	405	63	62	90
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00	0.92		0.84	
Flpb, ped/bikes	1.00	1.00	1.00		1.00	
Frt	1.00	1.00	0.98		0.92	
Flt Protected	0.95	1.00	1.00		0.98	
Satd. Flow (prot)	1719	3438	1629		1370	
Flt Permitted	0.95	1.00	1.00		0.98	
Satd. Flow (perm)	1719	3438	1629		1370	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	126	284	426	66	65	95
RTOR Reduction (vph)	0	0	8	0	60	0
Lane Group Flow (vph)	126	284	484	0	100	0
Confl. Peds. (#/hr)				420	186	186
Confl. Bikes (#/hr)				32		
Heavy Vehicles (%)	5%	5%	5%	5%	5%	5%
Turn Type	Prot					
Protected Phases	7	4	8		6	
Permitted Phases						
Actuated Green, G (s)	6.4	36.8	26.4		26.0	
Effective Green, g (s)	6.4	36.8	26.4		26.0	
Actuated g/C Ratio	0.09	0.52	0.37		0.37	
Clearance Time (s)	4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	155	1787	607		503	
v/s Ratio Prot	c0.07	0.08	c0.30		c0.07	
v/s Ratio Perm						
v/c Ratio	0.81	0.16	0.80		0.20	
Uniform Delay, d1	31.6	8.9	19.8		15.3	
Progression Factor	1.00	1.00	1.00		1.00	
Incremental Delay, d2	26.7	0.2	10.5		0.9	
Delay (s)	58.3	9.1	30.3		16.2	
Level of Service	E	A	C		B	
Approach Delay (s)		24.2	30.3		16.2	
Approach LOS		C	C		B	

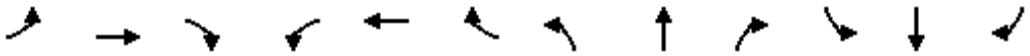
Intersection Summary			
HCM Average Control Delay	25.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.53		
Actuated Cycle Length (s)	70.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	56.5%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	32	260	60	144	21	84	236	202	20	191	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0	4.0		4.0			4.0	
Lane Util. Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Frpb, ped/bikes		1.00	0.76		1.00	0.70		0.93			0.99	
Flpb, ped/bikes		0.93	1.00		0.94	1.00		0.98			1.00	
Frt		1.00	0.85		1.00	0.85		0.95			0.99	
Flt Protected		0.98	1.00		0.99	1.00		0.99			1.00	
Satd. Flow (prot)		1684	1191		1708	1105		1576			1800	
Flt Permitted		0.87	1.00		0.90	1.00		0.91			0.94	
Satd. Flow (perm)		1500	1191		1569	1105		1446			1699	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	35	283	65	157	23	91	257	220	22	208	11
RTOR Reduction (vph)	0	0	182	0	0	14	0	33	0	0	2	0
Lane Group Flow (vph)	0	57	101	0	222	9	0	535	0	0	239	0
Confl. Peds. (#/hr)	121		102	102		121	82		75	75		82
Confl. Bikes (#/hr)			2			21			17			6
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm		Perm	Perm		Perm	Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8		8	2			6		
Actuated Green, G (s)		24.5	24.5		24.5	24.5		36.5			36.5	
Effective Green, g (s)		25.0	25.0		25.0	25.0		37.0			37.0	
Actuated g/C Ratio		0.36	0.36		0.36	0.36		0.53			0.53	
Clearance Time (s)		4.5	4.5		4.5	4.5		4.5			4.5	
Lane Grp Cap (vph)		536	425		560	395		764			898	
v/s Ratio Prot												
v/s Ratio Perm		0.04	0.08		c0.14	0.01		c0.37			0.14	
v/c Ratio		0.11	0.24		0.40	0.02		0.70			0.27	
Uniform Delay, d1		15.0	15.8		16.8	14.6		12.4			9.0	
Progression Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Incremental Delay, d2		0.4	1.3		2.1	0.1		5.3			0.7	
Delay (s)		15.4	17.1		18.9	14.7		17.7			9.8	
Level of Service		B	B		B	B		B			A	
Approach Delay (s)		16.8			18.5			17.7			9.8	
Approach LOS		B			B			B			A	

Intersection Summary			
HCM Average Control Delay	16.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.58		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	74.2%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	30	20	20	141	10	190	10	302	42	111	400	10
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Hourly flow rate (vph)	31	20	20	144	10	194	10	308	43	113	408	10

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	71	348	361	532
Volume Left (vph)	31	144	10	113
Volume Right (vph)	20	194	43	10
Hadj (s)	-0.03	-0.20	-0.01	0.08
Departure Headway (s)	7.9	6.7	6.6	6.3
Degree Utilization, x	0.16	0.65	0.66	0.93
Capacity (veh/h)	391	518	527	532
Control Delay (s)	12.4	21.1	21.3	47.6
Approach Delay (s)	12.4	21.1	21.3	47.6
Approach LOS	B	C	C	E

Intersection Summary				
Delay		31.4		
HCM Level of Service		D		
Intersection Capacity Utilization		85.8%	ICU Level of Service	E
Analysis Period (min)		15		

Intersection 8 **Piedmont Avenue/Bancroft Way** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn	131	115	87.5%	50.1	9.8	F
	Through	424	372	87.7%	51.3	9.5	F
	Right Turn						
	Subtotal	**555**	**487**	**87.7%**	**51.0**	**9.4**	**F**
SB	Left Turn						
	Through	399	354	88.7%	256.2	139.0	F
	Right Turn	192	172	89.6%	242.0	135.9	F
	Subtotal	**591**	**526**	**89.0%**	**251.5**	**137.8**	**F**
EB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**1146**	**1013**	**88.4%**	**154.1**	**67.4**	**F**

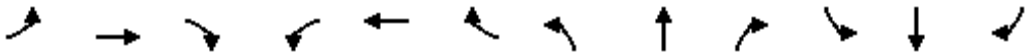
Intersection 9 **Piedmont Avenue/Durant Avenue** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn						
	Through	411	341	82.9%	428.2	165.0	F
	Right Turn						
	Subtotal	**411**	**341**	**82.9%**	**428.2**	**165.0**	**F**
SB	Left Turn						
	Through	390	352	90.2%	85.2	13.7	F
	Right Turn						
	Subtotal	**390**	**352**	**90.2%**	**85.2**	**13.7**	**F**
EB	Left Turn	133	136	102.0%	19.1	5.0	C
	Through						
	Right Turn	180	178	98.9%	21.9	6.3	C
	Subtotal	**313**	**314**	**100.2%**	**20.7**	**4.2**	**C**
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**1114**	**1006**	**90.3%**	**180.2**	**57.9**	**F**

Intersection	
Intersection Delay (sec/veh)	15.1
Intersection LOS	C

Approach	EB	WB	NB	SB
Entry Lanes	1	1	1	1
Conflicting Circle Lanes	1	1	1	1
Adjusted Approach Flow (vph)	138	212	527	621
Demand Flow Rate (pc/h)	141	216	537	633
Vehicles Circulating (pc/h)	612	527	151	301
Vehicles Exiting (pc/h)	322	161	602	442
Follow-Up Headway (s)	3.186	3.186	3.186	3.186
Ped Vol. Crossing Leg (#/hr)	210	9	117	78
Ped Capacity Adjustment	0.958	0.999	0.979	0.989
Approach Delay (sec/veh)	9.4	9.8	11.6	21.2
Approach LOS	A	A	B	C

Lane	Left	Left	Left	Left
Designated moves	LTR	LTR	LTR	LTR
Assumed Moves	LTR	LTR	LTR	LTR
Right Turn Channelized				
Lane Utilization	1.000	1.000	1.000	1.000
Critical Headway (s)	5.193	5.193	5.193	5.193
Entry Flow Rate (pc/h)	141	216	537	633
Capacity, Entry Lane (pc/h)	613	667	972	836
Entry HV Adjustment Factor	0.978	0.980	0.981	0.980
Flow Rate, Entry (vph)	138	212	527	621
Capacity, Entry (vph)	574	653	932	811
Volume to Capacity Ratio	0.240	0.324	0.565	0.765
Control Delay (sec/veh)	9.4	9.8	11.6	21.2
Level of Service	A	A	B	C
95th-Percentile Queue (veh)	1	1	4	7



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	127	120	220	41	0	100	0	495	10	20	432	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Util. Factor	1.00	1.00	1.00	1.00		1.00		*0.60			*0.60	
Frpb, ped/bikes	1.00	1.00	0.91	1.00		0.85		1.00			1.00	
Flpb, ped/bikes	0.87	1.00	1.00	0.94		1.00		1.00			1.00	
Frt	1.00	1.00	0.85	1.00		0.85		1.00			1.00	
Flt Protected	0.95	1.00	1.00	0.95		1.00		1.00			1.00	
Satd. Flow (prot)	1553	1881	1456	1672		1367		2240			2244	
Flt Permitted	0.95	1.00	1.00	0.68		1.00		1.00			0.91	
Satd. Flow (perm)	1553	1881	1456	1190		1367		2240			2051	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	134	126	232	43	0	105	0	521	11	21	455	0
RTOR Reduction (vph)	0	0	67	0	0	44	0	1	0	0	0	0
Lane Group Flow (vph)	134	126	165	43	0	61	0	531	0	0	476	0
Confl. Peds. (#/hr)	125		122	122		122	121		153	153		121
Confl. Bikes (#/hr)			5						13			14
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm		Perm	custom		custom				Perm		
Protected Phases		4						2			6	
Permitted Phases	4		4	8		8				6		
Actuated Green, G (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Effective Green, g (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Actuated g/C Ratio	0.48	0.48	0.48	0.48		0.48		0.43			0.43	
Clearance Time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Grp Cap (vph)	741	897	694	568		652		965			884	
v/s Ratio Prot		0.07						c0.24				
v/s Ratio Perm	0.09		c0.11	0.04		0.04					0.23	
v/c Ratio	0.18	0.14	0.24	0.08		0.09		0.55			0.54	
Uniform Delay, d1	9.7	9.5	10.0	9.2		9.3		13.8			13.7	
Progression Factor	1.00	1.00	1.00	1.00		1.00		1.00			1.00	
Incremental Delay, d2	0.5	0.3	0.8	0.3		0.3		2.3			2.3	
Delay (s)	10.3	9.9	10.8	9.5		9.6		16.1			16.1	
Level of Service	B	A	B	A		A		B			B	
Approach Delay (s)		10.4			9.6			16.1			16.1	
Approach LOS		B			A			B			B	

Intersection Summary			
HCM Average Control Delay	13.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.39		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	62.9%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	180	40	20	204	40	30
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.89	0.89	0.89	0.89	0.89	0.89
Hourly flow rate (vph)	202	45	22	229	45	34
Pedestrians	8			1		
Lane Width (ft)	12.0			12.0		
Walking Speed (ft/s)	4.0			4.0		
Percent Blockage	1			0		
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			247		507	226
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			247		507	226
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			98		91	96
cM capacity (veh/h)			1325		515	815

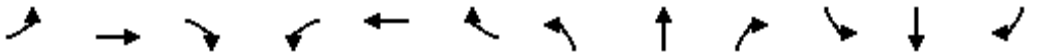
Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	247	252	79
Volume Left	0	22	45
Volume Right	45	0	34
cSH	1700	1325	611
Volume to Capacity	0.15	0.02	0.13
Queue Length 95th (ft)	0	1	11
Control Delay (s)	0.0	0.8	11.8
Lane LOS		A	B
Approach Delay (s)	0.0	0.8	11.8
Approach LOS			B

Intersection Summary			
Average Delay		2.0	
Intersection Capacity Utilization		37.8%	ICU Level of Service A
Analysis Period (min)		15	

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Sign Control	Stop		Stop			Stop
Volume (vph)	183	80	90	121	80	50
Peak Hour Factor	0.86	0.86	0.86	0.86	0.86	0.86
Hourly flow rate (vph)	213	93	105	141	93	58

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total (vph)	306	245	151
Volume Left (vph)	213	0	93
Volume Right (vph)	93	141	0
Hadj (s)	0.01	-0.29	0.17
Departure Headway (s)	4.9	4.6	5.2
Degree Utilization, x	0.41	0.32	0.22
Capacity (veh/h)	696	733	645
Control Delay (s)	11.3	9.7	9.6
Approach Delay (s)	11.3	9.7	9.6
Approach LOS	B	A	A

Intersection Summary			
Delay	10.4		
HCM Level of Service	B		
Intersection Capacity Utilization	46.3%	ICU Level of Service	A
Analysis Period (min)	15		



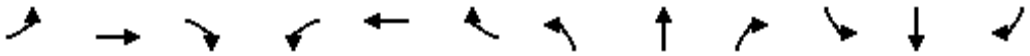
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	10	120	62	24	90	20	92	70	168	20	20	10
Peak Hour Factor	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Hourly flow rate (vph)	11	129	67	26	97	22	99	75	181	22	22	11

Direction, Lane #	EB 1	WB 1	NB 1	SB 1	SB 2
Volume Total (vph)	206	144	355	43	11
Volume Left (vph)	11	26	99	22	0
Volume Right (vph)	67	22	181	0	11
Hadj (s)	-0.17	-0.04	-0.23	0.12	-0.58
Departure Headway (s)	4.9	5.1	4.6	5.4	3.2
Degree Utilization, x	0.28	0.21	0.46	0.06	0.01
Capacity (veh/h)	675	638	740	593	1121
Control Delay (s)	9.9	9.5	11.5	8.8	6.2
Approach Delay (s)	9.9	9.5	11.5	8.3	
Approach LOS	A	A	B	A	

Intersection Summary				
Delay	10.4			
HCM Level of Service	B			
Intersection Capacity Utilization	47.5%	ICU Level of Service	A	
Analysis Period (min)	15			

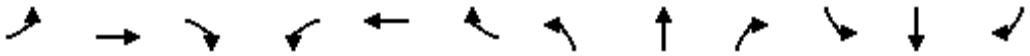
Near-Term (2018) Plus Phase 1 Project Conditions

FEHR PEERS



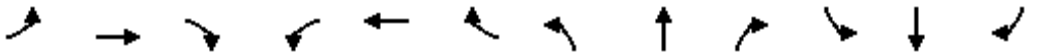
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	122	427	180	31	355	250	0	0	0	40	711	113
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Util. Factor	1.00	0.95			0.91	0.91					0.91	
Frpb, ped/bikes	1.00	0.97			0.99	0.89					0.96	
Flpb, ped/bikes	0.95	1.00			1.00	1.00					0.99	
Frt	1.00	0.96			0.98	0.85					0.98	
Flt Protected	0.95	1.00			1.00	1.00					1.00	
Satd. Flow (prot)	1619	3149			3149	1230					4552	
Flt Permitted	0.44	1.00			0.88	1.00					1.00	
Satd. Flow (perm)	745	3149			2780	1230					4552	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	133	464	196	34	386	272	0	0	0	43	773	123
RTOR Reduction (vph)	0	3	0	0	10	108	0	0	0	0	22	0
Lane Group Flow (vph)	133	657	0	0	462	112	0	0	0	0	917	0
Confl. Peds. (#/hr)	108		102	102		108	353		194	194		353
Confl. Bikes (#/hr)			10			6			1			20
Heavy Vehicles (%)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
Turn Type	Perm			Perm		Perm				Perm		
Protected Phases		4			8						6	
Permitted Phases	4			8		8				6		
Actuated Green, G (s)	46.0	46.0			46.0	46.0					36.0	
Effective Green, g (s)	46.0	46.0			46.0	46.0					36.0	
Actuated g/C Ratio	0.51	0.51			0.51	0.51					0.40	
Clearance Time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Grp Cap (vph)	381	1609			1421	629					1821	
v/s Ratio Prot		c0.21										
v/s Ratio Perm	0.18				0.17	0.09					0.20	
v/c Ratio	0.35	0.41			0.32	0.18					0.50	
Uniform Delay, d1	13.1	13.6			12.9	11.8					20.3	
Progression Factor	1.00	1.00			1.39	3.19					0.66	
Incremental Delay, d2	2.5	0.8			0.6	0.6					0.9	
Delay (s)	15.6	14.4			18.5	38.4					14.3	
Level of Service	B	B			B	D					B	
Approach Delay (s)		14.6			24.8			0.0			14.3	
Approach LOS		B			C			A			B	

Intersection Summary			
HCM Average Control Delay	17.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.45		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	83.3%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



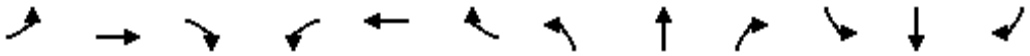
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	40	237	50	64	192	53	20	340	52	176	830	70
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95	1.00		0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes		1.00	0.88		0.99		1.00	0.99		1.00	0.99	
Flpb, ped/bikes		0.99	1.00		0.99		0.97	1.00		0.96	1.00	
Frt		1.00	0.85		0.97		1.00	0.98		1.00	0.99	
Flt Protected		0.99	1.00		0.99		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3460	1387		3303		1701	3392		1674	3425	
Flt Permitted		0.87	1.00		0.82		0.23	1.00		0.49	1.00	
Satd. Flow (perm)		3017	1387		2746		405	3392		862	3425	
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	43	255	54	69	206	57	22	366	56	189	892	75
RTOR Reduction (vph)	0	0	28	0	19	0	0	13	0	0	7	0
Lane Group Flow (vph)	0	298	26	0	313	0	22	409	0	189	960	0
Confl. Peds. (#/hr)	75		82	82		75	220		139	139		220
Confl. Bikes (#/hr)			64			7			5			18
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm		Perm	Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)		32.0	32.0		32.0		50.0	50.0		50.0	50.0	
Effective Green, g (s)		32.0	32.0		32.0		50.0	50.0		50.0	50.0	
Actuated g/C Ratio		0.36	0.36		0.36		0.56	0.56		0.56	0.56	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)		1073	493		976		225	1884		479	1903	
v/s Ratio Prot								0.12			c0.28	
v/s Ratio Perm		0.10	0.02		c0.11		0.05			0.22		
v/c Ratio		0.28	0.05		0.32		0.10	0.22		0.39	0.50	
Uniform Delay, d1		20.7	19.1		21.1		9.4	10.1		11.4	12.3	
Progression Factor		1.00	1.00		0.91		1.98	1.96		1.00	1.00	
Incremental Delay, d2		0.6	0.2		0.8		0.8	0.3		2.4	1.0	
Delay (s)		21.4	19.3		20.0		19.4	20.1		13.8	13.3	
Level of Service		C	B		C		B	C		B	B	
Approach Delay (s)		21.1			20.0			20.1			13.4	
Approach LOS		C			C			C			B	

Intersection Summary			
HCM Average Control Delay	16.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.43		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	114.0%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			



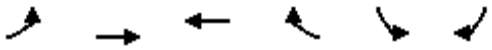
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	398	20	230	10	20	20	120	370	10	30	750	75
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.95	0.95			1.00		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	0.94			0.95		1.00	1.00		1.00	1.00	0.86
Flpb, ped/bikes	0.89	0.98			0.99		1.00	1.00		0.93	1.00	1.00
Frt	1.00	0.89			0.95		1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95	0.99			0.99		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1462	1398			1608		1736	3444		1617	3471	1332
Flt Permitted	0.78	0.93			0.92		0.95	1.00		0.50	1.00	1.00
Satd. Flow (perm)	1199	1310			1500		1736	3444		856	3471	1332
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	447	22	258	11	22	22	135	416	11	34	843	84
RTOR Reduction (vph)	0	110	0	0	15	0	0	2	0	0	0	35
Lane Group Flow (vph)	375	242	0	0	40	0	135	425	0	34	843	49
Confl. Peds. (#/hr)	136		77	77		136	135		85	85		135
Confl. Bikes (#/hr)			13			6			14			40
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm			Perm			Prot			Perm		Perm
Protected Phases		4			8		5	2			6	
Permitted Phases	4			8						6		6
Actuated Green, G (s)	30.0	30.0			30.0		6.0	52.0		42.0	42.0	42.0
Effective Green, g (s)	30.0	30.0			30.0		6.0	52.0		42.0	42.0	42.0
Actuated g/C Ratio	0.33	0.33			0.33		0.07	0.58		0.47	0.47	0.47
Clearance Time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Grp Cap (vph)	400	437			500		116	1990		399	1620	622
v/s Ratio Prot							c0.08	0.12			c0.24	
v/s Ratio Perm	c0.31	0.18			0.03					0.04		0.04
v/c Ratio	0.94	0.55			0.08		1.16	0.21		0.09	0.52	0.08
Uniform Delay, d1	29.1	24.5			20.6		42.0	9.2		13.3	16.9	13.3
Progression Factor	0.70	0.50			1.00		1.00	1.00		0.47	0.46	0.29
Incremental Delay, d2	31.1	4.8			0.3		134.2	0.2		0.3	1.0	0.2
Delay (s)	51.4	17.0			20.9		176.2	9.4		6.6	8.8	4.0
Level of Service	D	B			C		F	A		A	A	A
Approach Delay (s)		34.8			20.9			49.5			8.3	
Approach LOS		C			C			D			A	

Intersection Summary			
HCM Average Control Delay	27.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.73		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	69.6%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	30	354	80	245	209	22	50	280	418	45	530	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.5	2.5		2.5	2.5		2.5	2.5	2.5		2.5	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.95	1.00		0.95	
Frpb, ped/bikes	1.00	0.97		1.00	0.99		1.00	1.00	0.90		0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		0.97	1.00	1.00		1.00	
Frt	1.00	0.97		1.00	0.99		1.00	1.00	0.85		0.99	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00		1.00	
Satd. Flow (prot)	1736	3290		1579	3212		1681	3471	1399		3369	
Flt Permitted	0.95	1.00		0.95	0.99		0.20	1.00	1.00		0.91	
Satd. Flow (perm)	1736	3290		1579	3212		352	3471	1399		3075	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	32	373	84	258	220	23	53	295	440	47	558	53
RTOR Reduction (vph)	0	21	0	0	6	0	0	0	315	0	7	0
Lane Group Flow (vph)	32	436	0	165	330	0	53	295	125	0	651	0
Confl. Peds. (#/hr)	132		112	112		132	97		82	82		97
Confl. Bikes (#/hr)			64			2						21
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Split			Split			Perm		Perm	Perm		
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2		2	6		
Actuated Green, G (s)	32.0	32.0		25.0	25.0		25.5	25.5	25.5		25.5	
Effective Green, g (s)	32.0	32.0		25.0	25.0		25.5	25.5	25.5		25.5	
Actuated g/C Ratio	0.36	0.36		0.28	0.28		0.28	0.28	0.28		0.28	
Clearance Time (s)	2.5	2.5		2.5	2.5		2.5	2.5	2.5		2.5	
Lane Grp Cap (vph)	617	1170		439	892		100	983	396		871	
v/s Ratio Prot	0.02	c0.13		c0.10	0.10			0.08				
v/s Ratio Perm							0.15		0.09		c0.21	
v/c Ratio	0.05	0.37		0.38	0.37		0.53	0.30	0.31		0.75	
Uniform Delay, d1	19.0	21.5		26.2	26.2		27.2	25.3	25.4		29.3	
Progression Factor	1.29	1.37		1.00	1.00		0.79	0.74	1.59		1.00	
Incremental Delay, d2	0.2	0.9		2.4	1.2		15.9	0.7	1.7		5.8	
Delay (s)	24.7	30.4		28.7	27.3		37.3	19.4	42.2		35.1	
Level of Service	C	C		C	C		D	B	D		D	
Approach Delay (s)		30.0			27.8			33.3			35.1	
Approach LOS		C			C			C			D	

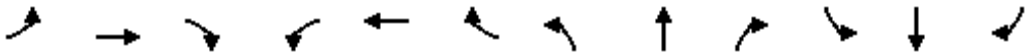
Intersection Summary			
HCM Average Control Delay	32.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.49		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	7.5
Intersection Capacity Utilization	102.5%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (vph)	90	577	225	22	70	130
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00	0.95		0.88	
Flpb, ped/bikes	1.00	1.00	1.00		1.00	
Frt	1.00	1.00	0.99		0.91	
Flt Protected	0.95	1.00	1.00		0.98	
Satd. Flow (prot)	1703	3406	1687		1416	
Flt Permitted	0.95	1.00	1.00		0.98	
Satd. Flow (perm)	1703	3406	1687		1416	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	95	607	237	23	74	137
RTOR Reduction (vph)	0	0	5	0	83	0
Lane Group Flow (vph)	95	607	255	0	128	0
Confl. Peds. (#/hr)				283	133	133
Confl. Bikes (#/hr)				5		
Heavy Vehicles (%)	6%	6%	6%	6%	6%	6%
Turn Type	Prot					
Protected Phases	7	4	8		6	
Permitted Phases						
Actuated Green, G (s)	6.3	31.8	21.5		26.0	
Effective Green, g (s)	6.3	31.8	21.5		26.0	
Actuated g/C Ratio	0.10	0.48	0.33		0.40	
Clearance Time (s)	4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	163	1646	551		560	
v/s Ratio Prot	c0.06	0.18	c0.15		c0.09	
v/s Ratio Perm						
v/c Ratio	0.58	0.37	0.46		0.23	
Uniform Delay, d1	28.5	10.7	17.6		13.2	
Progression Factor	1.00	1.00	1.00		1.00	
Incremental Delay, d2	5.2	0.6	2.8		1.0	
Delay (s)	33.7	11.3	20.3		14.2	
Level of Service	C	B	C		B	
Approach Delay (s)		14.4	20.3		14.2	
Approach LOS		B	C		B	

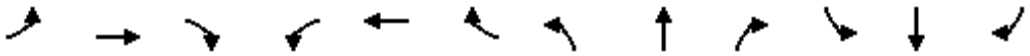
Intersection Summary			
HCM Average Control Delay	15.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.36		
Actuated Cycle Length (s)	65.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	45.2%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	257	311	28	50	11	97	161	229	25	217	30
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0	4.0		4.0			4.0	
Lane Util. Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Frpb, ped/bikes		1.00	0.79		1.00	0.78		0.94			0.99	
Flpb, ped/bikes		0.99	1.00		0.96	1.00		0.99			1.00	
Frt		1.00	0.85		1.00	0.85		0.94			0.99	
Flt Protected		1.00	1.00		0.98	1.00		0.99			1.00	
Satd. Flow (prot)		1779	1214		1706	1201		1550			1742	
Flt Permitted		0.98	1.00		0.85	1.00		0.88			0.94	
Satd. Flow (perm)		1750	1214		1479	1201		1377			1648	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	21	268	324	29	52	11	101	168	239	26	226	31
RTOR Reduction (vph)	0	0	187	0	0	7	0	49	0	0	7	0
Lane Group Flow (vph)	0	289	137	0	81	4	0	459	0	0	276	0
Confl. Peds. (#/hr)	100		95	95		100	51		59	59		51
Confl. Bikes (#/hr)			2									18
Heavy Vehicles (%)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Turn Type	Perm		Perm	Perm		Perm	Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8		8	2			6		
Actuated Green, G (s)		21.5	21.5		21.5	21.5		34.5			34.5	
Effective Green, g (s)		22.0	22.0		22.0	22.0		35.0			35.0	
Actuated g/C Ratio		0.34	0.34		0.34	0.34		0.54			0.54	
Clearance Time (s)		4.5	4.5		4.5	4.5		4.5			4.5	
Lane Grp Cap (vph)		592	411		501	406		741			887	
v/s Ratio Prot												
v/s Ratio Perm		c0.17	0.11		0.05	0.00		c0.33			0.17	
v/c Ratio		0.49	0.33		0.16	0.01		0.62			0.31	
Uniform Delay, d1		17.0	16.0		15.0	14.3		10.4			8.3	
Progression Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Incremental Delay, d2		2.9	2.2		0.7	0.0		3.9			0.9	
Delay (s)		19.9	18.2		15.7	14.3		14.2			9.2	
Level of Service		B	B		B	B		B			A	
Approach Delay (s)		19.0			15.6			14.2			9.2	
Approach LOS		B			B			B			A	

Intersection Summary			
HCM Average Control Delay	15.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	82.5%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	10	10	20	50	10	108	10	379	126	167	388	10
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Hourly flow rate (vph)	11	11	21	53	11	115	11	403	134	178	413	11

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	43	179	548	601
Volume Left (vph)	11	53	11	178
Volume Right (vph)	21	115	134	11
Hadj (s)	-0.13	-0.21	-0.02	0.17
Departure Headway (s)	7.6	6.9	5.7	5.8
Degree Utilization, x	0.09	0.34	0.87	0.97
Capacity (veh/h)	443	500	622	601
Control Delay (s)	11.3	13.4	34.6	51.9
Approach Delay (s)	11.3	13.4	34.6	51.9
Approach LOS	B	B	D	F

Intersection Summary				
Delay	38.7			
HCM Level of Service	E			
Intersection Capacity Utilization	85.5%	ICU Level of Service	E	
Analysis Period (min)	15			

Intersection 8 **Piedmont Avenue/Bancroft Way** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn	100	79	78.8%	56.7	13.1	F
	Through	625	502	80.3%	62.2	12.5	F
	Right Turn						
	Subtotal	**725**	**581**	**80.1%**	**61.4**	**11.8**	**F**
SB	Left Turn						
	Through	289	297	102.9%	13.5	1.1	B
	Right Turn	119	117	98.7%	11.3	0.7	B
	Subtotal	**408**	**415**	**101.7%**	**12.9**	**1.0**	**B**
EB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**1133**	**996**	**87.9%**	**41.2**	**6.8**	**E**

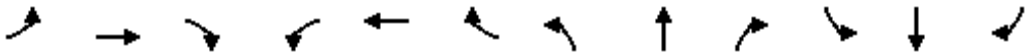
Intersection 9 **Piedmont Avenue/Durant Avenue** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn						
	Through	559	414	74.1%	746.4	206.4	F
	Right Turn						
	Subtotal	**559**	**414**	**74.1%**	**746.4**	**206.4**	**F**
SB	Left Turn						
	Through	280	297	105.9%	15.0	1.5	B
	Right Turn						
	Subtotal	**280**	**297**	**105.9%**	**15.0**	**1.5**	**B**
EB	Left Turn	162	160	98.8%	19.9	3.3	C
	Through						
	Right Turn	80	84	104.6%	7.6	0.8	A
	Subtotal	**242**	**244**	**100.7%**	**15.7**	**2.4**	**C**
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**1081**	**955**	**88.3%**	**330.4**	**80.4**	**F**

Intersection	
Intersection Delay (sec/veh)	10.8
Intersection LOS	B

Approach	EB	WB	NB	SB
Entry Lanes	1	1	1	1
Conflicting Circle Lanes	1	1	1	1
Adjusted Approach Flow (vph)	83	127	630	376
Demand Flow Rate (pc/h)	86	133	656	392
Vehicles Circulating (pc/h)	393	661	86	177
Vehicles Exiting (pc/h)	176	81	393	617
Follow-Up Headway (s)	3.186	3.186	3.186	3.186
Ped Vol. Crossing Leg (#/hr)	1	59	7	5
Ped Capacity Adjustment	1.000	0.992	0.999	0.999
Approach Delay (sec/veh)	6.1	9.6	12.8	8.8
Approach LOS	A	A	B	A

Lane	Left	Left	Left	Left
Designated moves	LTR	LTR	LTR	LTR
Assumed Moves	LTR	LTR	LTR	LTR
Right Turn Channelized				
Lane Utilization	1.000	1.000	1.000	1.000
Critical Headway (s)	5.193	5.193	5.193	5.193
Entry Flow Rate (pc/h)	86	133	656	392
Capacity, Entry Lane (pc/h)	763	583	1037	947
Entry HV Adjustment Factor	0.962	0.958	0.961	0.960
Flow Rate, Entry (vph)	83	127	630	376
Capacity, Entry (vph)	734	555	995	908
Volume to Capacity Ratio	0.113	0.230	0.633	0.414
Control Delay (sec/veh)	6.1	9.6	12.8	8.8
Level of Service	A	A	B	A
95th-Percentile Queue (veh)	0	1	5	2



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	167	132	150	30	0	50	0	667	12	10	277	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Util. Factor	1.00	1.00	1.00	1.00		1.00		*0.60			*0.60	
Frpb, ped/bikes	1.00	1.00	0.95	1.00		0.94		1.00			1.00	
Flpb, ped/bikes	0.96	1.00	1.00	0.97		1.00		1.00			1.00	
Frt	1.00	1.00	0.85	1.00		0.85		1.00			1.00	
Flt Protected	0.95	1.00	1.00	0.95		1.00		1.00			1.00	
Satd. Flow (prot)	1695	1863	1505	1714		1487		2226			2230	
Flt Permitted	0.95	1.00	1.00	0.67		1.00		1.00			0.92	
Satd. Flow (perm)	1695	1863	1505	1210		1487		2226			2061	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	170	135	153	31	0	51	0	681	12	10	283	0
RTOR Reduction (vph)	0	0	80	0	0	27	0	1	0	0	0	0
Lane Group Flow (vph)	170	135	73	31	0	24	0	692	0	0	293	0
Confl. Peds. (#/hr)	40		60	60		40	47		49	49		47
Confl. Bikes (#/hr)			1						13			
Turn Type	Perm		Perm	custom		custom				Perm		
Protected Phases		4						2			6	
Permitted Phases	4		4	8		8				6		
Actuated Green, G (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Effective Green, g (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Actuated g/C Ratio	0.48	0.48	0.48	0.48		0.48		0.43			0.43	
Clearance Time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Grp Cap (vph)	808	889	718	577		709		959			888	
v/s Ratio Prot		0.07						c0.31				
v/s Ratio Perm	c0.10		0.05	0.03		0.02					0.14	
v/c Ratio	0.21	0.15	0.10	0.05		0.03		0.72			0.33	
Uniform Delay, d1	9.9	9.6	9.3	9.1		9.0		15.3			12.3	
Progression Factor	1.00	1.00	1.00	1.00		1.00		1.00			1.00	
Incremental Delay, d2	0.6	0.4	0.3	0.2		0.1		4.7			1.0	
Delay (s)	10.5	9.9	9.6	9.3		9.1		20.0			13.3	
Level of Service	B	A	A	A		A		B			B	
Approach Delay (s)		10.0			9.2			20.0			13.3	
Approach LOS		B			A			B			B	

Intersection Summary			
HCM Average Control Delay	15.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.45		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	65.1%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	235	30	10	103	50	20
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.82	0.82	0.82	0.82	0.82	0.82
Hourly flow rate (vph)	287	37	12	126	61	24
Pedestrians	2					
Lane Width (ft)	12.0					
Walking Speed (ft/s)	4.0					
Percent Blockage	0					
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			323		457	305
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			323		457	305
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			99		89	97
cM capacity (veh/h)			1237		555	735

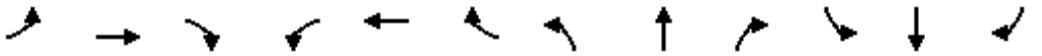
Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	323	138	85
Volume Left	0	12	61
Volume Right	37	0	24
cSH	1700	1237	597
Volume to Capacity	0.19	0.01	0.14
Queue Length 95th (ft)	0	1	12
Control Delay (s)	0.0	0.8	12.0
Lane LOS		A	B
Approach Delay (s)	0.0	0.8	12.0
Approach LOS			B

Intersection Summary			
Average Delay		2.1	
Intersection Capacity Utilization		24.8%	ICU Level of Service A
Analysis Period (min)		15	

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Sign Control	Stop		Stop			Stop
Volume (vph)	93	90	60	196	90	20
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	98	95	63	206	95	21

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total (vph)	193	269	116
Volume Left (vph)	98	0	95
Volume Right (vph)	95	206	0
Hadj (s)	-0.13	-0.39	0.23
Departure Headway (s)	4.6	4.1	4.9
Degree Utilization, x	0.25	0.31	0.16
Capacity (veh/h)	721	832	691
Control Delay (s)	9.2	9.0	8.8
Approach Delay (s)	9.2	9.0	8.8
Approach LOS	A	A	A

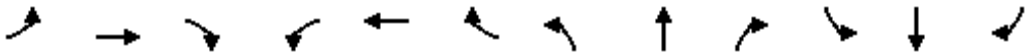
Intersection Summary			
Delay	9.0		
HCM Level of Service	A		
Intersection Capacity Utilization	42.5%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	10	120	132	226	80	20	33	20	37	20	60	10
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Hourly flow rate (vph)	11	136	150	257	91	23	38	23	42	23	68	11

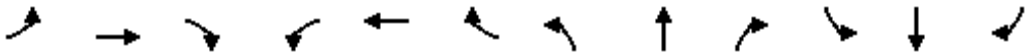
Direction, Lane #	EB 1	WB 1	NB 1	SB 1	SB 2
Volume Total (vph)	298	370	102	91	11
Volume Left (vph)	11	257	38	23	0
Volume Right (vph)	150	23	42	0	11
Hadj (s)	-0.28	0.12	-0.16	0.07	-0.58
Departure Headway (s)	4.7	5.0	5.6	5.8	3.2
Degree Utilization, x	0.39	0.51	0.16	0.15	0.01
Capacity (veh/h)	732	697	561	542	1121
Control Delay (s)	10.6	13.1	9.6	9.8	6.2
Approach Delay (s)	10.6	13.1	9.6	9.4	
Approach LOS	B	B	A	A	

Intersection Summary				
Delay	11.4			
HCM Level of Service	B			
Intersection Capacity Utilization	55.0%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	153	425	250	85	614	470	0	0	0	50	755	130
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Util. Factor	1.00	0.95			0.91	0.91					0.91	
Frpb, ped/bikes	1.00	0.91			0.96	0.69					0.95	
Flpb, ped/bikes	0.92	1.00			0.99	1.00					0.99	
Frt	1.00	0.94			0.98	0.85					0.98	
Flt Protected	0.95	1.00			0.99	1.00					1.00	
Satd. Flow (prot)	1620	3001			3141	986					4587	
Flt Permitted	0.25	1.00			0.77	1.00					1.00	
Satd. Flow (perm)	427	3001			2442	986					4587	
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	165	457	269	91	660	505	0	0	0	54	812	140
RTOR Reduction (vph)	0	0	0	0	10	191	0	0	0	0	24	0
Lane Group Flow (vph)	165	726	0	0	837	218	0	0	0	0	982	0
Confl. Peds. (#/hr)	323		260	260		323	783		278	278		783
Confl. Bikes (#/hr)			12			15						30
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm		Perm				Perm		
Protected Phases		4			8						6	
Permitted Phases	4			8		8				6		
Actuated Green, G (s)	48.0	48.0			48.0	48.0					34.0	
Effective Green, g (s)	48.0	48.0			48.0	48.0					34.0	
Actuated g/C Ratio	0.53	0.53			0.53	0.53					0.38	
Clearance Time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Grp Cap (vph)	228	1601			1302	526					1733	
v/s Ratio Prot		0.24										
v/s Ratio Perm	c0.39				0.34	0.22					0.21	
v/c Ratio	0.72	0.45			0.64	0.41					0.57	
Uniform Delay, d1	16.0	12.9			14.9	12.6					22.2	
Progression Factor	1.00	1.00			1.40	3.96					0.73	
Incremental Delay, d2	18.1	0.9			2.4	2.4					1.3	
Delay (s)	34.0	13.9			23.3	52.2					17.5	
Level of Service	C	B			C	D					B	
Approach Delay (s)		17.6			32.7			0.0			17.5	
Approach LOS		B			C			A			B	

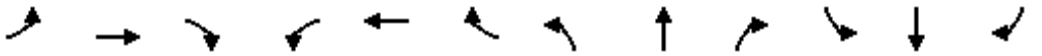
Intersection Summary			
HCM Average Control Delay	23.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.66		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	85.2%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	70	172	50	145	335	173	40	600	43	83	580	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95	1.00		0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes		1.00	0.90		0.94		1.00	0.99		1.00	0.98	
Flpb, ped/bikes		0.98	1.00		0.99		0.91	1.00		0.95	1.00	
Frt		1.00	0.85		0.96		1.00	0.99		1.00	0.99	
Flt Protected		0.99	1.00		0.99		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3436	1426		3135		1605	3468		1678	3425	
Flt Permitted		0.66	1.00		0.80		0.36	1.00		0.35	1.00	
Satd. Flow (perm)		2308	1426		2522		605	3468		622	3425	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	72	177	52	149	345	178	41	619	44	86	598	52
RTOR Reduction (vph)	0	0	20	0	41	0	0	6	0	0	7	0
Lane Group Flow (vph)	0	249	32	0	631	0	41	657	0	86	643	0
Confl. Peds. (#/hr)	186		99	99		186	417		236	236		417
Confl. Bikes (#/hr)			10			95			20			23
Turn Type	Perm		Perm	Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)		33.0	33.0		33.0		49.0	49.0		49.0	49.0	
Effective Green, g (s)		33.0	33.0		33.0		49.0	49.0		49.0	49.0	
Actuated g/C Ratio		0.37	0.37		0.37		0.54	0.54		0.54	0.54	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)		846	523		925		329	1888		339	1865	
v/s Ratio Prot								c0.19			0.19	
v/s Ratio Perm		0.11	0.02		c0.25		0.07			0.14		
v/c Ratio		0.29	0.06		0.68		0.12	0.35		0.25	0.34	
Uniform Delay, d1		20.2	18.5		24.1		10.0	11.5		10.8	11.5	
Progression Factor		1.00	1.00		1.56		1.61	1.63		1.00	1.00	
Incremental Delay, d2		0.9	0.2		2.8		0.6	0.4		1.8	0.5	
Delay (s)		21.1	18.7		40.4		16.8	19.2		12.6	12.0	
Level of Service		C	B		D		B	B		B	B	
Approach Delay (s)		20.7			40.4			19.0			12.1	
Approach LOS		C			D			B			B	

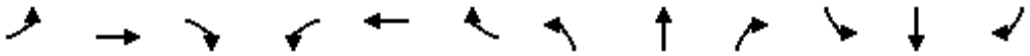
Intersection Summary			
HCM Average Control Delay	23.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.48		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	109.6%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	296	30	300	10	30	30	200	680	20	30	630	152
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.95	0.95			1.00		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	0.85			0.90		1.00	0.99		1.00	1.00	0.82
Flpb, ped/bikes	0.80	0.98			0.99		1.00	1.00		0.93	1.00	1.00
Frt	1.00	0.87			0.94		1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95	1.00			0.99		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1326	1277			1531		1752	3469		1628	3505	1286
Flt Permitted	0.75	0.98			0.94		0.95	1.00		0.38	1.00	1.00
Satd. Flow (perm)	1048	1251			1457		1752	3469		651	3505	1286
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	302	31	306	10	31	31	204	694	20	31	643	155
RTOR Reduction (vph)	0	174	0	0	20	0	0	2	0	0	0	75
Lane Group Flow (vph)	272	193	0	0	52	0	204	712	0	31	643	80
Confl. Peds. (#/hr)	254		187	187		254	179		132	132		179
Confl. Bikes (#/hr)			5			6			16			38
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Prot			Perm		Perm
Protected Phases		4			8		5	2			6	
Permitted Phases	4			8						6		6
Actuated Green, G (s)	31.0	31.0			31.0		10.0	51.0		37.0	37.0	37.0
Effective Green, g (s)	31.0	31.0			31.0		10.0	51.0		37.0	37.0	37.0
Actuated g/C Ratio	0.34	0.34			0.34		0.11	0.57		0.41	0.41	0.41
Clearance Time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Grp Cap (vph)	361	431			502		195	1966		268	1441	529
v/s Ratio Prot							c0.12	0.21			c0.18	
v/s Ratio Perm	c0.26	0.15			0.04					0.05		0.06
v/c Ratio	0.75	0.45			0.10		1.05	0.36		0.12	0.45	0.15
Uniform Delay, d1	26.1	22.9			20.0		40.0	10.6		16.4	19.1	16.6
Progression Factor	0.69	0.45			1.00		1.00	1.00		0.43	0.47	0.33
Incremental Delay, d2	12.9	3.2			0.4		77.1	0.5		0.7	0.8	0.5
Delay (s)	30.8	13.5			20.5		117.1	11.1		7.7	9.8	5.9
Level of Service	C	B			C		F	B		A	A	A
Approach Delay (s)		20.9			20.5			34.7			9.0	
Approach LOS		C			C			C			A	

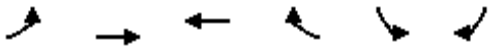
Intersection Summary			
HCM Average Control Delay	22.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	75.4%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	40	189	80	372	484	83	100	610	336	22	310	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.0	2.0		2.0	2.0		2.0	2.0			2.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.95			0.95	
Frpb, ped/bikes	1.00	0.97		1.00	0.97		1.00	0.95			0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		0.95	1.00			1.00	
Frt	1.00	0.96		1.00	0.98		1.00	0.95			0.98	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)	1770	3292		1610	3208		1686	3199			3407	
Flt Permitted	0.95	1.00		0.95	1.00		0.38	1.00			0.71	
Satd. Flow (perm)	1770	3292		1610	3208		679	3199			2429	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	43	201	85	396	515	88	106	649	357	23	330	53
RTOR Reduction (vph)	0	52	0	0	12	0	0	83	0	0	14	0
Lane Group Flow (vph)	43	234	0	329	658	0	106	923	0	0	392	0
Confl. Peds. (#/hr)	148		95	95		148	92		105	105		92
Confl. Bikes (#/hr)			6			86			14			9
Turn Type	Split			Split			Perm			Perm		
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	34.0	34.0		24.0	24.0		26.0	26.0			26.0	
Effective Green, g (s)	34.0	34.0		24.0	24.0		26.0	26.0			26.0	
Actuated g/C Ratio	0.38	0.38		0.27	0.27		0.29	0.29			0.29	
Clearance Time (s)	2.0	2.0		2.0	2.0		2.0	2.0			2.0	
Lane Grp Cap (vph)	669	1244		429	855		196	924			702	
v/s Ratio Prot	0.02	c0.07		0.20	c0.20			c0.29				
v/s Ratio Perm							0.16				0.16	
v/c Ratio	0.06	0.19		0.77	0.77		0.54	1.00			0.56	
Uniform Delay, d1	17.9	18.8		30.4	30.4		27.0	32.0			27.1	
Progression Factor	1.46	1.73		1.00	1.00		0.77	0.78			1.00	
Incremental Delay, d2	0.2	0.3		12.4	6.6		9.5	28.1			3.2	
Delay (s)	26.3	32.8		42.8	37.0		30.4	53.0			30.3	
Level of Service	C	C		D	D		C	D			C	
Approach Delay (s)		31.9			38.9			50.8			30.3	
Approach LOS		C			D			D			C	

Intersection Summary			
HCM Average Control Delay	41.5	HCM Level of Service	D
HCM Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	113.1%	ICU Level of Service	H
Analysis Period (min)	15		

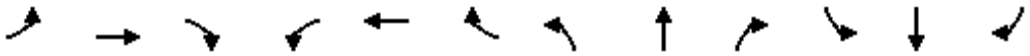
c Critical Lane Group



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (vph)	120	277	449	68	63	90
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00	0.92		0.84	
Flpb, ped/bikes	1.00	1.00	1.00		1.00	
Frt	1.00	1.00	0.98		0.92	
Flt Protected	0.95	1.00	1.00		0.98	
Satd. Flow (prot)	1719	3438	1632		1372	
Flt Permitted	0.95	1.00	1.00		0.98	
Satd. Flow (perm)	1719	3438	1632		1372	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	126	292	473	72	66	95
RTOR Reduction (vph)	0	0	8	0	60	0
Lane Group Flow (vph)	126	292	537	0	101	0
Confl. Peds. (#/hr)				420	186	186
Confl. Bikes (#/hr)				32		
Heavy Vehicles (%)	5%	5%	5%	5%	5%	5%
Turn Type	Prot					
Protected Phases	7	4	8		6	
Permitted Phases						
Actuated Green, G (s)	6.4	36.8	26.4		26.0	
Effective Green, g (s)	6.4	36.8	26.4		26.0	
Actuated g/C Ratio	0.09	0.52	0.37		0.37	
Clearance Time (s)	4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	155	1787	609		504	
v/s Ratio Prot	c0.07	0.08	c0.33		c0.07	
v/s Ratio Perm						
v/c Ratio	0.81	0.16	0.88		0.20	
Uniform Delay, d1	31.6	8.9	20.8		15.3	
Progression Factor	1.00	1.00	1.00		1.00	
Incremental Delay, d2	26.7	0.2	16.8		0.9	
Delay (s)	58.3	9.1	37.6		16.2	
Level of Service	E	A	D		B	
Approach Delay (s)		23.9	37.6		16.2	
Approach LOS		C	D		B	

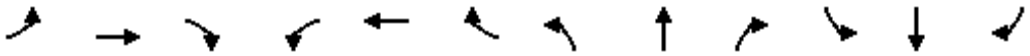
Intersection Summary			
HCM Average Control Delay	29.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	70.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	59.1%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	40	260	96	193	25	84	236	207	21	191	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0	4.0		4.0			4.0	
Lane Util. Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Frpb, ped/bikes		1.00	0.76		1.00	0.70		0.93			0.99	
Flpb, ped/bikes		0.95	1.00		0.93	1.00		0.98			1.00	
Frt		1.00	0.85		1.00	0.85		0.95			0.99	
Flt Protected		0.98	1.00		0.98	1.00		0.99			1.00	
Satd. Flow (prot)		1727	1191		1692	1105		1574			1799	
Flt Permitted		0.87	1.00		0.88	1.00		0.91			0.94	
Satd. Flow (perm)		1522	1191		1509	1105		1444			1692	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	43	283	104	210	27	91	257	225	23	208	11
RTOR Reduction (vph)	0	0	182	0	0	12	0	33	0	0	2	0
Lane Group Flow (vph)	0	65	101	0	314	15	0	540	0	0	240	0
Confl. Peds. (#/hr)	121		102	102		121	82		75	75		82
Confl. Bikes (#/hr)			2			21			17			6
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm		Perm	Perm		Perm	Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8		8	2			6		
Actuated Green, G (s)		24.5	24.5		24.5	24.5		36.5			36.5	
Effective Green, g (s)		25.0	25.0		25.0	25.0		37.0			37.0	
Actuated g/C Ratio		0.36	0.36		0.36	0.36		0.53			0.53	
Clearance Time (s)		4.5	4.5		4.5	4.5		4.5			4.5	
Lane Grp Cap (vph)		544	425		539	395		763			894	
v/s Ratio Prot												
v/s Ratio Perm		0.04	0.08		c0.21	0.01		c0.37			0.14	
v/c Ratio		0.12	0.24		0.58	0.04		0.71			0.27	
Uniform Delay, d1		15.1	15.8		18.3	14.7		12.4			9.1	
Progression Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Incremental Delay, d2		0.4	1.3		4.6	0.2		5.5			0.7	
Delay (s)		15.6	17.1		22.8	14.9		17.9			9.8	
Level of Service		B	B		C	B		B			A	
Approach Delay (s)		16.8			22.2			17.9			9.8	
Approach LOS		B			C			B			A	

Intersection Summary			
HCM Average Control Delay	17.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.66		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	77.2%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	30	20	20	141	10	190	10	307	42	111	436	10
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Hourly flow rate (vph)	31	20	20	144	10	194	10	313	43	113	445	10

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	71	348	366	568
Volume Left (vph)	31	144	10	113
Volume Right (vph)	20	194	43	10
Hadj (s)	-0.03	-0.20	-0.01	0.08
Departure Headway (s)	7.9	6.7	6.6	6.4
Degree Utilization, x	0.16	0.65	0.67	1.00
Capacity (veh/h)	391	518	530	560
Control Delay (s)	12.4	21.3	21.9	63.5
Approach Delay (s)	12.4	21.3	21.9	63.5
Approach LOS	B	C	C	F

Intersection Summary				
Delay		38.7		
HCM Level of Service		E		
Intersection Capacity Utilization		87.9%	ICU Level of Service	E
Analysis Period (min)		15		

Intersection 8 **Piedmont Avenue/Bancroft Way** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn	133	120	89.8%	46.1	8.1	E
	Through	429	377	87.9%	47.1	5.6	E
	Right Turn						
	Subtotal	**562**	**497**	**88.3%**	**46.8**	**6.1**	**E**
SB	Left Turn						
	Through	425	356	83.8%	354.1	146.6	F
	Right Turn	202	168	83.1%	332.8	137.6	F
	Subtotal	**627**	**524**	**83.6%**	**347.2**	**143.5**	**F**
EB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**1189**	**1021**	**85.8%**	**200.2**	**71.7**	**F**

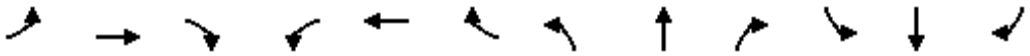
Intersection 9 **Piedmont Avenue/Durant Avenue** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn						
	Through	416	347	83.4%	475.8	257.8	F
	Right Turn						
	Subtotal	**416**	**347**	**83.4%**	**475.8**	**257.8**	**F**
SB	Left Turn						
	Through	420	354	84.3%	90.1	7.4	F
	Right Turn						
	Subtotal	**420**	**354**	**84.3%**	**90.1**	**7.4**	**F**
EB	Left Turn	134	138	103.2%	18.6	3.5	C
	Through						
	Right Turn	180	177	98.1%	20.9	5.5	C
	Subtotal	**314**	**315**	**100.3%**	**20.1**	**3.0**	**C**
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**1150**	**1016**	**88.4%**	**199.5**	**86.5**	**F**

Intersection	
Intersection Delay (sec/veh)	16.6
Intersection LOS	C

Approach	EB	WB	NB	SB
Entry Lanes	1	1	1	1
Conflicting Circle Lanes	1	1	1	1
Adjusted Approach Flow (vph)	138	216	534	652
Demand Flow Rate (pc/h)	141	220	544	665
Vehicles Circulating (pc/h)	648	533	151	305
Vehicles Exiting (pc/h)	322	162	638	448
Follow-Up Headway (s)	3.186	3.186	3.186	3.186
Ped Vol. Crossing Leg (#/hr)	210	9	117	78
Ped Capacity Adjustment	0.962	0.999	0.979	0.989
Approach Delay (sec/veh)	9.8	9.9	11.8	24.3
Approach LOS	A	A	B	C

Lane	Left	Left	Left	Left
Designated moves	LTR	LTR	LTR	LTR
Assumed Moves	LTR	LTR	LTR	LTR
Right Turn Channelized				
Lane Utilization	1.000	1.000	1.000	1.000
Critical Headway (s)	5.193	5.193	5.193	5.193
Entry Flow Rate (pc/h)	141	220	544	665
Capacity, Entry Lane (pc/h)	591	663	972	833
Entry HV Adjustment Factor	0.978	0.980	0.981	0.980
Flow Rate, Entry (vph)	138	216	534	652
Capacity, Entry (vph)	556	649	932	808
Volume to Capacity Ratio	0.248	0.332	0.572	0.807
Control Delay (sec/veh)	9.8	9.9	11.8	24.3
Level of Service	A	A	B	C
95th-Percentile Queue (veh)	1	1	4	9



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	129	120	220	42	0	100	0	498	10	20	452	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Util. Factor	1.00	1.00	1.00	1.00		1.00		*0.60			*0.60	
Frpb, ped/bikes	1.00	1.00	0.91	1.00		0.85		1.00			1.00	
Flpb, ped/bikes	0.87	1.00	1.00	0.94		1.00		1.00			1.00	
Frt	1.00	1.00	0.85	1.00		0.85		1.00			1.00	
Flt Protected	0.95	1.00	1.00	0.95		1.00		1.00			1.00	
Satd. Flow (prot)	1553	1881	1456	1672		1367		2240			2245	
Flt Permitted	0.95	1.00	1.00	0.68		1.00		1.00			0.91	
Satd. Flow (perm)	1553	1881	1456	1190		1367		2240			2054	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	136	126	232	44	0	105	0	524	11	21	476	0
RTOR Reduction (vph)	0	0	63	0	0	44	0	1	0	0	0	0
Lane Group Flow (vph)	136	126	169	44	0	61	0	534	0	0	497	0
Confl. Peds. (#/hr)	125		122	122		122	121		153	153		121
Confl. Bikes (#/hr)			5						13			14
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm		Perm	custom		custom				Perm		
Protected Phases		4						2			6	
Permitted Phases	4		4	8		8				6		
Actuated Green, G (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Effective Green, g (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Actuated g/C Ratio	0.48	0.48	0.48	0.48		0.48		0.43			0.43	
Clearance Time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Grp Cap (vph)	741	897	694	568		652		965			885	
v/s Ratio Prot		0.07						0.24				
v/s Ratio Perm	0.09		c0.12	0.04		0.04					c0.24	
v/c Ratio	0.18	0.14	0.24	0.08		0.09		0.55			0.56	
Uniform Delay, d1	9.7	9.5	10.1	9.2		9.3		13.8			13.9	
Progression Factor	1.00	1.00	1.00	1.00		1.00		1.00			1.00	
Incremental Delay, d2	0.5	0.3	0.8	0.3		0.3		2.3			2.6	
Delay (s)	10.3	9.9	10.9	9.5		9.6		16.1			16.5	
Level of Service	B	A	B	A		A		B			B	
Approach Delay (s)		10.5			9.6			16.1			16.5	
Approach LOS		B			A			B			B	

Intersection Summary			
HCM Average Control Delay	14.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.39		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	63.0%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	181	40	27	208	40	31
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.89	0.89	0.89	0.89	0.89	0.89
Hourly flow rate (vph)	203	45	30	234	45	35
Pedestrians	8			1		
Lane Width (ft)	12.0			12.0		
Walking Speed (ft/s)	4.0			4.0		
Percent Blockage	1			0		
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			248		528	227
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			248		528	227
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			98		91	96
cM capacity (veh/h)			1323		497	814

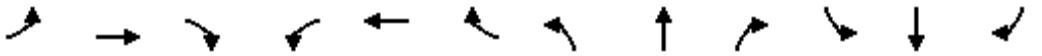
Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	248	264	80
Volume Left	0	30	45
Volume Right	45	0	35
cSH	1700	1323	599
Volume to Capacity	0.15	0.02	0.13
Queue Length 95th (ft)	0	2	11
Control Delay (s)	0.0	1.1	11.9
Lane LOS		A	B
Approach Delay (s)	0.0	1.1	11.9
Approach LOS			B

Intersection Summary			
Average Delay		2.1	
Intersection Capacity Utilization		38.5%	ICU Level of Service A
Analysis Period (min)		15	

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Sign Control	Stop		Stop			Stop
Volume (vph)	195	80	90	122	80	50
Peak Hour Factor	0.86	0.86	0.86	0.86	0.86	0.86
Hourly flow rate (vph)	227	93	105	142	93	58

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total (vph)	320	247	151
Volume Left (vph)	227	0	93
Volume Right (vph)	93	142	0
Hadj (s)	0.02	-0.29	0.17
Departure Headway (s)	4.9	4.7	5.2
Degree Utilization, x	0.44	0.32	0.22
Capacity (veh/h)	694	725	638
Control Delay (s)	11.6	9.8	9.7
Approach Delay (s)	11.6	9.8	9.7
Approach LOS	B	A	A

Intersection Summary			
Delay	10.6		
HCM Level of Service	B		
Intersection Capacity Utilization	47.0%	ICU Level of Service	A
Analysis Period (min)	15		



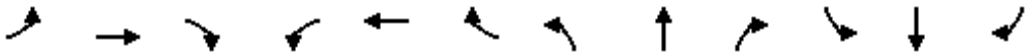
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	10	120	63	28	90	20	100	70	192	20	20	10
Peak Hour Factor	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Hourly flow rate (vph)	11	129	68	30	97	22	108	75	206	22	22	11

Direction, Lane #	EB 1	WB 1	NB 1	SB 1	SB 2
Volume Total (vph)	208	148	389	43	11
Volume Left (vph)	11	30	108	22	0
Volume Right (vph)	68	22	206	0	11
Hadj (s)	-0.17	-0.03	-0.25	0.12	-0.58
Departure Headway (s)	5.0	5.3	4.7	5.5	3.2
Degree Utilization, x	0.29	0.22	0.50	0.07	0.01
Capacity (veh/h)	659	622	729	581	1121
Control Delay (s)	10.1	9.7	12.3	8.9	6.2
Approach Delay (s)	10.1	9.7	12.3	8.4	
Approach LOS	B	A	B	A	

Intersection Summary				
Delay	11.0			
HCM Level of Service	B			
Intersection Capacity Utilization	51.2%	ICU Level of Service	A	
Analysis Period (min)	15			

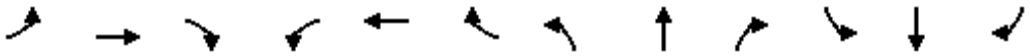
Cumulative (2035) No Project Conditions

FEHR PEERS



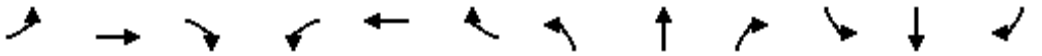
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	131	466	200	30	453	270	0	0	0	50	740	141
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Util. Factor	1.00	0.95			0.91	0.91					0.91	
Frpb, ped/bikes	1.00	0.96			0.99	0.87					0.95	
Flpb, ped/bikes	0.95	1.00			1.00	1.00					0.99	
Frt	1.00	0.96			0.99	0.85					0.98	
Flt Protected	0.95	1.00			1.00	1.00					1.00	
Satd. Flow (prot)	1622	3133			3190	1212					4488	
Flt Permitted	0.38	1.00			0.89	1.00					1.00	
Satd. Flow (perm)	655	3133			2833	1212					4488	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	142	507	217	33	492	293	0	0	0	54	804	153
RTOR Reduction (vph)	0	2	0	0	5	126	0	0	0	0	28	0
Lane Group Flow (vph)	142	722	0	0	555	132	0	0	0	0	983	0
Confl. Peds. (#/hr)	122		116	116		122	399		220	220		399
Confl. Bikes (#/hr)			12			7			1			22
Heavy Vehicles (%)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
Turn Type	Perm			Perm		Perm				Perm		
Protected Phases		4			8						6	
Permitted Phases	4			8		8				6		
Actuated Green, G (s)	46.0	46.0			46.0	46.0					36.0	
Effective Green, g (s)	46.0	46.0			46.0	46.0					36.0	
Actuated g/C Ratio	0.51	0.51			0.51	0.51					0.40	
Clearance Time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Grp Cap (vph)	335	1601			1448	619					1795	
v/s Ratio Prot		c0.23										
v/s Ratio Perm	0.22				0.20	0.11					0.22	
v/c Ratio	0.42	0.45			0.38	0.21					0.55	
Uniform Delay, d1	13.7	14.0			13.4	12.1					20.7	
Progression Factor	1.00	1.00			1.37	3.33					0.69	
Incremental Delay, d2	3.9	0.9			0.8	0.8					1.0	
Delay (s)	17.6	14.9			19.1	40.9					15.3	
Level of Service	B	B			B	D					B	
Approach Delay (s)		15.3			26.0			0.0			15.3	
Approach LOS		B			C			A			B	

Intersection Summary			
HCM Average Control Delay	18.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.49		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	83.3%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



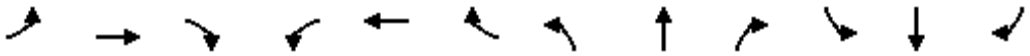
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	50	264	50	71	231	62	20	360	51	176	890	90
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95	1.00		0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes		1.00	0.87		0.99		1.00	0.99		1.00	0.99	
Flpb, ped/bikes		0.99	1.00		0.99		0.97	1.00		0.95	1.00	
Frt		1.00	0.85		0.97		1.00	0.98		1.00	0.99	
Flt Protected		0.99	1.00		0.99		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3455	1368		3301		1702	3395		1667	3405	
Flt Permitted		0.84	1.00		0.81		0.20	1.00		0.48	1.00	
Satd. Flow (perm)		2917	1368		2716		352	3395		836	3405	
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	54	284	54	76	248	67	22	387	55	189	957	97
RTOR Reduction (vph)	0	0	21	0	19	0	0	12	0	0	8	0
Lane Group Flow (vph)	0	338	33	0	372	0	22	430	0	189	1046	0
Confl. Peds. (#/hr)	85		92	92		85	248		157	157		248
Confl. Bikes (#/hr)			73			8			5			21
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm		Perm	Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)		32.0	32.0		32.0		50.0	50.0		50.0	50.0	
Effective Green, g (s)		32.0	32.0		32.0		50.0	50.0		50.0	50.0	
Actuated g/C Ratio		0.36	0.36		0.36		0.56	0.56		0.56	0.56	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)		1037	486		966		196	1886		464	1892	
v/s Ratio Prot								0.13			c0.31	
v/s Ratio Perm		0.12	0.02		c0.14		0.06			0.23		
v/c Ratio		0.33	0.07		0.38		0.11	0.23		0.41	0.55	
Uniform Delay, d1		21.1	19.2		21.7		9.5	10.2		11.5	12.8	
Progression Factor		1.00	1.00		0.95		1.92	1.88		1.00	1.00	
Incremental Delay, d2		0.8	0.3		1.0		1.1	0.3		2.6	1.2	
Delay (s)		22.0	19.4		21.6		19.3	19.4		14.1	14.0	
Level of Service		C	B		C		B	B		B	B	
Approach Delay (s)		21.6			21.6			19.4			14.0	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	17.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.49		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	114.8%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			



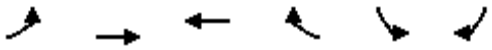
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	419	20	250	10	20	20	140	390	10	30	860	92
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.95	0.95			1.00		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	0.93			0.94		1.00	1.00		1.00	1.00	0.84
Flpb, ped/bikes	0.87	0.98			0.99		1.00	1.00		0.93	1.00	1.00
Frt	1.00	0.89			0.95		1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95	0.99			0.99		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1439	1380			1596		1736	3444		1606	3471	1306
Flt Permitted	0.78	0.93			0.92		0.95	1.00		0.49	1.00	1.00
Satd. Flow (perm)	1180	1299			1484		1736	3444		832	3471	1306
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	471	22	281	11	22	22	157	438	11	34	966	103
RTOR Reduction (vph)	0	107	0	0	15	0	0	2	0	0	0	37
Lane Group Flow (vph)	400	267	0	0	40	0	157	447	0	34	966	66
Confl. Peds. (#/hr)	153		87	87		153	152		96	96		152
Confl. Bikes (#/hr)			14			7			16			46
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm			Perm			Prot			Perm		Perm
Protected Phases		4			8		5	2			6	
Permitted Phases	4			8						6		6
Actuated Green, G (s)	30.0	30.0			30.0		6.0	52.0		42.0	42.0	42.0
Effective Green, g (s)	30.0	30.0			30.0		6.0	52.0		42.0	42.0	42.0
Actuated g/C Ratio	0.33	0.33			0.33		0.07	0.58		0.47	0.47	0.47
Clearance Time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Grp Cap (vph)	393	433			495		116	1990		388	1620	609
v/s Ratio Prot							c0.09	0.13			c0.28	
v/s Ratio Perm	c0.34	0.21			0.03					0.04		0.05
v/c Ratio	1.02	0.62			0.08		1.35	0.22		0.09	0.60	0.11
Uniform Delay, d1	30.0	25.2			20.6		42.0	9.2		13.3	17.7	13.5
Progression Factor	0.68	0.49			1.00		1.00	1.00		0.46	0.44	0.25
Incremental Delay, d2	49.0	6.2			0.3		205.1	0.3		0.3	1.3	0.3
Delay (s)	69.5	18.6			20.9		247.1	9.5		6.5	9.1	3.6
Level of Service	E	B			C		F	A		A	A	A
Approach Delay (s)		44.9			20.9			71.0			8.5	
Approach LOS		D			C			E			A	

Intersection Summary			
HCM Average Control Delay	34.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.82		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	72.1%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	30	371	90	272	235	21	60	300	409	42	610	60
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.5	2.5		2.5	2.5		2.5	2.5	2.5		2.5	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.95	1.00		0.95	
Frpb, ped/bikes	1.00	0.97		1.00	0.99		1.00	1.00	0.89		0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		0.97	1.00	1.00		1.00	
Frt	1.00	0.97		1.00	0.99		1.00	1.00	0.85		0.99	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00		1.00	
Satd. Flow (prot)	1736	3268		1579	3217		1686	3471	1383		3365	
Flt Permitted	0.95	1.00		0.95	0.99		0.16	1.00	1.00		0.92	
Satd. Flow (perm)	1736	3268		1579	3217		278	3471	1383		3092	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	32	391	95	286	247	22	63	316	431	44	642	63
RTOR Reduction (vph)	0	24	0	0	5	0	0	0	309	0	8	0
Lane Group Flow (vph)	32	462	0	183	367	0	63	316	122	0	741	0
Confl. Peds. (#/hr)	150		126	126		150	109		92	92		109
Confl. Bikes (#/hr)			73			3						23
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Split			Split			Perm		Perm	Perm		
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2		2	6		
Actuated Green, G (s)	32.0	32.0		25.0	25.0		25.5	25.5	25.5		25.5	
Effective Green, g (s)	32.0	32.0		25.0	25.0		25.5	25.5	25.5		25.5	
Actuated g/C Ratio	0.36	0.36		0.28	0.28		0.28	0.28	0.28		0.28	
Clearance Time (s)	2.5	2.5		2.5	2.5		2.5	2.5	2.5		2.5	
Lane Grp Cap (vph)	617	1162		439	894		79	983	392		876	
v/s Ratio Prot	0.02	c0.14		c0.12	0.11			0.09				
v/s Ratio Perm							0.23		0.09		c0.24	
v/c Ratio	0.05	0.40		0.42	0.41		0.80	0.32	0.31		0.85	
Uniform Delay, d1	19.0	21.8		26.5	26.5		29.9	25.4	25.4		30.4	
Progression Factor	1.32	1.41		1.00	1.00		0.79	0.73	1.53		1.00	
Incremental Delay, d2	0.2	1.0		2.9	1.4		47.4	0.7	1.7		9.9	
Delay (s)	25.3	31.6		29.4	27.9		71.0	19.4	40.6		40.3	
Level of Service	C	C		C	C		E	B	D		D	
Approach Delay (s)		31.2			28.4			34.7			40.3	
Approach LOS		C			C			C			D	

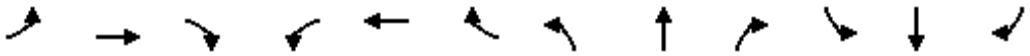
Intersection Summary			
HCM Average Control Delay	34.3	HCM Level of Service	C
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	7.5
Intersection Capacity Utilization	102.5%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (vph)	90	581	248	22	85	160
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00	0.96		0.86	
Flpb, ped/bikes	1.00	1.00	1.00		1.00	
Frt	1.00	1.00	0.99		0.91	
Flt Protected	0.95	1.00	1.00		0.98	
Satd. Flow (prot)	1703	3406	1694		1389	
Flt Permitted	0.95	1.00	1.00		0.98	
Satd. Flow (perm)	1703	3406	1694		1389	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	95	612	261	23	89	168
RTOR Reduction (vph)	0	0	5	0	102	0
Lane Group Flow (vph)	95	612	279	0	155	0
Confl. Peds. (#/hr)				320	151	151
Confl. Bikes (#/hr)				5		
Heavy Vehicles (%)	6%	6%	6%	6%	6%	6%
Turn Type	Prot					
Protected Phases	7	4	8		6	
Permitted Phases						
Actuated Green, G (s)	6.3	31.8	21.5		26.0	
Effective Green, g (s)	6.3	31.8	21.5		26.0	
Actuated g/C Ratio	0.10	0.48	0.33		0.40	
Clearance Time (s)	4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	163	1646	554		549	
v/s Ratio Prot	c0.06	0.18	c0.16		c0.11	
v/s Ratio Perm						
v/c Ratio	0.58	0.37	0.50		0.28	
Uniform Delay, d1	28.5	10.7	17.9		13.6	
Progression Factor	1.00	1.00	1.00		1.00	
Incremental Delay, d2	5.2	0.6	3.3		1.3	
Delay (s)	33.7	11.4	21.1		14.8	
Level of Service	C	B	C		B	
Approach Delay (s)		14.4	21.1		14.8	
Approach LOS		B	C		B	

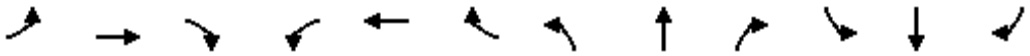
Intersection Summary			
HCM Average Control Delay	16.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	65.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	49.3%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	30	205	341	22	42	10	107	171	191	21	257	40
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0	4.0		4.0			4.0	
Lane Util. Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Frpb, ped/bikes		1.00	0.76		1.00	0.76		0.94			0.98	
Flpb, ped/bikes		0.97	1.00		0.95	1.00		0.99			1.00	
Frt		1.00	0.85		1.00	0.85		0.94			0.98	
Flt Protected		0.99	1.00		0.98	1.00		0.99			1.00	
Satd. Flow (prot)		1751	1173		1692	1161		1564			1734	
Flt Permitted		0.96	1.00		0.88	1.00		0.85			0.96	
Satd. Flow (perm)		1697	1173		1508	1161		1343			1671	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	31	214	355	23	44	10	111	178	199	22	268	42
RTOR Reduction (vph)	0	0	235	0	0	7	0	38	0	0	8	0
Lane Group Flow (vph)	0	245	120	0	67	3	0	450	0	0	324	0
Confl. Peds. (#/hr)	113		108	108		113	57		66	66		57
Confl. Bikes (#/hr)			3									21
Heavy Vehicles (%)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Turn Type	Perm		Perm	Perm		Perm	Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8		8	2			6		
Actuated Green, G (s)		21.5	21.5		21.5	21.5		34.5			34.5	
Effective Green, g (s)		22.0	22.0		22.0	22.0		35.0			35.0	
Actuated g/C Ratio		0.34	0.34		0.34	0.34		0.54			0.54	
Clearance Time (s)		4.5	4.5		4.5	4.5		4.5			4.5	
Lane Grp Cap (vph)		574	397		510	393		723			900	
v/s Ratio Prot												
v/s Ratio Perm		c0.14	0.10		0.04	0.00		c0.33			0.19	
v/c Ratio		0.43	0.30		0.13	0.01		0.62			0.36	
Uniform Delay, d1		16.6	15.8		14.9	14.3		10.4			8.6	
Progression Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Incremental Delay, d2		2.3	2.0		0.5	0.0		4.0			1.1	
Delay (s)		18.9	17.8		15.4	14.3		14.4			9.7	
Level of Service		B	B		B	B		B			A	
Approach Delay (s)		18.3			15.3			14.4			9.7	
Approach LOS		B			B			B			A	

Intersection Summary			
HCM Average Control Delay	15.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	77.9%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	10	10	20	60	10	118	20	381	136	177	412	30
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Hourly flow rate (vph)	11	11	21	64	11	126	21	405	145	188	438	32

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	43	200	571	659
Volume Left (vph)	11	64	21	188
Volume Right (vph)	21	126	145	32
Hadj (s)	-0.13	-0.19	-0.03	0.15
Departure Headway (s)	7.7	6.9	5.8	5.9
Degree Utilization, x	0.09	0.38	0.91	1.08
Capacity (veh/h)	436	499	612	615
Control Delay (s)	11.4	14.1	41.7	83.9
Approach Delay (s)	11.4	14.1	41.7	83.9
Approach LOS	B	B	E	F

Intersection Summary				
Delay	56.0			
HCM Level of Service	F			
Intersection Capacity Utilization	92.4%	ICU Level of Service	F	
Analysis Period (min)	15			

Intersection 8 **Piedmont Avenue/Bancroft Way** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn	130	91	70.1%	63.2	27.9	F
	Through	687	482	70.1%	62.4	9.6	F
	Right Turn						
	Subtotal	**817**	**573**	**70.1%**	**62.4**	**9.5**	**F**
SB	Left Turn						
	Through	315	322	102.1%	16.5	2.0	C
	Right Turn	127	127	99.8%	12.4	1.2	B
	Subtotal	**442**	**448**	**101.4%**	**15.3**	**1.7**	**C**
EB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**1259**	**1021**	**81.1%**	**41.7**	**5.3**	**E**

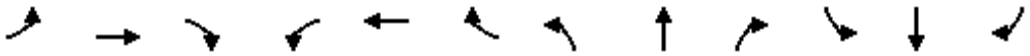
Intersection 9 **Piedmont Avenue/Durant Avenue** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn						
	Through	619	385	62.1%	1373.6	211.9	F
	Right Turn						
	Subtotal	**619**	**385**	**62.1%**	**1373.6**	**211.9**	**F**
SB	Left Turn						
	Through	305	321	105.3%	19.7	5.0	C
	Right Turn						
	Subtotal	**305**	**321**	**105.3%**	**19.7**	**5.0**	**C**
EB	Left Turn	190	181	95.3%	22.9	3.8	C
	Through						
	Right Turn	100	106	106.0%	9.0	0.5	A
	Subtotal	**290**	**287**	**99.0%**	**17.8**	**2.2**	**C**
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**1214**	**993**	**81.8%**	**542.6**	**76.1**	**F**

Intersection	
Intersection Delay (sec/veh)	11.7
Intersection LOS	B

Approach	EB	WB	NB	SB
Entry Lanes	1	1	1	1
Conflicting Circle Lanes	1	1	1	1
Adjusted Approach Flow (vph)	94	126	657	412
Demand Flow Rate (pc/h)	98	132	684	429
Vehicles Circulating (pc/h)	429	705	98	176
Vehicles Exiting (pc/h)	176	77	429	661
Follow-Up Headway (s)	3.186	3.186	3.186	3.186
Ped Vol. Crossing Leg (#/hr)	1	66	8	5
Ped Capacity Adjustment	1.000	0.991	0.999	0.999
Approach Delay (sec/veh)	6.6	10.1	14.1	9.5
Approach LOS	A	B	B	A

Lane	Left	Left	Left	Left
Designated moves	LTR	LTR	LTR	LTR
Assumed Moves	LTR	LTR	LTR	LTR
Right Turn Channelized				
Lane Utilization	1.000	1.000	1.000	1.000
Critical Headway (s)	5.193	5.193	5.193	5.193
Entry Flow Rate (pc/h)	98	132	684	429
Capacity, Entry Lane (pc/h)	736	558	1024	948
Entry HV Adjustment Factor	0.957	0.958	0.961	0.960
Flow Rate, Entry (vph)	94	126	657	412
Capacity, Entry (vph)	704	530	983	910
Volume to Capacity Ratio	0.133	0.239	0.668	0.453
Control Delay (sec/veh)	6.6	10.1	14.1	9.5
Level of Service	A	B	B	A
95th-Percentile Queue (veh)	0	1	5	2



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	163	141	160	50	0	60	0	717	11	20	324	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Util. Factor	1.00	1.00	1.00	1.00		1.00		*0.60			*0.60	
Frpb, ped/bikes	1.00	1.00	0.95	1.00		0.93		1.00			1.00	
Flpb, ped/bikes	0.95	1.00	1.00	0.96		1.00		1.00			1.00	
Frt	1.00	1.00	0.85	1.00		0.85		1.00			1.00	
Flt Protected	0.95	1.00	1.00	0.95		1.00		1.00			1.00	
Satd. Flow (prot)	1684	1863	1497	1708		1477		2227			2227	
Flt Permitted	0.95	1.00	1.00	0.67		1.00		1.00			0.87	
Satd. Flow (perm)	1684	1863	1497	1196		1477		2227			1940	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	166	144	163	51	0	61	0	732	11	20	331	0
RTOR Reduction (vph)	0	0	85	0	0	32	0	1	0	0	0	0
Lane Group Flow (vph)	166	144	78	51	0	29	0	742	0	0	351	0
Confl. Peds. (#/hr)	46		68	68		46	53		56	56		53
Confl. Bikes (#/hr)			1						14			
Turn Type	Perm		Perm	custom		custom				Perm		
Protected Phases		4						2			6	
Permitted Phases	4		4	8		8				6		
Actuated Green, G (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Effective Green, g (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Actuated g/C Ratio	0.48	0.48	0.48	0.48		0.48		0.43			0.43	
Clearance Time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Grp Cap (vph)	803	889	714	570		704		959			836	
v/s Ratio Prot		0.08						c0.33				
v/s Ratio Perm	c0.10		0.05	0.04		0.02					0.18	
v/c Ratio	0.21	0.16	0.11	0.09		0.04		0.77			0.42	
Uniform Delay, d1	9.9	9.6	9.4	9.3		9.1		15.8			12.9	
Progression Factor	1.00	1.00	1.00	1.00		1.00		1.00			1.00	
Incremental Delay, d2	0.6	0.4	0.3	0.3		0.1		6.1			1.5	
Delay (s)	10.4	10.0	9.7	9.6		9.2		21.8			14.4	
Level of Service	B	B	A	A		A		C			B	
Approach Delay (s)		10.1			9.4			21.8			14.4	
Approach LOS		B			A			C			B	

Intersection Summary			
HCM Average Control Delay	16.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.48		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	65.1%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	234	30	10	110	50	20
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.82	0.82	0.82	0.82	0.82	0.82
Hourly flow rate (vph)	285	37	12	134	61	24
Pedestrians	3					
Lane Width (ft)	12.0					
Walking Speed (ft/s)	4.0					
Percent Blockage	0					
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			322		465	304
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			322		465	304
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			99		89	97
cM capacity (veh/h)			1238		549	736

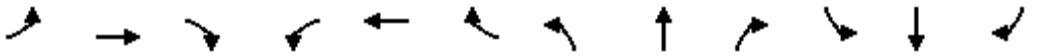
Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	322	146	85
Volume Left	0	12	61
Volume Right	37	0	24
cSH	1700	1238	592
Volume to Capacity	0.19	0.01	0.14
Queue Length 95th (ft)	0	1	13
Control Delay (s)	0.0	0.7	12.1
Lane LOS		A	B
Approach Delay (s)	0.0	0.7	12.1
Approach LOS			B

Intersection Summary			
Average Delay		2.1	
Intersection Capacity Utilization		24.8%	ICU Level of Service A
Analysis Period (min)		15	

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Sign Control	Stop		Stop			Stop
Volume (vph)	101	110	60	204	110	30
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	106	116	63	215	116	32

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total (vph)	222	278	147
Volume Left (vph)	106	0	116
Volume Right (vph)	116	215	0
Hadj (s)	-0.15	-0.40	0.23
Departure Headway (s)	4.7	4.3	5.0
Degree Utilization, x	0.29	0.33	0.20
Capacity (veh/h)	707	804	676
Control Delay (s)	9.7	9.3	9.3
Approach Delay (s)	9.7	9.3	9.3
Approach LOS	A	A	A

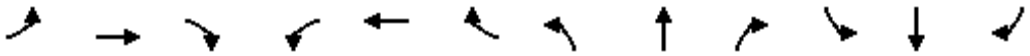
Intersection Summary			
Delay		9.4	
HCM Level of Service		A	
Intersection Capacity Utilization		46.3%	ICU Level of Service A
Analysis Period (min)		15	



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	20	130	133	211	90	20	41	40	44	30	80	20
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Hourly flow rate (vph)	23	148	151	240	102	23	47	45	50	34	91	23

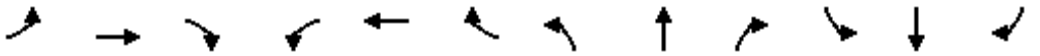
Direction, Lane #	EB 1	WB 1	NB 1	SB 1	SB 2
Volume Total (vph)	322	365	142	125	23
Volume Left (vph)	23	240	47	34	0
Volume Right (vph)	151	23	50	0	23
Hadj (s)	-0.25	0.11	-0.13	0.07	-0.58
Departure Headway (s)	5.0	5.3	5.8	6.1	3.2
Degree Utilization, x	0.45	0.54	0.23	0.21	0.02
Capacity (veh/h)	667	648	537	517	1121
Control Delay (s)	12.1	14.3	10.5	10.7	6.3
Approach Delay (s)	12.1	14.3	10.5	10.0	
Approach LOS	B	B	B	A	

Intersection Summary				
Delay	12.4			
HCM Level of Service	B			
Intersection Capacity Utilization	57.7%	ICU Level of Service		B
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	221	513	290	91	703	530	0	0	0	70	891	160
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Util. Factor	1.00	0.95			0.91	0.91					0.91	
Frpb, ped/bikes	1.00	0.90			0.97	0.68					0.94	
Flpb, ped/bikes	0.94	1.00			0.99	1.00					0.98	
Frt	1.00	0.95			0.99	0.85					0.98	
Flt Protected	0.95	1.00			0.99	1.00					1.00	
Satd. Flow (prot)	1640	2976			3169	974					4544	
Flt Permitted	0.21	1.00			0.72	1.00					1.00	
Satd. Flow (perm)	365	2976			2294	974					4544	
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	238	552	312	98	756	570	0	0	0	75	958	172
RTOR Reduction (vph)	0	0	0	0	8	224	0	0	0	0	26	0
Lane Group Flow (vph)	238	864	0	0	937	255	0	0	0	0	1179	0
Confl. Peds. (#/hr)	365		294	294		365	885		315	315		885
Confl. Bikes (#/hr)			13			17						34
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm		Perm				Perm		
Protected Phases		4			8						6	
Permitted Phases	4			8		8				6		
Actuated Green, G (s)	48.0	48.0			48.0	48.0					34.0	
Effective Green, g (s)	48.0	48.0			48.0	48.0					34.0	
Actuated g/C Ratio	0.53	0.53			0.53	0.53					0.38	
Clearance Time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Grp Cap (vph)	195	1587			1223	519					1717	
v/s Ratio Prot		0.29										
v/s Ratio Perm	c0.65				0.41	0.26					0.26	
v/c Ratio	1.22	0.54			0.77	0.49					0.69	
Uniform Delay, d1	21.0	13.8			16.6	13.3					23.5	
Progression Factor	1.00	1.00			1.33	3.69					0.70	
Incremental Delay, d2	136.4	1.3			4.6	3.3					2.1	
Delay (s)	157.4	15.2			26.7	52.3					18.5	
Level of Service	F	B			C	D					B	
Approach Delay (s)		45.9			35.3			0.0			18.5	
Approach LOS		D			D			A			B	

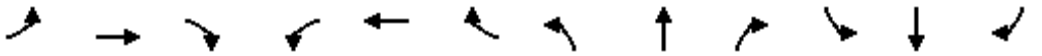
Intersection Summary			
HCM Average Control Delay	33.0	HCM Level of Service	C
HCM Volume to Capacity ratio	1.00		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	92.1%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	90	192	70	151	382	204	40	740	51	102	750	70
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95	1.00		0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes		1.00	0.89		0.94		1.00	0.99		1.00	0.98	
Flpb, ped/bikes		0.98	1.00		0.99		0.92	1.00		0.95	1.00	
Frt		1.00	0.85		0.96		1.00	0.99		1.00	0.99	
Flt Protected		0.98	1.00		0.99		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3428	1408		3102		1634	3466		1689	3408	
Flt Permitted		0.59	1.00		0.78		0.27	1.00		0.28	1.00	
Satd. Flow (perm)		2052	1408		2449		464	3466		501	3408	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	93	198	72	156	394	210	41	763	53	105	773	72
RTOR Reduction (vph)	0	0	10	0	28	0	0	5	0	0	8	0
Lane Group Flow (vph)	0	291	63	0	732	0	41	811	0	105	837	0
Confl. Peds. (#/hr)	211		112	112		211	472		267	267		472
Confl. Bikes (#/hr)			12			108			22			26
Turn Type	Perm		Perm	Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)		33.0	33.0		33.0		49.0	49.0		49.0	49.0	
Effective Green, g (s)		33.0	33.0		33.0		49.0	49.0		49.0	49.0	
Actuated g/C Ratio		0.37	0.37		0.37		0.54	0.54		0.54	0.54	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)		752	516		898		253	1887		273	1855	
v/s Ratio Prot								0.23			c0.25	
v/s Ratio Perm		0.14	0.04		c0.30		0.09			0.21		
v/c Ratio		0.39	0.12		0.82		0.16	0.43		0.38	0.45	
Uniform Delay, d1		21.0	18.9		25.7		10.2	12.2		11.8	12.4	
Progression Factor		1.00	1.00		1.52		1.52	1.53		1.00	1.00	
Incremental Delay, d2		1.5	0.5		4.9		0.8	0.4		4.1	0.8	
Delay (s)		22.5	19.4		44.0		16.4	19.1		15.9	13.2	
Level of Service		C	B		D		B	B		B	B	
Approach Delay (s)		21.9			44.0			19.0			13.5	
Approach LOS		C			D			B			B	

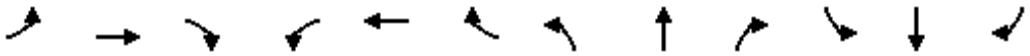
Intersection Summary			
HCM Average Control Delay	24.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	110.7%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	354	30	370	20	30	40	210	800	20	30	720	158
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.95	0.95			1.00		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	0.83			0.88		1.00	0.99		1.00	1.00	0.80
Flpb, ped/bikes	0.78	0.98			0.98		1.00	1.00		0.93	1.00	1.00
Frt	1.00	0.87			0.94		1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95	1.00			0.99		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1299	1240			1486		1752	3472		1633	3505	1252
Flt Permitted	0.72	0.97			0.81		0.95	1.00		0.34	1.00	1.00
Satd. Flow (perm)	981	1211			1212		1752	3472		580	3505	1252
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	361	31	378	20	31	41	214	816	20	31	735	161
RTOR Reduction (vph)	0	165	0	0	27	0	0	2	0	0	0	59
Lane Group Flow (vph)	325	280	0	0	65	0	214	834	0	31	735	102
Confl. Peds. (#/hr)	287		212	212		287	203		150	150		203
Confl. Bikes (#/hr)			5			7			18			43
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Prot			Perm		Perm
Protected Phases		4			8		5	2			6	
Permitted Phases	4			8						6		6
Actuated Green, G (s)	31.0	31.0			31.0		10.0	51.0		37.0	37.0	37.0
Effective Green, g (s)	31.0	31.0			31.0		10.0	51.0		37.0	37.0	37.0
Actuated g/C Ratio	0.34	0.34			0.34		0.11	0.57		0.41	0.41	0.41
Clearance Time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Grp Cap (vph)	338	417			417		195	1967		238	1441	515
v/s Ratio Prot							c0.12	0.24			c0.21	
v/s Ratio Perm	c0.33	0.23			0.05					0.05		0.08
v/c Ratio	0.96	0.67			0.16		1.10	0.42		0.13	0.51	0.20
Uniform Delay, d1	28.9	25.2			20.4		40.0	11.1		16.5	19.7	17.0
Progression Factor	0.73	0.61			1.00		1.00	1.00		0.48	0.51	0.25
Incremental Delay, d2	37.8	7.6			0.8		92.9	0.7		0.9	1.0	0.7
Delay (s)	58.9	22.9			21.2		132.9	11.8		8.7	11.0	5.0
Level of Service	E	C			C		F	B		A	B	A
Approach Delay (s)		38.1			21.2			36.5			9.9	
Approach LOS		D			C			D			A	

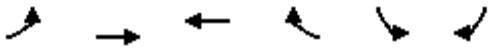
Intersection Summary			
HCM Average Control Delay	27.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.77		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	79.9%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	50	195	110	378	517	90	130	700	394	21	350	60
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.0	2.0		2.0	2.0		2.0	2.0			2.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.95			0.95	
Frpb, ped/bikes	1.00	0.96		1.00	0.97		1.00	0.95			0.98	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		0.95	1.00			1.00	
Frt	1.00	0.95		1.00	0.98		1.00	0.95			0.98	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)	1770	3227		1610	3193		1684	3177			3395	
Flt Permitted	0.95	1.00		0.95	1.00		0.34	1.00			0.70	
Satd. Flow (perm)	1770	3227		1610	3193		602	3177			2375	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	53	207	117	402	550	96	138	745	419	22	372	64
RTOR Reduction (vph)	0	69	0	0	13	0	0	86	0	0	14	0
Lane Group Flow (vph)	53	255	0	346	689	0	138	1078	0	0	444	0
Confl. Peds. (#/hr)	168		108	108		168	104		118	118		104
Confl. Bikes (#/hr)			7			98			16			10
Turn Type	Split			Split			Perm			Perm		
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	34.0	34.0		24.0	24.0		26.0	26.0			26.0	
Effective Green, g (s)	34.0	34.0		24.0	24.0		26.0	26.0			26.0	
Actuated g/C Ratio	0.38	0.38		0.27	0.27		0.29	0.29			0.29	
Clearance Time (s)	2.0	2.0		2.0	2.0		2.0	2.0			2.0	
Lane Grp Cap (vph)	669	1219		429	851		174	918			686	
v/s Ratio Prot	0.03	c0.08		0.21	c0.22			c0.34				
v/s Ratio Perm							0.23				0.19	
v/c Ratio	0.08	0.21		0.81	0.81		0.79	1.17			0.65	
Uniform Delay, d1	18.0	18.9		30.8	30.9		29.5	32.0			28.0	
Progression Factor	1.39	1.68		1.00	1.00		0.77	0.76			1.00	
Incremental Delay, d2	0.2	0.4		14.9	8.2		26.4	88.4			4.7	
Delay (s)	25.1	32.1		45.8	39.1		49.3	112.9			32.7	
Level of Service	C	C		D	D		D	F			C	
Approach Delay (s)		31.1			41.3			106.2			32.7	
Approach LOS		C			D			F			C	

Intersection Summary			
HCM Average Control Delay	65.4	HCM Level of Service	E
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	117.6%	ICU Level of Service	H
Analysis Period (min)	15		

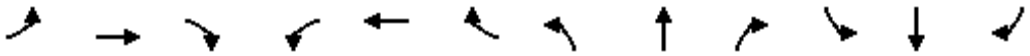
c Critical Lane Group



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (vph)	140	330	455	73	72	110
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00	0.91		0.82	
Flpb, ped/bikes	1.00	1.00	1.00		1.00	
Frt	1.00	1.00	0.98		0.92	
Flt Protected	0.95	1.00	1.00		0.98	
Satd. Flow (prot)	1719	3438	1617		1333	
Flt Permitted	0.95	1.00	1.00		0.98	
Satd. Flow (perm)	1719	3438	1617		1333	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	147	347	479	77	76	116
RTOR Reduction (vph)	0	0	9	0	73	0
Lane Group Flow (vph)	147	347	547	0	119	0
Confl. Peds. (#/hr)				475	211	211
Confl. Bikes (#/hr)				36		
Heavy Vehicles (%)	5%	5%	5%	5%	5%	5%
Turn Type	Prot					
Protected Phases	7	4	8		6	
Permitted Phases						
Actuated Green, G (s)	7.9	36.0	24.1		26.0	
Effective Green, g (s)	7.9	36.0	24.1		26.0	
Actuated g/C Ratio	0.11	0.51	0.34		0.37	
Clearance Time (s)	4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	194	1768	557		495	
v/s Ratio Prot	c0.09	0.10	c0.34		c0.09	
v/s Ratio Perm						
v/c Ratio	0.76	0.20	0.98		0.24	
Uniform Delay, d1	30.1	9.2	22.7		15.2	
Progression Factor	1.00	1.00	1.00		1.00	
Incremental Delay, d2	15.5	0.2	34.2		1.1	
Delay (s)	45.6	9.4	56.9		16.3	
Level of Service	D	A	E		B	
Approach Delay (s)		20.2	56.9		16.3	
Approach LOS		C	E		B	

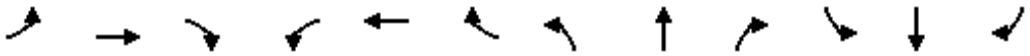
Intersection Summary			
HCM Average Control Delay	36.0	HCM Level of Service	D
HCM Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	63.0%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	30	32	320	60	144	21	94	256	202	20	201	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0	4.0		4.0			4.0	
Lane Util. Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Frpb, ped/bikes		1.00	0.73		1.00	0.67		0.92			0.99	
Flpb, ped/bikes		0.90	1.00		0.93	1.00		0.98			1.00	
Frt		1.00	0.85		1.00	0.85		0.95			0.99	
Flt Protected		0.98	1.00		0.99	1.00		0.99			1.00	
Satd. Flow (prot)		1623	1143		1695	1050		1568			1799	
Flt Permitted		0.83	1.00		0.90	1.00		0.90			0.94	
Satd. Flow (perm)		1378	1143		1551	1050		1423			1697	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	33	35	348	65	157	23	102	278	220	22	218	11
RTOR Reduction (vph)	0	0	224	0	0	14	0	30	0	0	2	0
Lane Group Flow (vph)	0	68	124	0	222	9	0	570	0	0	249	0
Confl. Peds. (#/hr)	137		116	116		137	92		85	85		92
Confl. Bikes (#/hr)			3			23			20			7
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm		Perm	Perm		Perm	Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8		8	2			6		
Actuated Green, G (s)		24.5	24.5		24.5	24.5		36.5			36.5	
Effective Green, g (s)		25.0	25.0		25.0	25.0		37.0			37.0	
Actuated g/C Ratio		0.36	0.36		0.36	0.36		0.53			0.53	
Clearance Time (s)		4.5	4.5		4.5	4.5		4.5			4.5	
Lane Grp Cap (vph)		492	408		554	375		752			897	
v/s Ratio Prot												
v/s Ratio Perm		0.05	0.11		c0.14	0.01		c0.40			0.15	
v/c Ratio		0.14	0.30		0.40	0.02		0.76			0.28	
Uniform Delay, d1		15.2	16.2		16.9	14.6		13.0			9.1	
Progression Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Incremental Delay, d2		0.6	1.9		2.2	0.1		7.1			0.8	
Delay (s)		15.8	18.2		19.0	14.7		20.0			9.9	
Level of Service		B	B		B	B		C			A	
Approach Delay (s)		17.8			18.6			20.0			9.9	
Approach LOS		B			B			C			A	

Intersection Summary			
HCM Average Control Delay	17.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	84.8%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	30	20	20	141	10	200	10	342	52	121	460	10
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Hourly flow rate (vph)	31	20	20	144	10	204	10	349	53	123	469	10

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	71	358	412	603
Volume Left (vph)	31	144	10	123
Volume Right (vph)	20	204	53	10
Hadj (s)	-0.03	-0.21	-0.02	0.08
Departure Headway (s)	8.2	6.8	6.6	6.5
Degree Utilization, x	0.16	0.68	0.76	1.10
Capacity (veh/h)	376	509	528	540
Control Delay (s)	12.8	23.2	27.8	92.1
Approach Delay (s)	12.8	23.2	27.8	92.1
Approach LOS	B	C	D	F

Intersection Summary				
Delay		52.7		
HCM Level of Service		F		
Intersection Capacity Utilization		93.1%	ICU Level of Service	F
Analysis Period (min)		15		

Intersection 8 **Piedmont Avenue/Bancroft Way** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn	151	117	77.5%	56.2	4.6	F
	Through	504	395	78.4%	58.1	9.9	F
	Right Turn						
	Subtotal	**655**	**512**	**78.2%**	**57.6**	**8.4**	**F**
SB	Left Turn						
	Through	469	328	69.8%	924.1	195.8	F
	Right Turn	212	146	69.0%	928.4	216.8	F
	Subtotal	**681**	**474**	**69.6%**	**925.0**	**200.7**	**F**
EB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**1336**	**986**	**73.8%**	**473.4**	**91.8**	**F**

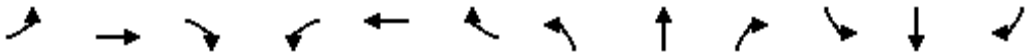
Intersection 9 **Piedmont Avenue/Durant Avenue** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn						
	Through	471	327	69.4%	941.9	231.0	F
	Right Turn						
	Subtotal	**471**	**327**	**69.4%**	**941.9**	**231.0**	**F**
SB	Left Turn						
	Through	460	327	71.1%	102.7	6.3	F
	Right Turn						
	Subtotal	**460**	**327**	**71.1%**	**102.7**	**6.3**	**F**
EB	Left Turn	163	166	102.0%	21.7	2.4	C
	Through						
	Right Turn	210	210	99.8%	26.1	6.1	D
	Subtotal	**373**	**376**	**100.8%**	**24.2**	**3.3**	**C**
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**1304**	**1030**	**79.0%**	**339.3**	**69.8**	**F**

Intersection	
Intersection Delay (sec/veh)	22.6
Intersection LOS	C

Approach	EB	WB	NB	SB
Entry Lanes	1	1	1	1
Conflicting Circle Lanes	1	1	1	1
Adjusted Approach Flow (vph)	158	222	590	716
Demand Flow Rate (pc/h)	161	227	602	730
Vehicles Circulating (pc/h)	698	592	172	323
Vehicles Exiting (pc/h)	355	182	687	496
Follow-Up Headway (s)	3.186	3.186	3.186	3.186
Ped Vol. Crossing Leg (#/hr)	238	10	133	88
Ped Capacity Adjustment	0.961	0.999	0.970	0.988
Approach Delay (sec/veh)	11.1	11.0	14.4	35.5
Approach LOS	B	B	B	E

Lane	Left	Left	Left	Left
Designated moves	LTR	LTR	LTR	LTR
Assumed Moves	LTR	LTR	LTR	LTR
Right Turn Channelized				
Lane Utilization	1.000	1.000	1.000	1.000
Critical Headway (s)	5.193	5.193	5.193	5.193
Entry Flow Rate (pc/h)	161	227	602	730
Capacity, Entry Lane (pc/h)	562	625	951	818
Entry HV Adjustment Factor	0.980	0.980	0.979	0.981
Flow Rate, Entry (vph)	158	222	590	716
Capacity, Entry (vph)	530	612	904	793
Volume to Capacity Ratio	0.298	0.364	0.652	0.903
Control Delay (sec/veh)	11.1	11.0	14.4	35.5
Level of Service	B	B	B	E
95th-Percentile Queue (veh)	1	2	5	12



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	137	150	270	41	0	110	0	575	20	20	502	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Util. Factor	1.00	1.00	1.00	1.00		1.00		*0.60			*0.60	
Frpb, ped/bikes	1.00	1.00	0.90	1.00		0.84		0.99			1.00	
Flpb, ped/bikes	0.85	1.00	1.00	0.93		1.00		1.00			1.00	
Frt	1.00	1.00	0.85	1.00		0.85		0.99			1.00	
Flt Protected	0.95	1.00	1.00	0.95		1.00		1.00			1.00	
Satd. Flow (prot)	1521	1881	1441	1663		1340		2227			2247	
Flt Permitted	0.95	1.00	1.00	0.65		1.00		1.00			0.91	
Satd. Flow (perm)	1521	1881	1441	1140		1340		2227			2046	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	144	158	284	43	0	116	0	605	21	21	528	0
RTOR Reduction (vph)	0	0	48	0	0	30	0	2	0	0	0	0
Lane Group Flow (vph)	144	158	236	43	0	86	0	624	0	0	549	0
Confl. Peds. (#/hr)	142		138	138		138	137		173	173		137
Confl. Bikes (#/hr)			5						14			16
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm		Perm	custom		custom				Perm		
Protected Phases		4						2			6	
Permitted Phases	4		4	8		8				6		
Actuated Green, G (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Effective Green, g (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Actuated g/C Ratio	0.48	0.48	0.48	0.48		0.48		0.43			0.43	
Clearance Time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Grp Cap (vph)	725	897	687	544		639		959			881	
v/s Ratio Prot		0.08						c0.28				
v/s Ratio Perm	0.09		c0.16	0.04		0.06					0.27	
v/c Ratio	0.20	0.18	0.34	0.08		0.13		0.65			0.62	
Uniform Delay, d1	9.8	9.7	10.6	9.2		9.5		14.6			14.4	
Progression Factor	1.00	1.00	1.00	1.00		1.00		1.00			1.00	
Incremental Delay, d2	0.6	0.4	1.4	0.3		0.4		3.4			3.3	
Delay (s)	10.4	10.1	12.0	9.5		9.9		18.0			17.7	
Level of Service	B	B	B	A		A		B			B	
Approach Delay (s)		11.1			9.8			18.0			17.7	
Approach LOS		B			A			B			B	

Intersection Summary			
HCM Average Control Delay	15.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.49		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	67.7%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	200	40	22	212	40	30
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.89	0.89	0.89	0.89	0.89	0.89
Hourly flow rate (vph)	225	45	25	238	45	34
Pedestrians	9			1		
Lane Width (ft)	12.0			12.0		
Walking Speed (ft/s)	4.0			4.0		
Percent Blockage	1			0		
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			270		544	248
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			270		544	248
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			98		91	96
cM capacity (veh/h)			1300		489	792

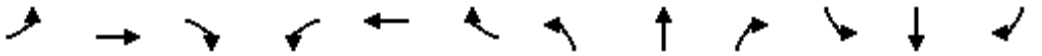
Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	270	263	79
Volume Left	0	25	45
Volume Right	45	0	34
cSH	1700	1300	585
Volume to Capacity	0.16	0.02	0.13
Queue Length 95th (ft)	0	1	12
Control Delay (s)	0.0	0.9	12.1
Lane LOS		A	B
Approach Delay (s)	0.0	0.9	12.1
Approach LOS			B

Intersection Summary			
Average Delay	1.9		
Intersection Capacity Utilization	39.4%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Sign Control	Stop		Stop			Stop
Volume (vph)	193	90	100	131	90	60
Peak Hour Factor	0.86	0.86	0.86	0.86	0.86	0.86
Hourly flow rate (vph)	224	105	116	152	105	70

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total (vph)	329	269	174
Volume Left (vph)	224	0	105
Volume Right (vph)	105	152	0
Hadj (s)	0.00	-0.29	0.17
Departure Headway (s)	5.0	4.8	5.3
Degree Utilization, x	0.46	0.35	0.26
Capacity (veh/h)	679	713	630
Control Delay (s)	12.1	10.3	10.2
Approach Delay (s)	12.1	10.3	10.2
Approach LOS	B	B	B

Intersection Summary			
Delay	11.1		
HCM Level of Service	B		
Intersection Capacity Utilization	49.8%	ICU Level of Service	A
Analysis Period (min)	15		



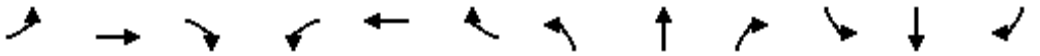
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	20	150	112	24	110	20	92	80	178	30	30	10
Peak Hour Factor	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Hourly flow rate (vph)	22	161	120	26	118	22	99	86	191	32	32	11

Direction, Lane #	EB 1	WB 1	NB 1	SB 1	SB 2
Volume Total (vph)	303	166	376	65	11
Volume Left (vph)	22	26	99	32	0
Volume Right (vph)	120	22	191	0	11
Hadj (s)	-0.21	-0.03	-0.24	0.12	-0.58
Departure Headway (s)	5.2	5.6	5.0	5.9	3.2
Degree Utilization, x	0.44	0.26	0.53	0.11	0.01
Capacity (veh/h)	644	586	669	525	1121
Control Delay (s)	12.1	10.5	13.5	9.6	6.2
Approach Delay (s)	12.1	10.5	13.5	9.1	
Approach LOS	B	B	B	A	

Intersection Summary				
Delay	12.2			
HCM Level of Service	B			
Intersection Capacity Utilization	51.7%	ICU Level of Service	A	
Analysis Period (min)	15			

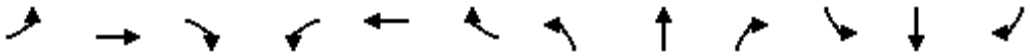
Cumulative (2035) Plus Phase 1 Project Conditions

FEHR PEERS



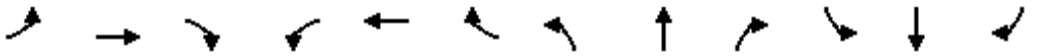
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	142	477	200	31	455	270	0	0	0	50	741	143
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Util. Factor	1.00	0.95			0.91	0.91					0.91	
Frpb, ped/bikes	1.00	0.96			0.99	0.87					0.95	
Flpb, ped/bikes	0.95	1.00			1.00	1.00					0.99	
Frt	1.00	0.96			0.99	0.85					0.98	
Flt Protected	0.95	1.00			1.00	1.00					1.00	
Satd. Flow (prot)	1622	3137			3195	1212					4485	
Flt Permitted	0.38	1.00			0.88	1.00					1.00	
Satd. Flow (perm)	655	3137			2826	1212					4485	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	154	518	217	34	495	293	0	0	0	54	805	155
RTOR Reduction (vph)	0	2	0	0	4	128	0	0	0	0	29	0
Lane Group Flow (vph)	154	733	0	0	557	133	0	0	0	0	985	0
Confl. Peds. (#/hr)	122		116	116		122	399		220	220		399
Confl. Bikes (#/hr)			12			7			1			22
Heavy Vehicles (%)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
Turn Type	Perm			Perm		Perm				Perm		
Protected Phases		4			8						6	
Permitted Phases	4			8		8				6		
Actuated Green, G (s)	46.0	46.0			46.0	46.0					36.0	
Effective Green, g (s)	46.0	46.0			46.0	46.0					36.0	
Actuated g/C Ratio	0.51	0.51			0.51	0.51					0.40	
Clearance Time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Grp Cap (vph)	335	1603			1444	619					1794	
v/s Ratio Prot		0.23										
v/s Ratio Perm	c0.24				0.20	0.11					0.22	
v/c Ratio	0.46	0.46			0.39	0.22					0.55	
Uniform Delay, d1	14.1	14.0			13.4	12.1					20.8	
Progression Factor	1.00	1.00			1.37	3.32					0.68	
Incremental Delay, d2	4.5	0.9			0.8	0.8					1.1	
Delay (s)	18.5	15.0			19.1	40.9					15.3	
Level of Service	B	B			B	D					B	
Approach Delay (s)		15.6			26.0			0.0			15.3	
Approach LOS		B			C			A			B	

Intersection Summary			
HCM Average Control Delay	18.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.50		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	83.3%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



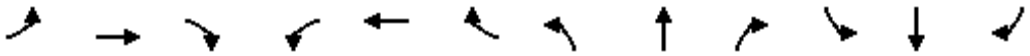
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	50	267	50	74	232	63	20	360	62	186	890	90
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95	1.00		0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes		1.00	0.87		0.99		1.00	0.98		1.00	0.99	
Flpb, ped/bikes		0.99	1.00		0.99		0.97	1.00		0.95	1.00	
Frt		1.00	0.85		0.97		1.00	0.98		1.00	0.99	
Flt Protected		0.99	1.00		0.99		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3456	1368		3299		1702	3375		1668	3405	
Flt Permitted		0.84	1.00		0.81		0.20	1.00		0.47	1.00	
Satd. Flow (perm)		2916	1368		2693		352	3375		824	3405	
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	54	287	54	80	249	68	22	387	67	200	957	97
RTOR Reduction (vph)	0	0	21	0	19	0	0	16	0	0	8	0
Lane Group Flow (vph)	0	341	33	0	378	0	22	438	0	200	1046	0
Confl. Peds. (#/hr)	85		92	92		85	248		157	157		248
Confl. Bikes (#/hr)			73			8			5			21
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm		Perm	Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)		32.0	32.0		32.0		50.0	50.0		50.0	50.0	
Effective Green, g (s)		32.0	32.0		32.0		50.0	50.0		50.0	50.0	
Actuated g/C Ratio		0.36	0.36		0.36		0.56	0.56		0.56	0.56	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)		1037	486		958		196	1875		458	1892	
v/s Ratio Prot								0.13			c0.31	
v/s Ratio Perm		0.12	0.02		c0.14		0.06			0.24		
v/c Ratio		0.33	0.07		0.39		0.11	0.23		0.44	0.55	
Uniform Delay, d1		21.2	19.2		21.7		9.5	10.2		11.7	12.8	
Progression Factor		1.00	1.00		0.97		1.91	1.89		1.00	1.00	
Incremental Delay, d2		0.8	0.3		1.0		1.1	0.3		3.0	1.2	
Delay (s)		22.0	19.4		22.0		19.2	19.6		14.7	14.0	
Level of Service		C	B		C		B	B		B	B	
Approach Delay (s)		21.7			22.0			19.5			14.1	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	17.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.49		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	115.3%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			



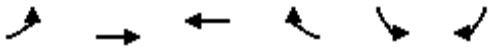
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	438	20	250	10	20	20	140	390	10	30	860	95
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.95	0.95			1.00		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	0.93			0.94		1.00	1.00		1.00	1.00	0.84
Flpb, ped/bikes	0.87	0.97			0.99		1.00	1.00		0.93	1.00	1.00
Frt	1.00	0.89			0.95		1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95	0.99			0.99		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1439	1383			1597		1736	3444		1606	3471	1306
Flt Permitted	0.78	0.92			0.92		0.95	1.00		0.49	1.00	1.00
Satd. Flow (perm)	1180	1287			1482		1736	3444		832	3471	1306
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	492	22	281	11	22	22	157	438	11	34	966	107
RTOR Reduction (vph)	0	106	0	0	15	0	0	2	0	0	0	39
Lane Group Flow (vph)	408	281	0	0	40	0	157	447	0	34	966	68
Confl. Peds. (#/hr)	153		87	87		153	152		96	96		152
Confl. Bikes (#/hr)			14			7			16			46
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm			Perm			Prot			Perm		Perm
Protected Phases		4			8		5	2			6	
Permitted Phases	4			8						6		6
Actuated Green, G (s)	30.0	30.0			30.0		6.0	52.0		42.0	42.0	42.0
Effective Green, g (s)	30.0	30.0			30.0		6.0	52.0		42.0	42.0	42.0
Actuated g/C Ratio	0.33	0.33			0.33		0.07	0.58		0.47	0.47	0.47
Clearance Time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Grp Cap (vph)	393	429			494		116	1990		388	1620	609
v/s Ratio Prot							c0.09	0.13			c0.28	
v/s Ratio Perm	c0.35	0.22			0.03					0.04		0.05
v/c Ratio	1.04	0.66			0.08		1.35	0.22		0.09	0.60	0.11
Uniform Delay, d1	30.0	25.6			20.6		42.0	9.2		13.3	17.7	13.5
Progression Factor	0.68	0.50			1.00		1.00	1.00		0.46	0.44	0.25
Incremental Delay, d2	54.7	7.3			0.3		205.1	0.3		0.3	1.2	0.3
Delay (s)	75.2	20.1			20.9		247.1	9.5		6.5	9.1	3.7
Level of Service	E	C			C		F	A		A	A	A
Approach Delay (s)		48.4			20.9			71.0			8.5	
Approach LOS		D			C			E			A	

Intersection Summary			
HCM Average Control Delay	35.9	HCM Level of Service	D
HCM Volume to Capacity ratio	0.82		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	72.5%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	30	394	90	275	239	22	60	300	428	45	610	60
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.5	2.5		2.5	2.5		2.5	2.5	2.5		2.5	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.95	1.00		0.95	
Frpb, ped/bikes	1.00	0.97		1.00	0.99		1.00	1.00	0.89		0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		0.97	1.00	1.00		1.00	
Frt	1.00	0.97		1.00	0.99		1.00	1.00	0.85		0.99	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00		1.00	
Satd. Flow (prot)	1736	3278		1579	3216		1686	3471	1383		3364	
Flt Permitted	0.95	1.00		0.95	0.99		0.16	1.00	1.00		0.91	
Satd. Flow (perm)	1736	3278		1579	3216		278	3471	1383		3080	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	32	415	95	289	252	23	63	316	451	47	642	63
RTOR Reduction (vph)	0	22	0	0	5	0	0	0	323	0	8	0
Lane Group Flow (vph)	32	488	0	185	374	0	63	316	128	0	744	0
Confl. Peds. (#/hr)	150		126	126		150	109		92	92		109
Confl. Bikes (#/hr)			73			3						23
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Split			Split			Perm		Perm	Perm		
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2		2	6		
Actuated Green, G (s)	32.0	32.0		25.0	25.0		25.5	25.5	25.5		25.5	
Effective Green, g (s)	32.0	32.0		25.0	25.0		25.5	25.5	25.5		25.5	
Actuated g/C Ratio	0.36	0.36		0.28	0.28		0.28	0.28	0.28		0.28	
Clearance Time (s)	2.5	2.5		2.5	2.5		2.5	2.5	2.5		2.5	
Lane Grp Cap (vph)	617	1166		439	893		79	983	392		873	
v/s Ratio Prot	0.02	c0.15		c0.12	0.12			0.09				
v/s Ratio Perm							0.23		0.09		c0.24	
v/c Ratio	0.05	0.42		0.42	0.42		0.80	0.32	0.33		0.85	
Uniform Delay, d1	19.0	22.0		26.6	26.6		29.9	25.4	25.5		30.5	
Progression Factor	1.29	1.36		1.00	1.00		0.79	0.74	1.65		1.00	
Incremental Delay, d2	0.2	1.1		3.0	1.4		46.8	0.7	1.7		10.3	
Delay (s)	24.6	31.0		29.5	28.0		70.4	19.4	43.7		40.8	
Level of Service	C	C		C	C		E	B	D		D	
Approach Delay (s)		30.6			28.5			36.5			40.8	
Approach LOS		C			C			D			D	

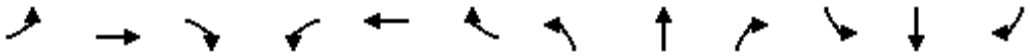
Intersection Summary			
HCM Average Control Delay	34.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	7.5
Intersection Capacity Utilization	102.5%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (vph)	90	627	255	22	90	160
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00	0.96		0.87	
Flpb, ped/bikes	1.00	1.00	1.00		1.00	
Frt	1.00	1.00	0.99		0.91	
Flt Protected	0.95	1.00	1.00		0.98	
Satd. Flow (prot)	1703	3406	1696		1396	
Flt Permitted	0.95	1.00	1.00		0.98	
Satd. Flow (perm)	1703	3406	1696		1396	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	95	660	268	23	95	168
RTOR Reduction (vph)	0	0	5	0	99	0
Lane Group Flow (vph)	95	660	286	0	164	0
Confl. Peds. (#/hr)				320	151	151
Confl. Bikes (#/hr)				5		
Heavy Vehicles (%)	6%	6%	6%	6%	6%	6%
Turn Type	Prot					
Protected Phases	7	4	8		6	
Permitted Phases						
Actuated Green, G (s)	6.3	31.8	21.5		26.0	
Effective Green, g (s)	6.3	31.8	21.5		26.0	
Actuated g/C Ratio	0.10	0.48	0.33		0.40	
Clearance Time (s)	4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	163	1646	554		552	
v/s Ratio Prot	c0.06	0.19	c0.17		c0.12	
v/s Ratio Perm						
v/c Ratio	0.58	0.40	0.52		0.30	
Uniform Delay, d1	28.5	10.9	17.9		13.6	
Progression Factor	1.00	1.00	1.00		1.00	
Incremental Delay, d2	5.2	0.7	3.4		1.4	
Delay (s)	33.7	11.6	21.4		15.0	
Level of Service	C	B	C		B	
Approach Delay (s)		14.4	21.4		15.0	
Approach LOS		B	C		B	

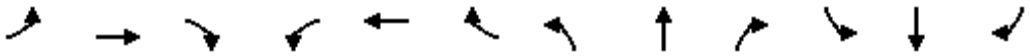
Intersection Summary			
HCM Average Control Delay	16.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.42		
Actuated Cycle Length (s)	65.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	49.8%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	30	257	341	28	50	11	107	171	229	25	257	40
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0	4.0		4.0			4.0	
Lane Util. Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Frpb, ped/bikes		1.00	0.76		1.00	0.76		0.93			0.98	
Flpb, ped/bikes		0.98	1.00		0.96	1.00		0.99			1.00	
Frt		1.00	0.85		1.00	0.85		0.94			0.98	
Flt Protected		0.99	1.00		0.98	1.00		0.99			1.00	
Satd. Flow (prot)		1762	1173		1699	1161		1546			1733	
Flt Permitted		0.97	1.00		0.85	1.00		0.86			0.95	
Satd. Flow (perm)		1715	1173		1468	1161		1339			1651	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	31	268	355	29	52	11	111	178	239	26	268	42
RTOR Reduction (vph)	0	0	197	0	0	7	0	46	0	0	8	0
Lane Group Flow (vph)	0	299	158	0	81	4	0	482	0	0	328	0
Confl. Peds. (#/hr)	113		108	108		113	57		66	66		57
Confl. Bikes (#/hr)			3									21
Heavy Vehicles (%)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Turn Type	Perm		Perm	Perm		Perm	Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8		8	2			6		
Actuated Green, G (s)		21.5	21.5		21.5	21.5		34.5			34.5	
Effective Green, g (s)		22.0	22.0		22.0	22.0		35.0			35.0	
Actuated g/C Ratio		0.34	0.34		0.34	0.34		0.54			0.54	
Clearance Time (s)		4.5	4.5		4.5	4.5		4.5			4.5	
Lane Grp Cap (vph)		580	397		497	393		721			889	
v/s Ratio Prot												
v/s Ratio Perm		c0.17	0.13		0.06	0.00		c0.36			0.20	
v/c Ratio		0.52	0.40		0.16	0.01		0.67			0.37	
Uniform Delay, d1		17.2	16.4		15.1	14.3		10.8			8.6	
Progression Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Incremental Delay, d2		3.3	3.0		0.7	0.0		4.9			1.2	
Delay (s)		20.5	19.4		15.8	14.3		15.7			9.8	
Level of Service		C	B		B	B		B			A	
Approach Delay (s)		19.9			15.6			15.7			9.8	
Approach LOS		B			B			B			A	

Intersection Summary			
HCM Average Control Delay	16.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	86.4%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	10	10	20	60	10	118	20	419	136	177	418	30
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Hourly flow rate (vph)	11	11	21	64	11	126	21	446	145	188	445	32

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	43	200	612	665
Volume Left (vph)	11	64	21	188
Volume Right (vph)	21	126	145	32
Hadj (s)	-0.13	-0.19	-0.02	0.15
Departure Headway (s)	7.8	7.0	5.8	6.0
Degree Utilization, x	0.09	0.39	0.98	1.11
Capacity (veh/h)	435	499	612	602
Control Delay (s)	11.6	14.4	55.6	93.3
Approach Delay (s)	11.6	14.4	55.6	93.3
Approach LOS	B	B	F	F

Intersection Summary				
Delay		65.5		
HCM Level of Service		F		
Intersection Capacity Utilization		94.6%	ICU Level of Service	F
Analysis Period (min)		15		

Intersection 8 **Piedmont Avenue/Bancroft Way** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn	130	91	69.6%	65.5	13.9	F
	Through	725	479	66.1%	67.2	13.3	F
	Right Turn						
	Subtotal	**855**	**569**	**66.6%**	**66.8**	**11.6**	**F**
SB	Left Turn						
	Through	319	331	103.9%	17.8	3.9	C
	Right Turn	129	120	93.3%	13.6	2.9	B
	Subtotal	**448**	**452**	**100.8%**	**16.7**	**3.7**	**C**
EB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**1303**	**1021**	**78.4%**	**44.6**	**6.6**	**E**

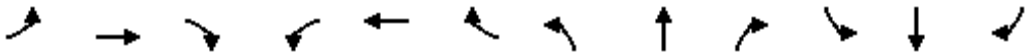
Intersection 9 **Piedmont Avenue/Durant Avenue** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn						
	Through	649	367	56.6%	1664.1	282.0	F
	Right Turn						
	Subtotal	**649**	**367**	**56.6%**	**1664.1**	**282.0**	**F**
SB	Left Turn						
	Through	310	329	106.2%	20.8	5.7	C
	Right Turn						
	Subtotal	**310**	**329**	**106.2%**	**20.8**	**5.7**	**C**
EB	Left Turn	202	197	97.6%	29.1	10.6	D
	Through						
	Right Turn	100	99	99.0%	8.6	0.7	A
	Subtotal	**302**	**296**	**98.1%**	**22.4**	**7.8**	**C**
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**1261**	**993**	**78.7%**	**626.6**	**93.0**	**F**

Intersection	
Intersection Delay (sec/veh)	12.5
Intersection LOS	B

Approach	EB	WB	NB	SB
Entry Lanes	1	1	1	1
Conflicting Circle Lanes	1	1	1	1
Adjusted Approach Flow (vph)	94	127	692	417
Demand Flow Rate (pc/h)	98	133	720	434
Vehicles Circulating (pc/h)	435	737	98	177
Vehicles Exiting (pc/h)	176	81	435	693
Follow-Up Headway (s)	3.186	3.186	3.186	3.186
Ped Vol. Crossing Leg (#/hr)	1	66	8	5
Ped Capacity Adjustment	1.000	0.991	0.999	0.999
Approach Delay (sec/veh)	6.6	10.6	15.4	9.6
Approach LOS	A	B	C	A

Lane	Left	Left	Left	Left
Designated moves	LTR	LTR	LTR	LTR
Assumed Moves	LTR	LTR	LTR	LTR
Right Turn Channelized				
Lane Utilization	1.000	1.000	1.000	1.000
Critical Headway (s)	5.193	5.193	5.193	5.193
Entry Flow Rate (pc/h)	98	133	720	434
Capacity, Entry Lane (pc/h)	731	541	1024	947
Entry HV Adjustment Factor	0.957	0.958	0.961	0.960
Flow Rate, Entry (vph)	94	127	692	417
Capacity, Entry (vph)	700	514	983	909
Volume to Capacity Ratio	0.134	0.248	0.704	0.459
Control Delay (sec/veh)	6.6	10.6	15.4	9.6
Level of Service	A	B	C	A
95th-Percentile Queue (veh)	0	1	6	2



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	177	142	160	50	0	60	0	737	12	20	327	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Util. Factor	1.00	1.00	1.00	1.00		1.00		*0.60			*0.60	
Frpb, ped/bikes	1.00	1.00	0.95	1.00		0.93		1.00			1.00	
Flpb, ped/bikes	0.95	1.00	1.00	0.97		1.00		1.00			1.00	
Frt	1.00	1.00	0.85	1.00		0.85		1.00			1.00	
Flt Protected	0.95	1.00	1.00	0.95		1.00		1.00			1.00	
Satd. Flow (prot)	1684	1863	1497	1708		1477		2226			2227	
Flt Permitted	0.95	1.00	1.00	0.66		1.00		1.00			0.86	
Satd. Flow (perm)	1684	1863	1497	1195		1477		2226			1913	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	181	145	163	51	0	61	0	752	12	20	334	0
RTOR Reduction (vph)	0	0	85	0	0	32	0	1	0	0	0	0
Lane Group Flow (vph)	181	145	78	51	0	29	0	763	0	0	354	0
Confl. Peds. (#/hr)	46		68	68		46	53		56	56		53
Confl. Bikes (#/hr)			1						14			
Turn Type	Perm		Perm	custom		custom				Perm		
Protected Phases		4						2			6	
Permitted Phases	4		4	8		8				6		
Actuated Green, G (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Effective Green, g (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Actuated g/C Ratio	0.48	0.48	0.48	0.48		0.48		0.43			0.43	
Clearance Time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Grp Cap (vph)	803	889	714	570		704		959			824	
v/s Ratio Prot		0.08						c0.34				
v/s Ratio Perm	c0.11		0.05	0.04		0.02					0.19	
v/c Ratio	0.23	0.16	0.11	0.09		0.04		0.80			0.43	
Uniform Delay, d1	10.0	9.6	9.4	9.3		9.1		16.0			12.9	
Progression Factor	1.00	1.00	1.00	1.00		1.00		1.00			1.00	
Incremental Delay, d2	0.7	0.4	0.3	0.3		0.1		6.8			1.6	
Delay (s)	10.6	10.0	9.7	9.6		9.2		22.8			14.6	
Level of Service	B	B	A	A		A		C			B	
Approach Delay (s)		10.1			9.4			22.8			14.6	
Approach LOS		B			A			C			B	

Intersection Summary			
HCM Average Control Delay	16.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.50		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	66.5%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	245	30	10	113	50	20
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.82	0.82	0.82	0.82	0.82	0.82
Hourly flow rate (vph)	299	37	12	138	61	24
Pedestrians	3					
Lane Width (ft)	12.0					
Walking Speed (ft/s)	4.0					
Percent Blockage	0					
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			335		482	317
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			335		482	317
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			99		89	97
cM capacity (veh/h)			1224		536	723

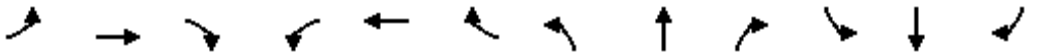
Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	335	150	85
Volume Left	0	12	61
Volume Right	37	0	24
cSH	1700	1224	579
Volume to Capacity	0.20	0.01	0.15
Queue Length 95th (ft)	0	1	13
Control Delay (s)	0.0	0.7	12.3
Lane LOS		A	B
Approach Delay (s)	0.0	0.7	12.3
Approach LOS			B

Intersection Summary			
Average Delay		2.0	
Intersection Capacity Utilization		25.4%	ICU Level of Service A
Analysis Period (min)		15	

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Sign Control	Stop		Stop			Stop
Volume (vph)	103	110	60	216	110	30
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	108	116	63	227	116	32

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total (vph)	224	291	147
Volume Left (vph)	108	0	116
Volume Right (vph)	116	227	0
Hadj (s)	-0.15	-0.40	0.23
Departure Headway (s)	4.8	4.3	5.0
Degree Utilization, x	0.30	0.34	0.21
Capacity (veh/h)	702	804	672
Control Delay (s)	9.7	9.5	9.3
Approach Delay (s)	9.7	9.5	9.3
Approach LOS	A	A	A

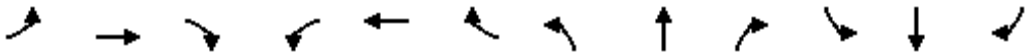
Intersection Summary			
Delay	9.5		
HCM Level of Service	A		
Intersection Capacity Utilization	47.1%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	20	130	142	236	90	20	43	40	47	30	80	20
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Hourly flow rate (vph)	23	148	161	268	102	23	49	45	53	34	91	23

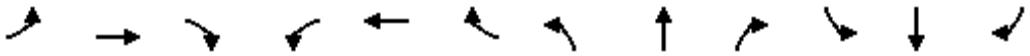
Direction, Lane #	EB 1	WB 1	NB 1	SB 1	SB 2
Volume Total (vph)	332	393	148	125	23
Volume Left (vph)	23	268	49	34	0
Volume Right (vph)	161	23	53	0	23
Hadj (s)	-0.26	0.12	-0.13	0.07	-0.58
Departure Headway (s)	5.1	5.4	5.9	6.2	3.2
Degree Utilization, x	0.47	0.59	0.24	0.22	0.02
Capacity (veh/h)	657	641	524	498	1121
Control Delay (s)	12.6	15.7	10.9	10.9	6.3
Approach Delay (s)	12.6	15.7	10.9	10.2	
Approach LOS	B	C	B	B	

Intersection Summary				
Delay	13.2			
HCM Level of Service	B			
Intersection Capacity Utilization	60.0%	ICU Level of Service		B
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	223	515	290	95	714	530	0	0	0	70	895	170
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Util. Factor	1.00	0.95			0.91	0.91					0.91	
Frpb, ped/bikes	1.00	0.90			0.97	0.68					0.94	
Flpb, ped/bikes	0.94	1.00			0.99	1.00					0.98	
Frt	1.00	0.95			0.99	0.85					0.98	
Flt Protected	0.95	1.00			0.99	1.00					1.00	
Satd. Flow (prot)	1642	2977			3177	974					4525	
Flt Permitted	0.21	1.00			0.71	1.00					1.00	
Satd. Flow (perm)	359	2977			2270	974					4525	
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	240	554	312	102	768	570	0	0	0	75	962	183
RTOR Reduction (vph)	0	0	0	0	8	226	0	0	0	0	28	0
Lane Group Flow (vph)	240	866	0	0	948	258	0	0	0	0	1192	0
Confl. Peds. (#/hr)	365		294	294		365	885		315	315		885
Confl. Bikes (#/hr)			13			17						34
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm		Perm				Perm		
Protected Phases		4			8						6	
Permitted Phases	4			8		8				6		
Actuated Green, G (s)	48.0	48.0			48.0	48.0					34.0	
Effective Green, g (s)	48.0	48.0			48.0	48.0					34.0	
Actuated g/C Ratio	0.53	0.53			0.53	0.53					0.38	
Clearance Time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Grp Cap (vph)	191	1588			1211	519					1709	
v/s Ratio Prot		0.29										
v/s Ratio Perm	c0.67				0.42	0.26					0.26	
v/c Ratio	1.26	0.55			0.78	0.50					0.70	
Uniform Delay, d1	21.0	13.8			16.8	13.3					23.7	
Progression Factor	1.00	1.00			1.33	3.71					0.69	
Incremental Delay, d2	150.8	1.4			5.0	3.3					2.2	
Delay (s)	171.8	15.2			27.5	52.9					18.6	
Level of Service	F	B			C	D					B	
Approach Delay (s)		49.2			36.0			0.0			18.6	
Approach LOS		D			D			A			B	

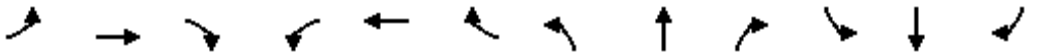
Intersection Summary			
HCM Average Control Delay	34.2	HCM Level of Service	C
HCM Volume to Capacity ratio	1.02		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	92.9%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	90	192	70	165	385	213	40	740	53	103	750	70
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95	1.00		0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes		1.00	0.89		0.94		1.00	0.99		1.00	0.98	
Flpb, ped/bikes		0.98	1.00		0.99		0.92	1.00		0.95	1.00	
Frt		1.00	0.85		0.96		1.00	0.99		1.00	0.99	
Flt Protected		0.98	1.00		0.99		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3431	1408		3095		1634	3463		1689	3408	
Flt Permitted		0.58	1.00		0.78		0.27	1.00		0.28	1.00	
Satd. Flow (perm)		2028	1408		2427		464	3463		500	3408	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	93	198	72	170	397	220	41	763	55	106	773	72
RTOR Reduction (vph)	0	0	10	0	28	0	0	6	0	0	8	0
Lane Group Flow (vph)	0	291	63	0	759	0	41	812	0	106	837	0
Confl. Peds. (#/hr)	211		112	112		211	472		267	267		472
Confl. Bikes (#/hr)			12			108			22			26
Turn Type	Perm		Perm	Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)		33.0	33.0		33.0		49.0	49.0		49.0	49.0	
Effective Green, g (s)		33.0	33.0		33.0		49.0	49.0		49.0	49.0	
Actuated g/C Ratio		0.37	0.37		0.37		0.54	0.54		0.54	0.54	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)		744	516		890		253	1885		272	1855	
v/s Ratio Prot								0.23			c0.25	
v/s Ratio Perm		0.14	0.04		c0.31		0.09			0.21		
v/c Ratio		0.39	0.12		0.85		0.16	0.43		0.39	0.45	
Uniform Delay, d1		21.1	18.9		26.3		10.2	12.2		11.9	12.4	
Progression Factor		1.00	1.00		1.54		1.51	1.52		1.00	1.00	
Incremental Delay, d2		1.5	0.5		5.9		0.8	0.4		4.2	0.8	
Delay (s)		22.6	19.4		46.3		16.3	19.0		16.0	13.2	
Level of Service		C	B		D		B	B		B	B	
Approach Delay (s)		22.0			46.3			18.9			13.5	
Approach LOS		C			D			B			B	

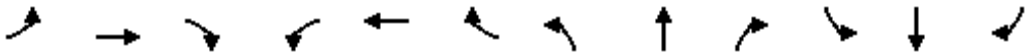
Intersection Summary			
HCM Average Control Delay	24.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	110.7%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	356	30	370	20	30	40	210	800	20	30	720	172
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.95	0.95			1.00		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	0.83			0.88		1.00	0.99		1.00	1.00	0.80
Flpb, ped/bikes	0.78	0.98			0.98		1.00	1.00		0.93	1.00	1.00
Frt	1.00	0.87			0.94		1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95	1.00			0.99		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1299	1240			1486		1752	3472		1633	3505	1252
Flt Permitted	0.72	0.97			0.81		0.95	1.00		0.34	1.00	1.00
Satd. Flow (perm)	981	1211			1212		1752	3472		580	3505	1252
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	363	31	378	20	31	41	214	816	20	31	735	176
RTOR Reduction (vph)	0	165	0	0	27	0	0	2	0	0	0	59
Lane Group Flow (vph)	327	280	0	0	65	0	214	834	0	31	735	117
Confl. Peds. (#/hr)	287		212	212		287	203		150	150		203
Confl. Bikes (#/hr)			5			7			18			43
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Prot			Perm		Perm
Protected Phases		4			8		5	2			6	
Permitted Phases	4			8						6		6
Actuated Green, G (s)	31.0	31.0			31.0		10.0	51.0		37.0	37.0	37.0
Effective Green, g (s)	31.0	31.0			31.0		10.0	51.0		37.0	37.0	37.0
Actuated g/C Ratio	0.34	0.34			0.34		0.11	0.57		0.41	0.41	0.41
Clearance Time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Grp Cap (vph)	338	417			417		195	1967		238	1441	515
v/s Ratio Prot							c0.12	0.24			c0.21	
v/s Ratio Perm	c0.33	0.23			0.05					0.05		0.09
v/c Ratio	0.97	0.67			0.16		1.10	0.42		0.13	0.51	0.23
Uniform Delay, d1	29.0	25.2			20.4		40.0	11.1		16.5	19.7	17.2
Progression Factor	0.73	0.61			1.00		1.00	1.00		0.47	0.50	0.25
Incremental Delay, d2	39.0	7.6			0.8		92.9	0.7		0.8	1.0	0.8
Delay (s)	60.2	22.9			21.2		132.9	11.8		8.6	10.9	5.1
Level of Service	E	C			C		F	B		A	B	A
Approach Delay (s)		38.7			21.2			36.5			9.8	
Approach LOS		D			C			D			A	

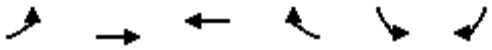
Intersection Summary			
HCM Average Control Delay	27.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.77		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	80.0%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	50	199	110	392	544	93	130	700	396	22	350	60
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.0	2.0		2.0	2.0		2.0	2.0			2.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.95			0.95	
Frpb, ped/bikes	1.00	0.96		1.00	0.97		1.00	0.95			0.98	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		0.95	1.00			1.00	
Frt	1.00	0.95		1.00	0.98		1.00	0.95			0.98	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)	1770	3232		1610	3196		1684	3176			3395	
Flt Permitted	0.95	1.00		0.95	1.00		0.34	1.00			0.69	
Satd. Flow (perm)	1770	3232		1610	3196		601	3176			2358	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	53	212	117	417	579	99	138	745	421	23	372	64
RTOR Reduction (vph)	0	66	0	0	13	0	0	87	0	0	14	0
Lane Group Flow (vph)	53	263	0	359	723	0	138	1079	0	0	445	0
Confl. Peds. (#/hr)	168		108	108		168	104		118	118		104
Confl. Bikes (#/hr)			7			98			16			10
Turn Type	Split			Split			Perm			Perm		
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	34.0	34.0		24.0	24.0		26.0	26.0			26.0	
Effective Green, g (s)	34.0	34.0		24.0	24.0		26.0	26.0			26.0	
Actuated g/C Ratio	0.38	0.38		0.27	0.27		0.29	0.29			0.29	
Clearance Time (s)	2.0	2.0		2.0	2.0		2.0	2.0			2.0	
Lane Grp Cap (vph)	669	1221		429	852		174	918			681	
v/s Ratio Prot	0.03	c0.08		0.22	c0.23			c0.34				
v/s Ratio Perm							0.23				0.19	
v/c Ratio	0.08	0.22		0.84	0.85		0.79	1.17			0.65	
Uniform Delay, d1	18.0	19.0		31.2	31.3		29.5	32.0			28.0	
Progression Factor	1.36	1.63		1.00	1.00		0.77	0.76			1.00	
Incremental Delay, d2	0.2	0.4		17.4	10.3		26.4	88.7			4.8	
Delay (s)	24.7	31.3		48.5	41.5		49.2	113.1			32.9	
Level of Service	C	C		D	D		D	F			C	
Approach Delay (s)		30.4			43.8			106.4			32.9	
Approach LOS		C			D			F			C	

Intersection Summary			
HCM Average Control Delay	65.9	HCM Level of Service	E
HCM Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	118.0%	ICU Level of Service	H
Analysis Period (min)	15		

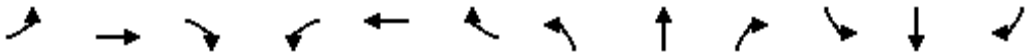
c Critical Lane Group



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (vph)	140	337	499	78	73	110
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00	0.91		0.82	
Flpb, ped/bikes	1.00	1.00	1.00		1.00	
Frt	1.00	1.00	0.98		0.92	
Flt Protected	0.95	1.00	1.00		0.98	
Satd. Flow (prot)	1719	3438	1622		1335	
Flt Permitted	0.95	1.00	1.00		0.98	
Satd. Flow (perm)	1719	3438	1622		1335	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	147	355	525	82	77	116
RTOR Reduction (vph)	0	0	8	0	73	0
Lane Group Flow (vph)	147	355	599	0	120	0
Confl. Peds. (#/hr)				475	211	211
Confl. Bikes (#/hr)				36		
Heavy Vehicles (%)	5%	5%	5%	5%	5%	5%
Turn Type	Prot					
Protected Phases	7	4	8		6	
Permitted Phases						
Actuated Green, G (s)	7.9	36.0	24.1		26.0	
Effective Green, g (s)	7.9	36.0	24.1		26.0	
Actuated g/C Ratio	0.11	0.51	0.34		0.37	
Clearance Time (s)	4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	194	1768	558		496	
v/s Ratio Prot	c0.09	0.10	c0.37		c0.09	
v/s Ratio Perm						
v/c Ratio	0.76	0.20	1.07		0.24	
Uniform Delay, d1	30.1	9.2	22.9		15.2	
Progression Factor	1.00	1.00	1.00		1.00	
Incremental Delay, d2	15.5	0.3	59.4		1.2	
Delay (s)	45.6	9.5	82.4		16.4	
Level of Service	D	A	F		B	
Approach Delay (s)		20.1	82.4		16.4	
Approach LOS		C	F		B	

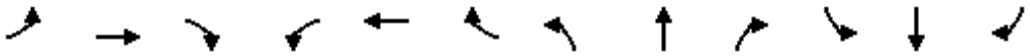
Intersection Summary			
HCM Average Control Delay	48.5	HCM Level of Service	D
HCM Volume to Capacity ratio	0.66		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	65.6%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	30	40	320	96	193	25	94	256	207	21	201	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0	4.0		4.0			4.0	
Lane Util. Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Frpb, ped/bikes		1.00	0.73		1.00	0.67		0.92			0.99	
Flpb, ped/bikes		0.93	1.00		0.92	1.00		0.98			1.00	
Frt		1.00	0.85		1.00	0.85		0.95			0.99	
Flt Protected		0.98	1.00		0.98	1.00		0.99			1.00	
Satd. Flow (prot)		1680	1143		1677	1050		1565			1799	
Flt Permitted		0.82	1.00		0.87	1.00		0.90			0.94	
Satd. Flow (perm)		1401	1143		1490	1050		1421			1691	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	33	43	348	104	210	27	102	278	225	23	218	11
RTOR Reduction (vph)	0	0	224	0	0	12	0	31	0	0	2	0
Lane Group Flow (vph)	0	76	124	0	314	15	0	574	0	0	250	0
Confl. Peds. (#/hr)	137		116	116		137	92		85	85		92
Confl. Bikes (#/hr)			3			23			20			7
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm		Perm	Perm		Perm	Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8		8	2			6		
Actuated Green, G (s)		24.5	24.5		24.5	24.5		36.5			36.5	
Effective Green, g (s)		25.0	25.0		25.0	25.0		37.0			37.0	
Actuated g/C Ratio		0.36	0.36		0.36	0.36		0.53			0.53	
Clearance Time (s)		4.5	4.5		4.5	4.5		4.5			4.5	
Lane Grp Cap (vph)		500	408		532	375		751			894	
v/s Ratio Prot												
v/s Ratio Perm		0.05	0.11		c0.21	0.01		c0.40			0.15	
v/c Ratio		0.15	0.30		0.59	0.04		0.76			0.28	
Uniform Delay, d1		15.3	16.2		18.3	14.7		13.1			9.1	
Progression Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Incremental Delay, d2		0.6	1.9		4.8	0.2		7.3			0.8	
Delay (s)		15.9	18.2		23.1	14.9		20.3			9.9	
Level of Service		B	B		C	B		C			A	
Approach Delay (s)		17.8			22.4			20.3			9.9	
Approach LOS		B			C			C			A	

Intersection Summary			
HCM Average Control Delay	18.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.69		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	85.5%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	30	20	20	141	10	200	10	347	52	121	496	10
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Hourly flow rate (vph)	31	20	20	144	10	204	10	354	53	123	506	10

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	71	358	417	640
Volume Left (vph)	31	144	10	123
Volume Right (vph)	20	204	53	10
Hadj (s)	-0.03	-0.21	-0.02	0.08
Departure Headway (s)	8.2	6.9	6.6	6.6
Degree Utilization, x	0.16	0.68	0.77	1.16
Capacity (veh/h)	377	507	528	549
Control Delay (s)	12.8	23.3	28.5	115.9
Approach Delay (s)	12.8	23.3	28.5	115.9
Approach LOS	B	C	D	F

Intersection Summary				
Delay		64.1		
HCM Level of Service		F		
Intersection Capacity Utilization		95.2%	ICU Level of Service	F
Analysis Period (min)		15		

SimTraffic Post-Processor **LBNL 2nd Campus**
Average Results from 10 Runs **Cumulative (2035) Plus Phase 1**
Volume and Delay by Movement **PM Peak Hour**

Intersection 8 **Piedmont Avenue/Bancroft Way** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn	153	120	78.5%	61.8	23.5	F
	Through	509	378	74.2%	60.5	11.3	F
	Right Turn						
	Subtotal	**662**	**498**	**75.2%**	**60.8**	**13.6**	**F**
SB	Left Turn						
	Through	495	322	64.9%	1208.8	243.4	F
	Right Turn	222	141	63.5%	1211.4	257.3	F
	Subtotal	**717**	**463**	**64.5%**	**1209.6**	**246.9**	**F**
EB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**1379**	**961**	**69.7%**	**613.2**	**114.7**	**F**

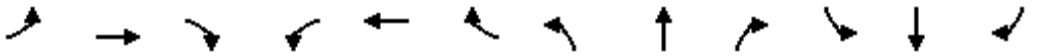
Intersection 9 **Piedmont Avenue/Durant Avenue** **Unsignalized**

		Volume (veh/hr)			Total Delay (sec/veh)		
Direction	**Movement**	**Demand**	**Served**	**% Served**	**Average**	**Std. Dev.**	**LOS**
NB	Left Turn						
	Through	476	313	65.7%	1060.4	200.7	F
	Right Turn						
	Subtotal	**476**	**313**	**65.7%**	**1060.4**	**200.7**	**F**
SB	Left Turn						
	Through	490	322	65.7%	106.7	7.0	F
	Right Turn						
	Subtotal	**490**	**322**	**65.7%**	**106.7**	**7.0**	**F**
EB	Left Turn	164	165	100.4%	21.3	3.3	C
	Through						
	Right Turn	210	216	103.0%	30.5	8.8	D
	Subtotal	**374**	**381**	**101.9%**	**26.6**	**4.9**	**D**
WB	Left Turn						
	Through						
	Right Turn						
	Subtotal						
Total		**1340**	**1016**	**75.8%**	**369.2**	**59.2**	**F**

Intersection	
Intersection Delay (sec/veh)	26.3
Intersection LOS	D

Approach	EB	WB	NB	SB
Entry Lanes	1	1	1	1
Conflicting Circle Lanes	1	1	1	1
Adjusted Approach Flow (vph)	158	226	596	748
Demand Flow Rate (pc/h)	161	231	609	763
Vehicles Circulating (pc/h)	735	598	172	327
Vehicles Exiting (pc/h)	355	183	724	502
Follow-Up Headway (s)	3.186	3.186	3.186	3.186
Ped Vol. Crossing Leg (#/hr)	238	10	133	88
Ped Capacity Adjustment	0.967	0.999	0.970	0.988
Approach Delay (sec/veh)	11.6	11.2	14.7	43.2
Approach LOS	B	B	B	E

Lane	Left	Left	Left	Left
Designated moves	LTR	LTR	LTR	LTR
Assumed Moves	LTR	LTR	LTR	LTR
Right Turn Channelized				
Lane Utilization	1.000	1.000	1.000	1.000
Critical Headway (s)	5.193	5.193	5.193	5.193
Entry Flow Rate (pc/h)	161	231	609	763
Capacity, Entry Lane (pc/h)	542	621	951	815
Entry HV Adjustment Factor	0.980	0.980	0.979	0.981
Flow Rate, Entry (vph)	158	226	596	748
Capacity, Entry (vph)	513	608	904	790
Volume to Capacity Ratio	0.307	0.372	0.660	0.948
Control Delay (sec/veh)	11.6	11.2	14.7	43.2
Level of Service	B	B	B	E
95th-Percentile Queue (veh)	1	2	5	14



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	139	150	270	42	0	110	0	578	20	20	522	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Util. Factor	1.00	1.00	1.00	1.00		1.00		*0.60			*0.60	
Frpb, ped/bikes	1.00	1.00	0.90	1.00		0.84		0.99			1.00	
Flpb, ped/bikes	0.85	1.00	1.00	0.93		1.00		1.00			1.00	
Frt	1.00	1.00	0.85	1.00		0.85		0.99			1.00	
Flt Protected	0.95	1.00	1.00	0.95		1.00		1.00			1.00	
Satd. Flow (prot)	1521	1881	1441	1663		1340		2227			2247	
Flt Permitted	0.95	1.00	1.00	0.65		1.00		1.00			0.91	
Satd. Flow (perm)	1521	1881	1441	1140		1340		2227			2049	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	146	158	284	44	0	116	0	608	21	21	549	0
RTOR Reduction (vph)	0	0	45	0	0	29	0	2	0	0	0	0
Lane Group Flow (vph)	146	158	239	44	0	87	0	627	0	0	570	0
Confl. Peds. (#/hr)	142		138	138		138	137		173	173		137
Confl. Bikes (#/hr)			5						14			16
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm		Perm	custom		custom				Perm		
Protected Phases		4						2			6	
Permitted Phases	4		4	8		8				6		
Actuated Green, G (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Effective Green, g (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Actuated g/C Ratio	0.48	0.48	0.48	0.48		0.48		0.43			0.43	
Clearance Time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Grp Cap (vph)	725	897	687	544		639		959			883	
v/s Ratio Prot		0.08						c0.28				
v/s Ratio Perm	0.10		c0.17	0.04		0.06					0.28	
v/c Ratio	0.20	0.18	0.35	0.08		0.14		0.65			0.65	
Uniform Delay, d1	9.8	9.7	10.7	9.2		9.5		14.7			14.6	
Progression Factor	1.00	1.00	1.00	1.00		1.00		1.00			1.00	
Incremental Delay, d2	0.6	0.4	1.4	0.3		0.4		3.5			3.6	
Delay (s)	10.5	10.1	12.1	9.5		9.9		18.1			18.2	
Level of Service	B	B	B	A		A		B			B	
Approach Delay (s)		11.1			9.8			18.1			18.2	
Approach LOS		B			A			B			B	

Intersection Summary			
HCM Average Control Delay	15.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.49		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	68.2%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	204	40	20	228	40	30
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.89	0.89	0.89	0.89	0.89	0.89
Hourly flow rate (vph)	229	45	22	256	45	34
Pedestrians	9			1		
Lane Width (ft)	12.0			12.0		
Walking Speed (ft/s)	4.0			4.0		
Percent Blockage	1			0		
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			274		562	253
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			274		562	253
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			98		91	96
cM capacity (veh/h)			1295		478	788

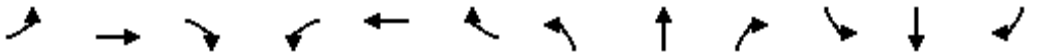
Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	274	279	79
Volume Left	0	22	45
Volume Right	45	0	34
cSH	1700	1295	575
Volume to Capacity	0.16	0.02	0.14
Queue Length 95th (ft)	0	1	12
Control Delay (s)	0.0	0.8	12.3
Lane LOS		A	B
Approach Delay (s)	0.0	0.8	12.3
Approach LOS			B

Intersection Summary			
Average Delay		1.9	
Intersection Capacity Utilization		39.3%	ICU Level of Service A
Analysis Period (min)		15	

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Sign Control	Stop		Stop			Stop
Volume (vph)	205	90	100	132	90	60
Peak Hour Factor	0.86	0.86	0.86	0.86	0.86	0.86
Hourly flow rate (vph)	238	105	116	153	105	70

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total (vph)	343	270	174
Volume Left (vph)	238	0	105
Volume Right (vph)	105	153	0
Hadj (s)	0.01	-0.29	0.17
Departure Headway (s)	5.0	4.8	5.4
Degree Utilization, x	0.48	0.36	0.26
Capacity (veh/h)	677	706	623
Control Delay (s)	12.5	10.5	10.2
Approach Delay (s)	12.5	10.5	10.2
Approach LOS	B	B	B

Intersection Summary			
Delay	11.3		
HCM Level of Service	B		
Intersection Capacity Utilization	50.5%	ICU Level of Service	A
Analysis Period (min)	15		



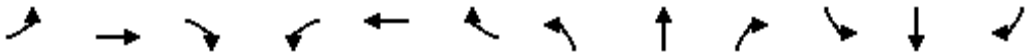
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	20	150	113	28	110	20	100	80	202	30	30	10
Peak Hour Factor	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Hourly flow rate (vph)	22	161	122	30	118	22	108	86	217	32	32	11

Direction, Lane #	EB 1	WB 1	NB 1	SB 1	SB 2
Volume Total (vph)	304	170	411	65	11
Volume Left (vph)	22	30	108	32	0
Volume Right (vph)	122	22	217	0	11
Hadj (s)	-0.21	-0.02	-0.25	0.12	-0.58
Departure Headway (s)	5.3	5.7	5.1	6.0	3.2
Degree Utilization, x	0.45	0.27	0.58	0.11	0.01
Capacity (veh/h)	629	570	669	502	1121
Control Delay (s)	12.5	10.8	14.8	9.8	6.2
Approach Delay (s)	12.5	10.8	14.8	9.3	
Approach LOS	B	B	B	A	

Intersection Summary				
Delay	12.9			
HCM Level of Service	B			
Intersection Capacity Utilization	53.3%	ICU Level of Service	A	
Analysis Period (min)	15			

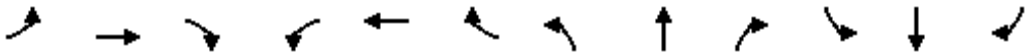
Near-Term (2018) Plus Additional Employment Alternative Conditions

FEHR PEERS



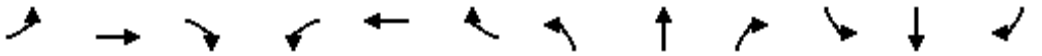
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	130	435	180	31	356	250	0	0	0	40	711	114
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Util. Factor	1.00	0.95			0.91	0.91					0.91	
Frpb, ped/bikes	1.00	0.97			0.99	0.89					0.96	
Flpb, ped/bikes	0.95	1.00			1.00	1.00					0.99	
Frt	1.00	0.96			0.98	0.85					0.98	
Flt Protected	0.95	1.00			1.00	1.00					1.00	
Satd. Flow (prot)	1619	3152			3150	1230					4550	
Flt Permitted	0.44	1.00			0.88	1.00					1.00	
Satd. Flow (perm)	744	3152			2777	1230					4550	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	141	473	196	34	387	272	0	0	0	43	773	124
RTOR Reduction (vph)	0	3	0	0	10	108	0	0	0	0	23	0
Lane Group Flow (vph)	141	666	0	0	463	112	0	0	0	0	917	0
Confl. Peds. (#/hr)	108		102	102		108	353		194	194		353
Confl. Bikes (#/hr)			10			6			1			20
Heavy Vehicles (%)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
Turn Type	Perm			Perm		Perm				Perm		
Protected Phases		4			8						6	
Permitted Phases	4			8		8				6		
Actuated Green, G (s)	46.0	46.0			46.0	46.0					36.0	
Effective Green, g (s)	46.0	46.0			46.0	46.0					36.0	
Actuated g/C Ratio	0.51	0.51			0.51	0.51					0.40	
Clearance Time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Grp Cap (vph)	380	1611			1419	629					1820	
v/s Ratio Prot		c0.21										
v/s Ratio Perm	0.19				0.17	0.09					0.20	
v/c Ratio	0.37	0.41			0.33	0.18					0.50	
Uniform Delay, d1	13.3	13.6			12.9	11.8					20.3	
Progression Factor	1.00	1.00			1.39	3.18					0.66	
Incremental Delay, d2	2.8	0.8			0.6	0.6					0.9	
Delay (s)	16.0	14.4			18.5	38.3					14.3	
Level of Service	B	B			B	D					B	
Approach Delay (s)		14.7			24.8			0.0			14.3	
Approach LOS		B			C			A			B	

Intersection Summary			
HCM Average Control Delay	17.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.45		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	83.3%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



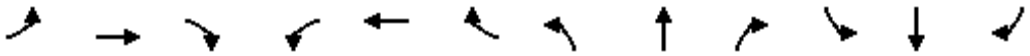
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	40	239	50	66	192	54	20	340	60	182	830	70
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95	1.00		0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes		1.00	0.88		0.99		1.00	0.99		1.00	0.99	
Flpb, ped/bikes		0.99	1.00		0.99		0.97	1.00		0.96	1.00	
Frt		1.00	0.85		0.97		1.00	0.98		1.00	0.99	
Flt Protected		0.99	1.00		0.99		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3461	1387		3301		1701	3377		1675	3425	
Flt Permitted		0.87	1.00		0.82		0.23	1.00		0.48	1.00	
Satd. Flow (perm)		3017	1387		2733		405	3377		852	3425	
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	43	257	54	71	206	58	22	366	65	196	892	75
RTOR Reduction (vph)	0	0	28	0	20	0	0	16	0	0	7	0
Lane Group Flow (vph)	0	300	26	0	315	0	22	415	0	196	960	0
Confl. Peds. (#/hr)	75		82	82		75	220		139	139		220
Confl. Bikes (#/hr)			64			7			5			18
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm		Perm	Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)		32.0	32.0		32.0		50.0	50.0		50.0	50.0	
Effective Green, g (s)		32.0	32.0		32.0		50.0	50.0		50.0	50.0	
Actuated g/C Ratio		0.36	0.36		0.36		0.56	0.56		0.56	0.56	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)		1073	493		972		225	1876		473	1903	
v/s Ratio Prot								0.12			c0.28	
v/s Ratio Perm		0.10	0.02		c0.12		0.05			0.23		
v/c Ratio		0.28	0.05		0.32		0.10	0.22		0.41	0.50	
Uniform Delay, d1		20.8	19.1		21.1		9.4	10.1		11.5	12.3	
Progression Factor		1.00	1.00		0.92		1.98	1.98		1.00	1.00	
Incremental Delay, d2		0.6	0.2		0.8		0.8	0.3		2.7	1.0	
Delay (s)		21.4	19.3		20.1		19.5	20.3		14.2	13.3	
Level of Service		C	B		C		B	C		B	B	
Approach Delay (s)		21.1			20.1			20.3			13.5	
Approach LOS		C			C			C			B	

Intersection Summary			
HCM Average Control Delay	16.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.43		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	115.1%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			



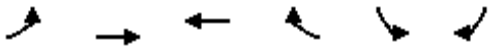
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	412	20	230	10	20	20	120	370	10	30	750	76
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.95	0.95			1.00		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	0.94			0.95		1.00	1.00		1.00	1.00	0.86
Flpb, ped/bikes	0.89	0.98			0.99		1.00	1.00		0.93	1.00	1.00
Frt	1.00	0.89			0.95		1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95	0.99			0.99		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1462	1399			1608		1736	3444		1617	3471	1332
Flt Permitted	0.78	0.92			0.92		0.95	1.00		0.50	1.00	1.00
Satd. Flow (perm)	1199	1303			1498		1736	3444		856	3471	1332
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	463	22	258	11	22	22	135	416	11	34	843	85
RTOR Reduction (vph)	0	102	0	0	15	0	0	2	0	0	0	35
Lane Group Flow (vph)	384	257	0	0	40	0	135	425	0	34	843	50
Confl. Peds. (#/hr)	136		77	77		136	135		85	85		135
Confl. Bikes (#/hr)			13			6			14			40
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm			Perm			Prot			Perm		Perm
Protected Phases		4			8		5	2			6	
Permitted Phases	4			8						6		6
Actuated Green, G (s)	30.0	30.0			30.0		6.0	52.0		42.0	42.0	42.0
Effective Green, g (s)	30.0	30.0			30.0		6.0	52.0		42.0	42.0	42.0
Actuated g/C Ratio	0.33	0.33			0.33		0.07	0.58		0.47	0.47	0.47
Clearance Time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Grp Cap (vph)	400	434			499		116	1990		399	1620	622
v/s Ratio Prot							c0.08	0.12			c0.24	
v/s Ratio Perm	c0.32	0.20			0.03					0.04		0.04
v/c Ratio	0.96	0.59			0.08		1.16	0.21		0.09	0.52	0.08
Uniform Delay, d1	29.4	24.9			20.6		42.0	9.2		13.3	16.9	13.3
Progression Factor	0.70	0.52			1.00		1.00	1.00		0.47	0.46	0.28
Incremental Delay, d2	35.4	5.7			0.3		134.2	0.2		0.3	1.0	0.2
Delay (s)	56.0	18.6			20.9		176.2	9.4		6.6	8.8	4.0
Level of Service	E	B			C		F	A		A	A	A
Approach Delay (s)		37.9			20.9			49.5			8.3	
Approach LOS		D			C			D			A	

Intersection Summary			
HCM Average Control Delay	28.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.74		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	69.9%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	30	371	80	246	212	22	50	280	432	46	530	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.5	2.5		2.5	2.5		2.5	2.5	2.5		2.5	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.95	1.00		0.95	
Frpb, ped/bikes	1.00	0.98		1.00	0.99		1.00	1.00	0.90		0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		0.97	1.00	1.00		1.00	
Frt	1.00	0.97		1.00	0.99		1.00	1.00	0.85		0.99	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00		1.00	
Satd. Flow (prot)	1736	3296		1579	3213		1682	3471	1399		3368	
Flt Permitted	0.95	1.00		0.95	0.99		0.20	1.00	1.00		0.91	
Satd. Flow (perm)	1736	3296		1579	3213		351	3471	1399		3071	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	32	391	84	259	223	23	53	295	455	48	558	53
RTOR Reduction (vph)	0	20	0	0	6	0	0	0	326	0	7	0
Lane Group Flow (vph)	32	455	0	166	333	0	53	295	129	0	652	0
Confl. Peds. (#/hr)	132		112	112		132	97		82	82		97
Confl. Bikes (#/hr)			64			2						21
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Split			Split			Perm		Perm	Perm		
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2		2	6		
Actuated Green, G (s)	32.0	32.0		25.0	25.0		25.5	25.5	25.5		25.5	
Effective Green, g (s)	32.0	32.0		25.0	25.0		25.5	25.5	25.5		25.5	
Actuated g/C Ratio	0.36	0.36		0.28	0.28		0.28	0.28	0.28		0.28	
Clearance Time (s)	2.5	2.5		2.5	2.5		2.5	2.5	2.5		2.5	
Lane Grp Cap (vph)	617	1172		439	893		99	983	396		870	
v/s Ratio Prot	0.02	c0.14		c0.11	0.10			0.08				
v/s Ratio Perm							0.15		0.09		c0.21	
v/c Ratio	0.05	0.39		0.38	0.37		0.54	0.30	0.33		0.75	
Uniform Delay, d1	19.0	21.7		26.2	26.2		27.2	25.3	25.5		29.3	
Progression Factor	1.27	1.34		1.00	1.00		0.79	0.74	1.70		1.00	
Incremental Delay, d2	0.2	0.9		2.5	1.2		16.1	0.6	1.8		5.9	
Delay (s)	24.3	30.0		28.7	27.4		37.6	19.3	45.1		35.2	
Level of Service	C	C		C	C		D	B	D		D	
Approach Delay (s)		29.6			27.8			35.1			35.2	
Approach LOS		C			C			D			D	

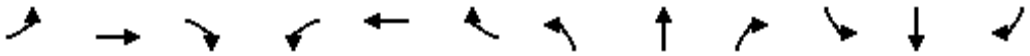
Intersection Summary			
HCM Average Control Delay	32.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.50		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	7.5
Intersection Capacity Utilization	102.5%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (vph)	90	609	231	23	74	130
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00	0.95		0.88	
Flpb, ped/bikes	1.00	1.00	1.00		1.00	
Frt	1.00	1.00	0.99		0.91	
Flt Protected	0.95	1.00	1.00		0.98	
Satd. Flow (prot)	1703	3406	1685		1421	
Flt Permitted	0.95	1.00	1.00		0.98	
Satd. Flow (perm)	1703	3406	1685		1421	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	95	641	243	24	78	137
RTOR Reduction (vph)	0	0	5	0	83	0
Lane Group Flow (vph)	95	641	262	0	132	0
Confl. Peds. (#/hr)				283	133	133
Confl. Bikes (#/hr)				5		
Heavy Vehicles (%)	6%	6%	6%	6%	6%	6%
Turn Type	Prot					
Protected Phases	7	4	8		6	
Permitted Phases						
Actuated Green, G (s)	6.3	31.8	21.5		26.0	
Effective Green, g (s)	6.3	31.8	21.5		26.0	
Actuated g/C Ratio	0.10	0.48	0.33		0.40	
Clearance Time (s)	4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	163	1646	551		561	
v/s Ratio Prot	c0.06	0.19	c0.16		c0.09	
v/s Ratio Perm						
v/c Ratio	0.58	0.39	0.47		0.24	
Uniform Delay, d1	28.5	10.8	17.7		13.3	
Progression Factor	1.00	1.00	1.00		1.00	
Incremental Delay, d2	5.2	0.7	2.9		1.0	
Delay (s)	33.7	11.5	20.6		14.3	
Level of Service	C	B	C		B	
Approach Delay (s)		14.4	20.6		14.3	
Approach LOS		B	C		B	

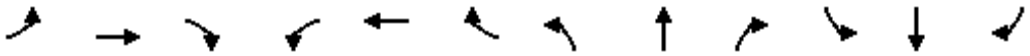
Intersection Summary			
HCM Average Control Delay	15.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.37		
Actuated Cycle Length (s)	65.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	45.7%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	292	311	32	56	11	97	161	255	28	217	30
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0	4.0		4.0			4.0	
Lane Util. Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Frpb, ped/bikes		1.00	0.79		1.00	0.78		0.93			0.99	
Flpb, ped/bikes		0.99	1.00		0.96	1.00		0.99			1.00	
Frt		1.00	0.85		1.00	0.85		0.93			0.99	
Flt Protected		1.00	1.00		0.98	1.00		0.99			0.99	
Satd. Flow (prot)		1783	1214		1712	1201		1540			1741	
Flt Permitted		0.98	1.00		0.83	1.00		0.88			0.93	
Satd. Flow (perm)		1756	1214		1454	1201		1374			1630	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	21	304	324	33	58	11	101	168	266	29	226	31
RTOR Reduction (vph)	0	0	165	0	0	7	0	55	0	0	7	0
Lane Group Flow (vph)	0	325	159	0	91	4	0	480	0	0	279	0
Confl. Peds. (#/hr)	100		95	95		100	51		59	59		51
Confl. Bikes (#/hr)			2									18
Heavy Vehicles (%)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Turn Type	Perm		Perm	Perm		Perm	Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8		8	2			6		
Actuated Green, G (s)		21.5	21.5		21.5	21.5		34.5			34.5	
Effective Green, g (s)		22.0	22.0		22.0	22.0		35.0			35.0	
Actuated g/C Ratio		0.34	0.34		0.34	0.34		0.54			0.54	
Clearance Time (s)		4.5	4.5		4.5	4.5		4.5			4.5	
Lane Grp Cap (vph)		594	411		492	406		740			878	
v/s Ratio Prot												
v/s Ratio Perm		c0.19	0.13		0.06	0.00		c0.35			0.17	
v/c Ratio		0.55	0.39		0.18	0.01		0.65			0.32	
Uniform Delay, d1		17.5	16.4		15.2	14.3		10.6			8.4	
Progression Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Incremental Delay, d2		3.6	2.7		0.8	0.0		4.4			1.0	
Delay (s)		21.1	19.1		16.0	14.3		15.0			9.3	
Level of Service		C	B		B	B		B			A	
Approach Delay (s)		20.1			15.8			15.0			9.3	
Approach LOS		C			B			B			A	

Intersection Summary			
HCM Average Control Delay	16.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	88.2%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	10	10	20	50	10	108	10	405	126	167	392	10
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Hourly flow rate (vph)	11	11	21	53	11	115	11	431	134	178	417	11

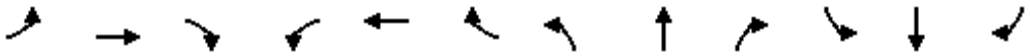
Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	43	179	576	605
Volume Left (vph)	11	53	11	178
Volume Right (vph)	21	115	134	11
Hadj (s)	-0.13	-0.21	-0.02	0.17
Departure Headway (s)	7.7	7.0	5.7	5.9
Degree Utilization, x	0.09	0.35	0.92	0.98
Capacity (veh/h)	443	499	615	605
Control Delay (s)	11.5	13.7	42.2	56.3
Approach Delay (s)	11.5	13.7	42.2	56.3
Approach LOS	B	B	E	F

Intersection Summary				
Delay	43.7			
HCM Level of Service	E			
Intersection Capacity Utilization	87.0%	ICU Level of Service	E	
Analysis Period (min)	15			

Intersection	
Intersection Delay, s/veh	11.3
Intersection LOS	B

Approach	EB	WB	NB	SB
Entry Lanes	1	1	1	1
Conflicting Circle Lanes	1	1	1	1
Adj Approach Flow, veh/h	83	127	655	380
Demand Flow Rate, veh/h	86	133	682	396
Vehicles Circulating, veh/h	397	685	86	177
Vehicles Exiting, veh/h	176	83	397	641
Follow-Up Headway, s	3.186	3.186	3.186	3.186
Ped Vol Crossing Leg, #/h	1	59	7	5
Ped Cap Adj	1.000	0.992	0.999	0.999
Approach Delay, s/veh	6.1	9.9	13.6	8.9
Approach LOS	A	A	B	A

Lane	Left	Left	Left	Left
Designated Moves	LTR	LTR	LTR	LTR
Assumed Moves	LTR	LTR	LTR	LTR
RT Channelized				
Lane Util	1.000	1.000	1.000	1.000
Critical Headway, s	5.193	5.193	5.193	5.193
Entry Flow, veh/h	86	133	682	396
Cap Entry Lane, veh/h	760	570	1037	947
Entry HV Adj Factor	0.962	0.958	0.961	0.960
Flow Entry, veh/h	83	127	655	380
Cap Entry, veh/h	731	541	995	909
V/C Ratio	0.113	0.235	0.658	0.419
Control Delay, s/veh	6.1	9.9	13.6	8.9
LOS	A	A	B	A
95th %tile Queue, veh	0	1	5	2



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	177	133	150	31	0	50	0	681	14	10	280	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Util. Factor	1.00	1.00	1.00	1.00		1.00		*0.60			*0.60	
Frpb, ped/bikes	1.00	1.00	0.95	1.00		0.94		1.00			1.00	
Flpb, ped/bikes	0.96	1.00	1.00	0.97		1.00		1.00			1.00	
Frt	1.00	1.00	0.85	1.00		0.85		1.00			1.00	
Flt Protected	0.95	1.00	1.00	0.95		1.00		1.00			1.00	
Satd. Flow (prot)	1695	1863	1505	1714		1487		2224			2230	
Flt Permitted	0.95	1.00	1.00	0.67		1.00		1.00			0.92	
Satd. Flow (perm)	1695	1863	1505	1209		1487		2224			2060	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	181	136	153	32	0	51	0	695	14	10	286	0
RTOR Reduction (vph)	0	0	80	0	0	27	0	1	0	0	0	0
Lane Group Flow (vph)	181	136	73	32	0	24	0	708	0	0	296	0
Confl. Peds. (#/hr)	40		60	60		40	47		49	49		47
Confl. Bikes (#/hr)			1						13			
Turn Type	Perm		Perm	custom		custom				Perm		
Protected Phases		4						2			6	
Permitted Phases	4		4	8		8				6		
Actuated Green, G (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Effective Green, g (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Actuated g/C Ratio	0.48	0.48	0.48	0.48		0.48		0.43			0.43	
Clearance Time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Grp Cap (vph)	808	889	718	577		709		958			887	
v/s Ratio Prot		0.07						c0.32				
v/s Ratio Perm	c0.11		0.05	0.03		0.02					0.14	
v/c Ratio	0.22	0.15	0.10	0.06		0.03		0.74			0.33	
Uniform Delay, d1	10.0	9.6	9.3	9.1		9.0		15.4			12.3	
Progression Factor	1.00	1.00	1.00	1.00		1.00		1.00			1.00	
Incremental Delay, d2	0.6	0.4	0.3	0.2		0.1		5.1			1.0	
Delay (s)	10.6	10.0	9.6	9.3		9.1		20.5			13.3	
Level of Service	B	A	A	A		A		C			B	
Approach Delay (s)		10.1			9.2			20.5			13.3	
Approach LOS		B			A			C			B	

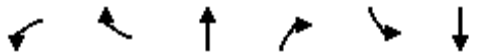
Intersection Summary			
HCM Average Control Delay	15.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.47		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	65.6%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	231	30	12	102	50	34
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.82	0.82	0.82	0.82	0.82	0.82
Hourly flow rate (vph)	282	37	15	124	61	41
Pedestrians	2					
Lane Width (ft)	12.0					
Walking Speed (ft/s)	4.0					
Percent Blockage	0					
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			318		456	300
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			318		456	300
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			99		89	94
cM capacity (veh/h)			1242		555	740

Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	318	139	102
Volume Left	0	15	61
Volume Right	37	0	41
cSH	1700	1242	617
Volume to Capacity	0.19	0.01	0.17
Queue Length 95th (ft)	0	1	15
Control Delay (s)	0.0	0.9	12.0
Lane LOS		A	B
Approach Delay (s)	0.0	0.9	12.0
Approach LOS			B

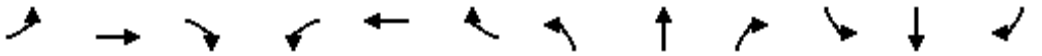
Intersection Summary			
Average Delay		2.4	
Intersection Capacity Utilization		26.9%	ICU Level of Service A
Analysis Period (min)		15	



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Sign Control	Stop		Stop			Stop
Volume (vph)	94	90	60	205	90	20
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	99	95	63	216	95	21

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total (vph)	194	279	116
Volume Left (vph)	99	0	95
Volume Right (vph)	95	216	0
Hadj (s)	-0.12	-0.40	0.23
Departure Headway (s)	4.7	4.1	4.9
Degree Utilization, x	0.25	0.32	0.16
Capacity (veh/h)	717	832	688
Control Delay (s)	9.2	9.1	8.8
Approach Delay (s)	9.2	9.1	8.8
Approach LOS	A	A	A

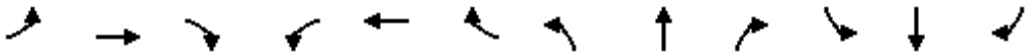
Intersection Summary			
Delay	9.1		
HCM Level of Service	A		
Intersection Capacity Utilization	43.1%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	10	120	138	244	80	20	34	20	40	20	60	10
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Hourly flow rate (vph)	11	136	157	277	91	23	39	23	45	23	68	11

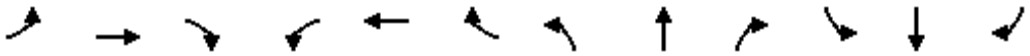
Direction, Lane #	EB 1	WB 1	NB 1	SB 1	SB 2
Volume Total (vph)	305	391	107	91	11
Volume Left (vph)	11	277	39	23	0
Volume Right (vph)	157	23	45	0	11
Hadj (s)	-0.28	0.12	-0.17	0.07	-0.58
Departure Headway (s)	4.7	5.0	5.6	5.9	3.2
Degree Utilization, x	0.40	0.54	0.17	0.15	0.01
Capacity (veh/h)	722	693	553	530	1121
Control Delay (s)	10.9	13.8	9.8	9.9	6.2
Approach Delay (s)	10.9	13.8	9.8	9.5	
Approach LOS	B	B	A	A	

Intersection Summary				
Delay	11.9			
HCM Level of Service	B			
Intersection Capacity Utilization	56.6%	ICU Level of Service	B	
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	154	426	250	88	621	470	0	0	0	50	758	138
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Util. Factor	1.00	0.95			0.91	0.91					0.91	
Frpb, ped/bikes	1.00	0.91			0.97	0.69					0.94	
Flpb, ped/bikes	0.93	1.00			0.99	1.00					0.99	
Frt	1.00	0.94			0.98	0.85					0.98	
Flt Protected	0.95	1.00			0.99	1.00					1.00	
Satd. Flow (prot)	1622	3001			3150	986					4571	
Flt Permitted	0.25	1.00			0.76	1.00					1.00	
Satd. Flow (perm)	422	3001			2417	986					4571	
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	166	458	269	95	668	505	0	0	0	54	815	148
RTOR Reduction (vph)	0	0	0	0	10	193	0	0	0	0	24	0
Lane Group Flow (vph)	166	727	0	0	844	221	0	0	0	0	993	0
Confl. Peds. (#/hr)	323		260	260		323	783		278	278		783
Confl. Bikes (#/hr)			12			15						30
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm		Perm				Perm		
Protected Phases		4			8						6	
Permitted Phases	4			8		8				6		
Actuated Green, G (s)	48.0	48.0			48.0	48.0					34.0	
Effective Green, g (s)	48.0	48.0			48.0	48.0					34.0	
Actuated g/C Ratio	0.53	0.53			0.53	0.53					0.38	
Clearance Time (s)	4.0	4.0			4.0	4.0					4.0	
Lane Grp Cap (vph)	225	1601			1289	526					1727	
v/s Ratio Prot		0.24										
v/s Ratio Perm	c0.39				0.35	0.22					0.22	
v/c Ratio	0.74	0.45			0.65	0.42					0.57	
Uniform Delay, d1	16.2	12.9			15.1	12.6					22.3	
Progression Factor	1.00	1.00			1.40	3.96					0.73	
Incremental Delay, d2	19.3	0.9			2.6	2.4					1.3	
Delay (s)	35.5	13.9			23.7	52.4					17.6	
Level of Service	D	B			C	D					B	
Approach Delay (s)		17.9			33.0			0.0			17.6	
Approach LOS		B			C			A			B	

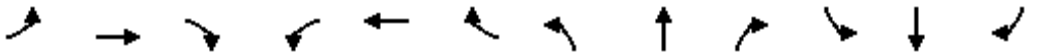
Intersection Summary			
HCM Average Control Delay	23.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	85.5%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	70	172	50	156	337	180	40	600	44	84	580	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		0.95	1.00		0.95		1.00	0.95		1.00	0.95	
Frpb, ped/bikes		1.00	0.90		0.94		1.00	0.99		1.00	0.98	
Flpb, ped/bikes		0.99	1.00		0.99		0.91	1.00		0.95	1.00	
Frt		1.00	0.85		0.96		1.00	0.99		1.00	0.99	
Flt Protected		0.99	1.00		0.99		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		3438	1426		3127		1605	3467		1678	3425	
Flt Permitted		0.65	1.00		0.79		0.36	1.00		0.35	1.00	
Satd. Flow (perm)		2284	1426		2502		605	3467		621	3425	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	72	177	52	161	347	186	41	619	45	87	598	52
RTOR Reduction (vph)	0	0	20	0	42	0	0	6	0	0	7	0
Lane Group Flow (vph)	0	249	32	0	652	0	41	658	0	87	643	0
Confl. Peds. (#/hr)	186		99	99		186	417		236	236		417
Confl. Bikes (#/hr)			10			95			20			23
Turn Type	Perm		Perm	Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)		33.0	33.0		33.0		49.0	49.0		49.0	49.0	
Effective Green, g (s)		33.0	33.0		33.0		49.0	49.0		49.0	49.0	
Actuated g/C Ratio		0.37	0.37		0.37		0.54	0.54		0.54	0.54	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)		837	523		917		329	1888		338	1865	
v/s Ratio Prot								c0.19			0.19	
v/s Ratio Perm		0.11	0.02		c0.26		0.07			0.14		
v/c Ratio		0.30	0.06		0.71		0.12	0.35		0.26	0.34	
Uniform Delay, d1		20.3	18.5		24.4		10.0	11.5		10.9	11.5	
Progression Factor		1.00	1.00		1.57		1.60	1.61		1.00	1.00	
Incremental Delay, d2		0.9	0.2		3.1		0.6	0.4		1.8	0.5	
Delay (s)		21.2	18.7		41.5		16.7	19.0		12.7	12.0	
Level of Service		C	B		D		B	B		B	B	
Approach Delay (s)		20.7			41.5			18.9			12.1	
Approach LOS		C			D			B			B	

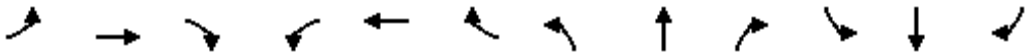
Intersection Summary			
HCM Average Control Delay	23.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.49		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	109.7%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	298	30	300	10	30	30	200	680	20	30	630	162
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	0.95	0.95			1.00		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	0.85			0.90		1.00	0.99		1.00	1.00	0.82
Flpb, ped/bikes	0.80	0.98			0.99		1.00	1.00		0.93	1.00	1.00
Frt	1.00	0.87			0.94		1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95	1.00			0.99		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1326	1277			1531		1752	3469		1628	3505	1286
Flt Permitted	0.75	0.98			0.94		0.95	1.00		0.38	1.00	1.00
Satd. Flow (perm)	1048	1251			1457		1752	3469		651	3505	1286
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	304	31	306	10	31	31	204	694	20	31	643	165
RTOR Reduction (vph)	0	174	0	0	20	0	0	2	0	0	0	75
Lane Group Flow (vph)	274	193	0	0	52	0	204	712	0	31	643	90
Confl. Peds. (#/hr)	254		187	187		254	179		132	132		179
Confl. Bikes (#/hr)			5			6			16			38
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm			Perm			Prot			Perm		Perm
Protected Phases		4			8		5	2			6	
Permitted Phases	4			8						6		6
Actuated Green, G (s)	31.0	31.0			31.0		10.0	51.0		37.0	37.0	37.0
Effective Green, g (s)	31.0	31.0			31.0		10.0	51.0		37.0	37.0	37.0
Actuated g/C Ratio	0.34	0.34			0.34		0.11	0.57		0.41	0.41	0.41
Clearance Time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	4.0
Lane Grp Cap (vph)	361	431			502		195	1966		268	1441	529
v/s Ratio Prot							c0.12	0.21			c0.18	
v/s Ratio Perm	c0.26	0.15			0.04					0.05		0.07
v/c Ratio	0.76	0.45			0.10		1.05	0.36		0.12	0.45	0.17
Uniform Delay, d1	26.2	22.9			20.0		40.0	10.6		16.4	19.1	16.8
Progression Factor	0.69	0.45			1.00		1.00	1.00		0.42	0.47	0.32
Incremental Delay, d2	13.2	3.2			0.4		77.1	0.5		0.7	0.8	0.5
Delay (s)	31.2	13.5			20.5		117.1	11.1		7.6	9.8	5.9
Level of Service	C	B			C		F	B		A	A	A
Approach Delay (s)		21.1			20.5			34.7			8.9	
Approach LOS		C			C			C			A	

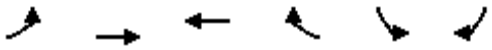
Intersection Summary			
HCM Average Control Delay	22.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	75.5%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	40	191	80	382	502	85	100	610	338	22	310	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.0	2.0		2.0	2.0		2.0	2.0			2.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.95			0.95	
Frpb, ped/bikes	1.00	0.97		1.00	0.97		1.00	0.95			0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		0.95	1.00			1.00	
Frt	1.00	0.96		1.00	0.98		1.00	0.95			0.98	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			1.00	
Satd. Flow (prot)	1770	3294		1610	3210		1686	3197			3407	
Flt Permitted	0.95	1.00		0.95	1.00		0.38	1.00			0.71	
Satd. Flow (perm)	1770	3294		1610	3210		679	3197			2423	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	43	203	85	406	534	90	106	649	360	23	330	53
RTOR Reduction (vph)	0	51	0	0	12	0	0	84	0	0	14	0
Lane Group Flow (vph)	43	237	0	337	681	0	106	925	0	0	392	0
Confl. Peds. (#/hr)	148		95	95		148	92		105	105		92
Confl. Bikes (#/hr)			6			86			14			9
Turn Type	Split			Split			Perm			Perm		
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	34.0	34.0		24.0	24.0		26.0	26.0			26.0	
Effective Green, g (s)	34.0	34.0		24.0	24.0		26.0	26.0			26.0	
Actuated g/C Ratio	0.38	0.38		0.27	0.27		0.29	0.29			0.29	
Clearance Time (s)	2.0	2.0		2.0	2.0		2.0	2.0			2.0	
Lane Grp Cap (vph)	669	1244		429	856		196	924			700	
v/s Ratio Prot	0.02	c0.07		0.21	c0.21			c0.29				
v/s Ratio Perm							0.16				0.16	
v/c Ratio	0.06	0.19		0.79	0.80		0.54	1.00			0.56	
Uniform Delay, d1	17.9	18.8		30.6	30.7		27.0	32.0			27.2	
Progression Factor	1.46	1.71		1.00	1.00		0.78	0.78			1.00	
Incremental Delay, d2	0.2	0.3		13.5	7.5		9.5	28.6			3.2	
Delay (s)	26.2	32.4		44.1	38.3		30.4	53.6			30.4	
Level of Service	C	C		D	D		C	D			C	
Approach Delay (s)		31.6			40.2			51.4			30.4	
Approach LOS		C			D			D			C	

Intersection Summary			
HCM Average Control Delay	42.2	HCM Level of Service	D
HCM Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	113.2%	ICU Level of Service	H
Analysis Period (min)	15		

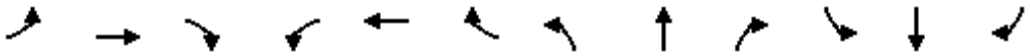
c Critical Lane Group



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (vph)	120	282	479	72	63	90
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	0.95	1.00		1.00	
Frpb, ped/bikes	1.00	1.00	0.92		0.84	
Flpb, ped/bikes	1.00	1.00	1.00		1.00	
Frt	1.00	1.00	0.98		0.92	
Flt Protected	0.95	1.00	1.00		0.98	
Satd. Flow (prot)	1719	3438	1633		1372	
Flt Permitted	0.95	1.00	1.00		0.98	
Satd. Flow (perm)	1719	3438	1633		1372	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	126	297	504	76	66	95
RTOR Reduction (vph)	0	0	8	0	60	0
Lane Group Flow (vph)	126	297	572	0	101	0
Confl. Peds. (#/hr)				420	186	186
Confl. Bikes (#/hr)				32		
Heavy Vehicles (%)	5%	5%	5%	5%	5%	5%
Turn Type	Prot					
Protected Phases	7	4	8		6	
Permitted Phases						
Actuated Green, G (s)	6.4	36.8	26.4		26.0	
Effective Green, g (s)	6.4	36.8	26.4		26.0	
Actuated g/C Ratio	0.09	0.52	0.37		0.37	
Clearance Time (s)	4.0	4.0	4.0		4.0	
Vehicle Extension (s)	3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	155	1787	609		504	
v/s Ratio Prot	c0.07	0.09	c0.35		c0.07	
v/s Ratio Perm						
v/c Ratio	0.81	0.17	0.94		0.20	
Uniform Delay, d1	31.6	8.9	21.4		15.3	
Progression Factor	1.00	1.00	1.00		1.00	
Incremental Delay, d2	26.7	0.2	24.4		0.9	
Delay (s)	58.3	9.1	45.8		16.2	
Level of Service	E	A	D		B	
Approach Delay (s)		23.8	45.8		16.2	
Approach LOS		C	D		B	

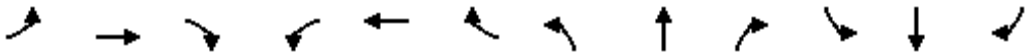
Intersection Summary			
HCM Average Control Delay	33.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	70.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	61.0%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	45	260	121	227	28	84	236	211	21	191	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0	4.0		4.0			4.0	
Lane Util. Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Frpb, ped/bikes		1.00	0.76		1.00	0.70		0.92			0.99	
Flpb, ped/bikes		0.96	1.00		0.93	1.00		0.98			1.00	
Frt		1.00	0.85		1.00	0.85		0.95			0.99	
Flt Protected		0.98	1.00		0.98	1.00		0.99			1.00	
Satd. Flow (prot)		1751	1191		1685	1105		1572			1799	
Flt Permitted		0.86	1.00		0.86	1.00		0.91			0.94	
Satd. Flow (perm)		1532	1191		1479	1105		1443			1692	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	22	49	283	132	247	30	91	257	229	23	208	11
RTOR Reduction (vph)	0	0	182	0	0	10	0	34	0	0	2	0
Lane Group Flow (vph)	0	71	101	0	379	20	0	543	0	0	240	0
Confl. Peds. (#/hr)	121		102	102		121	82		75	75		82
Confl. Bikes (#/hr)			2			21			17			6
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Turn Type	Perm		Perm	Perm		Perm	Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8		8	2			6		
Actuated Green, G (s)		24.5	24.5		24.5	24.5		36.5			36.5	
Effective Green, g (s)		25.0	25.0		25.0	25.0		37.0			37.0	
Actuated g/C Ratio		0.36	0.36		0.36	0.36		0.53			0.53	
Clearance Time (s)		4.5	4.5		4.5	4.5		4.5			4.5	
Lane Grp Cap (vph)		547	425		528	395		763			894	
v/s Ratio Prot												
v/s Ratio Perm		0.05	0.08		c0.26	0.02		c0.38			0.14	
v/c Ratio		0.13	0.24		0.72	0.05		0.71			0.27	
Uniform Delay, d1		15.2	15.8		19.5	14.7		12.5			9.1	
Progression Factor		1.00	1.00		1.00	1.00		1.00			1.00	
Incremental Delay, d2		0.5	1.3		8.1	0.2		5.6			0.7	
Delay (s)		15.7	17.1		27.6	15.0		18.1			9.8	
Level of Service		B	B		C	B		B			A	
Approach Delay (s)		16.8			26.7			18.1			9.8	
Approach LOS		B			C			B			A	

Intersection Summary			
HCM Average Control Delay	18.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	80.6%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	30	20	20	141	10	190	10	311	42	111	461	10
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Hourly flow rate (vph)	31	20	20	144	10	194	10	317	43	113	470	10

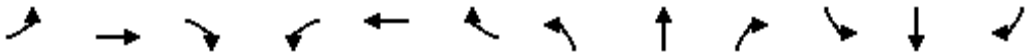
Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	71	348	370	594
Volume Left (vph)	31	144	10	113
Volume Right (vph)	20	194	43	10
Hadj (s)	-0.03	-0.20	-0.01	0.08
Departure Headway (s)	7.9	6.7	6.6	6.3
Degree Utilization, x	0.16	0.65	0.68	1.05
Capacity (veh/h)	390	517	529	560
Control Delay (s)	12.4	21.3	22.2	75.5
Approach Delay (s)	12.4	21.3	22.2	75.5
Approach LOS	B	C	C	F

Intersection Summary				
Delay	44.3			
HCM Level of Service	E			
Intersection Capacity Utilization	89.5%	ICU Level of Service	E	
Analysis Period (min)	15			

Intersection	
Intersection Delay, s/veh	18.0
Intersection LOS	C

Approach	EB	WB	NB	SB
Entry Lanes	1	1	1	1
Conflicting Circle Lanes	1	1	1	1
Adj Approach Flow, veh/h	138	220	537	673
Demand Flow Rate, veh/h	141	224	548	687
Vehicles Circulating, veh/h	674	537	151	309
Vehicles Exiting, veh/h	322	162	664	452
Follow-Up Headway, s	3.186	3.186	3.186	3.186
Ped Vol Crossing Leg, #/h	210	9	117	78
Ped Cap Adj	0.965	0.999	0.979	0.989
Approach Delay, s/veh	10.1	10.1	11.9	27.0
Approach LOS	B	B	B	D

Lane	Left	Left	Left	Left
Designated Moves	LTR	LTR	LTR	LTR
Assumed Moves	LTR	LTR	LTR	LTR
RT Channelized				
Lane Util	1.000	1.000	1.000	1.000
Critical Headway, s	5.193	5.193	5.193	5.193
Entry Flow, veh/h	141	224	548	687
Cap Entry Lane, veh/h	576	660	972	830
Entry HV Adj Factor	0.978	0.981	0.981	0.980
Flow Entry, veh/h	138	220	537	673
Cap Entry, veh/h	544	647	932	805
V/C Ratio	0.254	0.340	0.576	0.837
Control Delay, s/veh	10.1	10.1	11.9	27.0
LOS	B	B	B	D
95th %tile Queue, veh	1	2	4	10



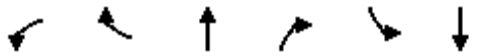
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	130	121	220	43	0	100	0	500	11	20	465	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Util. Factor	1.00	1.00	1.00	1.00		1.00		*0.60			*0.60	
Frpb, ped/bikes	1.00	1.00	0.91	1.00		0.85		0.99			1.00	
Flpb, ped/bikes	0.87	1.00	1.00	0.94		1.00		1.00			1.00	
Frt	1.00	1.00	0.85	1.00		0.85		1.00			1.00	
Flt Protected	0.95	1.00	1.00	0.95		1.00		1.00			1.00	
Satd. Flow (prot)	1553	1881	1456	1672		1367		2238			2245	
Flt Permitted	0.95	1.00	1.00	0.68		1.00		1.00			0.91	
Satd. Flow (perm)	1553	1881	1456	1189		1367		2238			2056	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	137	127	232	45	0	105	0	526	12	21	489	0
RTOR Reduction (vph)	0	0	61	0	0	44	0	2	0	0	0	0
Lane Group Flow (vph)	137	127	171	45	0	61	0	536	0	0	510	0
Confl. Peds. (#/hr)	125		122	122		122	121		153	153		121
Confl. Bikes (#/hr)			5						13			14
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm		Perm	custom		custom				Perm		
Protected Phases		4						2			6	
Permitted Phases	4		4	8		8				6		
Actuated Green, G (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Effective Green, g (s)	31.0	31.0	31.0	31.0		31.0		28.0			28.0	
Actuated g/C Ratio	0.48	0.48	0.48	0.48		0.48		0.43			0.43	
Clearance Time (s)	3.0	3.0	3.0	3.0		3.0		3.0			3.0	
Lane Grp Cap (vph)	741	897	694	567		652		964			886	
v/s Ratio Prot		0.07						0.24				
v/s Ratio Perm	0.09		c0.12	0.04		0.04					c0.25	
v/c Ratio	0.18	0.14	0.25	0.08		0.09		0.56			0.58	
Uniform Delay, d1	9.8	9.5	10.1	9.2		9.3		13.8			14.0	
Progression Factor	1.00	1.00	1.00	1.00		1.00		1.00			1.00	
Incremental Delay, d2	0.6	0.3	0.8	0.3		0.3		2.3			2.7	
Delay (s)	10.3	9.9	10.9	9.5		9.6		16.2			16.7	
Level of Service	B	A	B	A		A		B			B	
Approach Delay (s)		10.5			9.6			16.2			16.7	
Approach LOS		B			A			B			B	

Intersection Summary			
HCM Average Control Delay	14.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.40		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	66.7%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	182	40	31	212	40	32
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.89	0.89	0.89	0.89	0.89	0.89
Hourly flow rate (vph)	204	45	35	238	45	36
Pedestrians	8			1		
Lane Width (ft)	12.0			12.0		
Walking Speed (ft/s)	4.0			4.0		
Percent Blockage	1			0		
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			249		543	228
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			249		543	228
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			97		91	96
cM capacity (veh/h)			1322		486	813

Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	249	273	81
Volume Left	0	35	45
Volume Right	45	0	36
cSH	1700	1322	592
Volume to Capacity	0.15	0.03	0.14
Queue Length 95th (ft)	0	2	12
Control Delay (s)	0.0	1.2	12.0
Lane LOS		A	B
Approach Delay (s)	0.0	1.2	12.0
Approach LOS			B

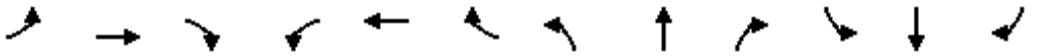
Intersection Summary			
Average Delay		2.2	
Intersection Capacity Utilization		39.1%	ICU Level of Service A
Analysis Period (min)		15	



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Sign Control	Stop		Stop			Stop
Volume (vph)	204	80	90	124	80	50
Peak Hour Factor	0.86	0.86	0.86	0.86	0.86	0.86
Hourly flow rate (vph)	237	93	105	144	93	58

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total (vph)	330	249	151
Volume Left (vph)	237	0	93
Volume Right (vph)	93	144	0
Hadj (s)	0.03	-0.30	0.17
Departure Headway (s)	4.9	4.7	5.3
Degree Utilization, x	0.45	0.32	0.22
Capacity (veh/h)	692	720	633
Control Delay (s)	11.9	9.9	9.8
Approach Delay (s)	11.9	9.9	9.8
Approach LOS	B	A	A

Intersection Summary			
Delay	10.8		
HCM Level of Service	B		
Intersection Capacity Utilization	47.5%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	10	120	64	30	90	20	105	70	208	20	20	10
Peak Hour Factor	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Hourly flow rate (vph)	11	129	69	32	97	22	113	75	224	22	22	11

Direction, Lane #	EB 1	WB 1	NB 1	SB 1	SB 2
Volume Total (vph)	209	151	412	43	11
Volume Left (vph)	11	32	113	22	0
Volume Right (vph)	69	22	224	0	11
Hadj (s)	-0.17	-0.03	-0.25	0.12	-0.58
Departure Headway (s)	5.1	5.3	4.7	5.6	3.2
Degree Utilization, x	0.30	0.22	0.54	0.07	0.01
Capacity (veh/h)	639	613	730	571	1121
Control Delay (s)	10.3	9.9	12.9	9.0	6.2
Approach Delay (s)	10.3	9.9	12.9	8.4	
Approach LOS	B	A	B	A	

Intersection Summary				
Delay	11.4			
HCM Level of Service	B			
Intersection Capacity Utilization	53.3%	ICU Level of Service	A	
Analysis Period (min)	15			