South Bay Salt Pond Restoration Project

Restoring the Wild Heart of the South Bay

Draft Environmental Impact Statement/Report, Phase 2, Eden Landing Ecological Reserve

Volume 2 | April 2018

Photo Credit: Cris Benton

California Department of Fish and Wildlife / U.S. Fish and Wildlife Service partnering with California State Coastal Conservancy

APPENDIX A

PHASE 2: PRELIMINARY OPTIONS FOR FUTURE ACTIONS

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South Bay Salt Pond Restoration Project

Restoring the Wild Heart of the South Bay

Phase 2: Preliminary Options for Future Actions

SBSP Project Management Team

September 2010

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PHASE 2 DESIGN IDEAS
PROJECT MANAGEMENT TEAM WORKING DRAFT
25 August 2010

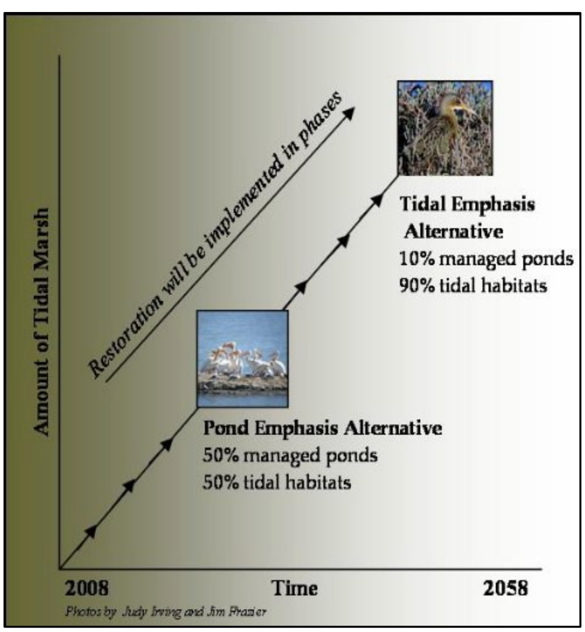
1. INTRODUCTION

The purpose of this brief report is to brief interested parties on the preliminary actions identified by the Project Management Team regarding the next phase of restoration and solicit input on these (and other) alternatives. The Project Management Team held a preliminary design charrette brainstorming workshop on May 13, 2010, and have refined their ideas in subsequent meetings through the summer. This document will serve as the baseline for an open dialogue with the stakeholders regarding Phase 2 of the Project.

The South Bay Salt Pond Restoration Project (Project) has three project goals:

- Wetland habitat enhancement and restoration
- Improved flood management
- Improved public access and recreation

These goals will be achieved as the Project is implemented in phases along an Adaptive Management continuum (see Figure 1 below). Adaptive Management is an integral part of the Project, allowing for lessons learned in earlier phases to be incorporated into subsequent phases as future restoration actions are formulated. Phase 1 Actions are currently underway, and the ultimate project configuration will be between the two "bookends" for the Project established in the EIS/R: a minimum of 50% tidal restoration to a maximum of 90% tidal restoration. Future phases of the Project will continue to fulfill the mission of the Project by integrating habitat restoration with flood management and wildlife-compatible public access.



Actions subsequent to Phase 1 will be based, in part, on the evaluation of adaptive management information collected in previous phases. For example, information collected in Phase 1 from monitoring and applied studies on bird response to pond management, methyl mercury, and public access- wildlife interactions will be instrumental in determining the extent and location of future tidal restoration and public access features. Future tidal restoration is also dependent upon the provision of flood management (either maintaining or improving existing flood protection levels). Additionally, public access actions will be included in future phases, either independent of, or in close coordination with, habitat restoration and flood management actions.

Guiding Principles

The overarching guiding principles for the selection of Phase 2 actions will be to first "do no harm" relative to flood impacts, and second to progress toward the 50:50 managed pond-tidal marsh "bookend" as outlined in the EIS/R. Collectively, these guiding principles mean that we are not able to take certain actions until adequate flood management levees are in place, and that ponds proposed to be managed ponds under the 50:50 scenario but tidal marsh under the 90:10 scenario will not be returned to tidal action as part of Phase 2. Until adaptive management results supply us with significant data to the contrary, the Project should adhere to the decisions made in previous planning processes.

Precedent Actions

Actions specific to any one of the three project goals of habitat restoration, flood management and public access may be dependent upon precedent actions. For example, many flood management actions proposed as part of the Project, such as levee construction, may wait for completion of the WRDA-authorized South San Francisco Bay Shoreline Study. However, the Shoreline Study is not expected to be complete for several years.

Evaluation Criteria

Phase 2 of the South Bay Salt Pond Restoration Project will take into consideration a number of evaluation criteria. Many of the criteria will be the same as those used in developing Phase 1 actions. Other criteria will be based on the results of Applied Studies and monitoring. Application of the criteria below, along with consideration of essential flood management actions and the layering of additional public access actions, will make implementation of future actions a varied mixture of habitat restoration, flood management, and public access activities occurring on unique schedules based on development of actions and associated design, funding and construction schedules.

Examples of this varied mix of Phase 2 actions could include:

- The construction of a flood management levee,
- Development of an additional viewing area,
- Tidal restoration of a pond on the bayside of the flood levee,
- Refinement of a Phase 1 Applied Study.

These actions will likely occur according to different time schedules, and in different pond complexes.

Alternatively, public access projects, such as completion of some Bay Trail spine segments, can proceed independently of changes in habitat. Many Bay Trail spine segments can and will be built (when funds are available) on existing or temporary levees that are ultimately proposed to be replaced with well-engineered flood protection levees.

However, the Project must be careful to avoid taking actions in Phase 2 that may impede restoration actions in subsequent phases. (Examples of such actions include breaching inboard ponds leaving bayside ponds more difficult to access, or providing public access in areas that may become tidal in the future and where public access and long-term operations and maintenance are not desired.)

II. PROPOSED TIMELINE

A preliminary draft timeline of the Phase 2 planning process is outlined below.

Phase 2 Action	2010				2011				2012				2013			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Design Charrette																
Specific Pond Complex Evaluations																
Stakeholder Meetings																
Release RFP																
Preliminary Design																
Environmental Review (NEPA/CEQA)																
Adaptive Management Input																
Regulatory Permitting																
Secure Funding																
Construction Documents																
Begin New Applied Studies																
Begin Construction																☼

III. EVALUATION CRITERIA

During the Phase 2 design charrette on 13 May 2010, the Project Management Team reviewed and revised the considerations used in selecting the set of Phase 1 actions. These criteria were adapted and expanded to include additional relevant criteria to be used in selecting the Phase 2 actions. These Evaluation Criteria, and the discussion that follows of potential preliminary range of options for Phase 2, are intended to be a starting point to engage the public and key stakeholders in an open dialogue regarding the next step in this important project.

Primary Evaluation Criteria

Likelihood of progress toward Project Objectives

- (Now) Will the action produce a significant habitat, flood management, or public access benefit?
- (Future) Will the action now lead toward greater success in later phases (e.g., current actions facilitate future acreage for restoration)?

Considerations:

- Are relevant Adaptive Management findings available? If so, are these findings incorporated into the proposed action?
- Is there any new relevant information that was not available during earlier planning that is now available and should be considered in planning this action?

Opportunities for adaptive management

- What high priority studies can we implement to answer key questions/ uncertainties not currently being addressed?

Considerations:

- How does the proposed action contribute to evaluating the risks and benefits of adaptive management actions?

Value in continuing to build Project support

- Does the Phase 2 action continue to build support for the project geographically (by complex or landowner), regionally, or for specific user groups?

Readiness to proceed

- If the proposed action were a standalone action, would it be likely to be permitted in a timely manner (within 5 years)?
- Ease of implementation and success. Is the project technically feasible? Are there significant constraints to designing and constructing the proposed action?
- Could construction commence in a timely manner (within 3 years of receipt of permits)?

Dependency on precedent actions

- Are there pre-requisites to implementing a particular action (e.g., flood management levee) that will not be completed within the Phase 2 timeframe, either by the SBSP project or by others? (See Guiding Principles section.)

Secondary Criteria

Visibility and accessibility

- Will the results be visible to the public and/or decision makers?
- Will the results be accessible to the public and/or decision makers?

Considerations:

- If other on-going or planned projects are nearby, how is the proposed action integrated with these projects?
- *Note:* Public access may be accomplished independent of the restoration and flood management aspects of the Project.

Balance (considered for the suite of Phase 2 actions)

- Does the slate of proposed actions represent an appropriate balance between the three project goals of habitat restoration, flood management, and public access?
- Is this balance evident within one complex, or across the entire Project Area?
- Does the action contribute to maintaining a balance between the two landowners (USFWS and CDFG)?
- Are the Phase 2 actions distributed throughout the Project Area, taking onto account the locations of the Phase 1 actions?

Availability of funding

- What is the amount of funding needed to carry out the action (planning, implementation, O&M, monitoring, Applied Studies)?
- What costs, if any, may be avoided by carrying out the proposed action?
- Is the level of funding needed for the entire project likely to be available?
- What are the funding sources, how secure are the funds and what restrictions might they apply?

IV. PHASE 2 OPTIONS

Using the guiding principles and evaluation criteria outlined above, the Project Management Team went through each complex at the 13 May 2010 Phase 2 design charrette and subsequent meetings to formulate the potential actions for the next phase of restoration.

As part of the charrette process, the Project Management Team also identified several Project-wide actions that warrant consideration for Phase 2. These are described below followed by sections outlining potential Phase 2 actions by pond complex.

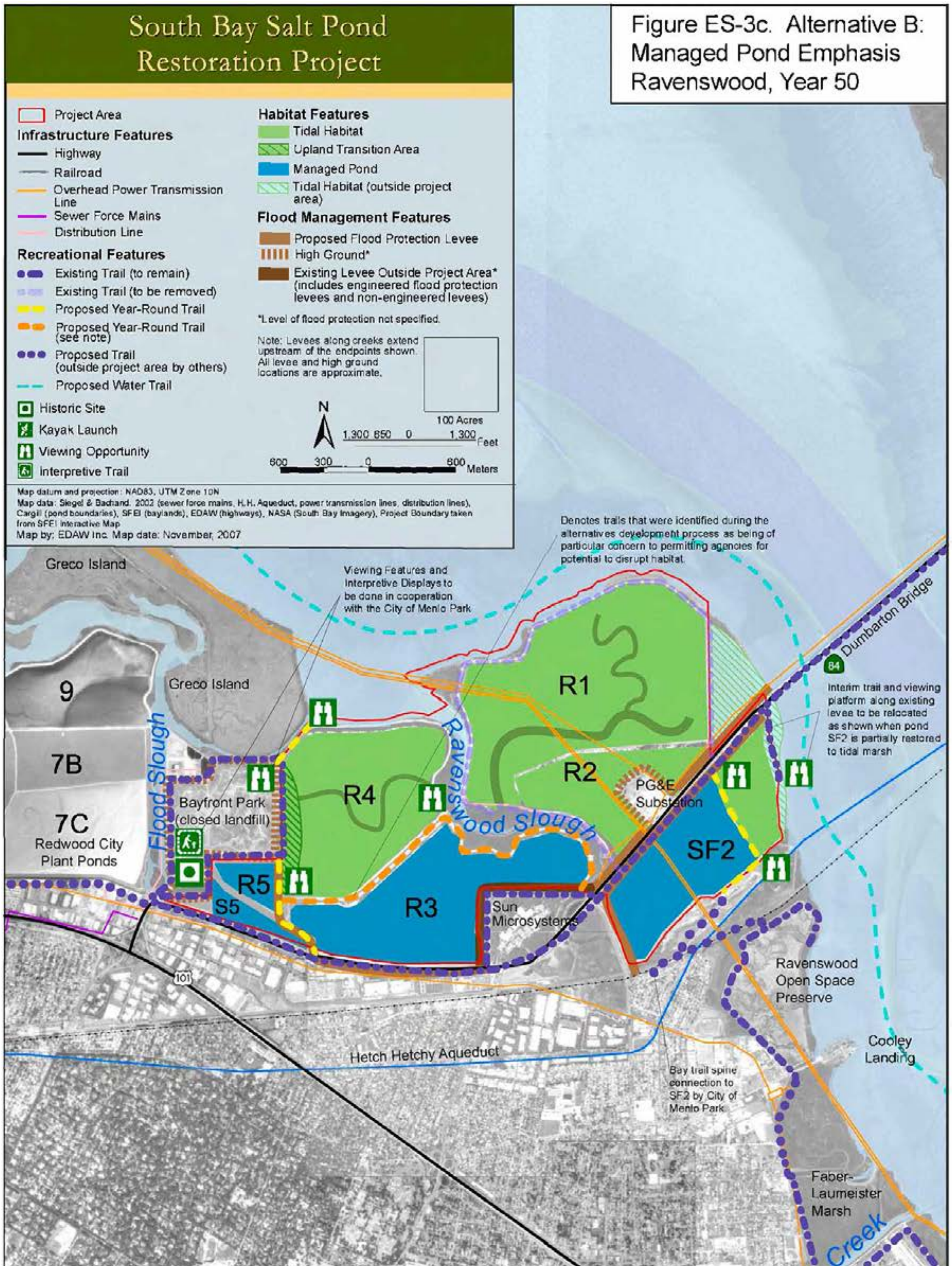
Overall next steps include discussions with key stakeholders, regulatory agencies, and the public and a subsequent refinement of the Project options.

A. Ravenswood Complex Actions

Below are the preliminary ideas discussed at the Phase 2 design charrette for the Ravenswood Complex. A major constraint to additional tidal restoration at this complex is the flood management issue along Highway 84. Next steps to address flood management improvements at Ravenswood include setting up a meeting to discuss these issues with the City of Menlo Park, Caltrans, and PG&E. These discussions should begin in 2010 in order to be resolved by Phase 3.

Table 1. Ravenswood Complex Phase 2 Options.

#	Restoration Action	Flood Management	Habitat Created	Public Access Opportunity	Key Uncertainties/ Questions
1	R4 Tidal Restoration	Requires raised levee between R4 & R3	▪ Tidal marsh ▪ Planned upland transition on west side ▪ Impact to nesting western snowy plovers, small shorebirds using R4	▪ R4 spur trail near Greco ▪ Hunting/ fishing may be possible ▪ Temporary trail along new R3/R4 levee?	▪ Place to store fill ▪ Bayfront Park solid waste exposed to tidal action ▪ Impact on future tidal restoration at R3 ▪ Inboard R4 levee versus internal levee between R3/R4 ▪ Caspian tern island in R3? (R3/R4 levee needed) ▪ Better to restore R3/R4 as 1 block?
2	R5/S5 managed ponds	Levee from 84 to Bayfront Park	Uncertain which species to manage these ponds for at this time.	Trail from highway to Bayfront Park	
3	R1/R4/R2 seasonal + re-plumb R3/S5/R5	Internal levee (non-flood management) between R3 and R4	Allows better pond management for maximizing waterbird habitat		▪ Requires water control structures for R2 & R3 ▪ R1/R2 without levee floods 84 & PG&E substation
4	New water control structures at R ponds		Allows better pond management for maximizing waterbird habitat	Hunting may be possible	



South Bay Salt Pond
Restoration Project
Figure ES-3c. Alternative B: Managed Pond Emphasis Ravenswood, Year 50
Project Area
Infrastructure Features
Highway
Railroad
Overhead Power Transmission Line
Sewer Force Mains
Distribution Line
Recreational Features
Existing Trail (to remain)
Existing Trail (to be removed)
Proposed Year-Round Trail
Proposed Year-Round Trail (see note)
Proposed Trail (outside project area by others)
Proposed Water Trail
Historic Site
Kayak Launch
Viewing Opportunity
Interpretive Trail
Habitat Features
Tidal Habitat
Upland Transition Area
Managed Pond
Tidal Habitat (outside project area)
Flood Management Features
Proposed Flood Protection Levee
High Ground*
Existing Levee Outside Project Area* (includes engineered flood protection levees and non-engineered levees)
*Level of flood protection not specified.
Note: Levees along creeks extend upstream of the endpoints shown. All levee and high ground locations are approximate.
100 Acres
N
1,300 650 0 1,300 Feet
600 300 0 600 Meters
Map datum and projection: NAD83, UTM Zone 10N
Map data: Siegel & Bachand. 2002 (sewer force mains, H.H. Aqueduct, power transmission lines, distribution lines), Cargill (pond boundaries), SFEI (baylands), EDAW (highways), NASA (South Bay Imagery), Project Boundary taken from SFEI interactive Map
Map by: EDAW Inc. Map date: November, 2007
Greco Island
Viewing Features and Interpretive Displays to be done in cooperation with the City of Menlo Park
Denotes trails that were identified during the alternatives development process as being of particular concern to permitting agencies for potential to disrupt habitat.
Dumbarton Bridge
84
Interim trail and viewing platform along existing levee to be relocated as shown when pond SF2 is partially restored to tidal marsh
9
Greco Island
7B
7C
Redwood City Plant Ponds
Flood Slough
Bayfront Park (closed landfill)
R1
R2
R3
R4
R5
S5
SF2
Ravenswood Slough
PG&E Substation
Sun Microsystems
101
Ravenswood Open Space Preserve
Hetch Hetchy Aqueduct
Bay trail spine connection to SF2 by City of Menlo Park
Cooley Landing
Faber-Laumeister Marsh
Creek

B. Eden Landing Complex

Below are the preliminary ideas discussed at the Phase 2 design charrette for the Eden Landing Complex. The general consensus of the PMT is that some form of tidal restoration in the southern half of the complex (between Old Alameda Creek and the Alameda Flood Control Channel) is the logical Phase 2 action. However, there are many options (see Table 2) for possible configurations of tidal restoration. Close coordination with the Alameda County Flood Control District is required to determine what actions can be taken prior to the construction of major flood management levees. In addition, careful consideration must be given to the existing water management regime and infrastructure to ensure that ponds not restored in Phase 2 can meet water management goals.

In addition, detailed designs for public access and recreation will involve close coordination and joint development with the East Bay Regional Park District to ensure expansion of trail options that to the extent possible meet the needs of the Project, the Department of Fish and Game (the landowner) and the District.

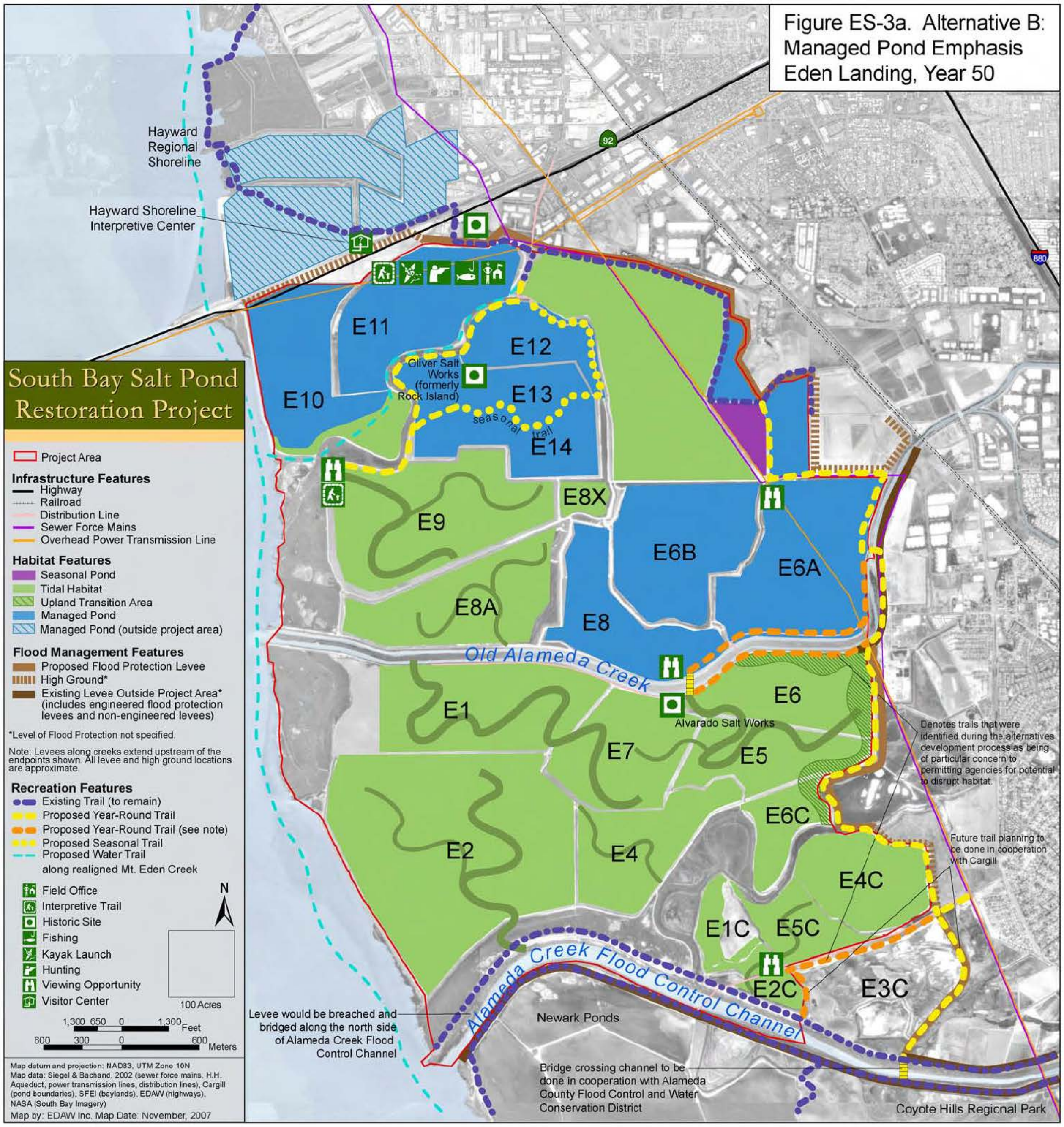
An Eden Landing working group has been initiated with the County and the Park District. Regular meetings will be established to closely coordinate on the necessary phasing of flood management and restoration actions. Next steps include involving other key stakeholders such as the Hayward Area Shoreline Planning Agency in the planning process. In addition, Cargill has been contacted to discuss options pertaining to the properties they have retained (Turk Island, “Cal” Hill and adjacent Pond E3C) in the southern Eden Landing area.

Table 2. Eden Landing Complex Phase 2 Options

#	Restoration Action	Flood Management	Habitat Created	Public Access Opportunity	Key Uncertainties/ Questions
1	E2 Tidal Restoration	New E1/E2 and E4/E7 levee improvements required.	▪ Tidal marsh including fish nursery habitat	▪ Spur trail along E6 on south side of Old Alameda Creek to Alvarado Salt Works (bridge will be needed if E6 becomes tidal in the future)	▪ Cargill mitigation pond (adjacent to E1) is example of how E pond restoration may respond ▪ E2-only option allows for continued inboard WQ mgmt through E1 intake.
2	E2 & E4 Tidal	New E1/E2 and E4/E7 levee improvements required.	▪ Tidal marsh including fish nursery habitat		▪ More separate pond intakes and outlets – desirable for operation but costly.
3	E5/E6/E6C Tidal	▪ G-1 levee along E5/E6 ▪ Add'l E6C inboard levee improvements ▪ E5/E4/E7 levee improvement required	▪ Tidal marsh including fish nursery habitat ▪ Upland transition habitat possible	EBRPD Bay Trail along new inboard flood management levee	▪ E12/E13 may inform what type of managed ponds are desirable at E5/E6 ▪ May increase scour along Old Alameda Creek
4	E1/E7 Tidal	Levee improvements in remaining ponds required, incl. E1-E2, E7- E2, E7-E4, E5-E7, E6-E7	▪ Tidal marsh including fish nursery habitat	▪ Spur trail along E6 on south side of Old Alameda Creek to Alvarado Salt Works	▪ Requires new intake in E6 to operate E2 pond system operation
5	E1/E2/E4/E7 Tidal	Levee improvements required to isolate E6-E5- E6C	▪ Tidal marsh including fish nursery habitat	▪ Spur trail along E6 on south side of Old Alameda Creek to Alvarado Salt Works	▪ Requires new E6 intake to operate remaining E6-E5-E6C pond system

Table 2. Eden Landing Complex Phase 2 Options

#	Restoration Action	Flood Management	Habitat Created	Public Access Opportunity	Key Uncertainties/ Questions
6	E1-7 + E6C Tidal	▪ G-1 levee along E5/E6 ▪ Add'l E6C inboard levee	▪ Tidal marsh including fish nursery habitat ▪ Upland Transition habitat possible		▪ E2C intake structure would require fish screen, new water control structure for E1C, E5C, E4C or operations budget for "Cal" Hill intake to E1C would be needed unless they remain seasonal (summer dry)
7	Eel Grass Subtidal Habitat (off E2)		▪ Fisheries		Review status of planned projects off of Eden Landing
8	G-1 pilot levee (adjacent to Ponds E6 and E5)	Pilot flood management levee project	▪ Upland transition habitat possible	EBRPD Bay Trail along inboard levee	▪ Needs to be coupled with wetland restoration
9	Managed pond improvements at E8, E6A and E6B		▪ Duck habitat in winter, nesting plover/shore- bird habitat in spring and summer		▪ New pumps required; need to assess the feasibility of this management possibility and identify long-term funding beyond Phase 2 timeline.



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C. Alviso Complex

Below are the preliminary ideas discussed at the Phase 2 design charrette for the Alviso Complex. A major constraint to additional tidal restoration at this complex is the need for flood management for large areas of Santa Clara County. Next steps to address flood management improvements at Alviso are largely dependent upon the South San Francisco Bay Shoreline Study (Shoreline Study).

The Shoreline Study is a Congressionally-authorized study being performed by the US Army Corps of Engineers together with the Santa Clara Valley Water District and State Coastal Conservancy to identify and recommend for Federal funding one or more projects for flood damage reduction, ecosystem restoration and related purposes such as public access.

Also, mercury continues to be a significant issue for the Alviso complex, and any tidal restoration planned in advance of the Applied Study results, including current Phase 1 actions, will continue to be carefully selected to avoid additional exposure risks.

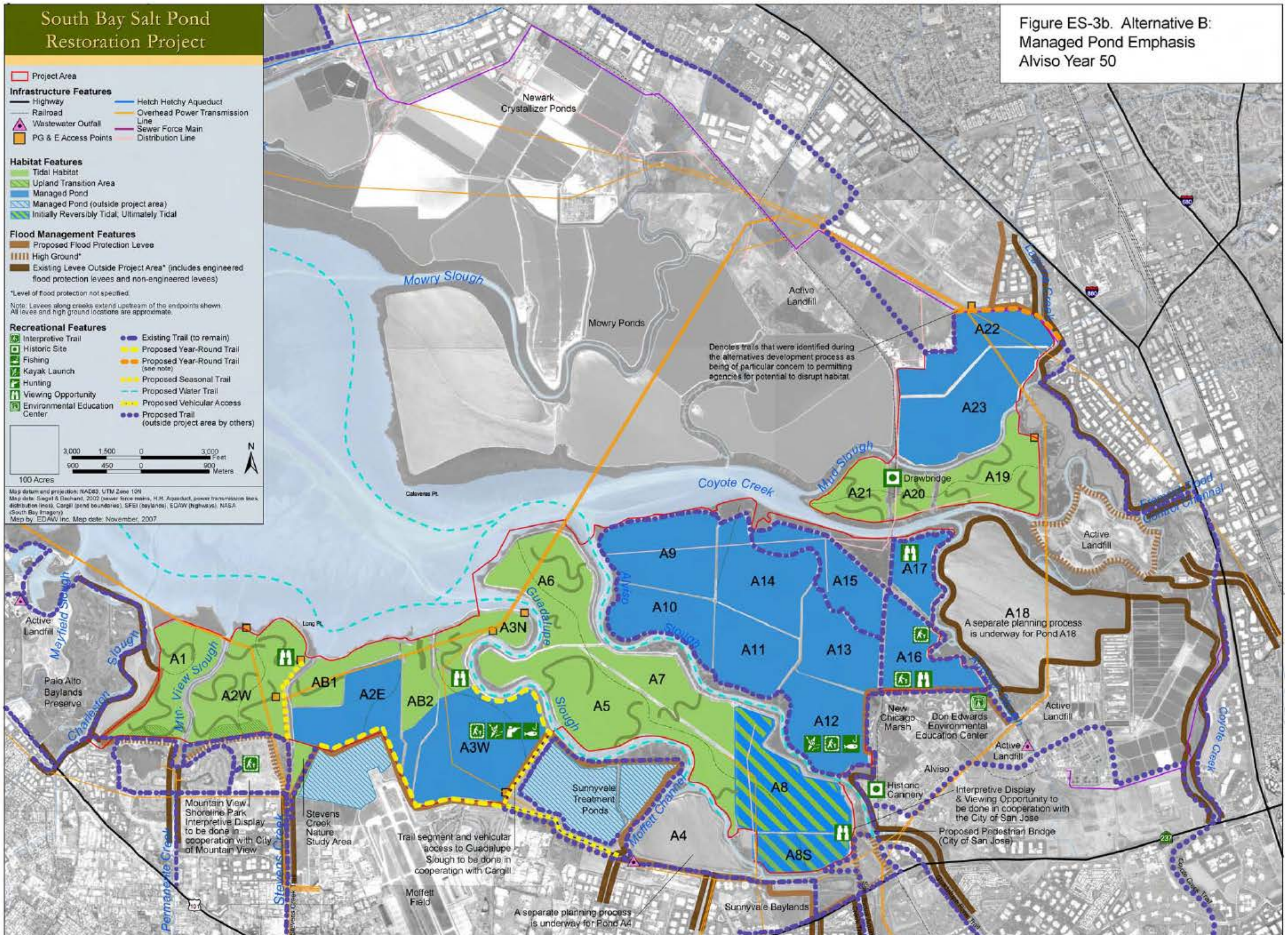
Table 3. Alviso Complex Phase 2 Options

	#	Optimal Restoration	Flood Manage ment	Habitat Modified	Public Access Opportunity	Key Uncertainties/ Questions
Without Corps Levees	1	A1 tidal	Is A1/Charles ton Slough levee needed?	Tie into existing restoration projects? Upland transition habitat possible.	Improved access to marsh on existing trail	▪ Landfill liner ▪ Possible preservation of islands within pond for tern colony
	2	A1 & A2W tidal		Habitat used by dabbling and diving ducks -- potential loss. Upland transition habitat possible.	Bay Trail enhancement	▪ If marsh, move trail on southern end of A2W? ▪ PG&E ▪ Fluvial tie-in for flooding ▪ Landfill liner
	3	Breach Island Ponds on mud slough	May need levee to protect north (A22/A23)		Water Trail access to marsh on Mud Slough	Feasibility study of benefits needed?
	4	A2W tidal		Future Upland transition habitat possible.	Bay Trail enhancement	
	5	A3W Seasonal Trail				
	6	A3W Managed Pond Enhancement				▪ Applied Study on pond management and algae/DO issues?

Table 3. Alviso Complex Phase 2 Options

	#	Optimal Restoration	Flood Management	Habitat Modified	Public Access Opportunity	Key Uncertainties/ Questions
With Levee 'Enhancement' Only	7	A3N tidal	Inland levee needed			▪ PG&E
With Corps Levees*	8	A9/10/11/14 fully tidal			Loss of A9 loop	▪ Need to find managed ponds elsewhere?
	9	Levee Stevens Creek to Sunnyvale west with restoration				
	10	Alviso levee and restore Ponds A9/10/11/12/13/14/15				▪ Railroad has to be raised to build Alviso levee
	11	A23 tidal				

*These are not under consideration for Phase 2 due to the likely timing of Corps flood management levee construction.



South Bay Salt Pond Restoration Project
Figure ES-3b. Alternative B: Managed Pond Emphasis Alviso Year 50
Project Area
Infrastructure Features
Highway
Railroad
Wastewater Outfall
PG & E Access Points
Hetch Hetchy Aqueduct
Overhead Power Transmission Line
Sewer Force Main
Distribution Line
Habitat Features
Tidal Habitat
Upland Transition Area
Managed Pond
Managed Pond (outside project area)
Initially Reversibly Tidal, Ultimately Tidal
Flood Management Features
Proposed Flood Protection Levee
High Ground*
Existing Levee Outside Project Area* (includes engineered flood protection levees and non-engineered levees)
*Level of flood protection not specified
Note: Levees along creeks extend upstream of the endpoints shown. All levee and high ground locations are approximate.
Recreational Features
Interpretive Trail
Historic Site
Fishing
Kayak Launch
Hunting
Viewing Opportunity
Environmental Education Center
Existing Trail (to remain)
Proposed Year-Round Trail
Proposed Year-Round Trail (see note)
Proposed Seasonal Trail
Proposed Water Trail
Proposed Vehicular Access
Proposed Trail (outside project area by others)
100 Acres
Newark Crystallizer Ponds
Mowry Slough
Mowry Ponds
Active Landfill
Denotes trails that were identified during the alternatives development process as being of particular concern to permitting agencies for potential to disrupt habitat.
A22
A23
Mud Slough
Coyote Creek
Drawbridge
A19
A21
A20
A9
A14
A15
A17
A18
A separate planning process is underway for Pond A18
A6
A10
Alviso Slough
A3N
Guadalupe
A11
A13
A16
A1
A2W
Mtn. View Slough
Mayfield Slough
Charleston Slough
Palo Alto Baylands Preserve
AB1
A2E
AB2
A7
A5
A3W
A12
New Chicago Marsh
Don Edwards Environmental Education Center
Alviso
Historic Cannery
A8
A8S
A4
Sunnyvale Treatment Ponds
Moffett Channel
Mountain View Shoreline Park Interpretive Display to be done in cooperation with City of Mountain View
Stevens Creek Nature Study Area
Trail segment and vehicular access to Guadalupe Slough to be done in cooperation with Cargill
Moffett Field
A separate planning process is underway for Pond A4
Sunnyvale Baylands
Interpretive Display & Viewing Opportunity to be done in cooperation with the City of San Jose
Proposed Pedestrian Bridge (City of San Jose)
Permanente Creek
Stevens Creek
Coyote Creek
Long Pt.
Calaveras Pt.
Map by: EDAW Inc. Map date: November, 2007

Project-wide Actions

Project-wide actions are those that the PMT felt were important to consider in Phase 2, but were not specific to an individual pond complex at this time. Upon further development, they may be focused on a specific geographic region, but for now are being considered at a landscape-scale.

Beneficial re-use of dredged material.

Get approval to opportunistically receive dredge material in 3-5 locations (matching the upland transition zones areas if possible) throughout the Project area.

Rationale: In light of sea-level rise, existing subsided ponds, potential reduction in suspended sediment concentrations in the Bay, and proposed broad upland transition zones, the Project can utilize as much sediment as possible. Since the inception of the Project, opportunities have arisen where unplanned sources of material were available. The Project is proposing to pursue approvals to receive material at various locations within the Project footprint as they become available. This will allow the Project to capitalize on sediment as it becomes available. Ideally these materials will be used to expedite marsh development, fill borrow ditches, and create broad upland transition zones. Applied Studies evaluating characteristics (such as contaminants) and placement of dredge materials would greatly inform future management actions.

Subtidal Habitat Goals pilot projects.

Pilot project(s) and/or studies at any of the complexes relative to the Subtidal Goals Project (e.g., eelgrass, oyster, living shoreline projects).

Rationale: The Draft Subtidal Habitat Goals Report is currently out for public review and will be finalized during the Phase 2 planning process. The long-term vision for the restoration of the South Bay by the PMT, Science Team, National Science Panel and Stakeholders Forum for the South Bay Salt Pond Restoration Project has always included subtidal habitat enhancements as part of the long-term vision. Numerous opportunities exist to further the goals of both projects through Applied Studies or pilot projects as part of Phase 2.

Public access and recreation study.

Continue to study user needs/wants for new public access and recreation features associated with the project.

Rationale: Public access and recreation is one of the three goals of the Project. However, planning for public use has been largely focused on site specific opportunities. The PMT will make a comprehensive evaluation of the needs and desires of the public in terms of public access and recreation is needed to help guide future phases of the Project to make sure that we are meeting the needs of the likely users.

V. PROJECT EVALUATION MATRIX

Potential Phase 2 options are laid out in the matrix below (Table 4) that takes into account the revised Phase 2 evaluation criteria described earlier in the report (see Section II, page 7). The purpose of the evaluation matrix below is to illustrate the Project Managers' initial assessment of each Phase 2 option, using the selection criteria described earlier. These criteria include:

- *Likelihood of progress toward Project Objectives*
- *Opportunities for adaptive management*
- *Readiness to proceed*
- *Visibility and accessibility*
- *Balance*
- *Availability of funding*
- *Value in continuing to build Project support**
- *Dependency on precedent actions**

Note: In general, actions that require a major precedent action, e.g. construction of a flood management levee, are not being considered in Phase 2. For that reason "dependency on precedent action" is not included in the matrix. In addition to "Value in continuing to build Project support," the "Visibility and Accessibility" criterion was also used as a proxy for assessing an action's overall value in continuing to develop public support for the Project

Table 4. Project evaluation Matrix for Phase 2 Actions.
(Ranking Convention: ○=Low, •=Medium, ●=High)

Restoration Action	Balance: Type[1]			Balance: Pond Complex[2]			Flood Protection Level[3]	Progress Toward Objectives[4]	Readiness to Proceed[5]	Value to the Project: Visibility and Accessibility[6]	Priority for Applied Study? (Y/N)[7]	Cost[8]
Beneficial re-use of dredged material	hr	fm		A	E	R	•	•	•	○	Y (1)	●
Subtidal Habitat Goals pilot projects	hr			A	E	R	●	●	•	○	Y (3)	•
Public access and recreation study			pa	A	E	R	●	●	○	○	Y (4)	●
R4 Tidal Restoration	hr					R	•	•	•	●	Y (5,7)	•
R5/S5 managed ponds	hr					R	●	•	•	●	N	•
R1/R4/R2 seasonal + re-plumb R3/S5/R5	hr					R	●	○	•	○	N	•
New water control structures at R ponds	hr					R	●	○	●	○	N	•
R4 spur trail			pa			R	●	●	●	•	Y (4,7)	●
Trail between Hwy and Bayfront Park			pa			R	●	●	●	•	Y (4,7)	●
E2 Tidal Restoration	hr	fm			E		•	•	•	•	Y (3, 9, 10)	•

Table 4. Project evaluation Matrix for Phase 2 Actions.
(Ranking Convention: ○=Low, •=Medium, ●=High)

Restoration Action	Balance: Type[1]			Balance: Pond Complex[2]			Flood Protection Level[3]	Progress Toward Objectives[4]	Readiness to Proceed[5]	Value to the Project: Visibility and Accessibility[6]	Priority for Applied Study? (Y/N)[7]	Cost[8]
E2/E4 Tidal Restoration	hr	fm			E		•	•	•	•	Y (3, 9, 10)	•
E5/E6/E6C Tidal Restoration	hr				E		○	•	●	●	Y (3, 5, 10)	○
E1/E7 Tidal Restoration	hr				E		•	•	•	•	Y (3, 9, 10)	•
E2/E4 + E1/E7 Tidal Restoration	hr				E		•	•	•	•	Y (3, 9, 10)	•
E1-6 + E6C Tidal Restoration	hr				E		○	•	●	●	Y (3, 5, 10)	○
Eel Grass Subtidal Habitat	hr				E		●	●	•	○	Y (3)	•
G-1 levee		fm			E		●	•	•	●	Y (5, 7)	○
Spur trail along E6 & E7 to Alvarado salt works			pa		E		•	●	•	•	N	●
EBRPD Bay Trail along inboard G-1 levee			pa		E		○	●	•	●	Y (7)	●

Table 4. Project evaluation Matrix for Phase 2 Actions.
(Ranking Convention: ○=Low, •=Medium, ●=High)

Restoration Action	Balance						Flood Protection Level[3]	Progress Toward Objectives[4]	Readiness to Proceed[5]	Value to the Project: Visibility and Accessibility[6]	Priority for Applied Study? (Y/N)[7]	Cost[8]
	Type[1]			Pond Complex[2]								
A1 Tidal	hr			A			•	•	•	●	Y (5,7)	•
A1 & A2W Tidal	hr			A			•	•	•	●	Y (5,7)	•
Breach Island Ponds on mud slough	hr			A			●	•	•	•	N	•
A2W Tidal	hr			A			•	•	•	●	Y (5,7)	•
A3W Seasonal Trail			pa	A			●	•	●	•	N	●
A3W Managed Pond Enhanceme nt	hr			A			●	•	●	○	N	●
A3N Tidal	hr			A			•	•	•	•	N	•

Key:
[1]hr=habitat restoration, fm=flood management, pa=public access or recreation
[2]A=Alviso, E=Eden Landing, R=Ravenswood
[3]Flood Protection Criterion:
- ○: FEMA flood management levee required
- •: Able to proceed without FEMA levee
- ●: No flood concerns/improves flood management

[4]Progress Toward Objectives:
- ○: Precludes planned progress to 50-50 Alternative
- •: Moves to/Equal to 50-50 Alternative
- ●: Moves past 50-50 Alternative toward 90-10

[5]Readiness Criterion:
- ○: Significant precedent actions needed (e.g., FEMA levee)
- •: Typical constraints (design, regulatory, etc.)
- ●: No impediments to proceeding

[6]Visibility and Accessibility Criterion:
- ○: Neither very visible nor accessible
- •: Visible, but not accessible, or vice versa
- ●: Both very visible and accessible

[7]See Table 5 below for referenced Applied Study number.
[8]Cost Criterion:
- ○: >$8 million
- •: $2-8 million
- ●: <$2 million

VI. APPLIED STUDIES

Many of the South Bay Salt Pond Restoration Project actions are specifically designed either to facilitate (or coordinate with Adaptive Management) a specific applied research question, or to respond to the findings of applied research regarding the optimal mix of tidal restoration, pond management, non-levee-dependent flood management and public access and recreation.

Phase 1 of the project includes the implementation of many Applied Studies. All of these studies are designed to provide the Project with important information about the potential for expanding tidal marshes while preserving habitat for pond-dependent species. Several Applied Studies in Phase 1 will also provide information on the effects of increased public access on the wildlife in the ponds and newly restored marshes.

As the Project Management Team developed the options for Phase 2, Project Lead Scientist Laura Valoppi, took the lead in developing concepts for relevant adaptive management Applied Studies that should proceed in Phase 2. The table below illustrates those proposed studies.

Table 5. Potential Phase 2 Applied Study Concepts

Number	Study Idea	All Complexes	Ravenswood	Eden Landing	Alviso
1	Dredge material and sediment plan -- number, sources, types ▪ Feasibility of use of dredge spoils	X			
2	*Spartina* hybrid issue ▪ How much hybridization is okay (genetic question)? ▪ How much invasive *Spartina* is okay before control actions are taken? This requires collaboration with others/ISP.	X			
3	Subtidal pilot project Collaboration with Subtidal Goals Project Eelgrass study/pilot project off E2	X		X	
4	Public access/use surveys/studies ▪ Different communities and user groups, languages ▪ Human disturbance on upland transition zones.	X			
5	Upland transition zones (possibly linked to Number 1 above) ▪ How, where? ▪ How to construct? ▪ How to best construct upland transition zones to maximize benefits to marsh species, especially clapper rail and salt marsh harvest mouse? ▪ Source of materials and stockpiles? ▪ What materials can be used vis-à-vis soil properties/texture? ▪ What contaminant concerns? ▪ Vegetation management: what to seed with? What is native in this habitat? How do we control non-native invasive vegetation on a large scale?	X	X	X	X
6	TAC recommended a long-term "holistic" mercury monitoring program for South Bay Salt Ponds ▪ PMT/TAC to reach consensus on biosentinels ▪ National panel to develop toxicity thresholds	X	X	X	X

Table 5. Potential Phase 2 Applied Study Concepts

Number	Study Idea	All Complexes	Ravenswood	Eden Landing	Alviso
7	What effect will a trail have on a planned transition zone habitat and species use? Could it make species more vulnerable to predation? (Linked to #4 above.) If E6/E5 made tidal first with upland transition habitat and trail adjacent – issue of increased predation or disturbance from trail to upland transition habitat		X	X	
8	Look at SF2 island/habitat for increase in number of snowy plover and shorebirds (re: potential loss of habitat for small shorebirds at R4)		X		
9	Salt pannes -- if they form in E2/E1: and E8A/E9: ▪ How do waterbirds use? ▪ Hg issues since wet/dry cycle? ▪ Muted Mt. Eden Creek pannes -- study those?			X	
10	How does opening/increasing tidal prism in Old Alameda Creek and/or Alameda Flood Control Channel affect fish resources in those channels?			X	
11	If A1/A2W became tidal and displaced dabbling and diving ducks, what effect on Pond A3W and its existing use by ducks? What is the carrying capacity of A3W? What are the effects of hunting within a smaller footprint of ponds?				X

APPENDIX B

EDEN LANDING PRELIMINARY ALTERNATIVES ANALYSIS REPORT

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South Bay Salt Pond Restoration Project

Eden Landing Preliminary Alternatives Analysis Report

June 2014

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Tables

Figures

Introduction

In 2003, Cargill Salt (Cargill) sold 15,100 acres of solar salt production ponds that had been owned and operated by Cargill in the southern San Francisco Bay. The sale and transfer to the U.S. Fish and Wildlife Service (USFWS) and the California Department of Fish and Wildlife (CDFW) became known as the South Bay Salt Pond Restoration Project (SBSP Restoration Project). The first phase of the SBSP Restoration Project will be completed in 2014. Phase 2 of the SBSP Restoration Project involves the selection, restoration design, environmental compliance, permitting, and construction activities at several former salt pond complexes under the ownership and management of USFWS or CDFW. The Alviso and Ravenswood complexes lie within the boundaries of the Don Edwards San Francisco Bay National Wildlife Refuge (Refuge), which is owned by USFWS. The Eden Landing complex, within the Eden Landing Ecological Reserve, is owned by CDFW.

The complexes consist of many individual salt ponds; several groups or “clusters” of these ponds are being analyzed for inclusion into the SBSP Restoration Project’s Phase 2 actions. Phase 2 actions at the Alviso and Ravenswood complexes are being undertaken by the Refuge and are described in other reports and environmental compliance documents. At the Eden Landing complex, Phase 2 of the SBSP Restoration Project involves the restoration and enhancement of the ponds south of Old Alameda Creek. The preliminary alternatives for the ponds at the Eden Landing complex are the subject of this report.

This document presents the purpose, methods, and results of developing the preliminary alternatives at Eden Landing for Phase 2 of the SBSP Restoration Project, developing screening criteria for those alternatives, and applying those criteria to select specific alternatives for inclusion in the SBSP Restoration Project’s Draft Environmental Impact Statement/Environmental Impact Report (DEIS/R).

The organization of the document is as follows:

- Section 1 discusses the purpose of an alternatives development and screening process and places this work in the context of the National Environmental Policy Act (NEPA), the California Environmental Quality Act (CEQA), and the SBSP Restoration Project’s three primary goals of habitat restoration, improved recreation and public access, and maintenance or improvement of current levels of flood risk protection.
- Section 2 presents the alternatives developed for this portion of Phase 2. Specifically, Section 2 discusses the individual components, the optional variations on those components, and the combinations of them that constitute the alternatives developed for inclusion in the DEIS/R. The DEIS/R will include evaluations and impact analyses of the habitat restoration, recreation and public access, and flood risk protection components. Based on those analyses and the comments received, some individual components of one or more of the draft alternatives may be selected and recombined into a Preferred Alternative for inclusion and analysis in the Final EIS/R.
- Section 3 presents the processes and methods by which the initial component actions were developed, modeled, analyzed, refined, and then selected. Section 3 includes more details about some of the key components, such as breach sizes, numbers, and locations.

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Section 1. Purpose

This document presents the methods, process, and results of the SBSP Restoration Project's Phase 2 alternatives development and screening process.

The alternatives themselves are developed in compliance with NEPA and CEQA. NEPA requires development and consideration of a range of "reasonable alternatives." CEQA requires alternatives that would "minimize significant impacts." In addition, the alternatives considered in a NEPA/CEQA document must meet the project's stated goals, purpose, need, and objectives. The SBSP Restoration Project has three primary goals: habitat restoration, improved recreation and public access, and maintenance or improvement of current levels of flood protection.

Previously, as part of NEPA and CEQA compliance, the project lead agencies completed a Programmatic EIS/R (PEIS/R) for the project as a whole. The PEIS/R developed long-term, end-project "target" habitat designations for each of the ponds in the project for each of two different programmatic action alternatives and a programmatic No Action Alternative:

- Programmatic Alternative A: no actions taken on the programmatic level; maintenance and operation of the ponds would proceed under "business as usual" conditions.
- Programmatic Alternative B: 50% (by acreage) restoration to tidal marsh and 50% managed ponds
- Programmatic Alternative C: 90% restoration to tidal marsh and 10% managed ponds

Programmatic Alternative C was selected and used for planning and implementation of Phase 1 actions. As part of the adaptive management approach to the project, the decision about when to cease restoration of tidal marshes may be reconsidered at a future time. When the total acreage of tidal marsh restoration is at or near 50%, there would be more specific decisions about whether to cease restoration of ponds to tidal marsh or continue to work toward the 90% target.

The intent of SBSP Restoration Project Phase 2 actions is to tier off of the PEIS/R. The preliminary alternatives considered were those that worked toward the end-project target habitat designation in the 50%-50% scenario presented in the PEIS/R. Even full implementation of these Phase 2 actions (i.e., restoring all of southern Eden Landing to tidal marsh) would not achieve the 50% tidal marsh threshold for the SBSP Restoration Project as a whole.

This document demonstrates the SBSP Restoration Project's success in meeting requirements to develop and consider a broad range of project action alternatives and a No Action Alternative for the Eden Landing ponds considered under Phase 2. This document includes map figures to explain and illustrate each of the preliminary alternatives and matrices to summarize each alternative's components. These alternatives encompass the full range of actions that may eventually be implemented as part of SBSP Restoration Project Phase 2 actions at Eden Landing.

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Section 2. Components and Preliminary Alternatives

The Eden Landing complex is in the Eden Landing Ecological Reserve (ELER), which is owned and operated by CDFW. This complex is near the eastern end of the San Mateo Bridge and is south of State Route (SR) 92 where it passes through Hayward in Alameda County. The Phase 2 actions at Eden Landing are focused on the ponds in the southern half of the ELER (specifically, the area south of the Old Alameda Creek channel and north of the federally constructed Alameda Creek Flood Control Channel [ACFCC]). Public access components include alignment of the San Francisco Bay Trail "spine" such that the trail connects from the existing San Francisco Bay Trail within the northern half of ELER to the existing Alameda Creek Regional Trail operated by the East Bay Regional Park District (EBRPD) along ACFCC.

2.1 Background and Goals

The southern portion of ELER includes 11 ponds that are described here in three groups based on their locations within the Eden Landing complex and their proximity and similarity to each other. As noted in Section 1, all of these ponds are intended to be restored to tidal marsh under both Programmatic Alternative B (a 50%-50% mix of tidal marsh and managed ponds) and Programmatic Alternative C (a 90%-10% mix of tidal marsh and managed ponds). These groups of ponds are addressed in the habitat restoration, added and improved public access and recreation opportunities, and flood risk protection measures considered in Phase 2. The groups are as follows:

- The Bay Ponds: Ponds E1, E2, E4, and E7 are the four large ponds closest to San Francisco Bay.
- The Inland Ponds: Ponds E5, E6, and E6C are somewhat smaller ponds in the northeast portion of the complex.
- The Southern Ponds: Also called the C-Ponds, Ponds E1C, E2C, E4C, and E5C are in the southeastern portion of the complex. They are separated from the Inland Ponds and the Bay Ponds by an Alameda County–owned freshwater outflow channel and diked marsh areas known collectively as "the J-ponds." The Southern Ponds surround a natural hill known as Turk Island that is on a private inholding.

The groups of ponds are intended to simplify the discussion of the ponds and the restoration alternatives rather than repeating names of individual ponds. These groups are discussed in more detail in the sections that follow.

Phase 1 actions at the Eden Landing complex were focused on the northern half of Eden Landing (north of Old Alameda Creek). They included adding managed pond improvements to Ponds E12, E13, and E14; restoring Ponds E8A, E8X, and E9 to tidal marsh; adding a kayak launch into Mt. Eden Creek; and adding and improving several trails and interpretive features.

Under the PEIS/R, all of the ponds in southern Eden Landing are intended to be restored to tidal marsh. This remains the plan and the expectation for these ponds; however, the Adaptive Management Plan developed by the SBSP Restoration Project and used to adjust both short-term management actions and long-term restoration planning depends on leaving open the possibility of some portions of southern Eden Landing remaining as managed ponds to achieve broader project goals. One example of these goals could be a need to retain pond habitat for diving birds, dabbling ducks, or other wildlife species. Further, much of the restoration may be constructed in stages and may require features to improve coastal flood risk protection to address "de facto" coastal flood protection that is currently provided by the intact southern Eden Landing ponds. This protection will be provided either by constructing levee improvements, a flood wall system, or other improvements to address coastal flood risk protection on the inboard sides of the ponds or by building a land mass on the outboard sides of the Bay Ponds. At least one of these two solutions must be in place in the ponds prior to restoring full tidal action into the pond complex.

The PEIS/R also laid out several goals for the major recreation and public access facilities at southern Eden Landing. These goals varied depending on whether Programmatic Alternative B or C was chosen. Alternative C was selected, but the Adaptive Management Plan could stop restoration and related project activities at any point between Alternative B and Alternative C. Thus, the exact list of program-level recreation and public access goals addressed in the Phase 2 actions may vary, but they will be drawn from the options in the PEIS/R or designed to achieve similar purposes.

Some recreation/public access options from the PEIS/R included in Phase 2 consideration at southern Eden Landing are:

- Maintain the existing trail that runs along the top of the large federal levee that forms the southern edge of the complex (i.e., the northern edge of ACFCC) (This option would involve constructing bridge(s) over any breaches that would be opened in that levee.)
- Complete the Bay Trail spine along the eastern edge of the pond complex
- Add a spur trail along the northern edge of Pond E6 from the Bay Trail spine to the site of the former Alvarado Salt Works
- Convert the above-referenced spur trail into a loop by building a footbridge over Old Alameda Creek and a trail back to the Bay Trail spine

2.2 Components and Variations

For Eden Landing, the recreation/public access components under consideration are developed, described, screened, and combined into partial alternatives separately from the habitat restoration and flood control components. The recreation/public access components are considered separately because the conceptual designs for the recreation/public access components can more easily be developed if done separately from the restoration and flood control components. Later in this document, these two different sets of components are developed into full alternatives for inclusion and analysis in the Phase 2 DEIS/R.

Coastal Flood Risk Protection Components

Primary coastal flood risk protection can be provided by standard approaches, such as constructing engineered levee improvements and/or a flood wall on the backside of the complex between the developed areas and the Inland Ponds and Southern Ponds. A new approach under development by Alameda County provides coastal flood risk protection by means of a “land mass”—a wide and high earthen feature—that would be constructed along the existing outboard levees of Ponds E1 and E2. The land mass feature would be designed to preclude catastrophic failures that sometimes occur on traditional levee features and may also include a broad slope that provides habitat elements such as an upland transition zone (UTZ). The land mass would function like a barrier island. More detail on the land mass is presented in Appendix A. Each of the alternatives developed below has either an engineered levee or a land mass to provide coastal flood risk protection.

Other coastal flood risk protection may be designed in the Phase 2 projects at Eden Landing. For example, a mid-complex levee may be constructed along a north-south alignment between the Bay Ponds and the Inland Ponds. At its southern end, a mid-complex levee would cross the Alameda County–owned J-ponds to connect with the western levee of Pond E1C and the ACFCC levee. Where possible, this mid-complex levee would be built on top of the existing internal berms and levees of these ponds. The mid-complex levee could be temporary or permanent. In its temporary use, it would allow for staged restoration by providing flood protection to the areas behind it while the Bay Ponds are breached and restored to tidal marsh, after which it could be removed or breached to allow tidal marsh restoration in the inland and/or southern ponds. In its permanent use, it would allow the Bay Ponds to be restored to tidal marsh, but either the Inland Ponds or the Southern Ponds (or portions of both) could be maintained as enhanced managed ponds.

Restoration Components

The restoration components considered for the Eden Landing complex fall into three categories of actions. These are discussed in turn and summarized in Table 1.

The first category of restoration components concerns the restoration goals of the various pond groups. The Bay Ponds are the simplest because they would be breached to become tidal marsh. The Inland Ponds and/or the Southern Ponds could be breached to become tidal marsh at the initial stage of the project, or—as explained above—could be enhanced as managed ponds behind the mid-complex levee. If the latter, they could remain that way indefinitely (“permanently”) or they could be temporarily managed until becoming part of a staged tidal restoration. There are components that cover each of these eventualities, though, as noted in Section 2.1, the intent is that the Inland Ponds and Southern Ponds would be restored to tidal marsh.

The second category of restoration components considers the use of material or water from external projects. The material could be upland fill material from construction projects or dredge material from channel maintenance or deepening projects. The material could be used for constructing UTZs (discussed below), adding habitat islands (also discussed below), building the land mass, or raising the bottom elevations of certain subsided ponds to speed their return to marsh-plain elevation. The water would be treated water from the Union Sanitary District (USD) and would be used to facilitate establishment of brackish marsh within portions of the ponds and/or native vegetation on the UTZs.

The third category of restoration components is habitat enhancements. One enhancement is adding habitat islands in some of the ponds for bird roosting, foraging, or nesting. Islands could be constructed from imported fill, as discussed above (second category), or by reinforcing and leaving portions of existing levees in place and breaching around them. As these ponds are subsequently breached and tidal marsh habitat develops, these islands would naturally transition to “marsh mounds,” which would be used as high-tide refugia for California clapper rail (*Rallus longirostris obsoletus*), salt marsh harvest mouse (*Reithrodontomys raviventris*), and other species. Another enhancement is constructing UTZs to increase flood protection, buffer against sea-level rise, and increase habitat diversity. There are options for UTZs in the Inland Ponds or the Southern Ponds if these become tidal marsh. However, if those pond groups are retained as enhanced managed ponds, then the UTZs would be built against the permanent version of the mid-complex levee within the Bay Ponds. Shells or sand toppings could be added to the top of the land mass, to remaining levees, or to constructed habitat islands to improve their suitability for nesting western snowy plover (*Charadrius alexandrines nivosus*). A final component in this category is creating deepwater channels to direct flows into different portions of the ponds and to improve the habitat quality and connectivity for fish species.

Table 1 lists all of these coastal flood risk protection and restoration components and the variations being considered for each of them. Some components have only two variations or options: implement or do not implement. An example of this component is armoring or otherwise controlling the sizes of the breaches. The armoring option would be implemented where the breach needs to remain at its constructed width, most notably wherever breach size affects coastal flood risk protection or where a bridge may be necessary to span the breach to provide ongoing access for operations and maintenance or for public access. Other components have a range of degrees of implementation or a range of locations where they are implemented: for example, how many UTZs are constructed and in which places. The alphanumeric codes in Table 1 are provided as a shorthand way to refer to certain configurations. For example, building the land mass would be component 1b; building the backside levee would be component 1c.

The combination of these various components into preliminary alternatives is discussed below.

Table 1. Restoration and Flood Control Components and Variations

Code #	Restoration and Flood Control Components	Component Variations Letter				
		a	b	c	d	e
1	Primary Flood Control	As-Is	Land Mass	Backside Levee		
2	Mid-Complex Levee	No	Yes - Temporary	Yes - Permanent		
3	Upland Transition Zone	No	In Inland Ponds	In Bay Ponds	In Southern Ponds	Against Land Mass
4	Inland Ponds	As-Is	Tidal Marsh	Temporary Managed Ponds	Permanent Managed Ponds	
5	Southern Ponds	As-Is	Tidal Marsh	Temporary Managed Ponds	Permanent Managed Ponds	
6	Breach Control	No	Yes (at bridges)			
7	Accept Dredge / Upland Material	No	Yes - for Land Mass	Yes - for UTZ	Yes - for Pond Bottoms	
8	Freshwater from USD	No	Yes - Inland Ponds - Brackish Marsh	Yes - Inland Ponds – Brackish Marsh and/or UTZ	Yes - Southern Ponds - Brackish Marsh and/or UTZ	
9	Deepwater Pilot Channels	No	Yes			
10	Islands/Mounds in Ponds	No	Yes - Managed Pond Islands	Yes - Marsh Mounds		
11	Shell Topping on Land Mass	No	Yes			

Recreation and Public Access Components

Seven primary components address public access and recreation, and two of these components have variations to achieve a similar goal and recreational experience or opportunity. Almost all of these components can be decided on independently. Any or none of these components may ultimately be chosen based on their feasibility and potential impacts. No components directly conflict with others, and very few are dependent on others being implemented. The exceptions are noted below. The recreational and public access components are:

1. Complete Bay Trail spine through Phase 2 Area
    - 1a – Bay Trail spine alignment placed on ELER levees on eastern side of (from north to south) Ponds E6, E5, E6C, and E4C; the southernmost portion of the alignment would be constructed on a levee east of Cargill Pond 3C (CP3C) (the trail would be on county-owned land to the east or be placed on CDFW land)
    - 1b – Bay Trail runs along an alternate route to the east of ELER on land owned by the county or landowners other than CDFW or Cargill
2. Spur trail on south side of Old Alameda Creek to Alvarado Salt Works
3. Maintain existing trail to bay on ACFCC Levee – this is essentially a bridge over an armored breach or alteration of the ACFCC levee to maintain the current trail
4. Trail around portions of the Southern Ponds; some components require acquiring the Cargill inholdings (Pond 3C, Turk Island, and Cal Hill)
    - 4a – Loop trail from Bay Trail spine around northern and western ends of the Southern Ponds; connects with the ACFCC trail
    - 4b – Cuts across the southern end of the Southern Ponds along the border of Cargill Pond 3C; then turns south to join the ACFCC trail
    - 4c – Turk Island Summit Loop Trail; initially, the same trail as component 4a but turns south over the Turk Island summit and then goes southeast to ACFCC
5. Pedestrian and bicycle bridge over ACFCC; this component would connect with the trail system in Coyote Hills Regional Park to the south
6. Trail on north side of Old Alameda Creek; this component requires component 2 to be chosen; it would run along the northern side of Old Alameda Creek and include a bridge to cross the creek and connect to the spur trail at the Alvarado Salt Works
7. Add recreational information and/or an interpretive feature along the ACFCC levee trail at a location to be determined

Table 2 lists these recreation and public access components. The combination of these various components into alternatives is discussed below.

Table 2. Recreation and Public Access Alternative Components

Code No.	Component Description
1	a – Complete Bay Trail spine through Phase 2 Area
	b – Bay Trail alternate route (east of ELER)
2	Spur trail on south side of Old Alameda Creek to Salt Works
3	Retain existing trail to bay on ACFCC levee (includes bridge over breach)
4	a – Loop trail around perimeter of Southern Ponds
	b –Trail through Southern Ponds
	c – Turk Island summit loop trail
5	Pedestrian / bicycle bridge over ACFCC
6	Trail on north side of Old Alameda Creek with bridge to #2
7	Recreation info and/or interpretive feature near Southern Ponds breach or culvert location

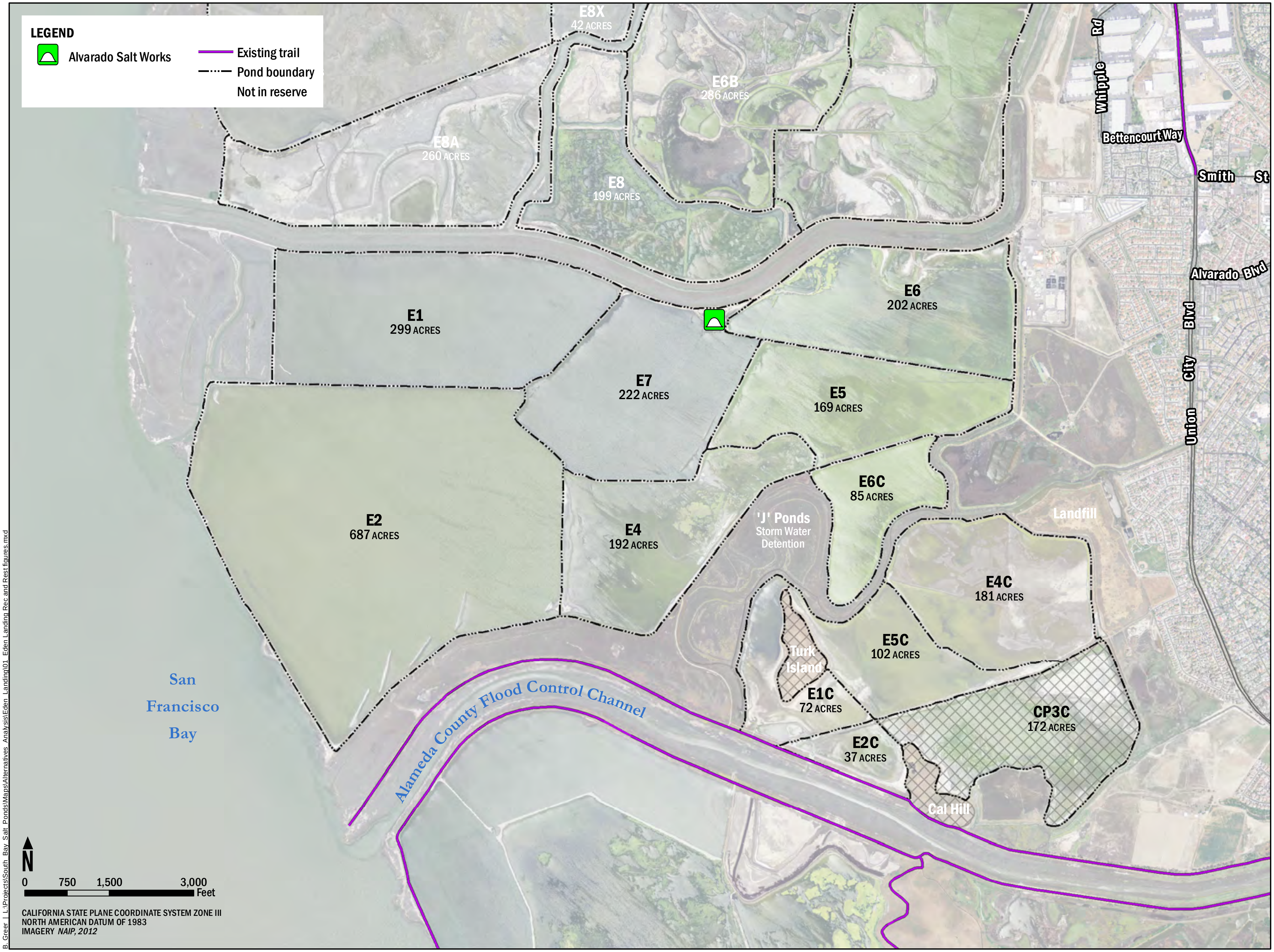
2.3 Development of Alternatives

Table 3 shows the combination of the above restoration and flood control components into four preliminary alternatives to achieve the SBSP Restoration Project goals plus a No-Action Alternative (“No Action” is the NEPA term; the equivalent term under CEQA is “No-Project

Alternative"). The names and numbers of the alternatives are for purposes of planning and internal discussion only. The names and numbers provide an indexing system and a brief description of the overall intent or effect of each alternative. They do not convey any order of preference or priority. Maps of these alternatives are presented on Figures Rest1 through Rest5.

Similarly, Table 4 shows the combination of the recreation and public access components into three preliminary alternatives and a no-project alternative. These alternatives are named and ordered in an array that reflects the provision of the fewest new access and recreation features to the greatest number of new features in this interim step of developing alternatives; they do not reflect any preference or priority. Maps of these alternatives are presented on Figures Access1 through Access4.

The figures are presented on the pages that follow.



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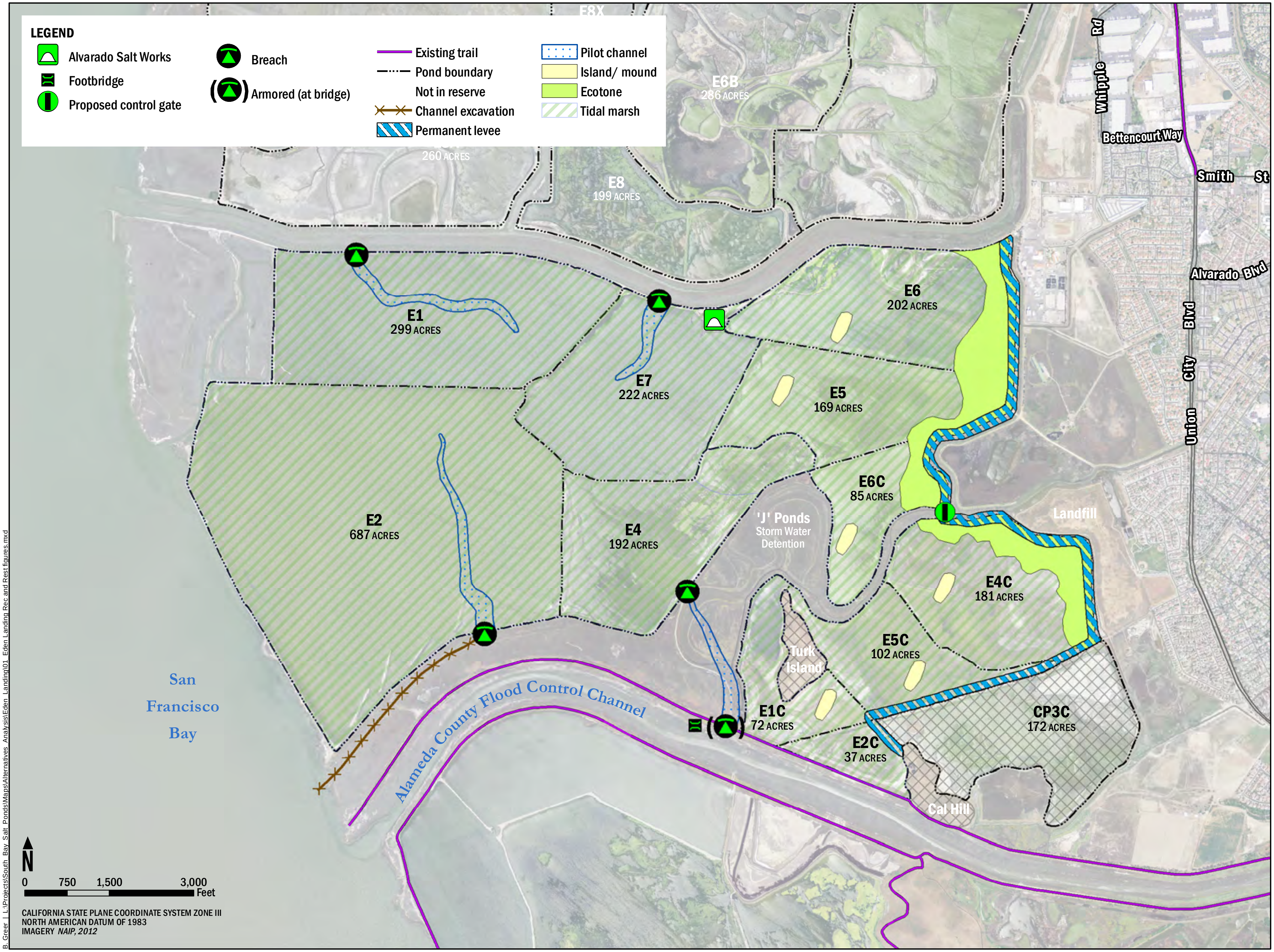
South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Rest1
No Project / No Action Alternative

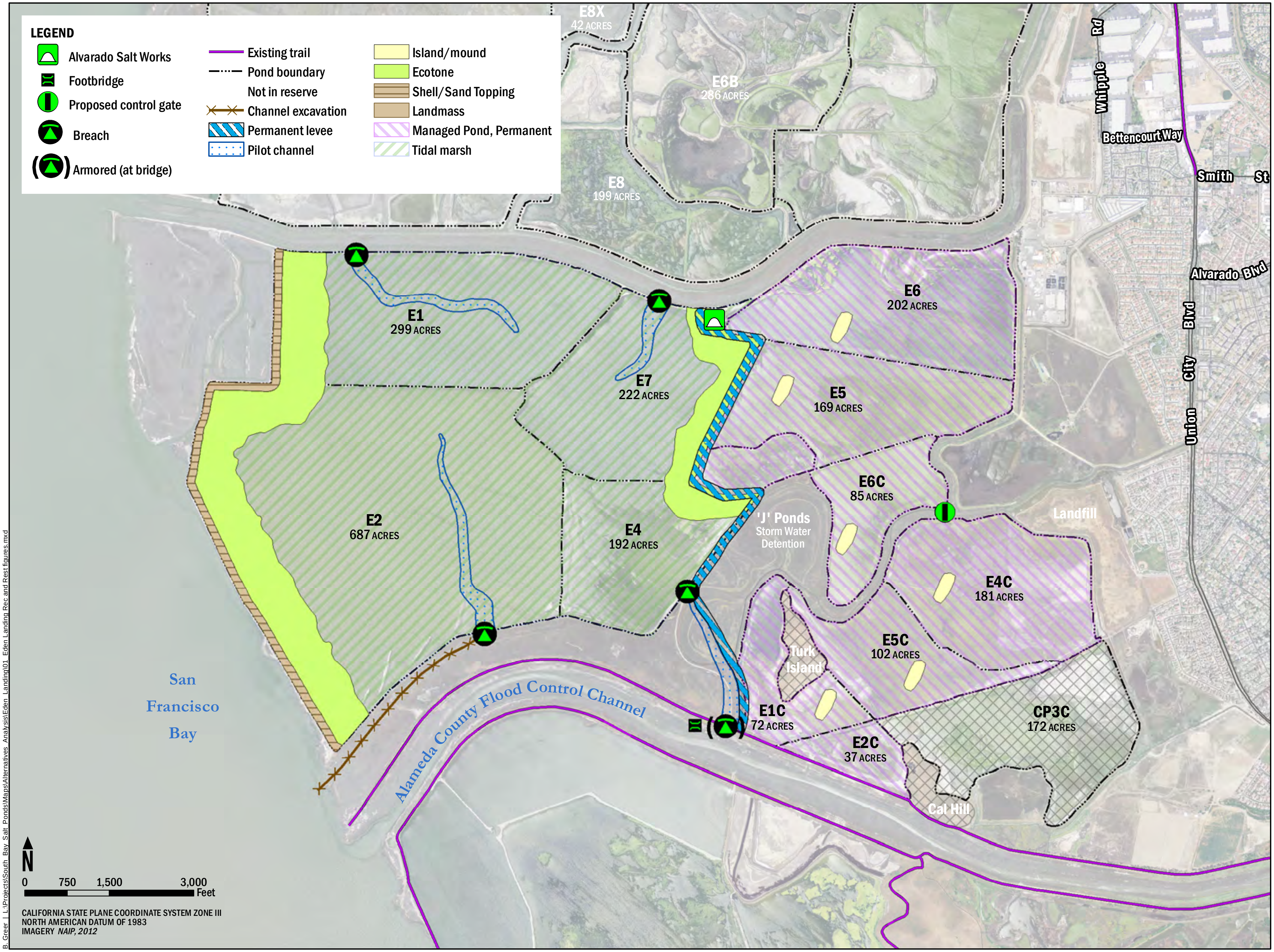


URS

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Rest2

Flood Protection from Backside Levee



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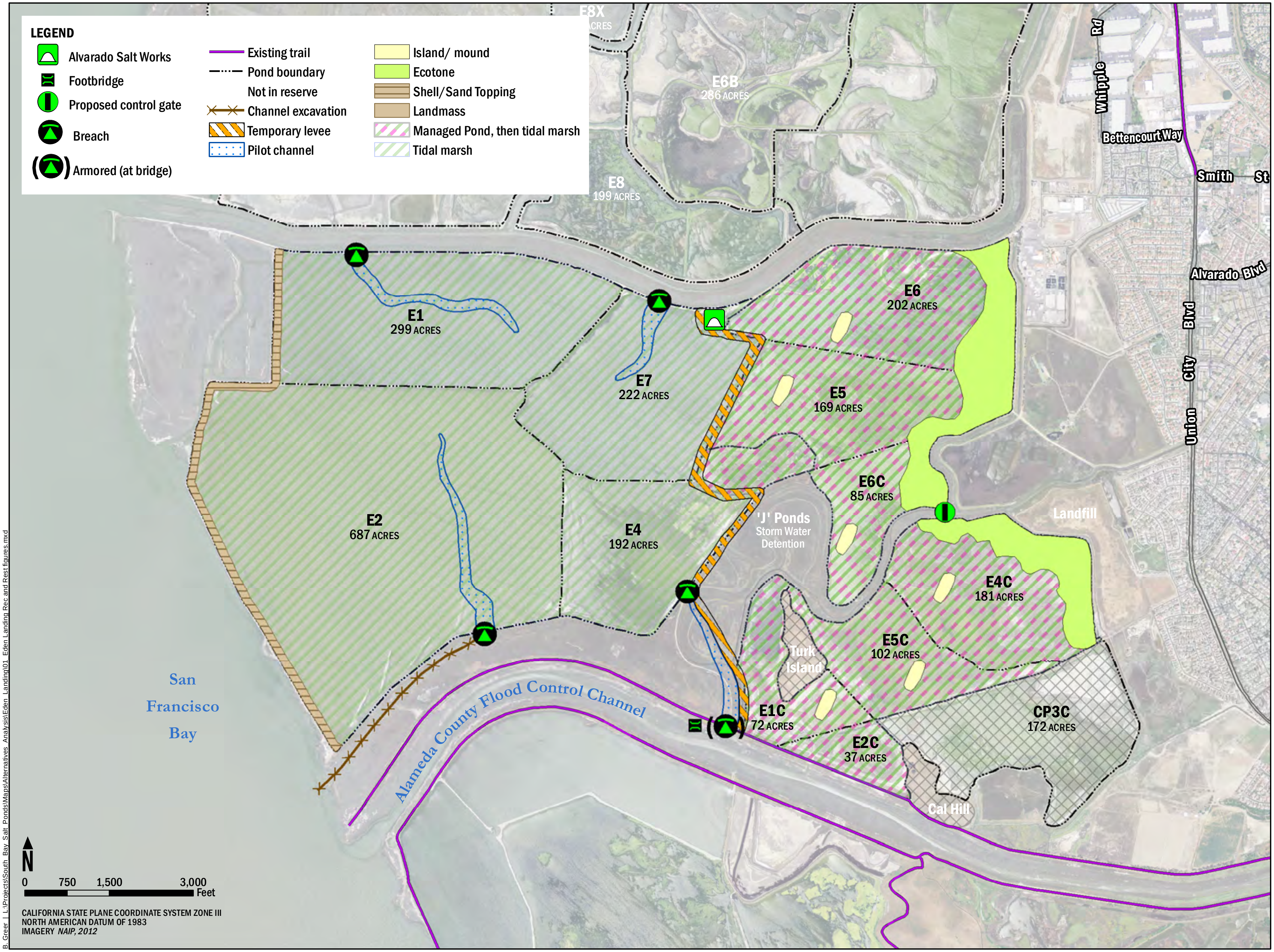
South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Rest3
Mix of Marsh & Ponds



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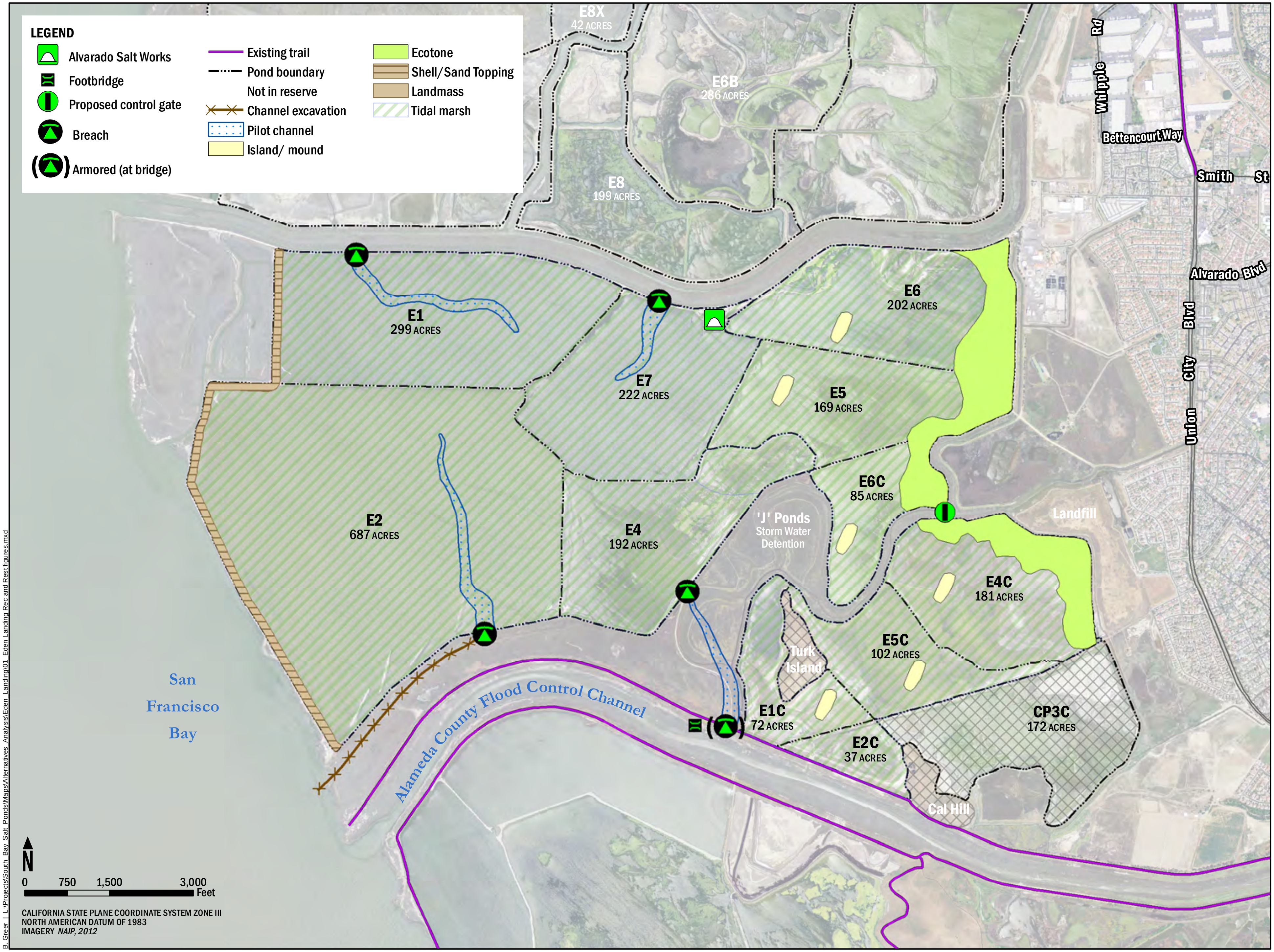
South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Rest4
Full Tidal Restoration (phased)



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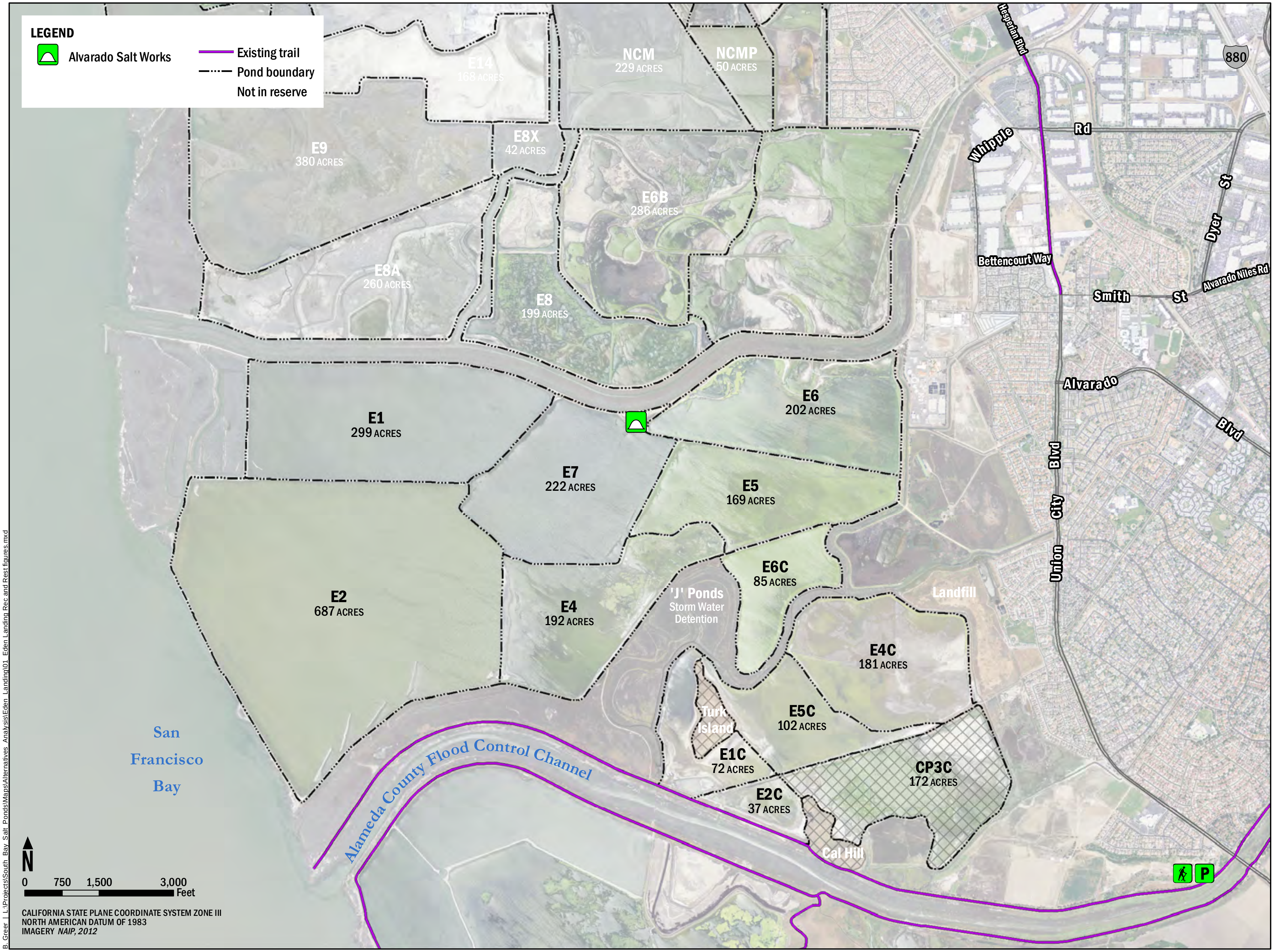
South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Rest5
Full Tidal Restoration (unphased)



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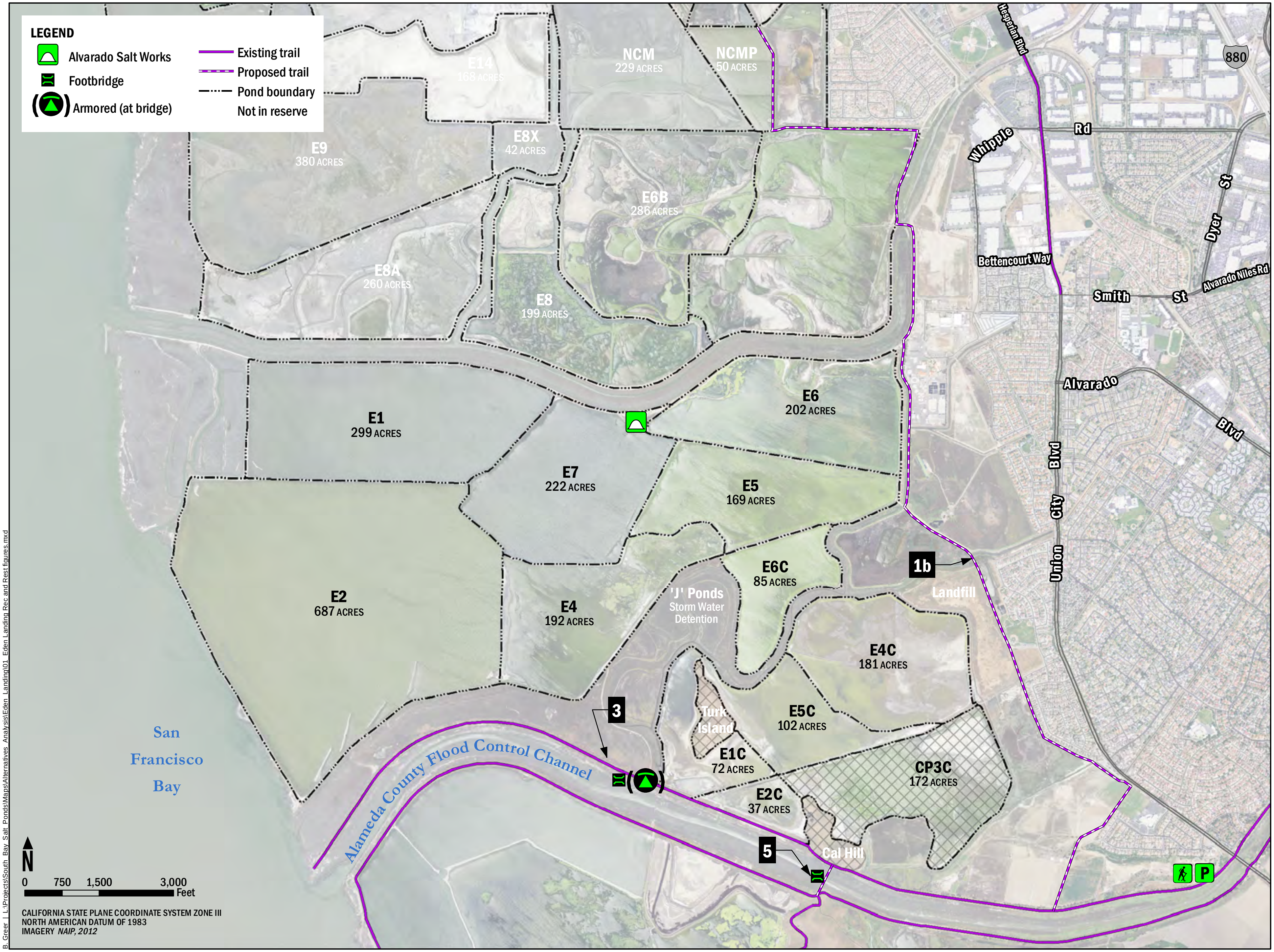
South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Access1
No Project / No Action Alternative



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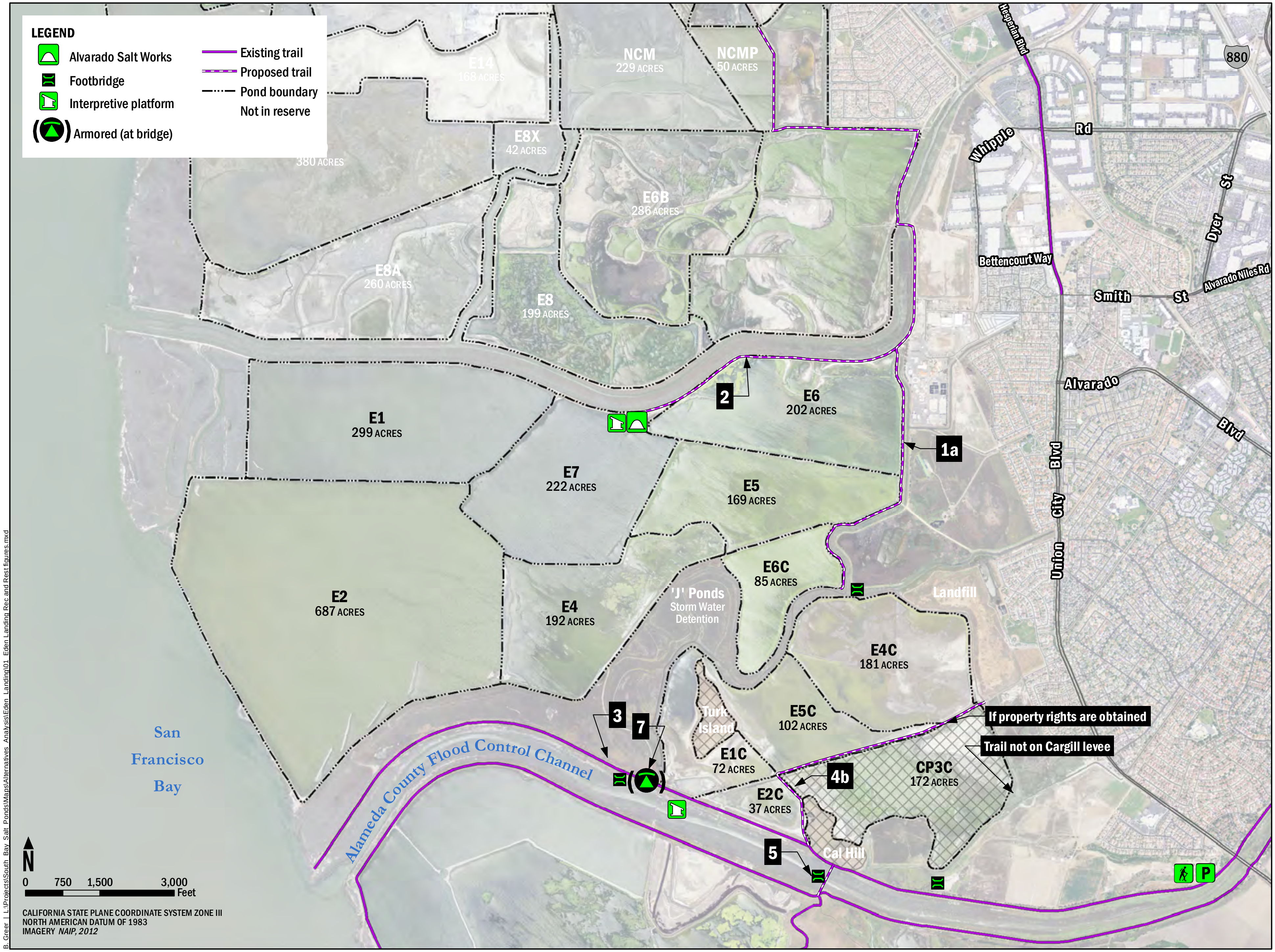
URS

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

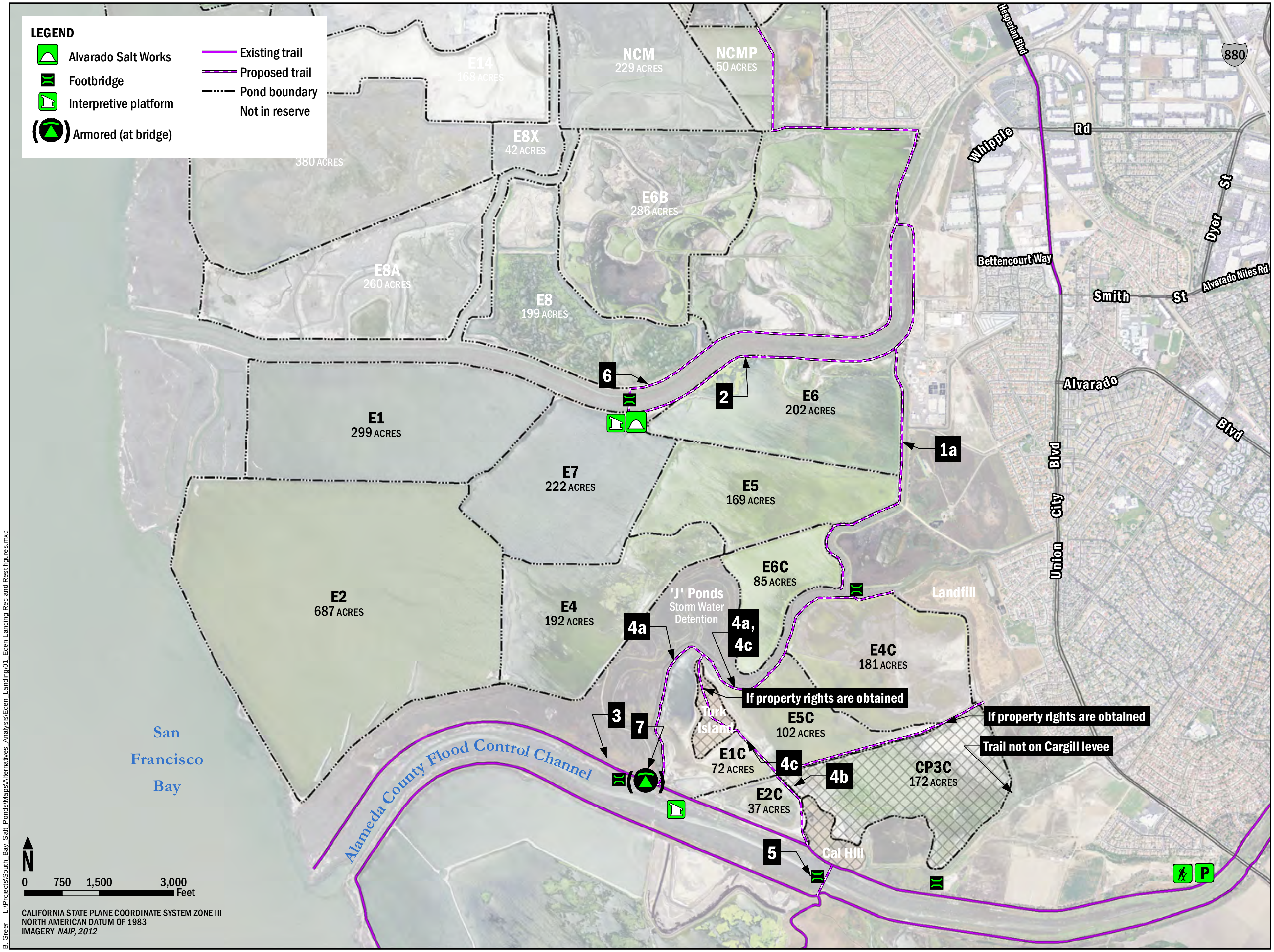
Access2
Least Recreation



URS

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Access3
Medium Recreation



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EDEN LANDING
Alameda County, CA

Access4
Most Recreation

Table 3. Restoration and Flood Protection Preliminary Alternatives

Fig. #	Preliminary Alternative Name (or Description, Purpose)	Primary Flood Control	Inland Ponds	Southern Ponds	Multi-Staged Resto-ration	Mid-Complex Levee	UTZs	Habitat Enhance-ments	Breach Control	Accept Dredge/ Upland Material	Fresh Water from USD
Rest1	No Action (No-Project)	Current (1a)	As Is (4a)	As Is (5a)	No	No (2a)	No (3a)	No (9a, 10a, 11a)	No (6a)	No (7a)	No (8a)
Rest2	Flood Protection from Backside Levee	Backside Levee (1c)	Tidal Marsh (4b)	Tidal Marsh (5b)	No	No (2a)	Yes (3b, 3d)	Yes (9b, 10c)	Yes (6b)	Yes (7c, 7d)	Yes (8c, 8d)
Rest3	Mix of Tidal Marsh and Managed Ponds	Land Mass (1b)	Managed Ponds (4d)	Managed Ponds (5d)	Yes	Yes – Perm. (2c)	Yes (3c, 3e)	Yes (9b, 10b, 11b)	Yes (6b)	Yes (7b, 7c, 7d)	Yes (8b)
Rest4	Full Tidal Restoration (staged)	Land Mass (1b)	Tidal Marsh (4c then 4b)	Tidal Marsh (5c then 5b)	Yes	Yes – Temp. (2b)	Yes (3b, 3d)	Yes (9b, 10b/c, 11b)	Yes (6b)	Yes (7b, 7c, 7d)	Yes (8b then 8c, 8d)
Rest5	Full Tidal Restoration (one-stage)	Land Mass (1b)	Tidal Marsh (4b)	Tidal Marsh (5b)	No	No (2a)	Yes (3b, 3d)	Yes (9b, 10b, 11b)	Yes (6b)	Yes (7b, 7c, 7d)	Yes (8c, 8d)

Table 4. Recreation and Public Access Preliminary Alternatives

Fig. #	Preliminary Alternative Name (Description*)	Recreation/Public Access Options
Access1	No-Project / No-Action	None
Access2	Least Recreation	1b, 3
Access3	Medium Recreation	1a, 2, 3, 4b, 5, 7
Access4	Most Recreation	1a, 2, 3, 4a, 4c, 5, 6, 7

*The use of terms such as “least” or “most” recreation is not intended to reflect a preference for or bias toward any particular degree of recreation. Rather, the terms are descriptions of the number of recreation and public access components included in that assemblage of components.

These components (i.e., those specific to restoration and flood control or to recreation/ public access) were then combined to form alternatives that would address all three project goals. These alternatives are those that would be carried forward into conceptual design and for consideration in the DEIS/R that will be prepared for Phase 2 activities at Eden Landing.

Two other adjustments were made. First, the recreation and public access components were reconfigured according to land ownership as follows:

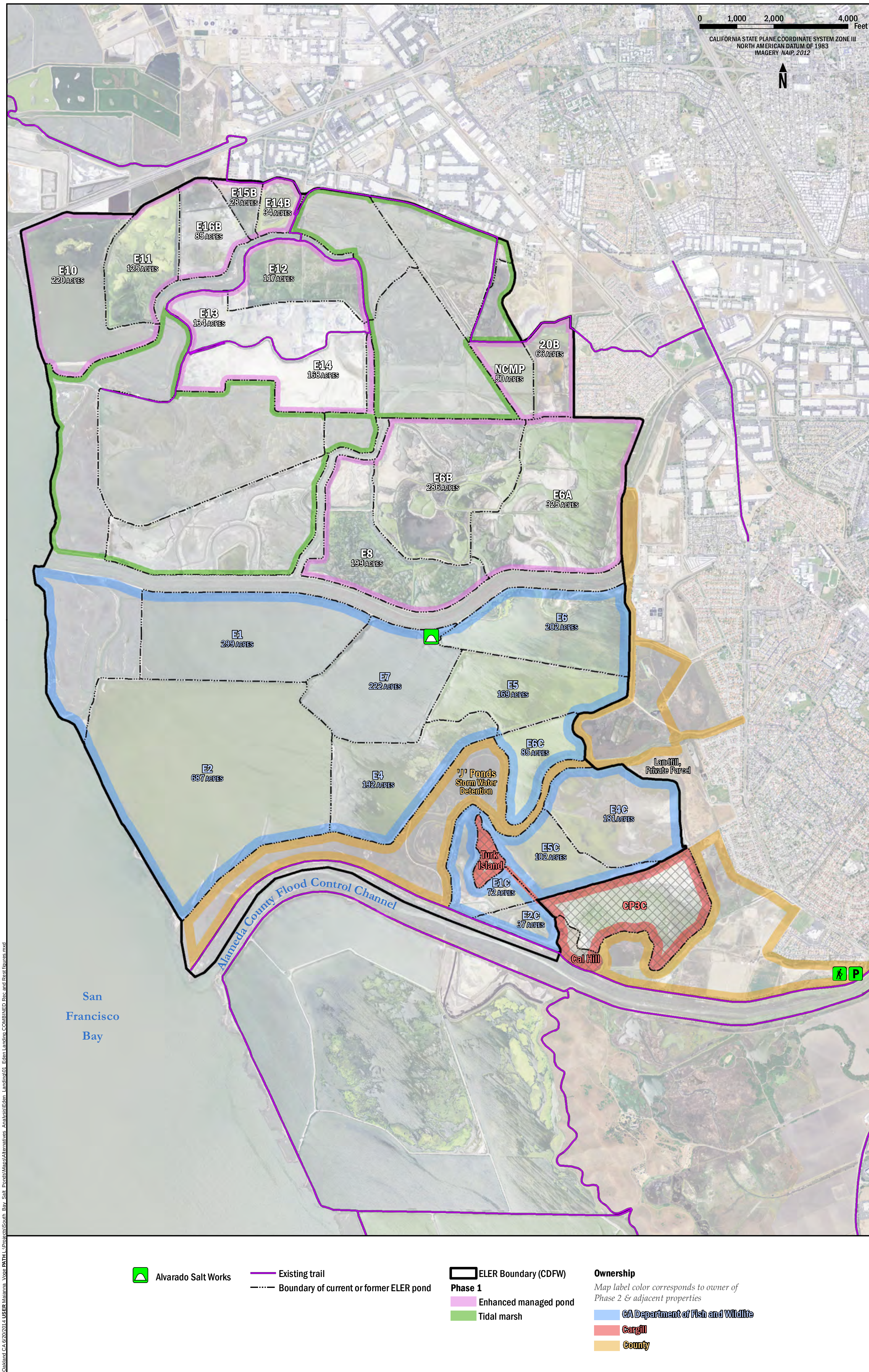
- No Action Alternative
- New recreation on Alameda County (and some CDFW) land
- New recreation entirely on CDFW land
- New recreation on lands acquired from Cargill & existing CDFW land

Note that the ownership was not used as a way to select the alternatives or the individual components. Rather, it was used as a way to group components and to illustrate how the range of options to include in the eventual selection of a Preferred Alternative would change based on the land that is available or that becomes available at that time.

Second, the backside levee and associated components in Rest2 were combined with the one-stage tidal recreation and associated components in Rest5. This combination reduced the number of preliminary alternatives to be carried forward without losing any individual component.

- No Action Alternative
- Flood protection from backside levee / one-stage tidal restoration
- Flood protection from land mass / mix of tidal marsh and managed ponds
- Flood protection from land mass / staged tidal restoration

Following those adjustments, the components were then combined into three preliminary action alternatives and a No Action (No-Project) Alternative. These preliminary alternatives will be refined as needed and evaluated in the DEIS/R for Phase 2 at Eden Landing. They are named Eden1 through Eden4, as noted in Table 5, which describes these preliminary alternatives and the components that make them up. Maps of these preliminary alternatives are presented as Figures Eden1 through Eden4 on the pages that follow.



South Bay Salt Pond Restoration Project
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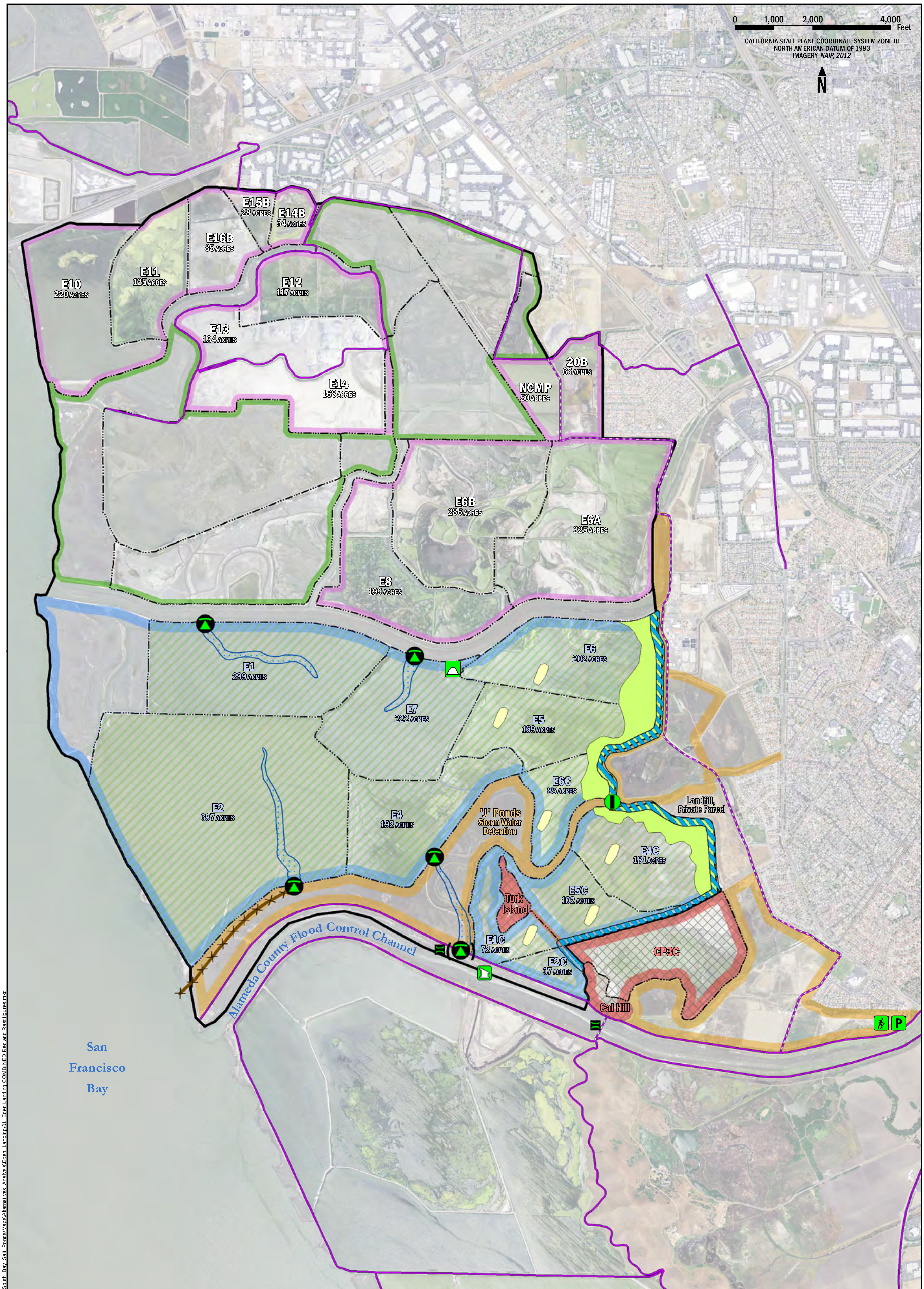
Eden1



Alvarado Salt Works
Footbridge
Interpretive platform
Proposed control gate
Breach
( ) Armored (at bridge)

Existing trail
Proposed trail
Boundary of current or former ELER pond
Channel excavation

Permanent levee
Pilot channel
Island/ mound
Upland transition zone

Phase 2 Goal
Tidal marsh

ELER Boundary (CDFW)

Phase 1
Enhanced managed pond
Tidal marsh

Ownership
Map label color corresponds to owner of Phase 2 & adjacent properties
CA Department of Fish and Wildlife
Cargill
County

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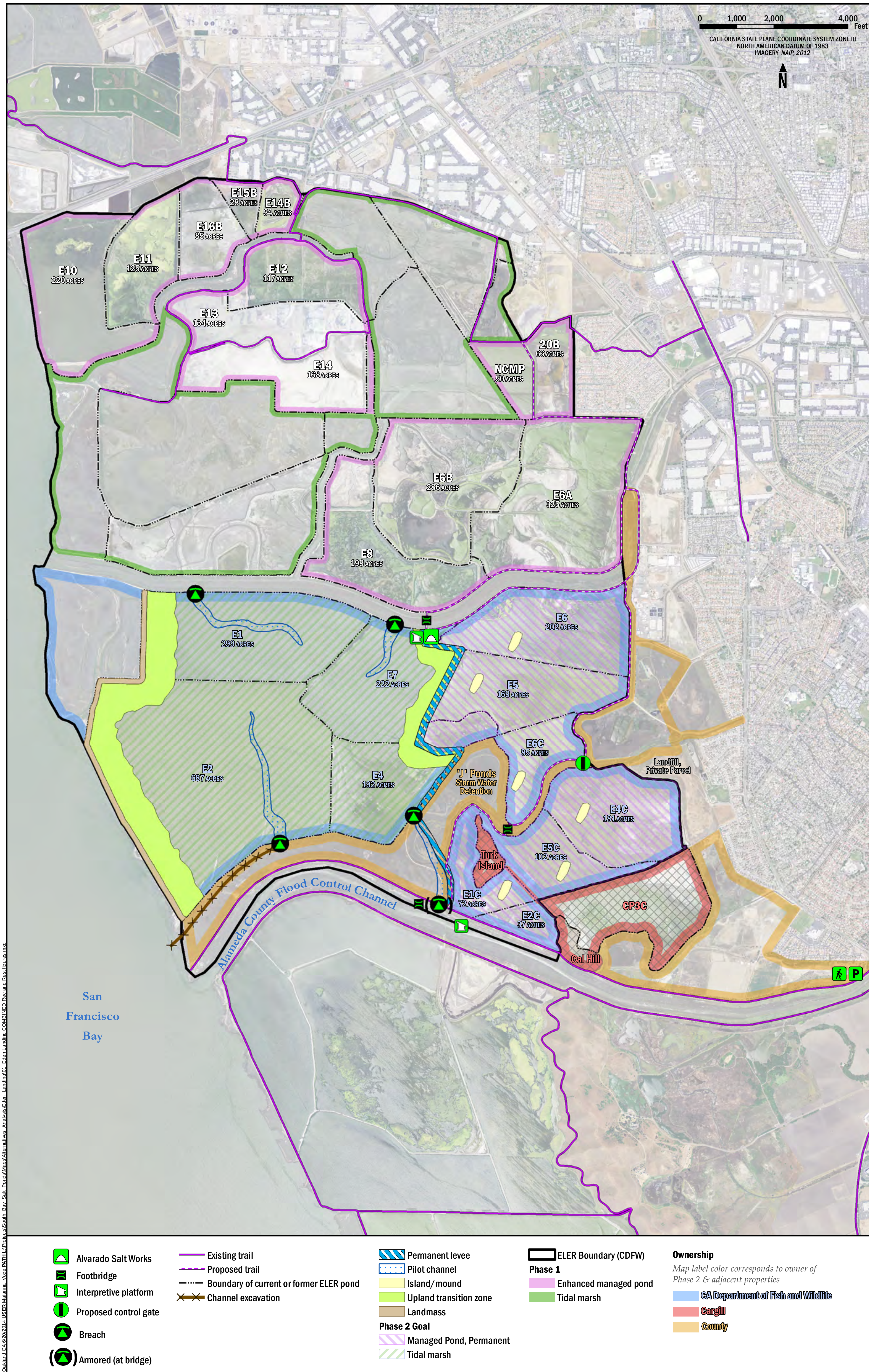
Eden2



South Bay Salt Pond Restoration Project
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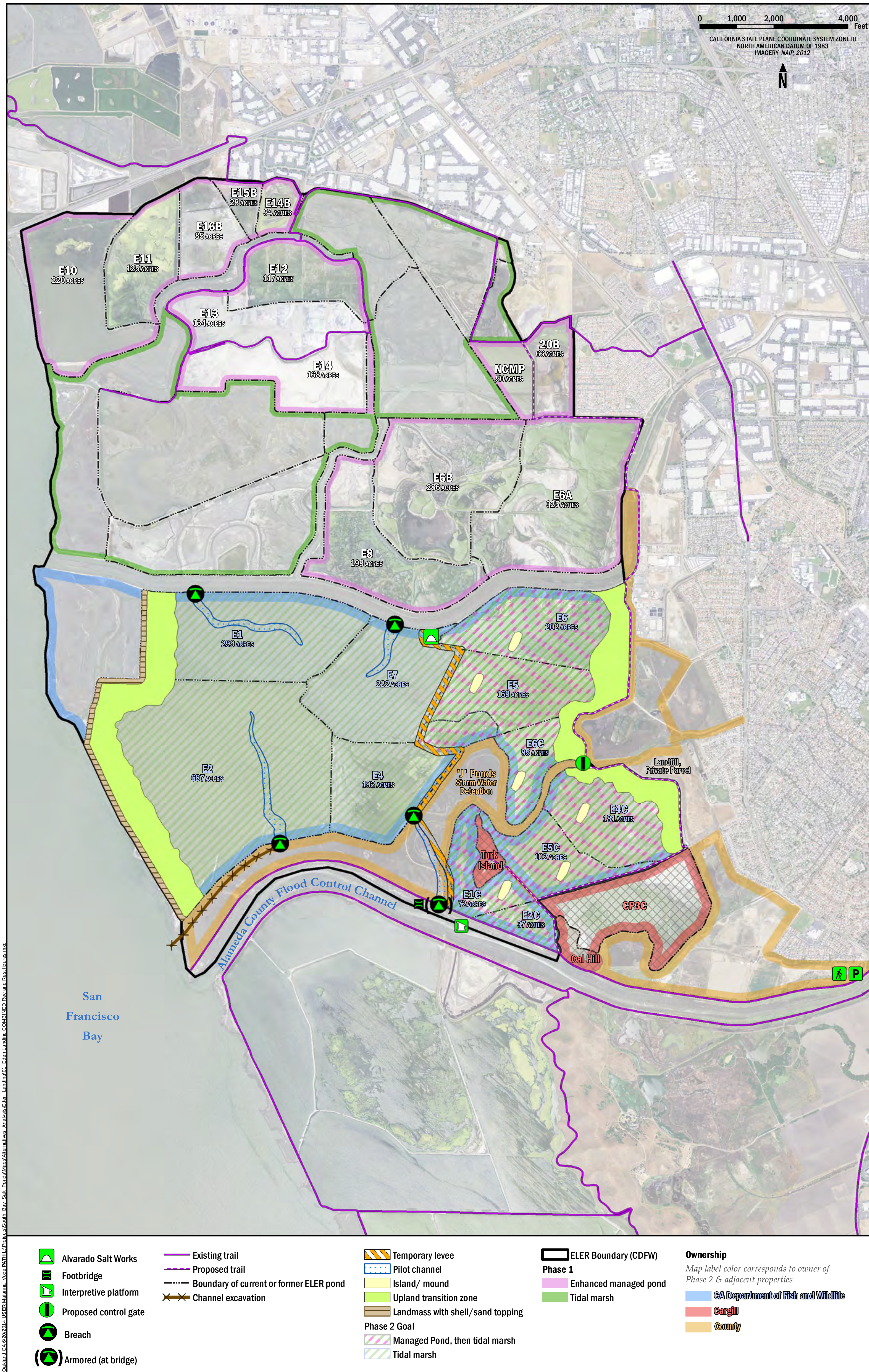
Eden3



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Eden4

Table 5. Preliminary Alternatives for Evaluation in DEIS/R as SBSP Restoration Project, Phase 2 Actions at Eden Landing

<table>
<tr><th>Alternative Name / Figure #</th><th>Alternative Description</th><th>Primary Flood Control</th><th>Inland Ponds</th><th>Southern Ponds</th><th>Multi-Staged</th><th>Recreation Components</th><th>Mid-Complex Levee</th><th>UTZs</th><th>Habitat Enhance-ments</th><th>Breach Control</th><th>Accept Dredge/ Upland Material</th><th>Fresh Water from USD</th></tr>
<tr><td>Eden1</td><td>No-Project / No-Action</td><td>Current</td><td>As Is</td><td>As Is</td><td>No</td><td>None</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td>Eden2</td><td>Backside Levee / One-stage Tidal Marsh Restoration / Recreation on Alameda Co. Land</td><td>Backside Levee</td><td>Tidal Marsh</td><td>Tidal Marsh</td><td>No</td><td>1b, 3, 5, 7</td><td>No</td><td>Inland Ponds and Southern Ponds</td><td>Deepwater channels; islands/marsh mounds</td><td rowspan="3">Armored at bridged breaches</td><td rowspan="3">For land mass, UTZs, and (if sufficient quantities available) for pond bottom elevation increases</td><td>On UTZs in Inland Ponds and Southern Ponds</td></tr>
<tr><td>Eden3</td><td>Mix of Tidal Marsh and Managed Ponds / Recreation on CDFW Land</td><td>Land Mass</td><td>Managed Ponds</td><td>Managed Ponds</td><td>Yes</td><td>1a, 2, 3, 4a, 6, 7</td><td>Yes - Permanent</td><td>Bay Ponds and Land Mass</td><td>Managed pond islands; shell topping on Land Mass</td><td>Into Inland Ponds for brackish marsh</td></tr>
<tr><td>Eden4</td><td>Two-staged Tidal Restoration / Recreation on CDFW land and land acquired from Cargill</td><td>Land Mass</td><td>Managed Pond, then Tidal Marsh</td><td>Tidal Marsh</td><td>Yes</td><td>1a, 4b, 4c, 7</td><td>Yes - Temporary</td><td>Inland Ponds, Southern Ponds, and Land Mass</td><td>Deepwater channels, islands/marsh mounts, shell topping on Land Mass</td><td>Into Inland Ponds (first for brackish marsh then for UTZ) and Southern Ponds (for UTZ)</td></tr>
</table>

Section 3. Alternative Development Process and Methods

Section 2 explained the development of the individual components and their rearrangement into preliminary alternatives. That discussion focused largely on the components, what they were intended to achieve, and their different combinations into preliminary alternatives for analysis in the DEIS/R. Other components and combinations of components not discussed in Section 2 had previously been created, developed, discussed, and eventually screened out as being unfeasible, prohibitively costly, or unacceptable from the position of one or more stakeholders.

In contrast, Section 3 presents the methods and processes by which some of the important details of these components were developed and selected. That is to say, Section 2 focuses on the “what,” while Section 3 focuses on the “how” and “why.” These ideas are presented in different sections to make the alternatives easier to find and compare with the maps that illustrate them, while separating out the details of the larger process, the modeling that went into certain aspects of the design, and so on.

The initial concepts for the preliminary conceptual designs were first drawn from the PEIS/R and the end state for each pond under Programmatic Alternative C. Then, the SBSP Restoration Project conducted an assessment of more recently developed ideas for enhancing restoration efforts by combining them with an innovative new idea for coastal flood risk protection—the land mass concept (discussed below)—and different staging options for restoration actions and recreation/public access improvements.

These options were explored and summarized in an Opportunities and Constraints Memorandum (O/C Memo), which was reviewed by the SBSP Restoration Project’s Project Management Team (PMT) and key stakeholders within it, including Alameda County. The memorandum was made available to outside stakeholders through the SBSP Restoration Project website. The O/C Memo was revised based on stakeholder input and several revised conceptual designs were presented at the Project’s annual Stakeholder Forum meeting.

In parallel with these efforts, the Alameda County Flood Control District (ACFCD) was conducting modeling and analysis on its own to determine the potential “solution space” for coastal flood risk protection using various combinations of breach numbers, sizes, and locations and what the associated tidal elevations were on the eastern edge of the Eden Landing complex. These models were run with and without a land mass in place.

The land mass, as has been presented at SBSP Restoration Project meetings, Stakeholder Forums, and other events by Rohin Saleh (MS, PE, Supervising Civil Engineer Watershed Planning Section, Alameda County Flood Control District), is a concept intended to obviate the need for a traditional backside levee placed directly between a developed area and a tidal body of water. The land mass would be a large earthen feature placed at some distance from the developed community, much like a barrier island is, with a smaller body of water between it and the developed land. The land mass would achieve with its large size (greater than 100 feet width at the top elevation and extending several thousand feet lengthwise) what more formally engineered levees achieve with tighter compaction of materials, footings, internal structures, and so on. ACFCD modeling efforts indicate that building a land mass on the western edge of Eden Landing and limited breaching of the levees within the interior of ELER to a small number of locations would dampen even the largest tidal flows and provide the necessary coastal flood risk protection to the developed lands behind the ponds. “Necessary”, here, is defined as providing sufficient flood protection such that the Federal Emergency Management Agency (FEMA) does not place those properties in its 100-year flood event inundation maps. Importantly, ACFCD also maintains that this protection could be provided at a lower cost than what it would take to build an engineered levee near the developed area. These costs include but are not limited to land or easement acquisition, design, construction, and certification.

A goal of ACFCD’s modeling was to determine feasible numbers, sizes, and locations of breaches in the exterior, perimeter, and interior levees that may be sufficient to provide adequate tidal exchange while maintaining coastal flood risk protection. Through this modeling, together with a series of workshops and meetings, the ACFCD, CDFW, and the SBSP Restoration Project were able to determine the feasibility of combined habitat restoration and coastal flood risk protection actions.

This determination led to the selection of up to four suitable sites for breaches on the northern and southern boundaries of southern Eden Landing. The breach locations were chosen to capitalize on the historical slough locations (as seen on digitized maps from before the levees were built for salt production). A breach in the northern ACFCC levee could be up to 100 feet wide and armored to allow a bridge to be placed on it (thus maintaining the current trail access to San Francisco Bay on that levee). The ACFCC armored breach would allow tidal flow from ACFCC into Pond E4 and provide adequate drainage. This breach may be fitted with a culvert, fish passage guide, or other infrastructure to help migrating steelhead or other salmonids enter and exit the high-value nursery and forage habitat that the pond interiors would become; this decision is for a future design stage and after additional negotiation with the National Marine Fisheries Service.

A second breach near the bay front would connect Pond E2 with the bay through an excavated channel through tidal marsh at the western end of the J-ponds. The excavated channel would be approximately 3,000 feet long.

The two northern breaches along Old Alameda Creek into Ponds E1 and E7 would not be armored or controlled, so their initial breach sizes (100 to 200 feet wide) could increase over time. Smaller breaches would be created along interior pond levees and could also be left unarmored and allowed to widen over time.

Working within that solution space, the Project then looked for habitat enhancements that could meet the habitat requirements of various species or guilds to provide habitat complexity and connectivity and to take advantage of opportunities for beneficial reuse of dredged material or material from upland construction projects or of treated water from the Union Sanitary District. The locations and combinations of these and other enhancements were discussed in Section 2.

The SBSP Restoration Project held a number of workshops to consider specific placement of the UTZs that had been previously described in the PEIS/R. Habitat islands for high-tide refugia and for use by nesting birds were added, drawing on the early results of the SBSP Project Science Program and applied studies. These islands would be created from grading remaining portions of levees or by constructing entirely new islands, but this decision is for a later design stage. The results from applied studies were discussed at workshops and were used to combine habitat features with suitable recreation and public access features.

The recreation and public access components were developed in collaboration with CDFW, the State Coastal Conservancy (SCC), EBRPD, the Association of Bay Area Governments (ABAG), other stakeholders, and the Project's contractors. Much like the restoration and habitat-enhancement features, the ideas for these components were initially pulled from the PEIS/R, included in the O/C Memo, and augmented with the Bay Trail Plan, the San Francisco Bay Conservation and Development Commission (BCDC) guidelines, and other sources. The recreation/public access components included some ideas that had not been previously considered because they are private land holdings that are not part of Eden Landing complex.

Several options would depend on the SBSP Restoration Project acquiring fee-title from Cargill for Pond 3C (also referred to as "CP3C") or uplands known as Turk Island and Cal Hill. The full list of many different recreation/public access components was presented at several working sessions. Some were infeasible because of access problems, expense, or conflict with restoration or flood control goals. Those were removed, but those that could become feasible if ownership changes or access easements were acquired were left in.

As noted in Section 2, consideration of all possible combinations of the restoration, recreation, and flood protection components would not have been feasible to present and analyze in an EIS/R. To narrow the options, CDFW, Alameda County, the PMT and other stakeholders decided to combine feasible restoration and coastal flood risk protection actions in such a way as to provide suitable locations for a reasonable range of recreation/public access improvements. This decision allowed development and screening of components and their combination into feasible preliminary alternatives that meet the SBSP Restoration Project goals to implement integrated habitat restoration, high-quality public access improvements, and coastal flood risk protection. These preliminary alternatives were presented to the PMT, the Stakeholder Forum, and other stakeholders; were refined as necessary; and combined into the most feasible preliminary alternatives for SBSP Restoration Project Phase 2 actions at Eden Landing. The combination of components required an analysis of feasibility (i.e., which restoration/public access components were technically possible to combine with the various restoration and flood control components), and the results of this analysis eliminated some, but not many, of the combinations.

Three primary combinations of restoration and flood control components were judged as most appropriate to include together: the backside levee would provide all necessary flood protection, so it was combined with full, one-stage tidal restoration. The land mass concept for flood protection allows tidal restoration with the improvement/construction of a mid-complex levee. That levee may be either temporary, which would leave the Inland Ponds and Southern Ponds as managed ponds for some time before they become tidal. If the Adaptive Management Plan findings show the need for more managed ponds, then the mid-complex levee could instead remain permanent, leaving the Inland Ponds, the Southern Ponds, or a subset of those ponds as enhanced managed ponds. These three main combinations of restoration and flood control components were then modified with enhancements like islands, UTZs, reuse of treated water, various fill materials, and so on.

Because it is extremely difficult and expensive to analyze more than three or four alternatives in an EIS/R, the process was similarly limited to three action alternatives for recreation/public access (ranging from new recreation opportunities on existing CDFW lands, on Alameda County lands, or a combination of both, as well as possible opportunities on other lands that may be acquired from Cargill). Those public access improvements were combined with the three primary action alternatives for habitat restoration and coastal flood risk protection to form the Preliminary Alternatives Eden2, Eden3, and Eden4, as described in Section 2. Combined with the No-Action/No-Project Alternative, this resulted in the preliminary Eden Landing Alternatives described in Section 2 and shown in the map figures. That list was presented to the PMT and stakeholders for their review, comment, and approval before being officially selected for analysis in the DEIS/R.

The DEIS/R will include evaluations and impact analyses of each of the individual components for habitat restoration, public access/recreation, and flood management. From those analyses and the comments received, some individual components of one or more of the draft alternatives may be selected and recombined into a Preferred Alternative for inclusion and analysis in the Final EIS/R.

APPENDIX C

PUBLIC SCOPING

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Scoping, or early consultation with persons or organizations concerned with the environmental effects of the project, is required when preparing a joint EIS/R. NEPA regulations Section 1506.6 requires that agencies make diligent efforts to involve the public in preparing and implementing their NEPA procedures. Pursuant to NEPA, a Notice of Intent to prepare an EIS/R for the South Bay Salt Pond Restoration Project, Phase 2 at Eden Landing was published in the Federal Register on June 20, 2016. Pursuant to CEQA Guidelines Section 15082, a Notice of Preparation was distributed to responsible agencies and the public on May 24, 2016. These notices announced a public comment period during which comments were received on the appropriate scope of the EIS/R. A public scoping meeting was held on June 30, 2016 to solicit comments on environmental issues to be addressed in the EIS/R. Scoping comments received during the scoping period, which ended July 20, 2016) are presented here.

I. Scoping Comment Letters Received (letters follow)

- Gayle Totton, Native American Heritage Commission
- Stacy Moskol
- L. Goldzband, Long-term Management Strategy
- Karen Vitulano, U.S. Environmental Protection Agency, Region IX
- Mike Giari, Port of Redwood City
- John Coleman, Bay Planning Commission
- Sandra Hamlat, East Bay Regional Parks District
- Carin High, Citizens Committee to Complete the Refuge
- Jeffrey Volberg, California Waterfowl
- Brenda Goeden, San Francisco Bay Conservation and Development Commission
- Lee Chien Huo, Bay Trail
- Erika Castillo, Alameda County Mosquito Abatement
- Ngoc Nguyen, Santa Clara Valley Water District

II. Summary Table of Scoping Comments

#	Commenter	Topic(s)
1	Gayle Totton, Native American Heritage Commission	Suggests including AB 52 and SB 18 consultation.
2	Stacy Moskol	Concerns about diving duck populations at E1 & E2, invasive plants islands clustering the marsh species and making them vulnerable to predators. Supports habitat transition zones.
3	L. Goldzband, LTMS; for other LTMS agencies and people	Supports beneficial reuse of dredge material, especially using Port of Redwood City and Port of Oakland material. References the Moffatt and Nichol feasibility study.
4	Karen Vitulano, EPA	Include sea-level rise (SLR) explicitly in the alternatives analysis. Include habitat transition zones. Place levee breaches at tidal marsh channels. Include beneficial reuse of dredged material. Identify and quantify all wetlands and waters of the U.S. and evaluate impacts on them. Discuss existing water quality conditions and how they would change: discuss runoff of sediments and pollutants, effects on fisheries, possible use of herbicides (including volumes, frequencies of application, etc.). Detailed discussion of ambient air conditions, NAAQS and nonattainment areas, estimate emissions from all project phases. Include evaluation of climate change effects from the project. They want details of invasive species control including costs. Requests details of funding costs for all project phases.

#	Commenter	Topic(s)
5	Mike Giari, Port of Redwood City	Supports beneficial reuse of dredge material, especially using Port of Redwood City. References the Moffatt and Nichol feasibility study.
6	John Coleman, Bay Planning Commission	Supports beneficial reuse of dredge material, especially using Port of Redwood City. References the Moffatt and Nichol feasibility study.
7	Sandra Hamlat, EBRPD	Points us to several applicable Master Plan policies that we need to include and address. Also expressed serious concern about the alternatives going onto city streets. They prefer the routes with bridges and then note that the bridges need to be drivable for 6,000-lb. maintenance trucks. The bridges that cross OAC and ACFCC need to have removable center sections so that the channels can be dredged.
8	Carin High, Citizens Committee to Complete the Refuge	General support; request to include the following information: baseline data of all species; mapping showing depths and salinities of ponds; existing management challenges that may affect the Phase 2 actions; species that may be displaced by the Phase 2 actions and possible places for them to go. Recommend phased tidal marsh restoration (Alt Eden D), along with an implementation timeline. Request details on how managed ponds would be managed; invasive species management; outboard levee; and root wads. Address species near the proposed public access trails and what measures could be used to protect those species.
9	Jeffrey Volberg, California Waterfowl	Would like to maintain or increase hunting opportunities at Eden Landing.
10	Brenda Goeden, BCDC	Clarifies BCDC jurisdiction at Eden Landing. Refers to the Bay Plan and its guidance. Fill in the bay for restoration. Encourages maximum feasible public access. Encourages beneficial reuse of dredged material. Recommends alternatives that consider SLR adaptation and other aspects of it. Public access features should be built to avoid future impacts from SLR. Include habitat features that protect shorelines.
11	Lee Chien Huo, Bay Trail	Support for Bay Trail inclusion at southern Eden Landing. Wants the Bay Trail as close to the bay as possible, has views of the bay, that is separated from streets, and that has connection with shoreline parks. To that end, they like the Route 1 trail through Eden Landing, and they want the bridge over the ACFCC.
12	Erika Castillo, Alameda County Mosquito Abatement	Support for including vector control in the EIS/R. Provided several measures to reduce possible future impacts from mosquitoes. Prefers unphased tidal marsh restoration (Alt Eden B) for best avoidance of mosquito issues.
13	Ngoc Nguyen, Santa Clara Valley Water District	Supports beneficial reuse of dredge material, especially using Port of Redwood City. References the Moffatt and Nichol feasibility study.

III. June 30, 2016, Scoping Meeting: Agenda and Sign-In Sheet

APPENDIX D

SOUTHERN EDEN LANDING PRELIMINARY DESIGN MEMORANDUM

ATTACHMENT 1. SOUTHERN EDEN LANDING RESTORATION PRELIMINARY DESIGN: 1D AND 2D HYDRODYNAMIC MODELING

ATTACHMENT 2. EDEN LANDING GEOTECHNICAL INVESTIGATION AND ANALYSES

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MEMORANDUM

TO: Members of the South Bay Salt Pond Restoration Project Management Team

FROM: AECOM

DATE: October 2016

RE: **Southern Eden Landing Restoration Preliminary Design**

1. INTRODUCTION

This memorandum documents the preliminary design of the South Bay Salt Pond (SBSP) Restoration Project's Phase 2 actions at the southern half of the Eden Landing Ecological Reserve (ELER). For the purposes of this document, these ponds are referred to as the southern Eden Landing Ponds. This memorandum provides information for the CEQA and NEPA clearance, regulatory agency permitting processes, and a basis for the next, more detailed design phase.

1.1 Project Background

The ELER, and the southern Eden Landing Ponds within it, are owned and operated by the California Department of Fish and Wildlife (CDFW). This complex is near the eastern end of the San Mateo Bridge, south of State Route (SR) 92 as it passes through the City of Hayward in Alameda County (see Appendix A, Figure A-1). The Phase 2 actions at southern Eden Landing are focused on the ponds south of the Old Alameda Creek (OAC) and north of the federally constructed Alameda Creek Flood Control Channel (ACFCC). Existing public access components include alignment of the San Francisco Bay Trail "spine" such that the trail connects from the existing SF Bay Trail within the northern half of ELER to the existing Alameda Creek Regional Trail operated by East Bay Regional Park District (EBRPD) along ACFCC.

The Phase 2 Eden Landing preliminary design, along with the rest of the SBSP Restoration Project, is managed by the SBSP Project Management Team (PMT), which includes the State Coastal Conservancy (SCC), U.S. Fish and Wildlife Service (USFWS), CDFW, Santa Clara Valley Water District (SCVWD), and others.

The Programmatic EIS/R for the SBSP Restoration Project (EDAW 2007) prescribed the initial framework under which restoration would proceed. In that document, program-level alternatives range from a restoration design of 50/50 tidal action/managed pond scenario for the entire restoration project area (Programmatic Alternative B) to a 90/10 tidal action/managed pond scenario for the entire restoration project area (Programmatic Alternative C) (see Appendix A, Figures A-11 and A-12). Programmatic Alternative C was selected and used as a foundation for project-level planning. Phase 1 of the project has since been completed, and involved restoring clusters of ponds at all three pond complexes. The Phase 1 actions at northern Eden Landing were completed in 2016 and included year-round and seasonal trails, a kayak launch, and a combination of tidal marsh restoration and enhancements to managed ponds to improve habitat for various species.

A design charrette was held May 13, 2010 to discuss conceptual restoration design ideas for Phase 2 of the project. Ideas proposed in the charrette document were further refined in coordination with the PMT to develop memoranda that described the opportunities and constraints associated with the construction or implementation of design ideas (URS 2012).

From this, through a year-long process of developing and screening alternatives, modeling the tidal and fluvial peak water elevations that would result, and assessing rational combinations of recreation and public access alternatives, three conceptual designs for action alternatives were developed and finalized with the PMT and other stakeholders including the Alameda County Flood Control and Water Conservation District (ACFCWCD), the EBRPD, and the Association of Bay Area Governments (ABAG). These three preliminary design concepts are described in detail in the Eden Landing Preliminary Alternatives Analysis Report (URS 2014a) and served as the basis for the alternatives proposed in this preliminary design memorandum.

This set of three alternatives was developed for conceptual design and analysis in the site-specific Public Draft EIS/EIR for Phase 2 at Eden Landing. Following the public comment period, a preferred alternative that best meets the project objectives while providing a cost-efficient design will be identified in the Final EIS/EIR. This memorandum describes the work conducted as part of the conceptual level design.

1.2 Organization and Scope

This memorandum presents the conceptual (approximately 10% to 30%) design for the Phase 2 action alternatives at the southern Eden Landing Ponds. It also briefly documents the design constraints and considerations that formed the basis for the conceptual design.

The preliminary design memorandum is organized as follows:

- Section 1: introduction, organization, and limitations
- Section 2: objectives, design constraints, and considerations
- Section 3: preliminary design analyses, including hydraulic modeling, salinity/water quality management approaches, and topography and geotechnical data
- Section 4: preliminary design including restoration components, construction implementation

1.3 Limitations

This memorandum provides a preliminary design based on information available at the time and professional judgment pending future engineering analyses. Future design decisions or additional information may change the findings, and corresponding professional judgments presented in this memo. Additional engineering will be necessary prior to construction. In the event that conclusions or recommendations based on the information in this memorandum are made by others, such conclusions are not the responsibility of AECOM, or its subconsultants, unless we have been given an opportunity to review and concur with such conclusions in writing.

2. OBJECTIVES, DESIGN CONSTRAINTS, AND CONSIDERATIONS

The southern Eden Landing Ponds includes 11 ponds that are described in three groups in this memorandum, based on their location within the complex and their proximity and similarity to each other. The groups are as follows and as shown in Figure 2.1:

- The Bay Ponds: Ponds E1, E2, E4, and E7 are the four large ponds closest to San Francisco Bay, bordered to the north by the OAC and to the south by Alameda County-owned property including the Alameda County Wetlands and the ACFCC.
- The Inland Ponds: Ponds E5, E6, and E6C are somewhat smaller ponds in the northeast portion of the complex. They are bordered to the north by OAC, to the east by the Union Sanitary District Waste Water Treatment Plant and Alameda County owned property (used by the Southern Alameda County Radio Controllers Aircraft Club), and to the south by an Alameda County-owned freshwater outflow channel and diked marsh areas known collectively as the "J-Ponds".
- The Southern Ponds or C-Ponds: Also sometimes called the C-Ponds, the Ponds E1C, E2C, E4C, and E5C are in the southeastern portion of the complex. They are separated from the Inland Ponds and the Bay Ponds by the J-Ponds. The Southern Ponds are bordered to the east by property owned by Cargill (Cargill Pond 3C).

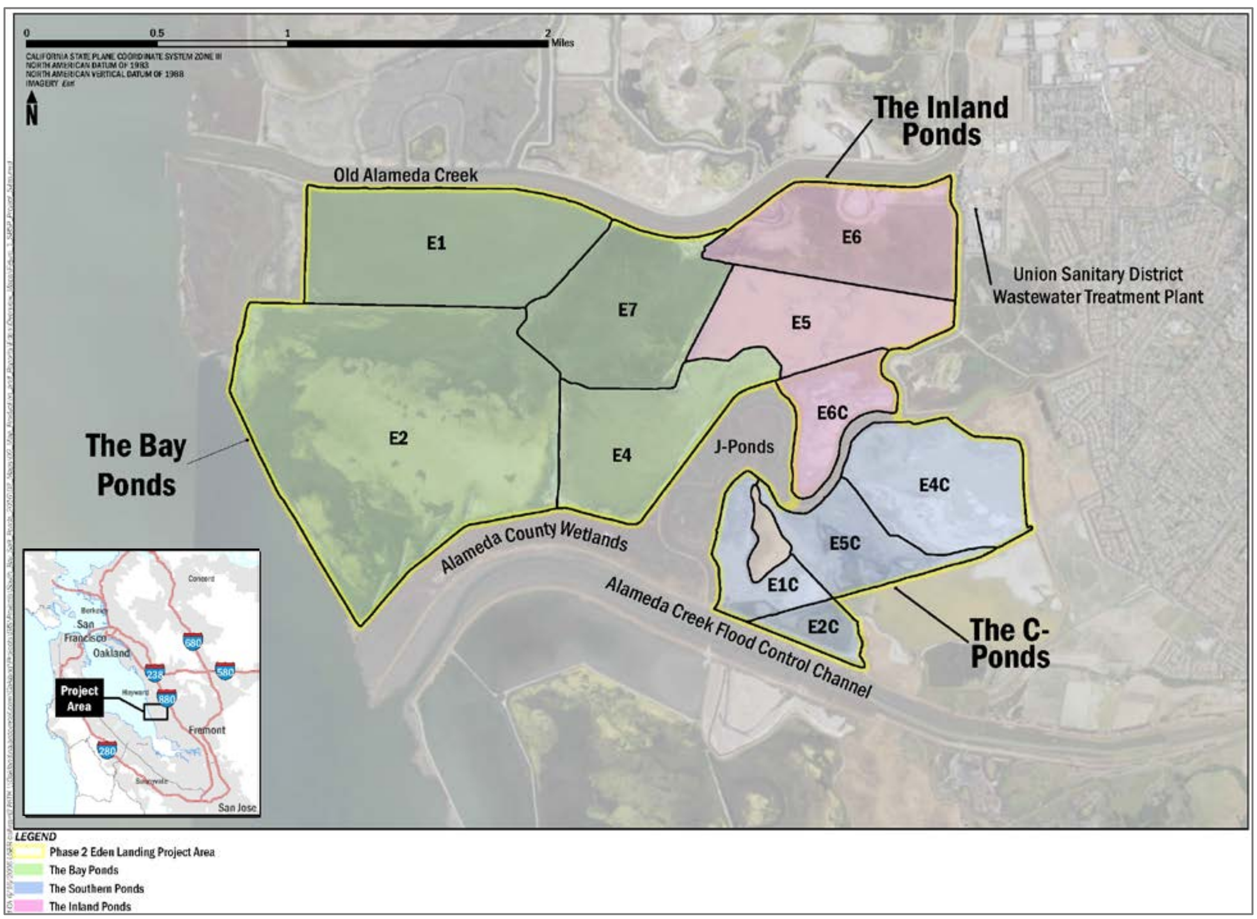

Figure 2.1. Project Vicinity Map

2.1 Objectives

The Phase 2 objectives for southern Eden Landing include a restoration action objective, a flood protection objective, and a recreation and public access objective. The objectives are summarized below.

- *To restore and enhance a mix of wetland habitats*. Restored habitat should be of sufficient size, function, and appropriate structure to promote restoration of special status species, support current migratory bird species that utilize existing salt ponds and associated structures, and increase abundance and diversity of native species in various South San Francisco Bay aquatic and terrestrial ecosystem components (EDAW et al. 2007). In particular, under both Programmatic Alternative B and Programmatic Alternative C, the entire southern Eden Landing ponds would all be restored to tidal marsh. Under Alternative D a portion of the Eden Landing ponds would be restored to tidal marsh.
- *To provide flood protection in the South Bay*. All project designs and features (e.g. levee improvements) would provide the same level of protection as existing features (i.e. match existing outboard levee elevations), and restored tidal marsh is expected to provide additional flood protection in the long-term. Additionally, at Eden Landing, the flood protection options must direct attention to the topic of fluvial flooding and drainage in the federal ACFCC and not increase current flood risk or reduce the level of protection currently provided against both tidal and fluvial flooding.
- *To provide wildlife-oriented public access and recreational opportunities*. Public access activities may include hiking, wildlife viewing, occasional hunting and fishing, and other wildlife-compatible recreational activities.

The restoration preliminary design summarized in this memorandum was developed taking into account several design constraints and considerations. Design constraints are limiting factors that must be considered while developing the design. Design considerations are issues that contribute to design formulation, but are not limiting factors.

2.2 Design constraints

- *Flooding.* The primary constraint on the introduction of tidal action is that – following breaching of the Eden Landing ponds – fluvial and/or tidal flooding could increase in the areas to the east of the ponds unless additional flood protection is provided. Thus, in order to introduce tidal action to southern Eden Landing, additional flood protection may be required. There are two primary options for coastal flood protection: a landside and a mid-complex levee. Multiple-staged (or phased) restoration could be supported by a mid-complex levee, which could be kept either permanently or temporarily for adaptive management purposes and/or monitoring wildlife response to restoration activities.
- *Breaches.* The number, size, and location of internal and external levee breaches were sized to allow tidal flows into the ponds at southern Eden Landing. AECOM performed hydrodynamic modeling to simulate regular daily tides as well as 100-year tides separately and in combination with peak storm water outflows (e.g., 100-year fluvial flows) under a range of breach scenarios. The alternatives developed and presented here satisfy the SBSP Restoration Project's goal of filling and draining the ponds with each day's tides while still providing the same or better flood protection against extreme tidal and fluvial elevations.

- *Federal Levees.* The ACFCC is bordered by the northern and southern Federal levees. Breaching the northern levee to connect the C-Ponds or the Alameda County Wetlands to the ACFCC would require a permit from the ACFCWCD, a Section 408 permit from the U.S. Army Corps of Engineers (USACE), potential de-authorization of a portion of the Federal project, and act of Congress to do so, and potential construction of additional Federal levees to protect against the 100-year fluvial flows. For these reasons, full breaches in the ACFCC were eliminated in the design and replaced with water control structure (i.e., culvert) options for the purpose of fish passage from ACFCC into southern Eden Landing.
- *Erosion and scour.* Reintroducing tidal flows into southern Eden Landing may result in erosion and scour of the OAC, which will be the main conveyance channel for the increased tidal prism entering southern Eden Landing. An undersized or non-hardened levee breach may result in erosion and scour of the remaining levee; in some places, this effect is a goal of the project. Tidal flows through new breaches are also expected to scour channels in the tidal marsh.
- *Volume of fill material.* The ability to construct habitat transition zones between pond bottoms and the adjacent uplands or levees, the bay-side levee, the mid-complex or landside levee, and extent of levee enhancements will depend on the volume and type of fill available for reuse. Fill material may come from onsite pilot channel excavation or from offsite (upland) construction sources. From a construction perspective, the excavation and placement of material is ideally balanced on a site understanding that different material types may not be used for all purposes.
- *Public access near sensitive species habitat.* Providing recreation and public access is a key goal of the project, but in some areas, public access may negatively affect wildlife using the area.
- *Permitting.* Impacts to wetlands, fill volumes, and impacts to special-status species could all affect the ability to obtain permits on the desired schedule.
- *Long-term maintenance.* Constructed features such as levees, trails, and water control structures will need to be maintained into the future.
- *Soils and hydrology*. Habitat restoration is in part dependent on the soils and hydrology of the site. Habitat opportunities are limited by the existing or constructed environmental conditions. Because the C-Ponds will continue to experience a muted tide due to the limited conveyance through culverts (as opposed to a breach), habitat establishment may be slower and of a different value compared to the other restored areas in the complex.
- *Existing rights-of-way, easements, and utilities.* These features may serve as constraints to installation of control structures, culverts, or other features. The preliminary design needs to consider rights-of-way owned by Alameda County, the Cargill Company, and others. These groups would need to be notified and included during the design process if construction would impact their properties, facilities, or rights-of-way.

2.3 Design considerations

- *Reconnection of historic sloughs.* The design breach locations consider the position and size of historic slough systems, taking advantage of areas where natural conditions may already exist for channel formation and water exchange capacity.
- *Sedimentation.* The existing levees, if left in place, will help slow the discharge of flood and tidal waters, increasing the potential for natural sedimentation within the ponds. This sedimentation is desired to raise pond surface elevations to levels that promote the growth of tidal marsh vegetation species and to provide resiliency for sea level rise.

- *Predation.* Levee breaches may serve to isolate habitat from upland predators. Connecting levees through bridges and trails for public access may limit this value.
- *Fish nursery habitat.* The tidal marsh habitat and channel network provided through the restoration of tidal action into the ponds could provide protected fish nursery habitat, ultimately increasing fish and populations and recreational opportunities for fishing and birding.
- *Habitat transition zone habitat.* The primary purpose of the habitat transition zones is to provide habitat complexity and refugia for tidal marsh wildlife species during high tides. In addition, the transitional area will provide resiliency to sea level rise and may provide opportunity for improved public education and outreach.
- *Western snowy plover.* Ponds in northern Eden Landing were enhanced for and are currently being managed to provide habitat for nesting western snowy plover. This provides some latitude for emphasizing tidal marsh restoration in southern Eden Landing. However, additional habitat to support this species may be able to be provided in the short-term (e.g., by leaving large sections of breached levees as habitat islands or by retaining some of the Inland Ponds or C-Ponds as managed ponds with habitat suitable for western snowy plover nesting). Long-term maintenance of these features would continue under a managed pond scenario, however would cease with the tidal marsh restoration scenario as the islands will either become vegetated or eroded over time. Substrate (e.g., shells, salt, sand), visual screens, and size and location (e.g., distance from trails) are all factors in the design of western snowy plover habitat.
- *Hydrology.* The number and location of the breaches and the decision to utilize and expand existing borrow ditches influences filling and draining of the restored ponds. Hydrology was assessed and modeled to inform the preliminary design.
- *Recreation.* Retained levees provide opportunity for recreation and educational signage describing the restoration. Breaches and sensitive wildlife habitat may limit locations for recreational opportunities.
- *Site access.* In addition to serving as recreational facilities, trails increase accessibility for scientists to study wildlife and conduct required monitoring, while also increasing access for maintenance and operational activities.
- *Water quality.* Adequate circulation, more of an issue in managed ponds than in the breached and tidal ponds planned for southern Eden Landing, remains necessary to prevent dissolved oxygen (DO) levels from dropping too low. Pond design elements, such as complete tidal drainage, can reduce the risk of low DO.
- *Material quality.* Imported fill material from upland sources will require environmental screening to assess suitability based on material type and constituent concentrations (USFWS 2012). A Quality Assurance Project Plan (QAPP) and permit will be required to accept upland fill placement at southern Eden Landing.

3. AVAILABLE DATA AND PRELIMINARY DESIGN ANALYSES

AECOM developed a two-dimensional hydrodynamic model using MIKE21 to refine the design of restoration features including levee breach and pilot channel dimensions, levee raising and lowering heights and locations, and culvert locations and numbers. A one-dimensional hydraulic model using HEC-RAS was also developed to efficiently analyze culvert sizes for the C-Ponds and Inland Ponds, as HEC-RAS has a more robust culvert routine and the model runtime is minutes instead of hours with MIKE21. Analyses were performed on the three project action alternatives (Alternatives Eden B, C and D). These alternatives are graphically depicted in Appendix A on Figures A-3, A-4, and A-5.

3.1 Site Topography and Project Datum

Table 3.1 lists the three sources of topographic and bathymetric data used in this preliminary design and associated modeling analysis.

Table 3.1. Topographic and Bathymetric Data

Data Source	Year Collected	Horizontal Datum	Vertical Datum	Projection
USGS 2010 SBSP Project LiDAR	2010	NAD83	NAVD88	UTM-10 10N
USGS 2005 SBSP Project Bathymetry	2003-2004	NAD83	NAVD88	CA State Plane III
USGS (Foxgrover et al.) 2007 South San Francisco Bay Bathymetry	2005	NAD83	NAVD88	UTM-10 10N

The available site topography is high-accuracy LiDAR from the 2010 USGS San Francisco Coastal LiDAR project (San Francisco, Marin, Solano, Contra Costa, Alameda, San Mateo, Santa Clara counties, California). The LiDAR data was collected between June 11, 2010 and July 11, 2010.

USGS (2005) also conducted a bathymetric survey of the SBSP Project pond complexes between August 2003 and March 2004 using a shallow-water sounding system to measure water depths with a precision of 1 cm. The system was comprised of a single beam echosounder, a differential global positioning system (DGPS) unit, and a laptop computer on a shallow-draft kayak with a trolling motor. Sample depths were converted to elevation based on water surface elevations recorded every 15-20 minutes at the ponds. Transects were made at 100 meter intervals.

The below water elevations in the Bay adjacent to the project site were obtained from 2005 Hydrographic Survey of South San Francisco Bay, California by Foxgrover et al. (USGS), published in 2007. These data consisted of xyz data collected using a single beam acoustic sampler.

The digital elevation point files used in the hydrodynamic model were generated by merging the three sets of data using the horizontal spatial reference system of NAD83, CA State Plane III meters and vertical datum NAVD88, meters.

The data from the bathymetric survey of the SBSP pond complexes and the bathymetric survey of the South Bay were inserted into areas with no LiDAR coverage (to prevent overlapping points between the datasets). To reduce the number of LiDAR points for use in CADD and the hydrodynamic model, the LiDAR datasets were down sampled using a “model key point” algorithm. “Model key points” are points selected to represent local topography and are not removed during a point thinning process. This algorithm thins the ground class within a user-specified vertical tolerance. Areas which exhibit a greater variation in the terrain have more model key points than in areas with a smaller variation in terrain (for example a parking lot). The vertical tolerance parameter required for the algorithm mandates that a triangulated irregular network (TIN) surface generated from the model key points would be within the user-specified distance of a TIN surface generated from the original ground points. The algorithm vertical tolerance parameter was set to 6 inches (0.15 meters) for this study.

In general, the project site is comprised of fairly flat pond bottoms separated by levees. Many of the levees have borrow ditches directly adjacent to them. Figure 3.1 depicts the distribution of pond bottom elevations of the three groups of ponds, most of which are between MSL and MHW. About half of the pond bottoms are 1 ½ to 2 feet or more below MHW and less than 10% are higher than MHW. The C-Ponds are the highest group of ponds, followed by the Inland and Bay Ponds.

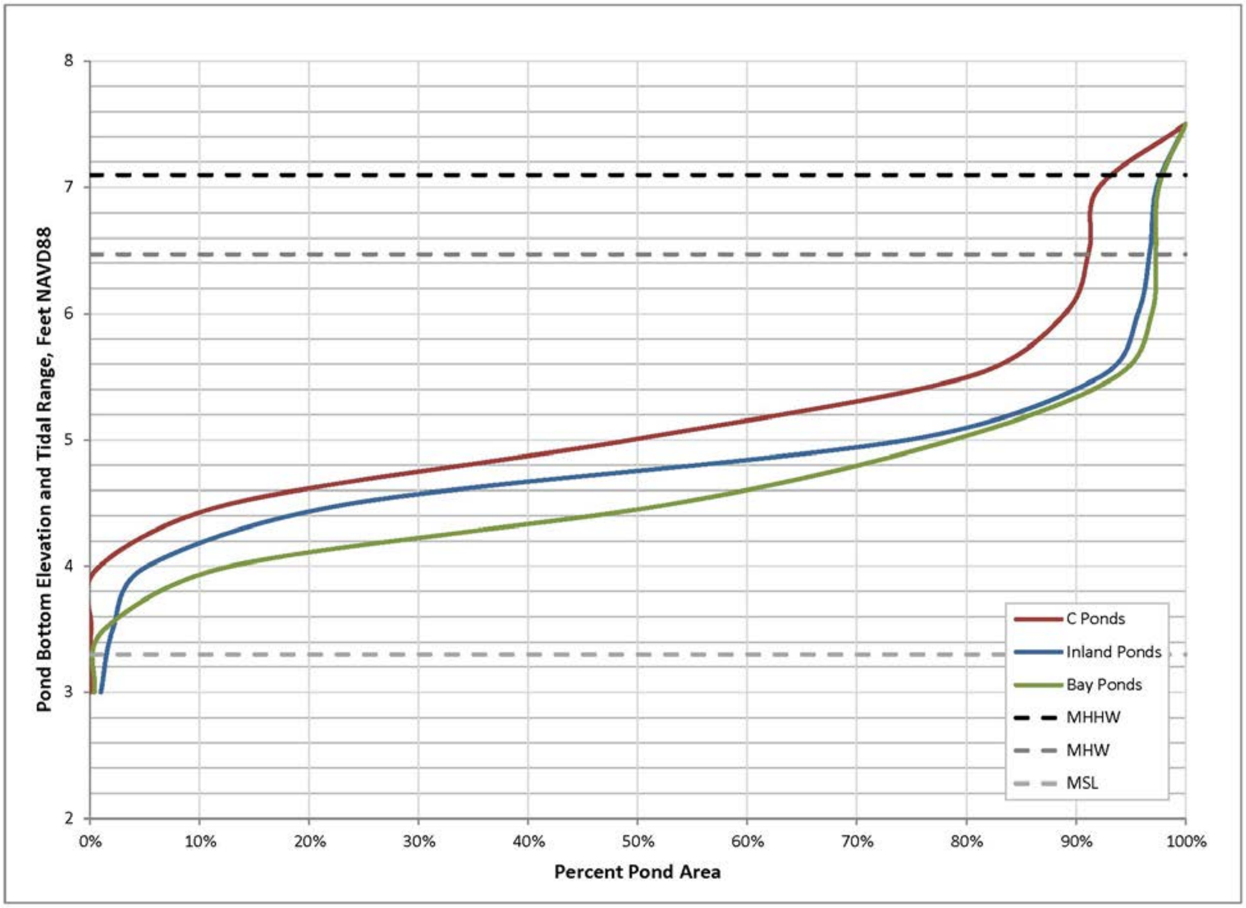

Figure 3.1. Average Pond Group Bottom Elevations

3.2 Historical Slough Network

The historical slough network (mid-1800s) in the project vicinity is shown in Figure 3.2 (SFEI 2013). As indicated by the red arrows and the dashed line, approximately half of the Bay and Inland Ponds historically drained to the south across the present-day Alameda County property and towards the present location of the ACFCC. A large part of Pond E2 drained directly to San Francisco Bay. Because breaching the federal ACFCC levees and the County's J Pond Stormwater Detention Basin levees is a design constraint, recreating the historical slough network was not possible. The proposed levee breach and pilot channel designs described in this memo attempt to align with historical slough features where possible.

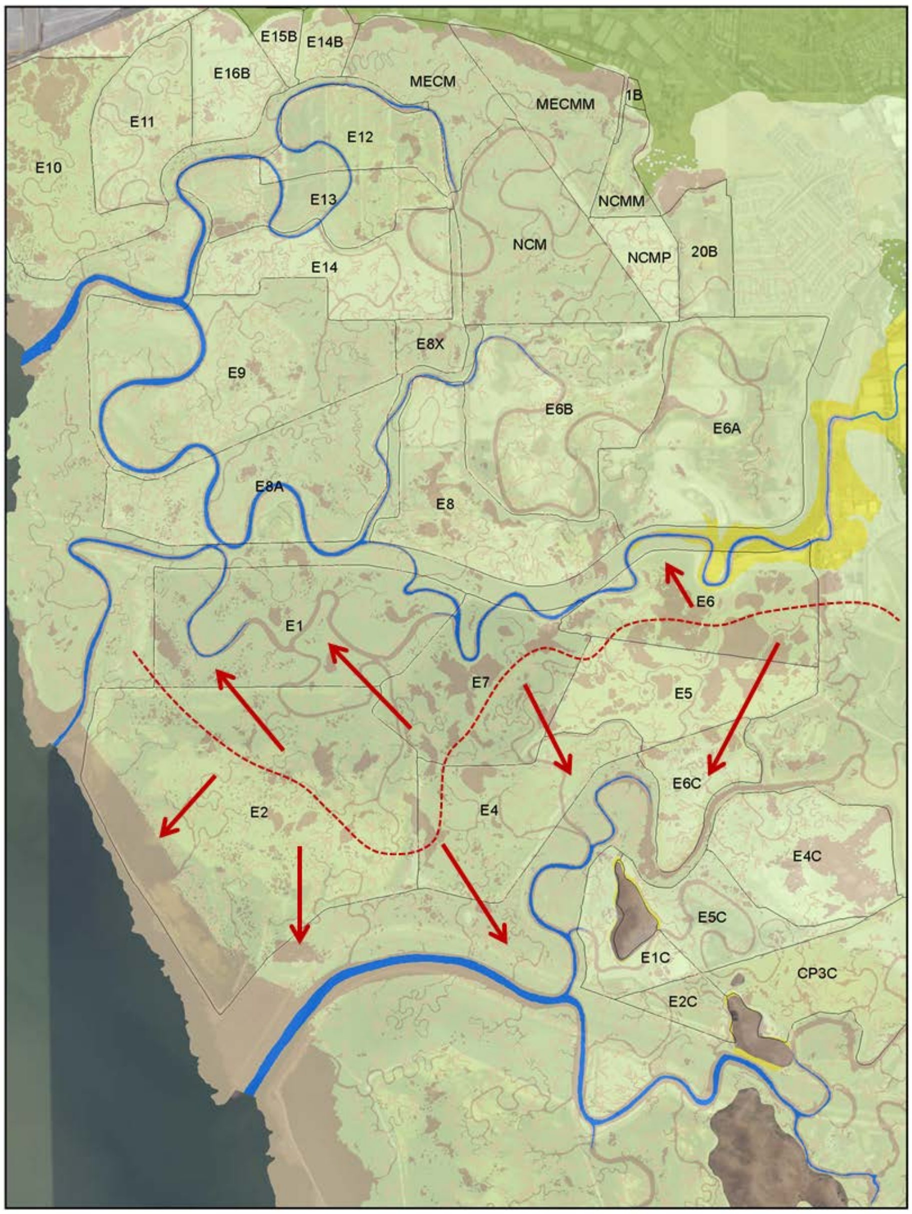

Figure 3.2. Historical Tidal Sloughs and Local Watershed Division

3.3 Hydrologic Data

Water Levels

Water surface elevations representative of tides at Eden Landing were obtained from the Redwood City tide gauge (NOAA gauge 9414523), located roughly 7 miles (11 kilometers) west of Eden Landing. The 6 minute daily tide data were obtained from National Oceanic Atmospheric Administration's Tides and Currents website (NOAA 2016) and converted to NAVD88 using NOAA conversions listed in AECOM 2016. Table 3.2 summarizes the tidal datums for the three NOAA tide gauges near the project site, showing that the mixed-semidiurnal tides are amplified in the South Bay from a MHHW elevation of 6.9 feet at San Mateo Bridge up to 7.2 feet at Dumbarton Bridge and MLLW from -0.8 to -1.4 feet. Sources of conversions from tidal to geodetic (NAVD88) datum are listed in Table 3.2.

Table 3.2. Tidal Datums and Extreme Still Water Tide Levels in South Bay

	San Mateo Bridge West, CA Station ID 9414458	Redwood City, CA Station ID 9414523	Dumbarton Bridge, CA Station ID 9414509
	Feet, NAVD88	Feet, NAVD88	Feet, NAVD88
100-year[1]	10.4	10.7	10.9
10-year[1]	9.3	9.4	9.6
MHHW	6.92	7.10	7.20
MHW	6.29	6.47	6.59
MSL	3.31	3.30	3.27
MTL	3.34	3.28	3.22
NAVD88	0	0.00	0
MLW	0.39	0.10	-0.15
MLLW	-0.80	-1.10	-1.41
NAVD88 Datum Source	Foxgrover et al. 2007	AECOM 2016	NOAA 2016

[1]Extreme still water tide levels from the *San Francisco Bay Tidal Datums and Extreme Tides Study Final Report* (AECOM 2016).

Riverine Discharge

The hydrographs for the 10- and 100-year discharge events from the OAC and ACFCC are shown in Figure 3.3. The hydrographs were obtained from DHI (2015). To confirm that the hydrographs represent a reasonable approximations to the 10- and 100-year events HEC-SSP V2.0 was used to analyze 56 years of peak flow data collected in the Federal Flood Control Channel at Union City (USGS # 11180700, located 0.2 mi upstream of Interstate 880 crossing). The analysis resulted in a 100-year peak flow of 30,410 cfs and a 10-year flow of 14, 116 cfs consistent with the hydrographs in DHI (2015). Sufficient data were not available for the OAC so the DHI (2015) values were assumed to also be sufficiently accurate for conceptual design.

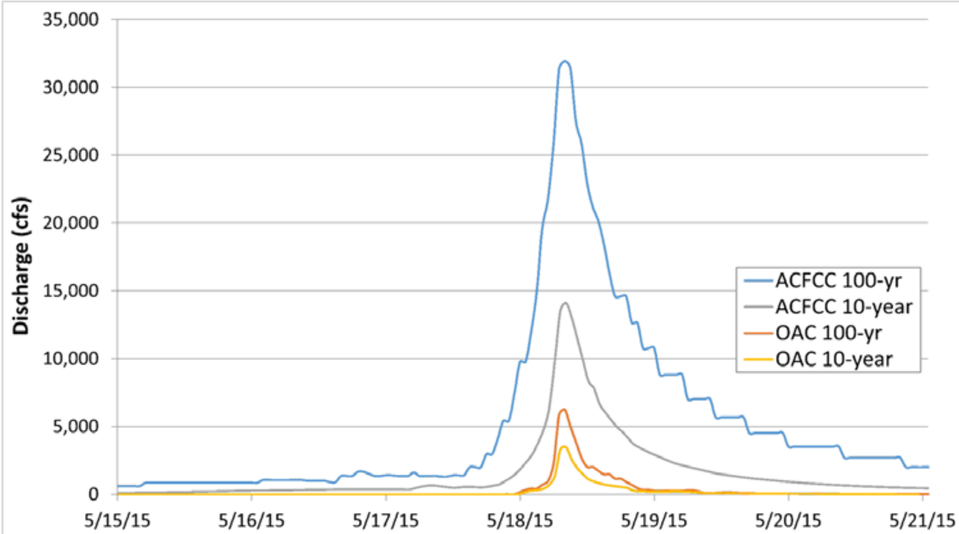

Figure 3.3. 10- and 100-year Discharge Event Hydrographs of ACFCC and OAC

3.4 Hydraulic Modeling

AECOM developed a two-dimensional hydrodynamic model using MIKE21 to refine the design of restoration features including levee breach and pilot channel dimensions, levee raising and lowering heights and locations, and culvert sizes and numbers. A one-dimensional hydraulic model using HEC-RAS was also developed to analyze culvert sizes for the C-Ponds and Inland Ponds. The methodology and results of both of these analyses are located in Attachment 1.

The result of the modeling analyses are the restoration features shown in Alternatives B, C, and D Figures (Appendix A Figures A-3, A-4, and A-5) and the content of this preliminary design beginning in Section 4 of this memo.

3.5 Water Quality Management Approaches in Managed Ponds

Currently the southern Eden Landing pond complex is managed to meet water quality objectives in accordance with the Initial Stewardship Plan, Phase 1 actions and the requirements of the Regional Water Quality Control Board's (RWQCB) Final Order, and other regulatory requirements (CDFW 2016). Alternatives C and D include continued pond management of the Inland and C-Ponds, where current management practices would continue and be supported with the installation of additional water control structures, many of which are replacements of existing deteriorating structures.

Described below are the hydraulic design criteria and managed pond operations for key water quality objectives including salinity, dissolved oxygen, and pH. The following information coincides with CDFW's (2016) System E2 and E2C Operation Plan and PWA's (2009) northern Eden Landing Pond E12/E13 Restoration Preliminary Design.

3.5.1 Hydraulic Design Criteria

The design of the managed pond hydraulics and water control structures for the Inland and C-Ponds in Alternatives C and D is based on the following design criteria.

1. Provide water level flexibility through the use of water control structures to adaptively adjust the depth and area of shallow water habitat.
2. Rely on gravity-driven flow where possible to manage water depths and meet discharge criteria. Minimize pumping.
3. During normal operations, reduce the amount and frequency of manual management of the ponds.
4. Provide management flexibility and redundant flow paths where possible.
5. Provide for supplemental approaches to salinity management when managed pond discharge criteria are not met through normal operations.

3.5.2 Managed Pond Operations

In the Inland Ponds, managed pond hydraulics are designed to flow from the OAC into Pond E6, through Pond E5 and E6C, using gravity-flow water control structures (with gravity flows driven by the tides). Water will exit in a similar path. Combination gates at both the inlets and outlets throughout the ponds will allow for flexibility in water level control.

In the C-Ponds, managed pond hydraulics are designed to flow from the ACFCC into Pond E2C, then through breaches and culverts into Ponds E2C, E5C, and CP3C. Pond E4C is fed with water from Pond E5C. Weekly readings of pond salinity and water levels, as well as visual structure inspections, will continue in ponds proposed for pond management.

3.5.2.1 Salinity

Salinity in the C-Ponds is currently maintained between 35-44 parts per thousand (ppt) over the summer, with a maximum discharge salinity of 44 ppt. Pond salinity is decreased by increasing pond inflows, in addition to circulation with adjacent seasonal ponds (such as E5C, E4C, and E1C). Whereas intake gates are usually kept fully open, discharge gate settings are routinely modified. By adjusting flow rates in this way, salinity throughout the ponds can be manipulated over a period of days to weeks.

The Inland Ponds are typically operated in the summer as seasonal (dry) or as “batch” ponds, which retain high salinity waters. Salinity in batch ponds typically increases from approximately 30 ppt in May to 120 ppt by November. Water levels and salinities in the Inland Ponds are controlled by inflows from the Bay Ponds. At the end of the evaporation season (typically October), higher salinity water from the Inland Ponds is rerouted through the Bay Ponds where it is diluted to below 44 ppt prior to discharge into the Bay. Circulation flows can also be reduced to increase pond salinity if intake salinity or pond salinity is low (~20 ppt at the intake or 30 ppt in the ponds).

These salinity management practices will continue in the C-Ponds and Inland Ponds for the managed pond Alternatives C and D.

3.5.2.2 Dissolved Oxygen

Currently the ponds are managed to retain water if dissolved oxygen falls below, or is anticipated to fall below, the trigger value of 3.3 mg/L. Discharge gates are adjusted on an approximately weekly basis. Pond E2C waters may be periodically drained into the adjacent seasonal ponds to improve circulation and water quality. Continued monitoring of receiving waters is being conducted to identify potential effects of low dissolved oxygen discharges and to evaluate whether the slough conditions meet water quality objectives. These operations will continue for the managed pond Alternatives C and D.

3.5.2.3 pH

Currently if the pH of the discharge is expected to fall outside the range of 6.5 to 8.5, an analysis of the impact of discharge pH on the receiving water waters may be performed; if the pH in the receiving waters approaches 9.0, samples may be collected from the receiving waters for analysis. Corrective measures (outlined above for dissolved oxygen and salinity) may be implemented to reduce pond discharges if it is determined that receiving water quality is being impacted. These operations will continue for the managed pond Alternatives C and D.

3.6 Geotechnical Analysis

There is limited existing geotechnical data available near the Eden Landing Pond Complex and no available subsurface data within the project area. Two previous geotechnical investigations conducted by ACFCWCD in 2011 and AMEC (2009) in 2010 provide some general geotechnical information near the project area.

The ACFCWCD's investigation of the ACFCC levees in 2011 included a series of soil borings, cone penetration tests (CPTs), and laboratory testing along the north levee of the ACFCC from the intersection of the creek and Union City Boulevard and extending downstream towards the Bay approximately 8,650 feet. The western extent of the investigation was near Pond CP3C, just south of Cal Hill. AMEC conducted an investigation in 2010 of the northern Eden Landing Ponds E8/E9 and E12/E13. The investigation included three soil borings, collection of bulk samples, and laboratory testing. Data from both of these investigations may aid in the design of project elements and provide general information about the subsurface conditions in the Eden complex, but due to the investigations occurring outside the project area, an additional investigation is recommended to support detailed design.

AECOM executed a subsurface investigation in the summer of 2016 to obtain data within the project area. Six soil borings were collected across the project area located in the vicinity of specific project elements such as levee raisings and bridge installations (see Figure 3.4). Soil samples were collected during drilling and analyzed based on the material encountered and the design inputs needed in the boring locations. Laboratory tests and geotechnical analysis are summarized in Attachment 2, Eden Landing Geotechnical Analysis.

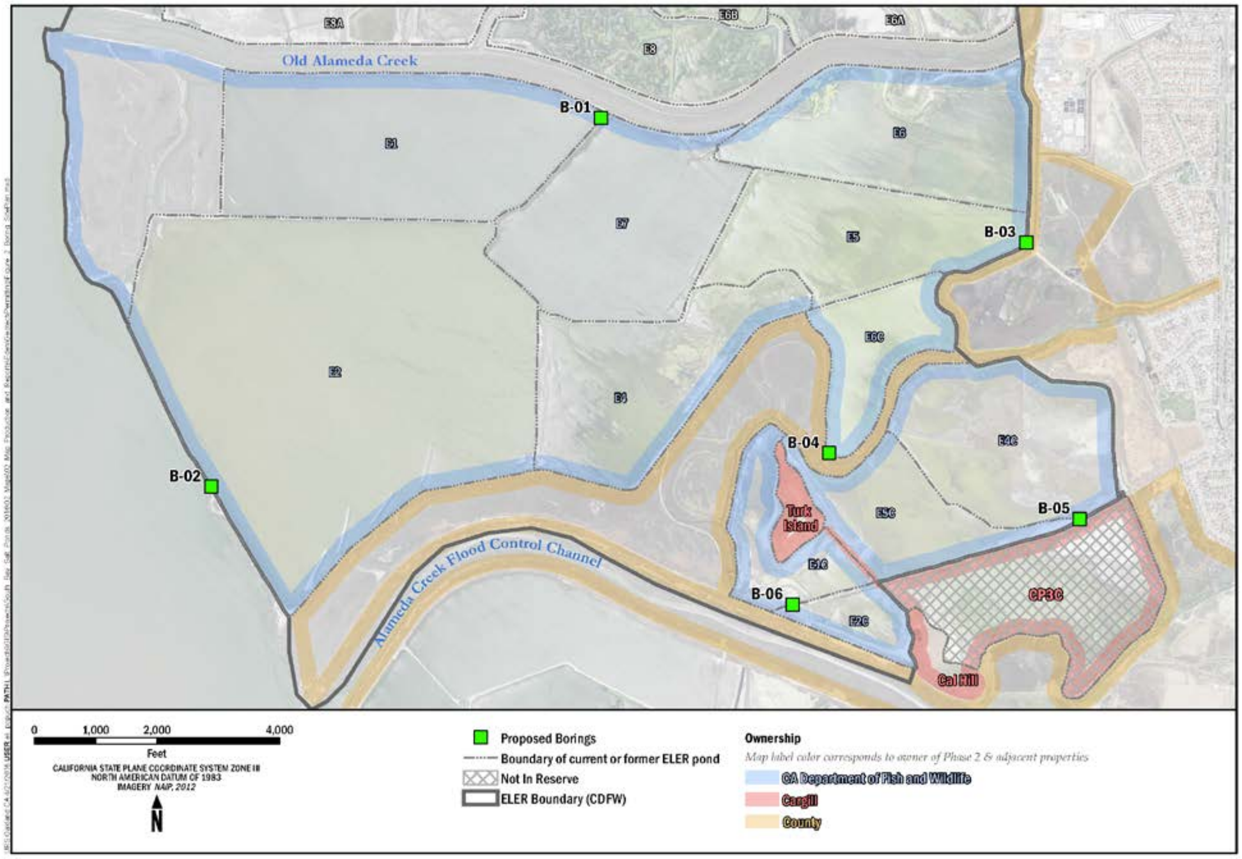

Figure 3.4. Boring Locations

During future design phases, this geotechnical data will be used to assess the existing levees' ability to support construction equipment, to perform seepage and slope stability analysis for raised levees, to evaluate the potential magnitude of consolidation settlement induced by placement of additional levee fill, and to design foundation elements for water control structures, bridge abutments, and boardwalks. Consolidation settlement will also be evaluated in areas designated for habitat transition zone fill; placement of additional fill may be required to account for settlement and achieve the proposed finished grade.

For this preliminary design, conservative assumptions were made for proposed slopes and bulking factors. Later design phases will be based off the geotechnical investigation results.

4. PRELIMINARY DESIGN

The preliminary design elements of the Eden Landing ponds are discussed in the sections below.

4.1 Preliminary Design Components

4.1.1 Site Clearance and Demolition Activities

Prior to performing construction activities, existing vegetation in areas that will be disturbed will be cleared and disposed of off-site. Similarly, sensitive vegetation located in the immediate construction areas will be handpicked, salvaged and replanted elsewhere, as appropriate.

Southern Eden Landing contains two stretches of existing power distribution lines, shown in Figure 4.1:

- Approximately 9,500 feet of power lines and 30 power poles located along the southern OAC levee.
- Approximately 8,000 feet of power lines and 35 power poles located in and near the C-Ponds, not including the span crossing the ACFCC.

In Alternatives B, C and D, the power lines and poles located along the southern OAC levee will be demolished as they currently power the pump between the OAC and Pond E1, which will be removed as part of the restoration project (in all alternatives). All other power lines and poles, including those located in and near the C-Ponds, will remain in place and operational. Proposed breaches (described in Section 4.1.4) in the C-Pond levees will not impact the current location of these lines and poles.

Existing water control structures are also shown in Figure 4.1 and detailed in Table 4.1. Two water control structures in the Island Ponds (E6 – E5 and E5 – E6C) and two water control structures in the C-Ponds (ACFCC – E2C and E2C – CP3C) will be replaced or repaired as necessary for continued operation. All remaining water control structures and associated support structures will be demolished. Demolished materials will be salvaged for re-use elsewhere, or disposed or recycled off-site. Levee breaches will be created where water control structures are removed, except at the E2-Bay, E6C-E4C, ACFCC-E1C, and E2C-E5C water control structures where the levee will be backfilled to match pre-removal heights and widths. Locations where the levees will be backfilled are noted in Table 4.1, and are a result of either maintaining flood control protection or access to Cargill or Alameda County property.

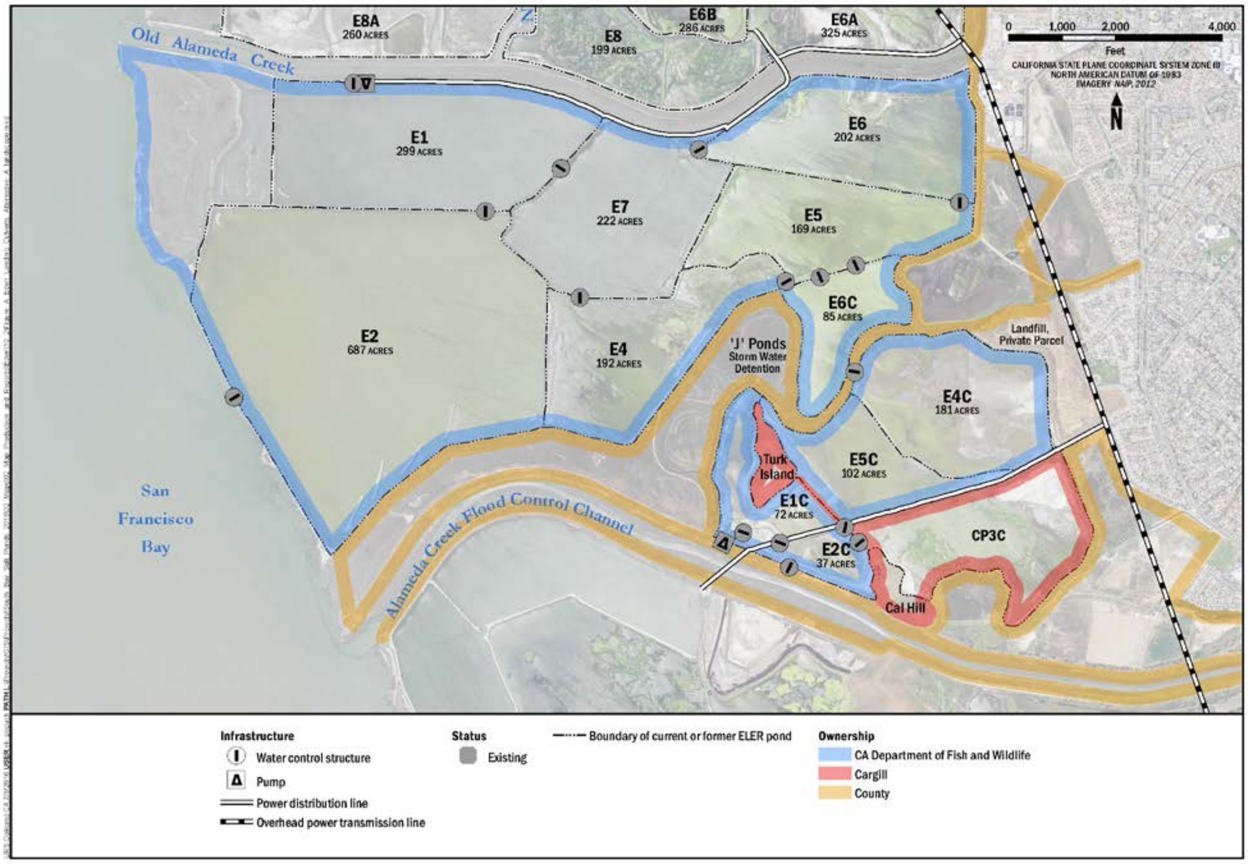

Figure 4.1. Existing Infrastructure

Table 4.1. Existing Water Control Structures Proposed Action

Location	Quantity	Size	Type	Action
E2 - Bay	2	48 in.	Intake/discharge gates	Demolish (backfill levee)
OAC - E1	4	48 in.	(2) Intake/discharge open pipes/combo gates	Demolish
			(2) Intake/discharge slide gates/flap gates	
OAC - E1	1	10,000 gpm	Pump (#1 Baumberg Intake)	
E1 - E2	1	48 in.	Slide gate	
E1 - E7	1	48 in.	Slide gate	
E7 - E4	1	48 in.	Slide gate	
E7 - E6	1	48 in.	Slide gate	
E4 - E5	1	48 in.	Combo gate	
E6 - E5	4	30 in.	Wood gates	Demolish (Alt. B) or Replace/repair (Alt. C & D)
E5 - E6C	2	36 in.	Combo gates	
E6C - E4C	2	30 in.	Siphons (not operable)	Demolish (backfill levee)
E2C - E5C	1	36 in.	Combo gate	
ACFCC - E1C	1	7,660 gpm	Pump (Cal Hill Intake) (not operable)	
ACFCC - E2C	2	48 in.	Intake/discharge combo gates	Replace/repair
E2C - CP3C	1	48 in.	Slide gate	
E2C - E2C donut	1	36 in.	Unknown (open)	Demolish
E1C - E2C donut	1 1	24 in. 10,000 gpm	Unknown (not operable) Pump (Call Hill Transfer) (not operable)	

4.1.2 Levee Raising

The design goals of levee raising include providing an equal or improved level of flood protection relative to existing conditions, providing support for Bay Trail construction, and providing support for high refuge habitat and adjacent habitat transition zones. Table 4.2 summarizes the location and length of raised levees for each alternative. Based on the hydrodynamic flood modeling summarized in Attachment 1, a raised levee elevation of 12 feet NAVD88 will provide equal or better flood protection, compared to existing conditions, thereby meeting the project flood protection objective. This is 5 feet above MHHW and provides a freeboard of about 1.5 to 2.5 feet above the maximum water surface elevation within the ponds during the design hydrologic events. Some levees will be raised also to 12 feet NAVD88 for construction of recreational trails and adjacent habitat transition zones, which are detailed in Section 4.1.9 and Section 4.1.5, respectively. Appendix A, Figures A-3, A-4, and A-5 contain plan views of these levee improvements.

Table 4.2. Proposed Raised Levees

Levee Raising Location	**Alternative B** Linear Feet	**Alternative C** Linear Feet	**Alternative D** Linear Feet	**Purpose**
Inland Ponds Landside Levee	6,000	-	6,000	Flood Protection
C-Pond Landside Levee	10,500	-	10,500	Flood Protection
Bay Trail Levee (E6C-ACFCC)	7,500	-	-	Bay Trail
Bay Levee	-	5,900	10,900	Habitat
Mid Complex Levee	-	12,900	12,900	Habitat
Total	24,000	18,800	40,300	

Design:

- Top elevation: Raised levees will have a minimum crest elevation of 12 feet NAVD88.
- Top width: Raised levees will have a minimum crest width of 12 feet.
- Side slope: The improved levees will have side slopes of 4:1 (H:V).

A typical cross-section of the proposed levee raising is shown in Figure 4.2.

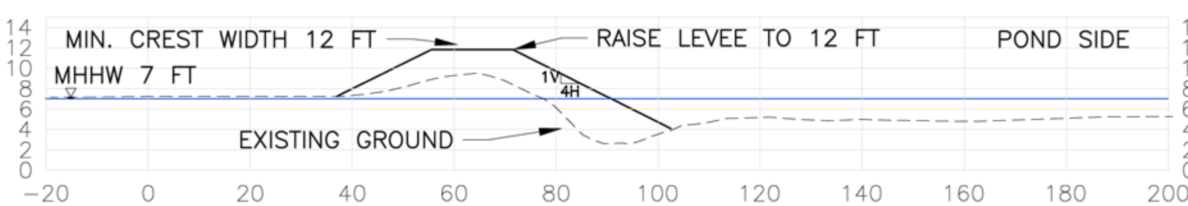

Figure 4.2. Proposed Levee Raising – Typical Section

Material for levee raising may be sourced on-site from levee lowering, levee breaching, pilot channel excavations, existing levee reshaping, and/or from off-site upland re-use materials. Levee lowering to MHHW may coincide with levee raising, without significant volumes of water entering the Bay and Inland Ponds (which will not be drained for construction).

Additional detail on the raised levees follows. Plan views are clipped from Figures A-3, A-4, and A-5 in Appendix A.

Inland Ponds Landside Levee

(Alternative B and D) Approximately 6,000 feet of perimeter levee raising, spanning from the northeast corner of Pond E6, to the south and west along Ponds E5 and E6C, and ending at the eastern corner of Pond E6C. The levees to be raised all border Alameda County property. Figure 4.3 shows the plan view (of Alt. B only), and Figure 4.4 shows profile with the existing levee (as of the 2010 LiDAR) with the proposed height increase to 12 feet NAVD88.

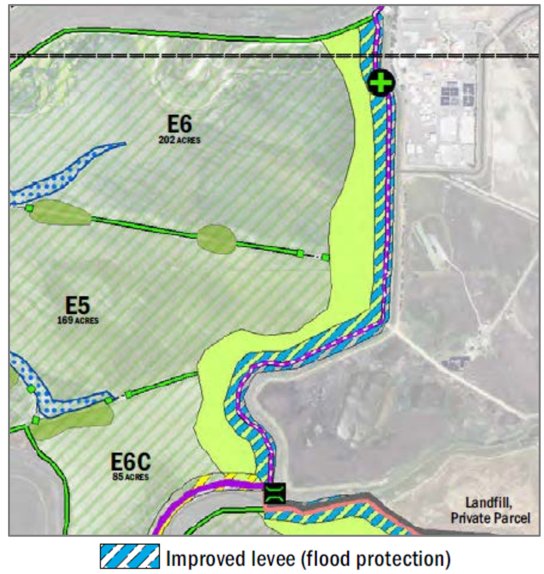

Figure 4.3. Plan of Inland Ponds Landside Levee (Alt. B)

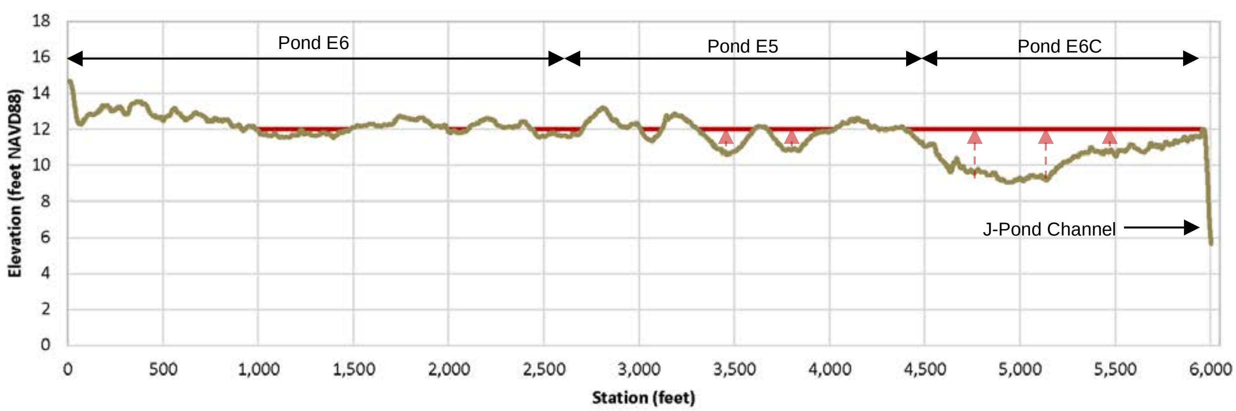

Figure 4.4. Raised Levee Profile of Inland Ponds Landside Levee

C-Ponds Landside Levee

(Alternative B and D) Approximately 10,500 feet of perimeter levee raising along the landside portion of the C-Ponds, spanning from the northern corner of Pond E4C (where the E6C levee raising ends), to the south and east around Pond E4C and then west and south along Pond CP3C ending at Cal Hill. Also includes the existing Cargill access levee to Turk Island. The eastern levee to be raised near Ponds E4C borders Alameda County property. The southern levees to be raised near Ponds E4C, E5C, and E2C border Cargill's Pond CP3C. Figure 4.4 shows the plan view (of Alt. B only) and Figure 4.6 shows the profile with the existing levee (as of the 2010 LiDAR) with the proposed height increase to 12 feet NAVD88.

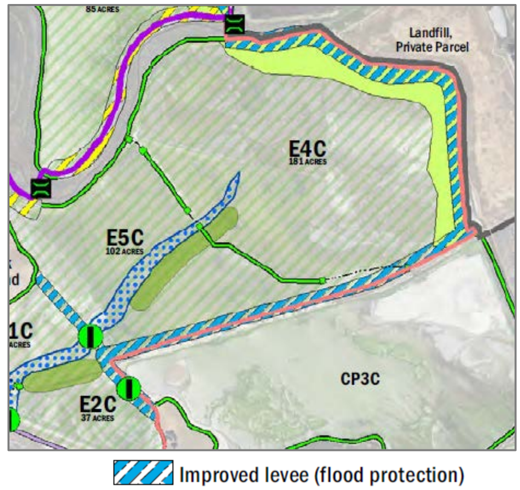

Figure 4.5. Plan of C-Ponds Landside Levee (Alt. B)

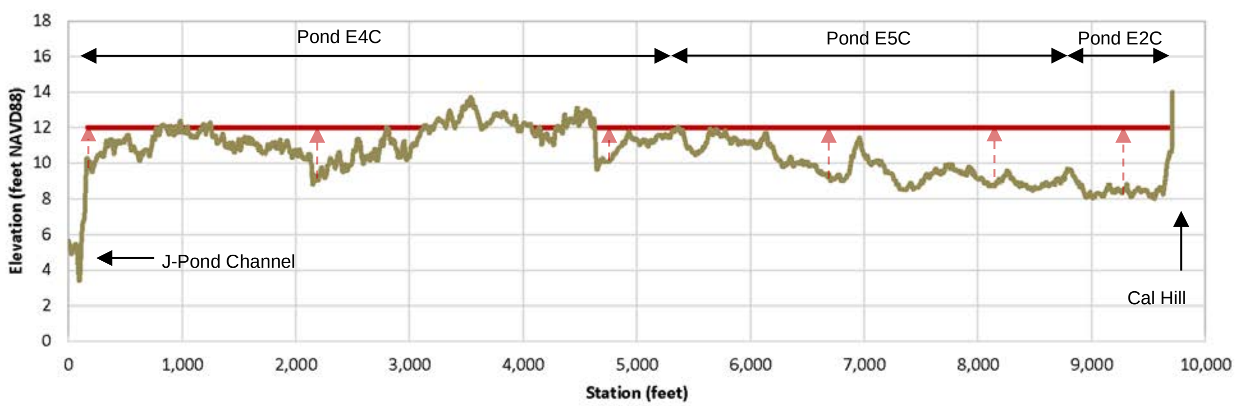

Figure 4.6. Raised Levee Profile of C-Ponds Landside Levee

Bay Trail Levee (E6C – ACFCC)

(Alternative B) Approximately 7,500 feet of perimeter levee raising along the southern E6C levee and northern E5C and E1C levees will provide a raised base levee for the Bay Trail; this levee improvement provides no flood protection. The proposed levee alignment falls all on CDFW property, except for a connecting bridge over Alameda County's J-Ponds. Figure 4.7 shows the plan view and Figure 4.8 shows the profile with the existing levee (as of the 2010 LiDAR) with the proposed height increase to 12 feet NAVD88.

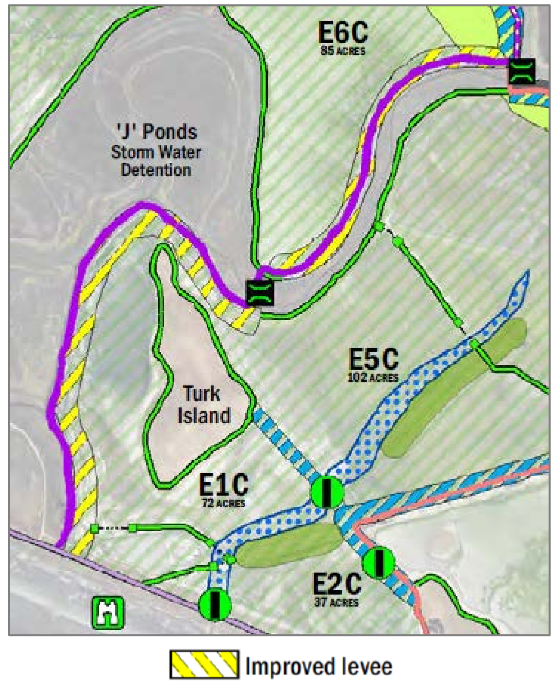

Figure 4.7. Plan of Bay Trail Levee (E6C – ACFCC) (Alt. B)

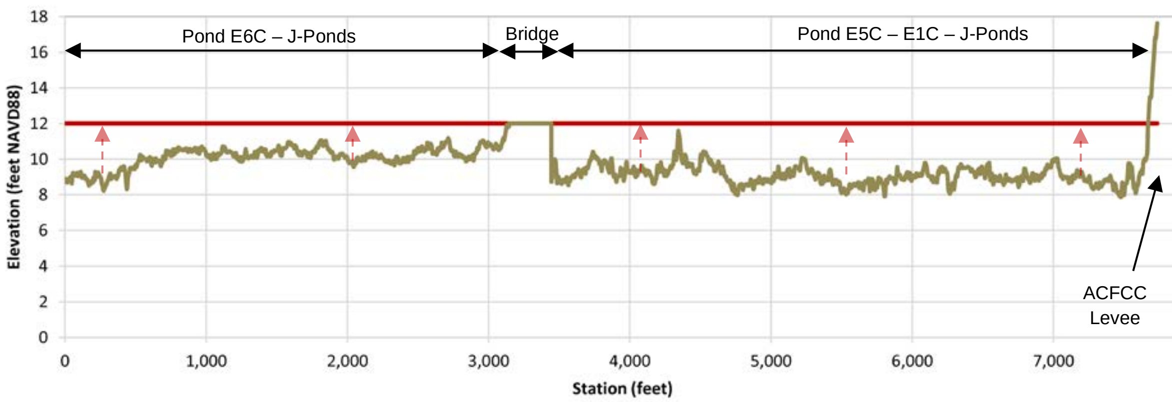

Figure 4.8. Raised Levee Profile of Bay Trail Levee (E6C – ACFCC)

Bay Levee

(Alternative C and D) Approximately 5,900 (Alt. C) and 10,900 (Alt. D) feet of perimeter levee raising along the western bay front levees of Ponds E1 and E2. The levees to be raised border the Cargill Mitigation Marsh, Southern Whale's Tale Marsh, and San Francisco Bay. Figure 4.9 shows the plan views and Figure 4.10 shows the existing levee (as of the 2010 LiDAR) with the proposed height increase to 12 feet NAVD88. The profile view shows that in Alternative C, little raising will be performed because the existing levee is near or above the 12-foot design elevation.

The Bay Levee will be raised for habitat enhancement, not flood protection. The Eden Landing Preliminary Alternatives Analysis (URS 2014a) proposed raising the levee located between the Bay and Ponds E1 and E2. Hydrodynamic modeling results described in Attachment 1 show that tide waters will enter southern Eden Landing through the OAC breaches and lowered levees, and therefore increasing the height of the Bay levee will not reduce the water surface elevation within the Bay and Inland Ponds. Raising this Bay levee may reduce wave overtopping, however the segments lower than 12 feet NAVD88 are protected behind 1,000 to 2,500 feet of fringing marsh (and the partial Cargill Mitigation Marsh western levee).

Figure 4.9. Plan of Bay Levee (Alt. C left, Alt. D right)

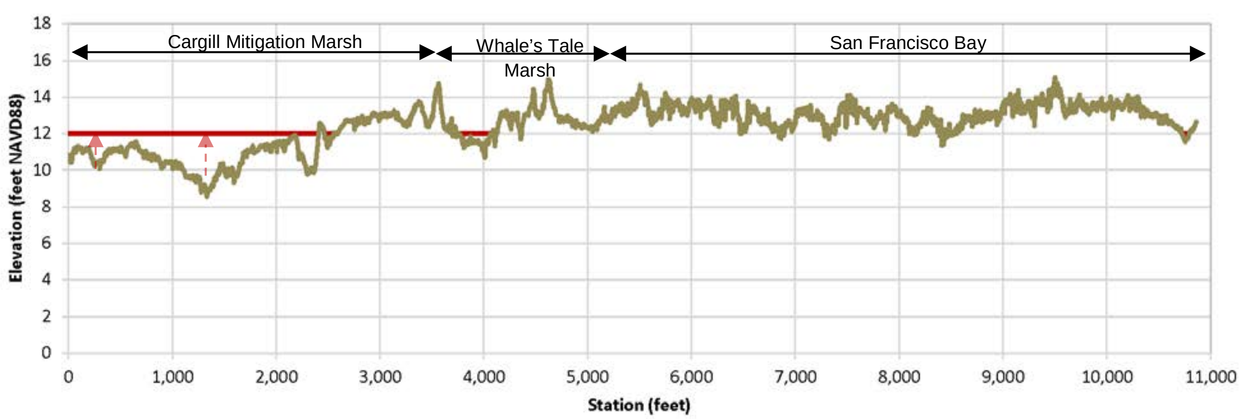

Figure 4.10. Raised Levee Profile of Bay Levee

Other approaches may also be taken for habitat enhancement, such as placing small tree trunks strategically in the ponds near or on the islands. In Alternative B, tree roots are proposed to be placed along the outer Bay levee to help create high tide refuge and help protect the levee from wave erosion. Tree "rootwads" are a natural slope stabilization technique often used in stream restoration design.

Mid-Complex Levee

(Alternative C and D) Approximately 12,900 feet of perimeter levee raising along a mid-complex levee spanning from the southwest corner of Pond E6, between Ponds E7, E5, and E4, across the Alameda County's "J" Ponds, connecting to the ACFCC levee near the southwest corner of Pond E1C. For Alternative C, the levee will be permanently raised. For Alternative D, the levee will be temporarily raised and a later Project Phase would breach and may also lower or remove sections of the levee to restore tidal influence to the Inland and C Ponds. Figure 4.12 shows the existing levee (as of the 2010 LiDAR) with the proposed height increase to 12 feet NAVD88.

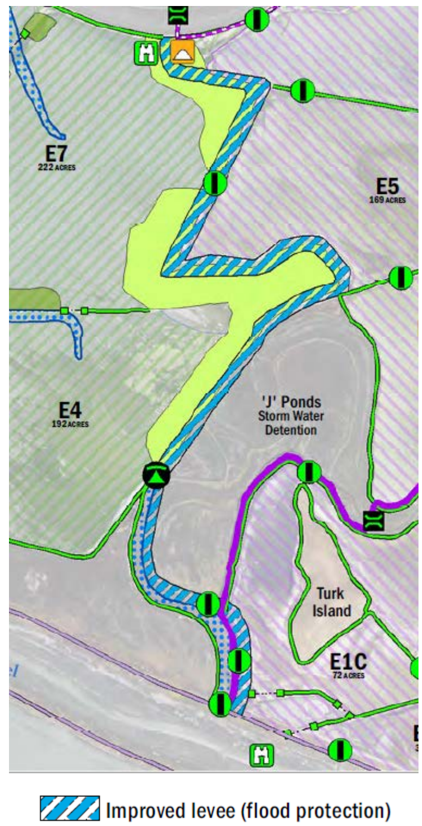

Figure 4.11. Plan of Mid-Complex Levee (Alt. C)

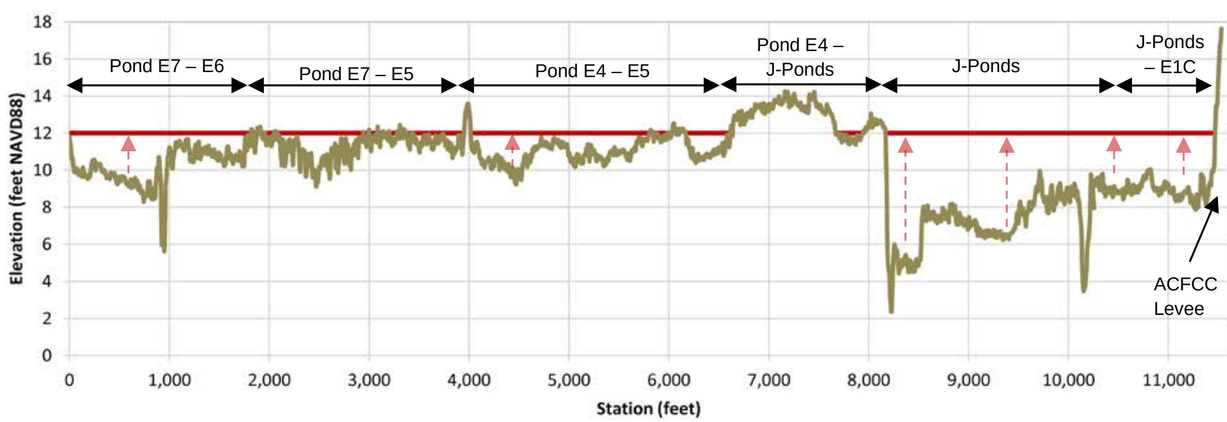

Figure 4.12. Raised Levee Profile of Mid Complex Levee

4.1.3 Levee Lowering

The design goals of levee lowering include providing an increased frequency of levee overtopping to help provide an equal or improved level of flood protection relative to existing conditions, as well as to promote increased hydraulic connectivity between channels and marshes. Table 4.3 and Figure 4.13 show the location and length of lowered levees for each alternative. Based on the hydrodynamic flood modeling summarized in Attachment 1, a lowered levee elevation to MHHW (7 feet NAVD88) will help provide equal or better flood protection by large ACFCC discharge events to overtop the lowered levees into the Bay Ponds and exit through the OAC to the Bay. This will in turn reduce flood levels traveling upstream through the J-Ponds and into inland Alameda County properties. With this approach, the restored ponds can support temporary detention of flood waters to benefit inland low-lying regions. As the ponds accrete over time and begin to support marsh habitat, the periodic tidal overtopping of the highest tides will create new breaches along these lowered levees and will increase hydraulic and habitat connectivity.

Table 4.3. Proposed Lowered Levees

Levee Lowering Location	Alternative B Linear Feet	Alternative C Linear Feet	Alternative D Linear Feet
OAC/E1 & E7 Levee	5,400	5,400	5,400
Fringing Marsh/E1&E2	3,800	3,800	-
ACFCC/E2 Levee	3,600	3,600	3,600
Total	12,800	12,800	9,000

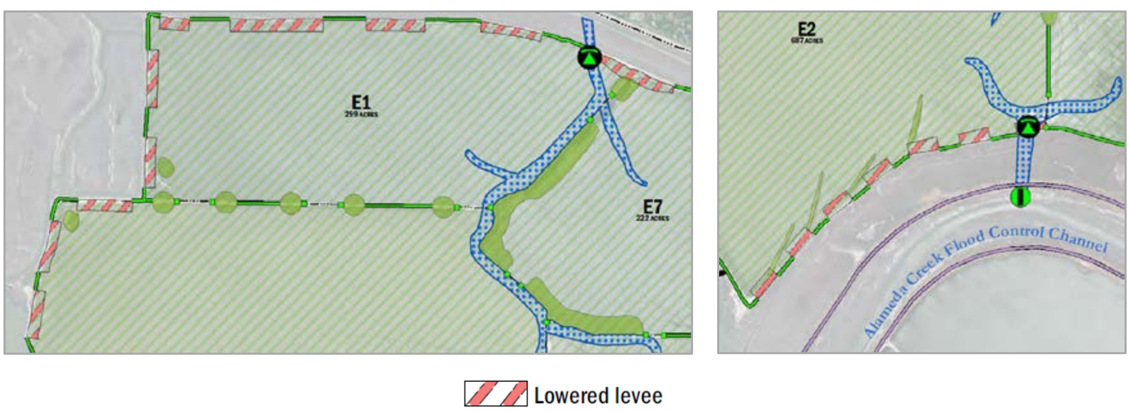

Figure 4.13. Plan of Lowered Levees (Alt. B)

Design:

- Top elevation: Lowered levees will be lowered to MHHW, 7 feet NAVD88.
- High Tide Refuge Habitat: Portions of lowered levees will remain at two feet above MHHW, or 9 feet NAVD88 to provide high tide refuge habitat.

A typical cross-section of the proposed levee lowering is shown in Figure 4.14.

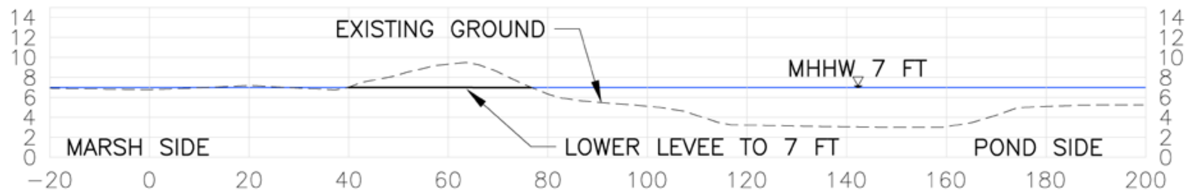

Figure 4.14. Proposed Levee Lowering – Typical Section

Material excavated from levee lowering will be reused onsite to raise levees and/or build habitat transition zones. Additional detail on the lowered levees follows.

<u>OAC – Pond E1 and E7 Levee</u>

(Alternatives B, C, and D) Along the 7,000-foot long northern levee of Pond E1 and E7 bordering the OAC, approximately 75% of the length (5,400 feet) will be lowered. The remaining 25% of the levee length will be left at existing elevations to provide high water refuge habitat at intervals along the levee alignment. Figure 4.15 shows the existing levee (as of the 2010 LiDAR) with the proposed levee lowering to MHHW (7 feet NAVD88).

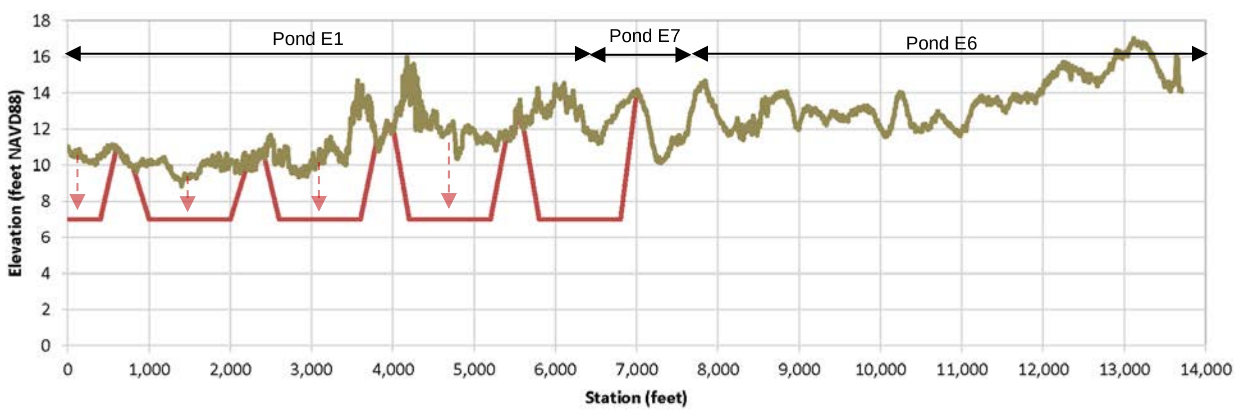

Figure 4.15. Lowered Levee Profile of OAC and Pond E1 and E7 Levees

<u>Fringing Marsh – Pond E1 & E2 Levee</u>

(Alternatives B and C) Along the 5,000-foot long western levee of Pond E1 and E2 bordering the Bay, approximately 75% of the length (3,800 feet) will be lowered. The remaining 25% of the levee length will be left as existing conditions to provide high water refuge habitat at intervals along the levee length. Figure 4.16 shows the existing levee (as of the 2010 LiDAR) with the proposed levee lowering to MHHW (7 feet NAVD88).

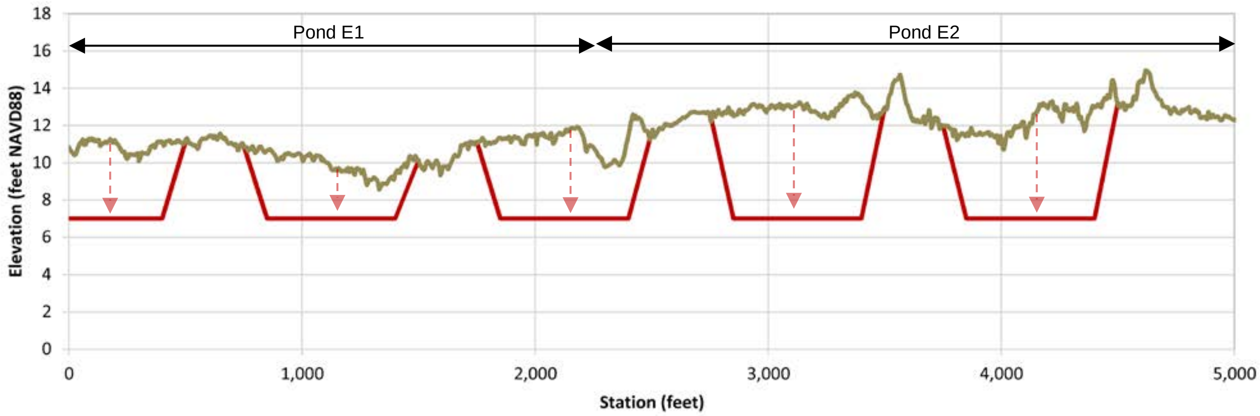

Figure 4.16. Lowered Levee Profile of Bay and Pond E2 and E1 Levee

<u>ACFCC – Pond E2 Levee</u>

(Alternatives B, C, and D) Along the 4,900-foot long southern levee of Pond E2 bordering Alameda property adjacent to the ACFCC, approximately 75% of the length (3,600 feet) will be lowered. The remaining 25% of the levee length will be left as existing conditions to provide high water refuge habitat at intervals along the levee length. Figure 4.17 shows the existing levee (as of the 2010 LiDAR) with the proposed levee lowering to MHHW (7 feet NAVD88).

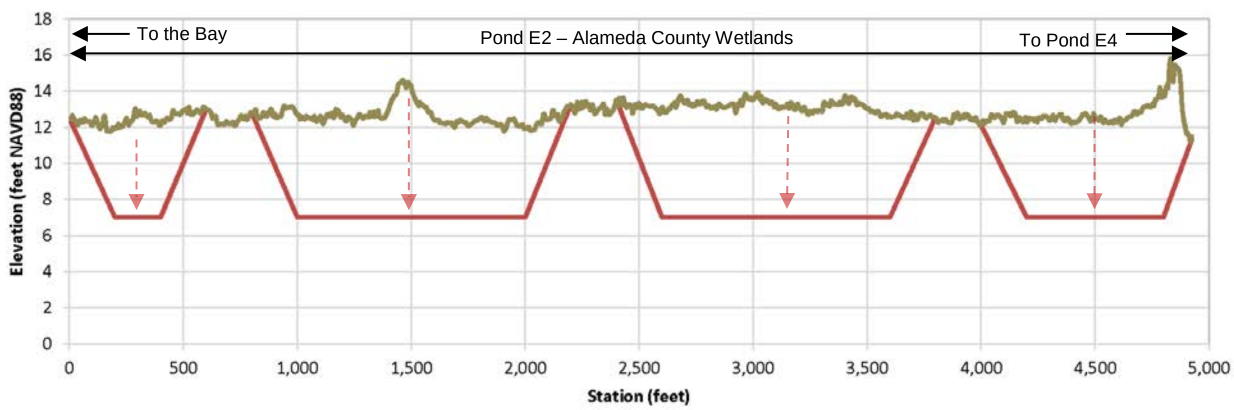

Figure 4.17. Lowered Levee Profile of Pond E2 and Alameda County Wetland Levee

4.1.4 Levee Breach

The design goal of levee breaching was to increase hydraulic connectivity between nearby sloughs and ponds. Levee breach locations were selected based on the historical slough locations and proposed pilot channel locations to maximize hydraulic connectivity between ponds. Breaches were classified as being either external or internal; external defined as a connection to an adjoining property not owned by CDFW, and internal defined as a connection between ponds (owned by CDFW). Breach locations, design details, and associated alternatives are summarized in Table 4.4 for external breaches and in Table 4.5 for internal breaches. Locations of the breaches can be seen in Appendix A Figures A-3, A-4, and A-5.

Table 4.4. External Levee Breach Design

Location	Width (ft.) (perpen. crest)	Length (ft.) (parallel crest)	Bottom Elev. (ft. NAVD88)	Slope	Purpose	Applicable Alternatives
OAC/E6	200	160	-4	3H:1V	Hydraulic connectivity	B
OAC/E1 (east)	150	380	-4			B, C and D
OAC/E1 (west)	150	30	0		Remove existing pump	B, C and D
Alameda County Wetlands/E2/E4	100	50	2.7 or higher		Fish passage	B
Alameda County Wetlands/E2	100	50	2.7 or higher			C

Table 4.5. Internal Levee Breach Design

Location	Width (ft.) (perpen. crest)	Length (ft.) (parallel crest)	Bottom Elev. (ft. NAVD88)	Slope	Purpose	Applicable Alternatives
E1/E2 (west)	50	120	-4	3H:1V	Hydraulic connectivity	B, C and D
E1/E2 (mid)	50	120	-4			B, C and D
E1/E2 (east)	50	120	-4			B, C and D
E1/E7	75	50	-4			B, C and D
E2/E7	75	50	5 (EG)			B, C and D
E7/E4	75	100	-4			B, C and D
E2/E4 (north)	50	50	-4			B, C and D
E2/E4 (south)	50	50	6 (EG)			B, C and D
E7/E6 (west)	25	25	5 (EG)			B
E7/E6 (east)	75	100	-4			B
E5/E7	75	110	-4			B
E4/E5	75	50	5 (EG)			B
E6/E5 (west)	50	50	0			B
E6/E5 (east)	50	50	0			B
E5/E6C	100	50	-4			B
E1C/E2C Donut	100	100	2.7			B, C and D
E2C Donut (west)	50	50	2.7			B, C and D
E2C Donut (east)	50	50	2.7			B, C and D
E4C/E5C (mid)	20	50	2.7			B and D
E4C/E5C (south)	20	50	2.7			B and D

Note: EG = Existing Ground

Levee breach design bottom elevations range from -4 feet to about 6 feet NAVD88. The elevation of -4 feet was chosen to align with the pilot channel depths, which were designed to allow for about one foot of water in the channels during the lowest spring tide (approximately -2.8 feet NAVD88) to prevent fish stranding. Levee breaches not connected to a pilot channel have design bottom elevations near existing grade of the ponds, or if they border a channel (as in the case of the Pond E6/E5 east and west breaches) an average elevation of 0 feet was proposed.

Levee breach widths (perpendicular to the levee crest) were based on existing topography to connect breach bottoms to pond bottoms or adjoining pilot channels. Levee breach lengths (parallel to the levee crest) were initially sized based on empirical hydraulic geometries of historic marshes in San Francisco Bay (PWA et al. 2004), and confirmed and modified as needed with MIKE21 model results (as described in Attachment 1). PWA et al.'s empirical relationships correlate equilibrium channel depth, top width, and cross-sectional area with tidal prism. As detailed in Appendix B, the potential diurnal tidal prism was calculated for each breach using the anticipated marsh area that will receive tide waters from each breach. Using the estimated tidal prism, the average channel cross-sectional area was estimated and informed the breach length when used in combination with the desired breach depth. Both the short term (immediately after the breach) and long term (future accreted marsh) tidal prisms were analyzed. The breach lengths were sized based on the channel depth assumptions, and will increase in length if the bottom channel elevation increases.

Breaches will not be armored and are expected to evolve naturally with erosion or deposition from incoming and outgoing tidal flows. The side slopes for these breaches are recommended for construction stability only. Breaches will be excavated with long reach excavators positioned on the existing levee crests. The material will be hauled to or directly placed onto locations identified to receive fill for levee raising, island or mound creation, or construction of habitat transition zones.

A typical cross-section of the proposed levee breach is shown in Figure 4.18.

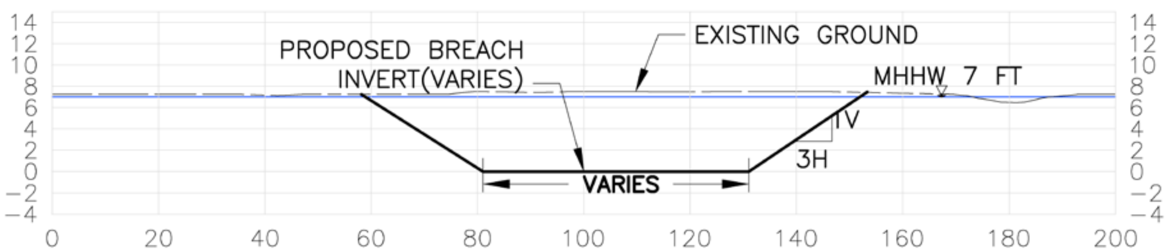

Figure 4.18. Proposed Levee Breach – Typical Section

4.1.5 Habitat Transition Zone

Habitat transition zones are areas with a wide transition in elevation from upland zones to tidal marsh zones. Low marsh, high marsh, tidal fringe, and upland habitats will develop over a habitat transition zone. The design goal of habitat transition zones is to provide areas varying in elevation to increase habitat diversity and complexity.

Table 4.6 summarizes the location and length of habitat transition zones for each alternative. Habitat transition zones will be constructed of material generated on-site from excavations of pilot channels, levee breaches, and lowered levees. Upland fill material may also be used if available from off-site construction projects, assuming it meets suitability requirements. In the case of Alternative B, material should first be utilized to construct the habitat transition zone in the Inland Ponds, as opposed to in the C-Ponds, because Pond E4C is relatively high and will be exposed to already muted tides.

Table 4.6. Proposed Habitat Transition Zones

Habitat Transition Zone Location	Alternative B Linear Feet	Alternative C Linear Feet	Alternative D Linear Feet
Inland Ponds Landside Levee	6,000	-	-
C-Pond Landside Levee	4,500	-	-
Mid Complex Levee	-	7,800	-
Bay Levee	-	-	10,900
Total	10,500	7,800	10,900

The preliminary design assumes a slope of 30:1 (H:V), which is the flattest slope that will be considered for construction, and thus the maximum fill volume and footprint for the habitat transition zones. Future designs may include slopes as steep as 10:1 (H:V), but these will require less fill material and have a smaller footprint. Habitat transition zones will be sized based on the amount of material available. Slopes varying from 10:1(H:V) to 30:1(H:V) will provide both a wide habitat transition zone as well as a gentle slope for dissipating wave energy and reducing erosion potential; all important design features for increasing sea level rise resiliency of the future marshes.

Design:

- Top elevation and slope: The top of habitat transition zone will begin at an elevation of 9.0 feet NAVD88 and extend down to pond bottom with slopes between 10:1(H:V) and 30:1(H:V).
- Slope protection: Hydroseeding with native seed mix and/or a planting schema will speed establishment of a range of vegetation, transiting from tidal marsh to upland vegetation.

Figure 4.19 shows a typical cross-section of the proposed habitat transition zone slopes along the proposed levee alignments.

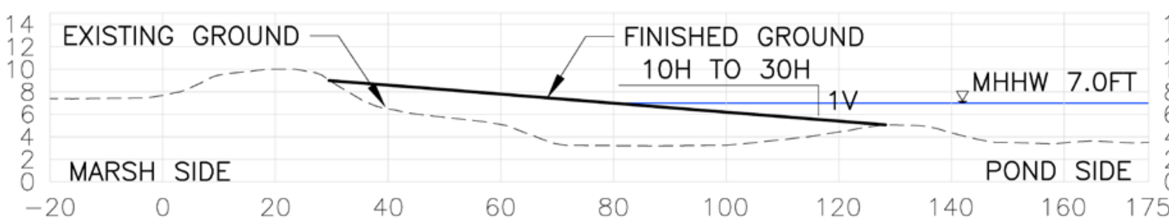

Figure 4.19. Proposed Habitat Transition Zone – Typical Section

4.1.6 Pilot Channel

The design goal of pilot channels is to facilitate draining and filling of the ponds. Without the channels, the low-lying pond depressions in the center of the ponds will not drain, slowing vegetation growth in the restored marsh. As depicted in Figure 3.2, about half of the project site historically drained towards the ACFCC or directly out to the Bay, which is currently not possible given existing property lines, levees and flood concerns. As an alternative, new main channel alignments will be constructed adjacent to existing levees in order to utilize the higher ground of the levees to support equipment access during construction, as well as to utilize the existing borrow ditch geometry to limit excavation. Channel “spurs” will offshoot the main channels into the deeper pond centers where necessary to reach pond depressions. These channel spurs will be minimized as they are more time-consuming (i.e. expensive) to construct.

Pilot channel locations, design details, and applicable alternatives are summarized in Table 4.7 and correspond to channels shown in Figures A-3, A-4 and A-5 found in Appendix A.

Table 4.7. Pilot Channel Design Details

Location	Top Channel Width (ft.)	Length (ft.)	Existing Elev. (ft. NAVD88)	Design Bottom Elev. (ft. NAVD88)	Design Slope	Applicable Alternatives
Bay Ponds Channel						
OAC island cut near E1 breach	15	250	7	0	1H:1V	B, C and D
E1 borrow ditch	30	2,500	6	-4		B, C and D
E2 borrow ditch	30	2,600	6	-4		B, C and D
E4 borrow ditch	30	1,400	6	-4		B, C and D
E1 spur	15	600	4.5	0		B, C and D
E2 spur	15	2,200	4	0		B, C and D
E7 spur	15	900	4.5	0		B, C and D
E4 spur	15	300	5	0		B, C and D
Inland Ponds Channel						
OAC island cut near E6 breach	15	250	7.5	0	1H:1V	B
E6 borrow ditch	30	2,000	5	-4		B
E7 borrow ditch	30	1,000	6	-4		B
E5 borrow ditch	30	3,400	6	-4		B
E6 spur	15	1,300	5	0		B
OAC island cut near E7 culvert	15	250	7.5	0		C and D
E6 borrow ditch (culvert route)	30	2,000	5	0		D
E5 borrow ditch (culvert route)	30	4,400	5.5	0		D
C-Ponds Channel						
E2C-E1C channel	30	1,600	5.5	2.7	1H:1V	B and D
E5C channel	30	2,000	5.5	2.7		B and D
E4C channel	30	700	5.5	2.7		B and D
Fish Passage Channel						
ACFCC to E2 and E4	15	3,100	7.5	0	1H:1V	B
ACFCC to E4 borrow ditch	15	3,100	7	2.7		C

The smaller spur channels, island cuts, and fish passage channels have design widths of 15 feet and slopes of 1:1 (H:V) with the assumption that future scouring will widen and create stable marsh slopes over time (although marsh channel slopes are relatively steep). The larger main channels have design widths of 30 feet and slopes of 1:1 (H:V), which can be constructed with a long reach excavator positioned on existing levees and reaching to the side of the levee. Excavated material will be deposited nearby to create island habitats.

In the Bay and Inland Ponds, a main channel bottom elevation of -4 feet NAVD88 was chosen to allow for about one foot of water in the channels during the lowest spring tide (approximately -2.8 feet NAVD88) to prevent fish stranding. During a MLLW tide (-1.1 feet NAVD88), about three feet of water will remain in the channels. Some sedimentation and scouring is anticipated to occur in and near the channels as they equilibrate, however, by excavating to a relatively low elevation, natural channel morphology will not be slowed by hard sills. (Hard sills created by the weight of historic levees were encountered in the northern Eden Landing Phase 1 ponds).

In the C-Ponds, a main channel bottom elevation of 2.7 feet NAVD88 was chosen to match the existing culvert invert elevation located between the ACFCC and Pond E2C. In the Inland Ponds, a main channel bottom elevation of 0 feet NAVD88 was chosen in Alternative D to align with the proposed culvert invert elevations in those ponds.

The OAC channel is comprised of a large northern stream and a smaller southern stream separated by a middle island of existing marsh. As part of Alternatives B, C and D, three different “island cuts” are proposed in the existing marsh within the OAC to connect the flow through the proposed external breaches and culverts into the larger and deeper northern stream of the OAC. If not constructed, the scouring power of the restored tidal prism will scour the southern stream, as opposed to the northern stream that is the main conveyance for flood flows. Scouring of the southern stream may cause accretion in the northern stream, which is undesired. The island cuts are narrow and intended to begin the erosion process towards a stable channel equilibrium that would develop over time.

A typical cross-section of the proposed pilot channel is shown in Figure 4.20.

Figure 4.20. Proposed Pilot Channel – Typical Section

4.1.7 Island Habitat

The design goal of the island habitats is to provide high tide refuge habitat and a means to beneficially reuse excavated material onsite. Island habitats will be constructed throughout the pond complex where existing levees will remain, separated by new levee breaches. Material excavated from the levee breaches and nearby pilot channels will be used to improve the remnant levees (island habitat) in footprint and height. The islands will be built to an elevation above MHHW to minimize exposure to tidal waters. Given the islands will be constructed from remnant levees and adjacent pilot channels, the islands will be linear in nature and the majority will be located significant distances from recreational trails to avoid habitat disturbance.

The island in Ponds E5C and E4C will be located in the middle of the pond adjacent to the pilot channel, as these ponds are relatively higher than others in the pond complex and the pond bottoms are believed accessible with heavy equipment. All other islands will be constructed from existing levees.

A select group of islands will be treated to create nesting habitat for western snowy plover, California least tern, or other bird species. The top surface of the islands will be treated with a 12-inch thick sand layer underlain by a 6-inch thick crushed rock to minimize weed establishment. The sand layer will include oyster shells or other materials to provide a primarily unvegetated, diverse landscape that is typically preferred by nesting birds.

Design:

- Top elevation: The islands will have a minimum crest elevation of 9 feet NAVD88, not including sand and rock substrate placed for habitat on top of the levee crest.
- Side slope: The nesting island will have side slopes no steeper than 7:1 (H:V) to the pond bottom.

A typical cross-section of the island habitats is shown in Figure 4.21.

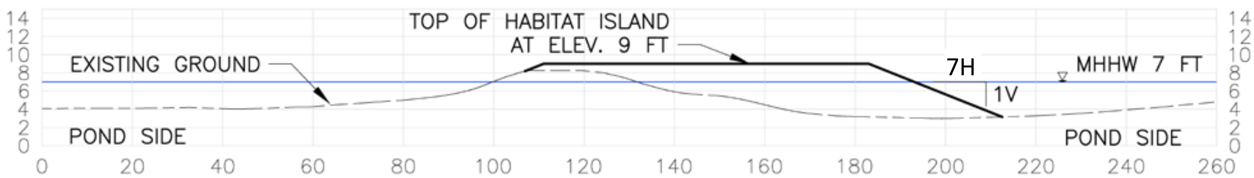

Figure 4.21 Island Habitat – Typical Section

4.1.8 Water Control Structures

The design goal of new water control structures is to facilitate the controlled movement of water between the ponds. Redundancy is desired in the proposed culvert system to provide reliability. The water control structures will have combination gates at both the inlets and outlets for maximum flexibility in water level control. A combination gate can be operated as a slide gate to allow flow in both directions, or may act as a tide gate in both directions when closed.

The design details of the proposed water control structures (new and modifications to existing) are shown in Table 4.8.

Table 4.8. Water Control Structure Design Details

Location	(Number), Size, Type	Length (ft.)	Existing Invert Elev. (ft. NAVD88)	Design Invert Elev. (ft. NAVD88)	Purpose	Applicable Alternatives
ACFCC/E2C (existing)	(2) 48 in. dia. HPDE/CMP	170	2.7	-	Hydraulic connectivity (Alt. B) or Pond management (Alt. C and D)	B, C and D
ACFCC/E2C	(2) 48 in. dia. HPDE/CMP	170	-	2.7		
E1C/E5C (south)	(2) 48 in. dia. HPDE/CMP	60	-	2.7		
E1C/E5C (north)	(1) 48 in. dia. HPDE/CMP	50	-	2.7		C and D
E2C/CP3C (existing)	(1) 48 in. dia. HPDE/CMP	60	Unknown	-		B and D
OAC/E6	(2) 48 in. dia. HPDE/CMP	150	-	0		C and D
E6/E5 (west)[1]	(1) 48 in. dia. HPDE/CMP	40	-	0		
E6/E5 (east)[1] (existing)	(1) 48 in. dia. HPDE/CMP	40	-	0		
E5/E6C (west)[2] (existing)	(1) 36 in. dia. HDPE/CMP	60	Unknown	0		
E5/E6C (east)[2] (existing)	(1) 36 in. dia. HDPE/CMP	60	Unknown	0		
ACFCC/E2&E4 via Alameda County Wetlands	(1) 6 ft. x 6 ft. concrete box or (3) 48 in. diam. HDPE/CMP	200	-	2.7	Fish passage	B
E7/E5	(1) 48 in. dia. HPDE/CMP	50	-	0	Culvert redundancy	C
ACFCC/Alameda County Wetlands	(1) 6 ft. x 6 ft. concrete box or (3) 48 in. diam. HDPE/CMP	200	-	2.7	Fish passage	
Alameda County Wetlands/E1C	(1) 48 in. dia. HPDE/CMP	30	-	2.7	Fish passage/pond management	
Alameda County Wetlands/J-Ponds	(1) 48 in. dia. HPDE/CMP	50	-	2.7	Detention basin management	

Note 1: E6/E5 (west) and (east) could be combined into a single set of culverts to reduce costs as opposed to two separate culverts.

Note 2: E5/E6C (west) and (east) could be combined into a single set of culverts to reduce costs as opposed to two separate culverts.

Water control structures will include prefabricated box culverts or circular high density polyethylene (HDPE) or corrugated metal pipe (CMP) installed through levees with either headwalls or T-shaped bridge structures to operate gate valves. For the larger water control structures, a concrete box culvert may be used to mitigate corrosion concerns typically expected in estuarine water. Alternatively, solid wall HDPE pipes may be employed as they provide a longer service life (greater than 50 years) but are typically more expensive.

A culvert, as opposed to a bridged beach, was proposed to join Ponds E1C and E5C (Cargill-owned levee) because a culvert is believed to be more cost effective than a bridge able to support maintenance vehicle access. Some of the culverts that require coordination with either Cargill or the ACFCWCD may be phased in at a later time in the project to allow for stakeholder involvement and agreement.

Additional Design Details:

- Cover: Concrete box culverts will have a minimum of 1.0 foot of cover. HDPE and CMP will require more cover than that of concrete box culverts and will be based on the diameter of the pipe and future cover analysis calculations.
- Fish Passage: Culverts intended for fish passage will consider adult and juvenile life stages and associated low and high passage flow criteria in future design phases. Because these culverts are in both a tidal and riverine system environment, different culvert heights will be considered to limit the time the culvert is flowing full. A natural culvert bottom will also be considered to encourage fish passage into the Bay Ponds from ACFCC.
- Seepage Control: Culverts will be designed to prevent through seepage along the pipe trench alignment. Engineered seepage prevention collars may be required.
- Floatation: Culverts (pipe material and wall thickness) will be designed to prevent floatation when fully inundated. Engineered concrete collars on the pipe may be required.

4.1.9 Recreational Trails

The design goal of recreational trails is to meet the recreation objectives of the project. Table 4.9 includes the trail locations and lengths. Each action alternative includes continuing the Bay Trail from its existing extent in the northern Eden Landing Ponds to the southeast corner of Pond E6C; from there three routes are proposed to connect the trail to the ACFCC levee. Plan views of the proposed trail routes are shown in Appendix A Figures A-3, A-4, and A-5.

Table 4.9. Trail Details

<table>
<tr><th>Location</th><th>Length (ft.) (parallel crest)</th><th>Purpose</th><th>Applicable Alternatives</th></tr>
<tr><td>N. Eden Landing Ponds to E6C</td><td>16,000</td><td rowspan="7">Public Access / Recreation</td><td>B, C and D</td></tr>
<tr><td>E6C to ACFCC</td><td></td><td></td></tr>
<tr><td>Route 1: CDFW Property only</td><td>7,400</td><td rowspan="3">B, C and D</td></tr>
<tr><td>Route 2: CDFW & Cargill Property</td><td>10,500</td></tr>
<tr><td>Route 3: CDFW & Alameda County Property</td><td>11,900</td></tr>
<tr><td>Alvarado Salt Works Loop</td><td>13,500</td><td>C</td></tr>
<tr><td>S. ACFCC levee connection</td><td>NA (bridge)</td><td>C</td></tr>
</table>

The trail though the Northern Eden Landing Ponds to Pond E6 includes crossing the existing tide gate structure located along the OAC. Handrails and appropriate access features would be included in the design to modify this existing, operating tide gate structure for pedestrian access.

Design:

- Width: trails designed to be part of the Bay Trail will follow Bay Trail design guidelines and may be at least 12 feet wide with a three-foot shoulder on either side, totaling to 18 feet. Trails not designated as part of the Bay Trail will be a minimum of 10 feet wide with a one-foot should on either side, totaling to 12 feet.

- Surfacing: trails will be built on improved or existing levees. Erosion or uneven surfaces on existing levees will be regraded for ADA compliance. Surfacing materials may be compacted gravel, decomposed granite, and/or native soil with stabilizing agents.
- Bridges: all bridges will be passable by pedestrians, and depending on bridge length and location may also be passable by maintenance or emergency vehicles. Maintenance and emergency vehicles currently have access to all levees via existing access routes.

4.1.10 Bridges

The design goal of bridges is to meet the recreation objectives of the project. Table 4.10 details bridge locations and lengths. Plan views of the proposed bridges are shown in Appendix A Figures A-3, A-4, and A-5.

Table 4.10. Bridge Details

Location	Length (ft.)	Purpose	Applicable Alternatives
Across J-Ponds from E6C to E4C	250	Public Access / Recreation	B, C and D
Across J-Ponds from E6C to E5C	310		B, C and D
Across OAC to Alvarado Salt Works	500		C
Across ACFCC at Cal Hill	600		C

Design Details:

- Bridge Loading: all bridges will be passable by pedestrians and bicycles. The two shorter bridges across the J-Ponds will also be accessible by maintenance and emergency vehicles. The two longer bridges across the OAC and ACFCC already have existing nearby vehicle access (i.e. the OAC tide gate structure and Union City Blvd. over ACFCC).
- Bridge Support: Given the long spans, bridges may be supported by numerous driven piles in the channels.
- Bridge Bottom Elevation: bridges spanning the OAC and ACFCC will allow for the 100-year flood event to pass underneath the bridges with sufficient freeboard. Floating structures (such as maintenance dredging and Coast Guard equipment) must also pass under, or a portion of the bridge removed for passage past, the bridge at MHHW tide. Bridges spanning the J-Ponds will be constructed to allow for Alameda County equipment access under the bridge.
- Abutment Scour: bridge abutments will be protected against scour.

Figure 4.22 depicts a typical light-duty bridge suitable for pedestrians and bicycles.

Figure 4.22 Representative Light-duty Bridge with Abutment Armoring
Source: Questa 2011

4.1.11 Interpretive Signage and Benches

Interpretive signage and benches will support the recreation objective of the project. One interpretive sign and bench may be placed near the proposed viewing platform near the intersection of the C-Ponds and the ACFCC levee (Alternatives B, C, and D). The interpretive sign will be similar to that shown in Figure 4.23. Benches will be approximately 7 or 8 feet long with coated steel supports and wood slat finished surfaces, similar to that shown in Figure 4.23.

Figure 4.23 Representative Interpretive Sign and Bench (located at northern Eden Landing Ponds)

4.1.12 Viewing Platform

Viewing platforms will provide a scenic lookout area to support the recreation objective of the project. A viewing platform will be comprised of asphalt or similar surfacing material as the proposed recreational trails and may be built near the intersection of the C-Ponds and the ACFCC levee (Alternatives B, C, and D) as well as near the Alvarado Salt Works (Alternative C). The viewing platforms will be constructed on or near levee crests and may vary in size to accommodate the existing space. Access to the platforms will be ADA accessible. A typical viewing platform is shown in Figure 4.24.

Figure 4.24 Proposed Viewing Platform

4.1.13 Union Sanitary District Connection

Union Sanitary District (USD) provides wastewater collection, treatment, and disposal services to Fremont, Newark and Union City. USD's wastewater treatment plant is located immediately east of Pond E6. Given the close proximity to the plant, southern Eden Landing may be a suitable location for wet-weather detention storage or a treated freshwater discharge. The SBSP Restoration Project team and USD are currently discussing such options and applicable permits. Alternative B contains an approximate location of a USD connection to Pond E6.

4.2 Construction Implementation

Construction will be implemented by procuring the services of a general contractor with experience in performing restoration activities, levee improvements, and working within and near tidal waters and bay mud. Site access information, along with a preliminary analysis of the schedule and cost estimate to complete the construction activities, is discussed below.

4.2.1 Access

Primary access to southern Eden Landing is near the Union Sanitary District Headquarters at the end of Horner Street, which can be reached from Dyer/Whipple Road or Alvarado-Niles exits off I-880, and Union City Blvd. Alternative access to the southern portion of southern Eden Landing is at the end of Westport Way via Carmel Way (near Sea Breeze Park) off Union City Blvd. Access routes are shown on Figure 4.25. Access throughout the pond complex is via former salt pond levee maintenance roads. Public foot and road access is permitted within some locations within the northern pond complex and along the ACFCC levees currently.

Construction vehicles shall avoid crossing any structures if the vehicle exceeds the weight-bearing capacity. If this is not possible, engineer-approved precautions shall be taken to avoid damaging the structures.

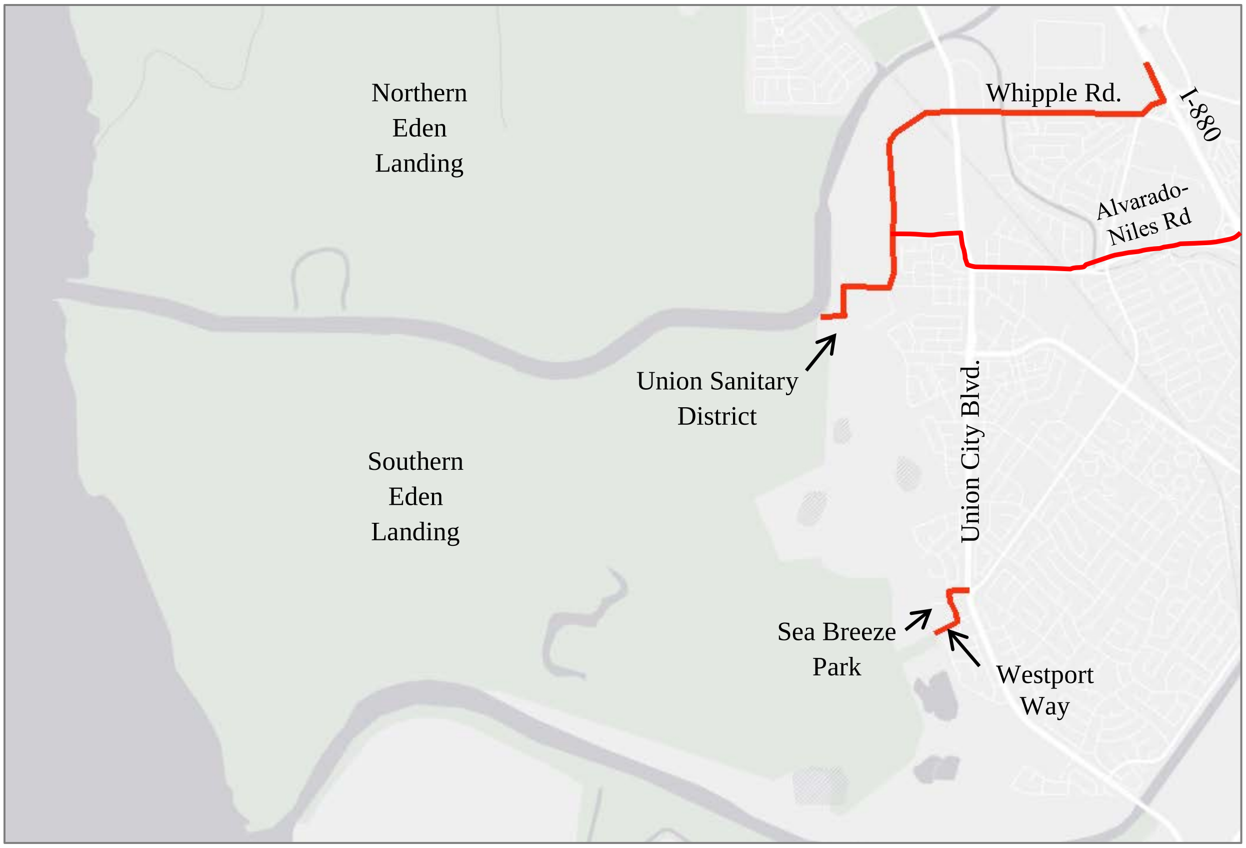

Figure 4.25 Site Access

4.2.2 Earthwork Volumes

Based on the preliminary design, estimated volumes of earthwork proposed for the Eden Landing alternatives are detailed in Table 4.11. Quantities were measured using AutoCAD Civil3D software based on terrain models of the existing and proposed ground surfaces. A bulking factor of 30% was included in both cut and fill volumes, as well as a 20% contingency.

Because the levees are comprised of dry, compacted material, material excavated from levee lowering and external breaches is most suitable for construction of raised levees. Wet bay mud generated from pilot channel excavation will be used to construct the habitat islands. Excavation of internal levee breaches will also be used to construct habitat islands to minimize hauling small amounts of material far distances around the site. Habitat transition zones will be constructed with any excess excavation from levee breaches and lowered levees, and will be supplemented with imported material if needed.

Table 4.11 shows that in Alternative B, approximately 155,000 CY of dry material will be excavated, of which 91,000 CY will be placed on levees to raise them. The remaining 64,000 CY will help build habitat transition zones and trails, although an additional 92,000 CY of material will need to be imported to construct the Alternative B habitat transition zones. Lastly, approximately 240,000 CY of wet material will be excavated and used to create habitat islands throughout the complex in this Alternative.

Table 4.11. Preliminary Earthwork Volumes

Dry Material Excavation and Placement	Alternative B Cut (CY)	Fill (CY)	Alternative C Cut (CY)	Fill (CY)	Alternative D Cut (CY)	Fill (CY)
Levee Raising						
Inland Ponds Landside Levee	-	9,000	-	-	-	9,000
C-Pond Landside Levee	-	44,000	-	-	-	44,000
Bay Trail Levee	-	38,000	-	-	-	-
Bay Levee	-	-	-	2,000	-	9,000
Mid Complex Levee	-	-	-	81,000	-	81,000
Levee Lowering						
OAC/E1 & E7 Levee	-28,000	-	-28,000	-	-28,000	-
Fringing Marsh/E1&E2	-17,000	-	-17,000	-	-	-
ACFCC/E2 Levee	-25,000	-	-25,000	-	-25,000	-
Levee Breaches						
External	-85,000	-	-42,000	-	-41,000	-
Total	-155,000	91,000	-112,000	83,000	-94,000	143,000
Net Dry Material		**-64,000**		**-29,000**		**49,000**
Wet Material Excavation and Placement						
Pilot Channels						
Bay Ponds	-80,000	-	-80,000	-	-80,000	-
Inland Ponds	-71,000	-	-2,000	-	-39,000	-
C-Ponds	-13,000	-	-	-	-13,000	-
Fish Passage Channel	-18,000	-	-1,000	-	-	-
Levee Breaches						
Internal	-58,000	-	-37,000	-	-38,000	-
Habitat Islands						
Throughout Complex		240,000		120,000		170,000
Total	-240,000	240,000	-120,000	120,000	-170,000	170,000
Net		**0**		**0**		**0**
Imported Upland Fill Placement						
Habitat Transition Zones						
Inland Ponds Landside Levee	-	101,000	-	-	-	-
C-Ponds Landside Levee	-	46,000	-	-	-	-
Mid Complex Levee	-	-	-	75,000	-	-
Bay Levee	-	-	-	-	-	96,000
Trails						
Imported Trail Base	-	9,000	-	13,000	-	9,000
Total	0	156,000	0	88,000	0	105,000
Excess Dry Material Excavation		-64,000		-29,000		49,000
Net Fill Import		**92,000**		**59,000**		**154,000**

Note: Levee raise volumes assume a conservative levee crest width of 16 feet, as opposed to a minimum 12 feet.

4.2.3 Construction Methods and Equipment

Probable construction equipment includes:

- Long reach excavator(s) and drag-line excavator (working off crane mats in soft areas)
- Amphibious excavator(s) (for channel excavation)
- End dump trucks (for onsite and offsite hauling)
- Low-ground pressure (LGP) trucks (for onsite hauling)
- LGP dozer(s) (for material pushing around site)
- LGP loader(s) (for material loading into trucks)
- LGP backhoe (for trenching)
- Motor grader (for levee road leveling and upkeep)
- Temporary matting (wood or plastic for equipment support)
- Water truck(s) (dust control, moisture conditioning)
- Compactor(s) (material compaction)
- HDPE pipe fuser (culvert construction)
- Crane(s) (equipment/material loading/unloading)
- Auger drill (bridge and/or water control structure foundation piles)

This equipment list does not include smaller items such as fuel service, maintenance service, personal vehicles, small tools and equipment.

Currently, the Bay and Inland Ponds are hydraulically separated from the C-Ponds. Almost all construction at the C-Ponds may therefore be phased separately than the Bay and Inland Ponds (with levee raising in the C-Ponds being the exception because it requires excavated material from levee lowering in the Bay Ponds). Assuming construction is performed in the Bay, Inland, and C-Ponds concurrently (un-phased throughout the site) the sequence of construction tasks for Alternative B may include the following:

- <u>Pre-construction Pond Management</u>: Lower pond water levels to lowest possible levels for improved site access.
- <u>Mobilization</u>: develop submittals, staging areas, and other facilities. Mobilize equipment to the site via ground transportation.
- <u>Site Preparation</u>: Where necessary, clear and grub work areas, scarify slopes, and repair/raise low access roads in preparation of work.
- <u>Demolition</u>: Demolish existing structures and backfill as identified.
- <u>USD Connection:</u> Construct, if included in project.
- <u>Bridges:</u> Construct pedestrian bridges. Construction methods may include cofferdams, foundation piles, cast in-place concrete abutments, and placement of riprap scour protection.
- <u>Water Control Structures:</u> Excavate trenches and temporarily store material. Install HDPE or CMP pipe using flatbed trucks for delivery, loaders for lowering pipe in place, and HDPE pipe fuser to connect pipe sections (if necessary). Install valves.

- Internal Breaches, Channels & Habitat Islands: Excavate internal breaches and channels. Place material nearby to create habitat islands. Dozers would move material laterally as necessary to construct habitat islands with excavated material.
- OAC Island Cuts: Construct limited temporary roads (with mats and material) as necessary to excavate island cuts in existing OAC marsh. Load material on trucks and place onsite as habitat islands/habitat transition zones.
- Habitat Transition Zones: Utilize excess onsite material as it becomes available, or import material from offsite locations to place and grade for construction of habitat transition zones. Scarify slopes prior to placement. Shape material with a dozer.
- Lower & Raise Levees: Working from the levee top, excavate material, load onto trucks, transport onsite and place at levee raising locations. If excess material is available, use material to build habitat transition zones.
- External Breaches & Raise Levees: Excavate external breaches with long reach excavators. Haul material onsite to complete levee raises. Import material to raise levees as needed.
- Trails and Viewing Platforms: Grade and compact proposed trail pathways. Import, place and compact trail base material. Geotextile fabric may be laid out, gravel compacted in-place, and quarry fines compacted on top to create an accessible surface. Create viewing platforms at-grade off-set from the main trail pathway; or if elevated, drill platform foundations and assemble onsite using small power tools.
- Signage and Benches: Install trails, signage, and benches on identified levees.
- Demobilization: Demobilize equipment via ground transportation.

A similar task construction sequence may be performed if Alternatives C and D are selected; however with the construction of a mid-complex levee, the contractor may choose to phase tasks between the Bay Ponds (planned to be tidal habitat) and the Inland and C-Ponds (planned to be managed ponds). For instance, if the Inland and/or C-Ponds are desired managed pond habitat for species, their project features may be constructed after completion of the features within the Bay Ponds (including the mid-complex levee). Some sequence constraints in these options, such as constructing the habitat transition zones before lowering access levees (Alternative D).

It is assumed that the bottom of the Bay and Inland Ponds will not support LGP equipment without temporary access road construction. It is also assumed that the bottom of the C-Ponds, with the exception of possibly Pond E2C, will support LGP equipment for the construction of channels within the pond bottoms. It is also assumed that fill will be imported as a rate that ensures an efficient construction operation. All fill is assumed to be imported from a dirt broker at no cost to the project.

The final equipment and sequencing will be developed by the selected contractor based on the contractor’s detailed work plan.

4.2.4 Schedule

The construction schedule will be driven by the volume of earthwork, construction work windows, weather conditions, and contractor means and methods.

4.2.4.1 Construction Work Windows

Construction activities will occur within permitted work windows to avoid impacts to special-status and other sensitive species. The dates provided were developed based on the Eden Landing Pond E12/13 Restoration Preliminary Design (PWA 2009) and the Alviso-Island Ponds A19, A20, and A21 Preliminary Design Memorandum (URS 2014b). Permits for this project may have different construction limitations.

In-channel construction will likely be limited between April 15 to October 15 when water levels are lowest. Considerations include:

- Steelhead could be present from December 15 to April 30. In-channel work between April 15 and April 30 should have an approved biological monitor present and should be done at low tides whenever possible.
- Longfin smelt and sturgeon could be present year-round. In-channel work should have an approved biological monitor present and should be conducted at low tide if possible.

Construction activities in bird nesting areas could be limited during the following periods listed for each species:

- March 1 to September 15 for western snowy plover
- February 1 to September 1 for terns, avocets, and stilts
- February 1 to September 1 or earlier (as allowed) for California Ridgway's rail

Negative results of pre-construction surveys and monitoring efforts could lengthen the permitted construction periods. Work in the spring and summer (March - August) is not prohibited, but approved buffer zones could be implemented to allow work to continue during nesting seasons.

4.2.4.2 Construction Schedule

Construction is expected to begin in 2018. Assuming a construction window of September 1 through March 1, a preliminary estimate of the overall duration of construction is shown in Table 4.12.

Table 4.12. Preliminary Project Construction Durations

Alternative	Duration (months) *
Alternative Eden B	29
Alternative Eden C	27
Alternative Eden D	27

*Duration is from initiation of mobilization to final demobilization and includes sequential, seasonal down time.

The construction durations for habitat transition zone creation will be primarily controlled by the availability of upland fill material that can be imported to the project site. Durations assume that sufficient fill material is available to allow for continuous operation during the construction windows, but that the quantity available will only allow for one habitat transition zone construction crew at a time. Habitat transition zone construction durations range from 7, 3.5, to 5 months (five 8-hour working days per week, with 4.35 weeks/month) for Alternatives B, C, and D (assuming single crews), which is a significant portion of the project duration. These durations also assume upland material is hauled onsite at the rate of possible placement, although road capacity will likely restrict delivery of material, possibly doubling the time required to build the habitat transition zones. Based on experiences at Inner Bair Island, if fill material will be provided by an independent dirt broker at no cost to the project, it is recommended that the above durations be increased if used for permitting or scheduling.

Other construction elements were allowed to occur concurrently with multiple crews provided that they made reasonable sense. The estimate is based on the assumption that some heavy construction activities may be permitted to occur during the nesting habitat window under the watch of a biological monitor.

4.2.5 Preliminary Cost Estimate

Table 4.13, Table 4.14, and Table 4.15 contain preliminary rough order of magnitude construction cost estimates for the three Eden Landing action alternatives. Each estimate depends on distinct features that may or may not be included in the final preferred alternative. Unit costs were developed based on a combination of similar AECOM project experience, unit construction costs from a contractor experienced in salt marsh restoration construction, the R.S. Means estimate guide, and vendor quotes.

Item #	Line Item	Quantity	Unit	Unit Cost	Amount
1	Mobilization & Demobilization				$1,881,300
1.1	Mobilization & Demobilization	1	LS	15%	$1,881,300
2	Site Preparation				$413,400
2.1	Clear & Grub	39	ACRE	$4,000	$156,000
2.2	Demolition Water Control Structures	16	EACH	$8,900	$142,400
2.3	Demolition Electrical Lines	1	LS	$115,000	$115,000
3	Earthwork				$6,728,000
3.1	Levee Raising (haul, fill)	91,000	CY	$17	$1,547,000
3.2	Levee Lowering (cut)	56,000	CY	$3	$168,000
3.3	Levee Breaches - External (cut)	68,000	CY	$7	$476,000
3.4	Levee Breaches - Internal (cut, haul, fill)	47,000	CY	$13	$611,000
3.5	Channels & Islands (cut, fill)	110,000	CY	$9	$990,000
3.6	Channel spurs (access road, cut, haul, fill)	36,000	CY	$27	$972,000
3.7	Habitat Transition Zones (haul, fill)	147,000	CY	$12	$1,764,000
3.8	Hydroseeding	20	ACRE	$10,000	$200,000
4	Structures				$4,450,000
4.1	Water Control Structures	-	-	-	-
4.1.1	ACFCC/E2C (add to existing; two 48" pipes, 170 lf with headwalls & gates)	1	EACH	$670,000	$670,000
4.1.2	ACFCC/E2&E4 via Alameda County Wetlands (6'x6' concrete box, 200 lf with headwalls & gates)	1	EACH	$630,000	$630,000
4.1.3	E2C/CP3C (replace existing one 48" pipe, 75 lf, with gates)	1	EACH	$375,000	$375,000
4.1.4	E1C/E5C (south) (one 48" pipe, 75 lf, with gates)	1	EACH	$375,000	$375,000
4.2	Bridges (~300 ft long)	2	EACH	$1,600,000	$3,200,000
4.3	Bridges (~500 ft long)	0	EACH	$2,100,000	$0
5	Public Access Features				$950,300
5.1	Recreational Trails	311,200	SF	$3	$933,600
5.2	Interpretive Signage	1	EACH	$3,900	$3,900
5.3	Benches	1	EACH	$6,800	$6,800
5.4	Viewing Platform	1,000	SF	$6	$6,000
	Subtotal				$15,343,000
	Design & Unit Cost Contingency			25%	$3,835,800
	Total Direct Construction Cost				$19,178,800
	Construction Contingency			30%	$5,753,700
	Total				**$24,932,500**

Table 4.13. Preliminary Cost Estimate for Eden Landing – Alternative B

Item #	Line Item	Quantity	Unit	Unit Cost	Amount
1	Mobilization & Demobilization				$2,554,100
1.1	Mobilization & Demobilization	1	LS	15%	$2,554,100
2	Site Preparation				$353,800
2.1	Clear & Grub	33	ACRE	$4,000	$132,000
2.2	Demolition Water Control Structures	12	EACH	$8,900	$106,800
2.3	Demolition Electrical Lines	1	LS	$115,000	$115,000
3	Earthwork				$4,145,000
3.1	Levee Raising (haul, fill)	82,000	CY	$17	$1,394,000
3.2	Levee Lowering (cut)	56,000	CY	$3	$168,000
3.3	Levee Breaches - External (cut)	34,000	CY	$7	$238,000
3.4	Levee Breaches - Internal (cut, haul, fill)	29,000	CY	$13	$377,000
3.5	Channels & Islands (cut, fill)	48,000	CY	$9	$432,000
3.6	Channel spurs (access road, cut, haul, fill)	18,000	CY	$27	$486,000
3.7	Habitat Transition Zones (haul, fill)	75,000	CY	$12	$900,000
3.8	Hydroseeding	15	ACRE	$10,000	$150,000
4	Structures				$11,075,000
4.1	Water Control Structures	-	-	-	-
4.1.1	ACFCC/E2C (add to existing; two 48" pipes, 170 lf with headwalls & gates)	1	EACH	$670,000	$670,000
4.1.2	ACFCC/Alameda County Wetlands (6'x6' concrete box, 200 lf with headwalls & gates)	1	EACH	$630,000	$630,000
4.1.3	OAC/E6 (two 48" pipes, 150 lf with gates)	1	EACH	$430,000	$430,000
4.1.4	E1C/E5C (south) (one 48" pipe, 60 lf with gates)	1	EACH	$370,000	$370,000
4.1.5	E1C/E5C (north) (one 48" pipe, 50 lf with gates)	1	EACH	$365,000	$365,000
4.1.6	Wetlands/E1C (one 48" pipe, 30 lf with gates)	1	EACH	$355,000	$355,000
4.1.7	Wetlands/J-Ponds (one 48" pipe, 50 lf with gates)	1	EACH	$365,000	$365,000
4.1.8	E6/E5 (west) (one 48" pipe, 40 lf with gates)	1	EACH	$360,000	$360,000
4.1.9	E6/E5 (east, replace existing) (one 48" pipe, 40 lf with gates)	1	EACH	$360,000	$360,000
4.1.10	E5/E6C (west, repair gates only)	1	EACH	$100,000	$100,000
4.1.11	E5/E6C (east, repair gates only)	1	EACH	$100,000	$100,000
4.1.12	E7/E5 (one 48" pipe, 50 lf with gates)	1	EACH	$370,000	$370,000
4.2	Bridges (~300 ft long)	2	EACH	$1,600,000	$3,200,000
4.3	Bridges (~500 ft long)	2	EACH	$2,100,000	$4,200,000
5	Public Access Features				$1,453,000
5.1	Recreational Trails	473,200	SF	$3	$1,419,600
5.2	Interpretive Signage	2	EACH	$3,900	$7,800
5.3	Benches	2	EACH	$6,800	$13,600
5.4	Viewing Platform	2,000	SF	$6	$12,000
	Subtotal				$20,500,900
	Design & Unit Cost Contingency			25%	$5,125,300
	Total Direct Construction Cost				$25,626,200
	Construction Contingency			30%	$7,687,900
	Total				**$33,314,100**

Table 4.14. Preliminary Cost Estimate for Eden Landing – Alternative C

Item #	Line Item	Quantity	Unit	Unit Cost	Amount
1	Mobilization & Demobilization				$1,955,700
1.1	Mobilization & Demobilization	1	LS	15%	$1,955,700
2	Site Preparation				$450,700
2.1	Clear & Grub	55	ACRE	$4,000	$220,000
2.2	Demolition Water Control Structures	13	EACH	$8,900	$115,700
2.3	Demolition Electrical Lines	1	LS	$115,000	$115,000
3	Earthwork				$5,867,000
3.1	Levee Raising (haul, fill)	143,000	CY	$17	$2,431,000
3.2	Levee Lowering (cut)	42,000	CY	$3	$126,000
3.3	Levee Breaches - External (cut)	33,000	CY	$7	$231,000
3.4	Levee Breaches - Internal (cut, haul, fill)	30,000	CY	$13	$390,000
3.5	Channels & Islands (cut, fill)	89,000	CY	$9	$801,000
3.6	Channel spurs (access road, cut, haul, fill)	17,000	CY	$27	$486,000
3.7	Habitat Transition Zones (haul, fill)	96,000	CY	$12	$1,152,000
3.8	Hydroseeding	25	ACRE	$10,000	$250,000
4	Structures				$5,770,000
4.1	Water Control Structures	-	-	-	-
4.1.1	ACFCC/E2C (add to existing; two 48" pipes, 170 lf with headwalls & gates)	1	EACH	$670,000	$670,000
4.1.2	E2C/CP3C (replace existing one 48" pipe, 75 lf, with gates)	1	EACH	$375,000	$375,000
4.1.3	OAC/E6 (two 48" pipes, 150 lf with gates)	1	EACH	$670,000	$670,000
4.1.4	E1C/E5C (south) (one 48" pipe, 60 lf with gates)	1	EACH	$370,000	$370,000
4.1.5	E1C/E5C (north) (one 48" pipe, 50 lf with gates)	1	EACH	$365,000	$365,000
4.1.6	E6/E5 (west) (one 48" pipe, 40 lf with gates)	1	EACH	$360,000	$360,000
4.1.7	E6/E5 (east, replace existing) (one 48" pipe, 40 lf with gates)	1	EACH	$360,000	$360,000
4.1.8	E5/E6C (west, repair gates only)	1	EACH	$100,000	$100,000
4.1.9	E5/E6C (east, repair gates only)	1	EACH	$100,000	$100,000
4.2	Bridges (~300 ft long)	2	EACH	$1,600,000	$3,200,000
4.3	Bridges (~500 ft long)	0	EACH	$2,100,000	$0
5	Public Access Features				$950,300
5.1	Recreational Trails	311,200	SF	$3	$933,600
5.2	Interpretive Signage	1	EACH	$3,900	$3,900
5.3	Benches	1	EACH	$6,800	$6,800
5.4	Viewing Platform	1,000	SF	$6	$6,000
	Subtotal				$15,913,700
	Design & Unit Cost Contingency			25%	$3,978,500
	Total Direct Construction Cost				$19,892,200
	Construction Contingency			30%	$5,967,700
	Total				**$25,859,900**

Table 4.15. Preliminary Cost Estimate for Eden Landing – Alternative D

Note: LS = lump sum; CY = cubic yards; apparent errors in table totals due to rounding.

The following assumptions were made in developing this preliminary cost estimate.

- Pond bottoms of the Bay and Inland Ponds will be wet during construction and will not support low ground pressure equipment without matting and road construction out into the ponds. Pond bottoms of the C-Ponds will be dry during construction and have the ability to support low ground pressure equipment.
- Building temporary roads out into the ponds to excavate channels requires construction sequencing considerations because fill material will have to be brought into the site, and efficient management of this fill material could reduce costs.
- Import fill is assumed to be provided to the projects by a dirt broker at no cost to the project and in a quantity that does not limit typical equipment production rates.
- Significant culvert costs include T-shaped bridge structures (on both sides) to operate gates, sheet piling, dewatering, trenching, HDPE piping, and combination gates on either side of the pipe. (HDPE pipe is assumed in this estimate as opposed to CMP.)
- Significant concrete box culvert costs include concrete headwalls (both sides), sheet piling, dewatering, trenching, cast-in-place concrete, and combination gates on either side of the culvert.
- Approximately half of the disturbed acreage from levee raising and cutting is assumed to be hydroseeded, as areas exposed to tidal waters are anticipated to be naturally seeded once tidal exchange is returned to the ponds.
- Each Alternative contains optional Trail Routes 1, 2, and 3. An average distance of Trail Routes 1, 2, and 3 (approximately 10,000 linear feet) was used in cost estimates.
- The estimate includes a design and unit cost contingency of 25 percent to cover changes to the design assumptions and components and uncertainty in material unit costs.
- The estimate includes a construction contingency of 30 percent to cover changes to the project costs during construction.
- The contingencies do not include costs for engineering design, environmental documentation, permits, or contract and construction administration.

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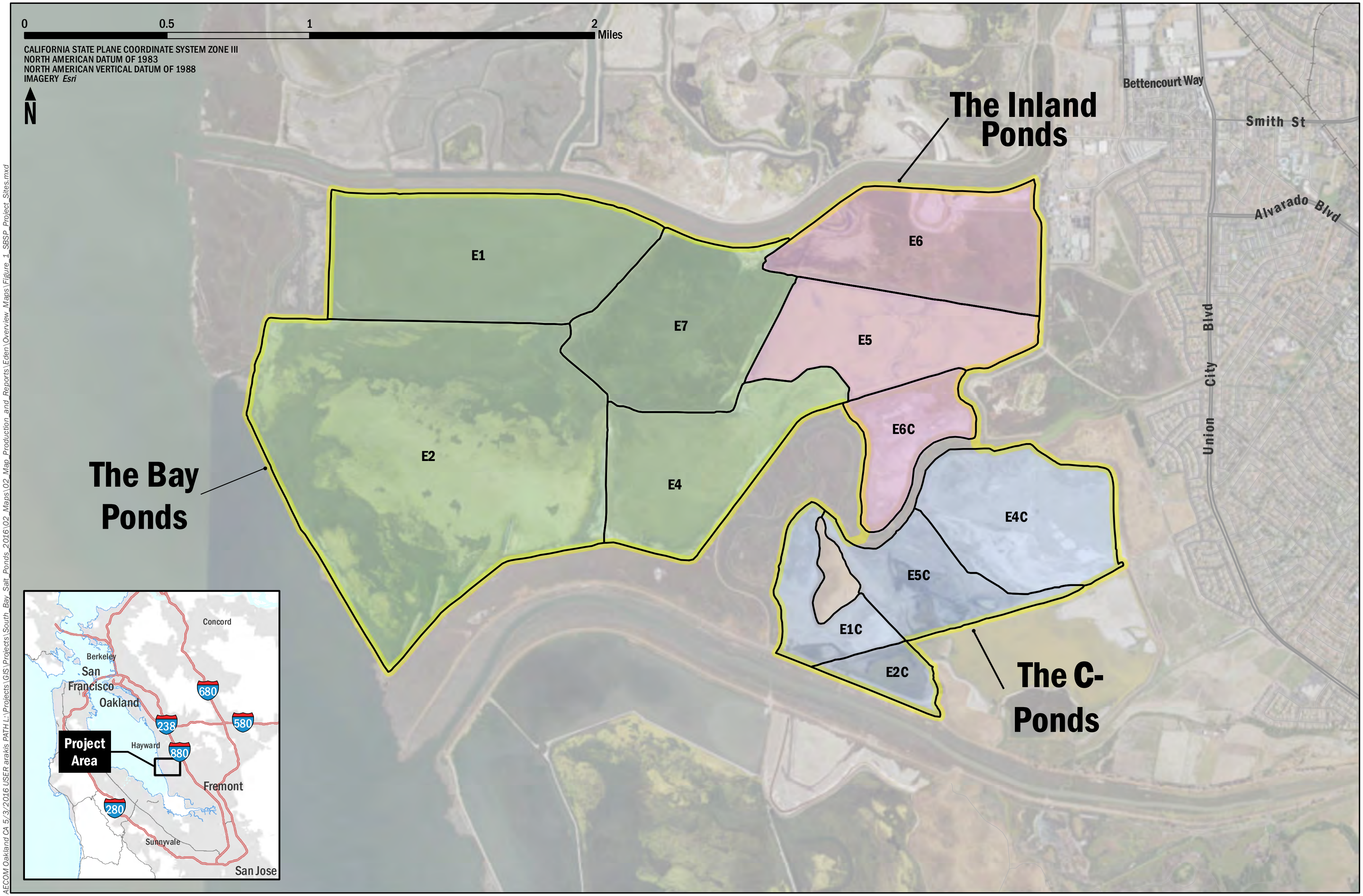
Appendix A

Eden Landing Figures



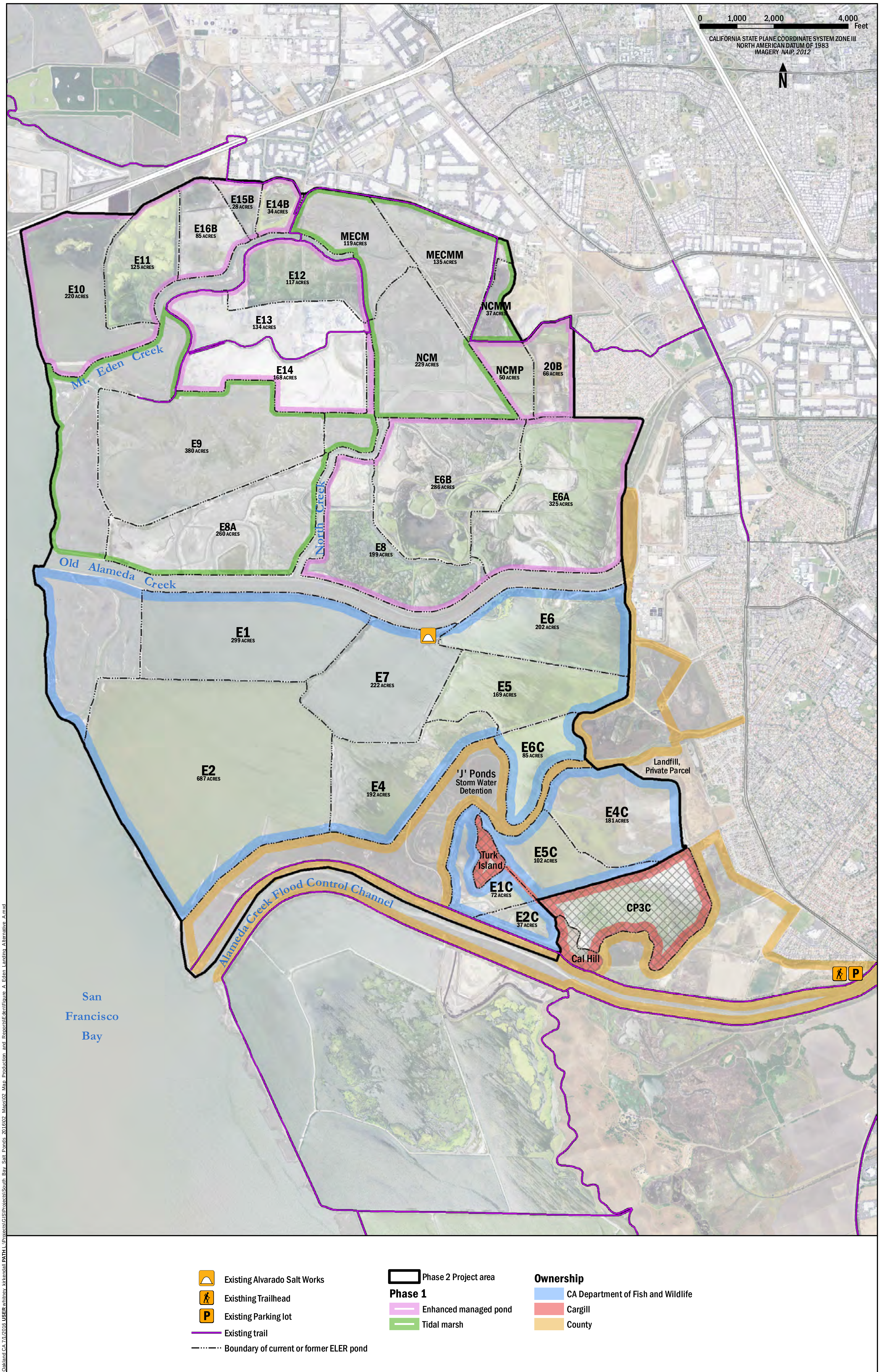
LEGEND

- Phase 2 Eden Landing Project Area
- The Bay Ponds
- The C Ponds
- The Inland Ponds

AECOM

South Bay Salt Pond Restoration Project
Eden Landing Phase 2: Project Area

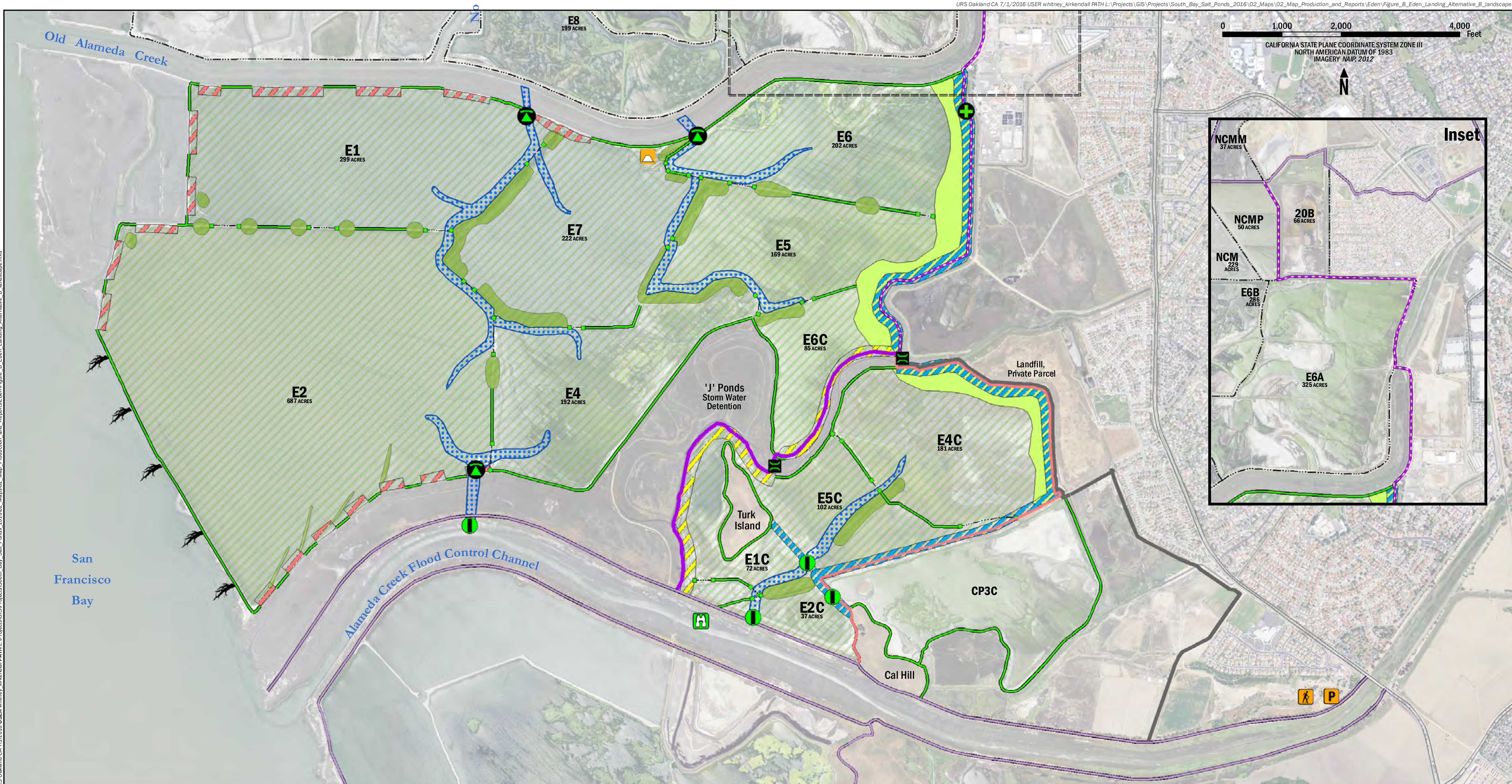
Figure A-1
Eden Landing Phase 2: Project Area



AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Alternative Eden A

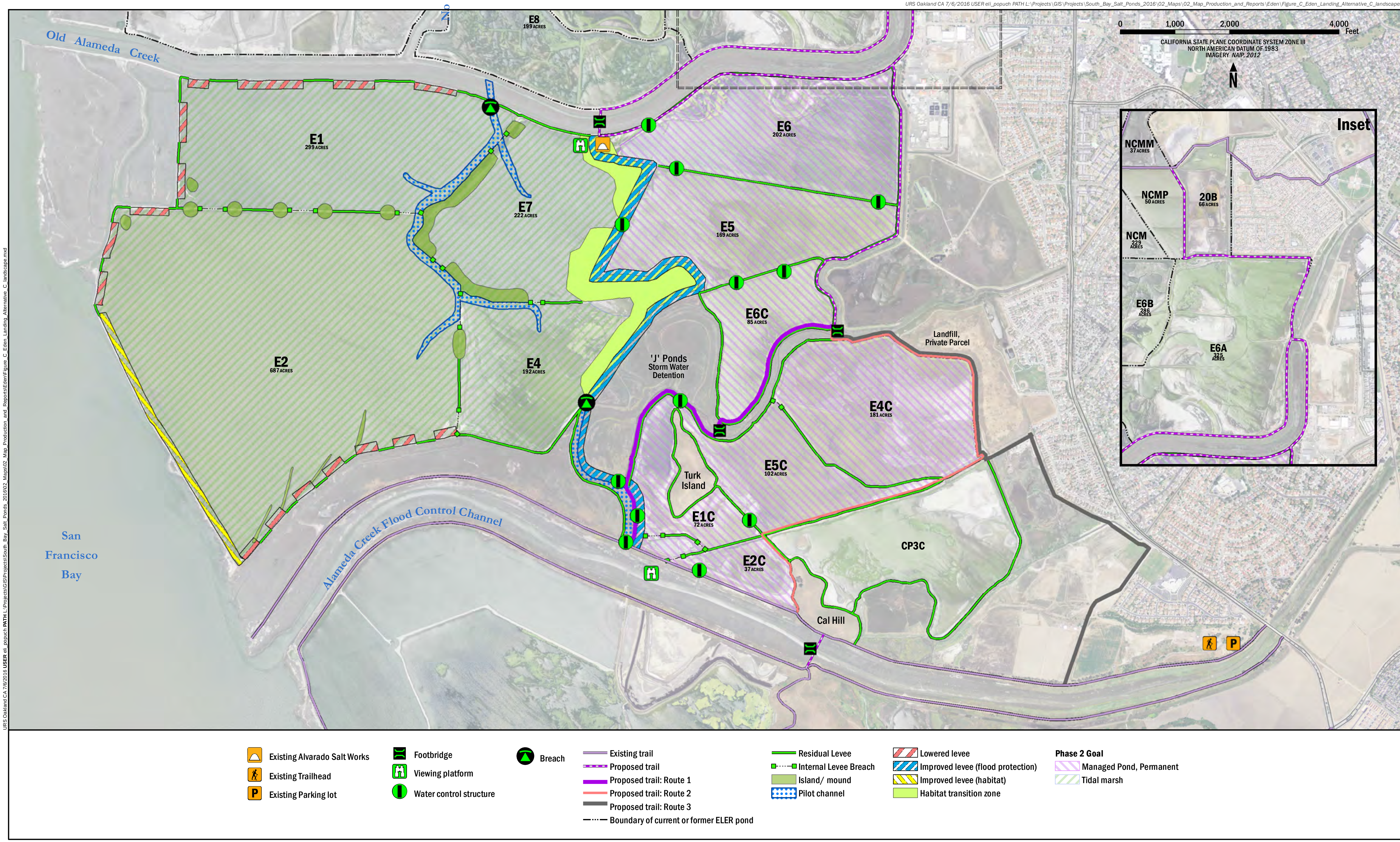


Existing Alvarado Salt Works
Existing Trailhead
Existing Parking lot
Logs for marsh enhancement
Footbridge
Viewing platform
Water control structure
Breach
Union Sanitary District connection
Existing trail
Proposed trail
Proposed trail: Route 1
Proposed trail: Route 2
Proposed trail: Route 3
Boundary of current or former Northern ELER pond
Residual Levee
Internal Levee Breach
Island/ mound
Pilot channel
Lowered levee
Improved levee (habitat)
Improved levee (flood protection)
Habitat transition zone
Phase 2 Goal
Tidal marsh

AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

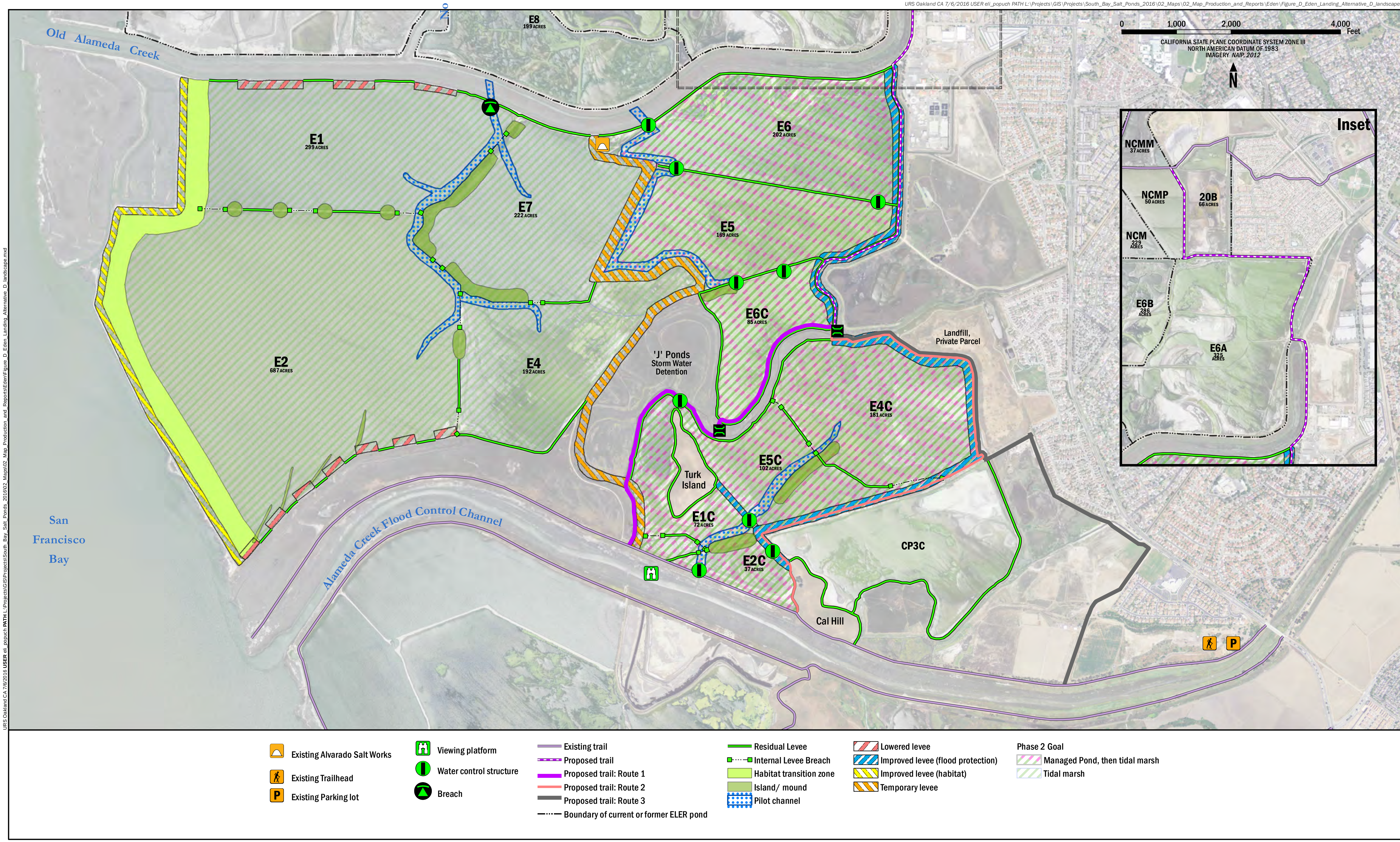
Alternative Eden B



AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

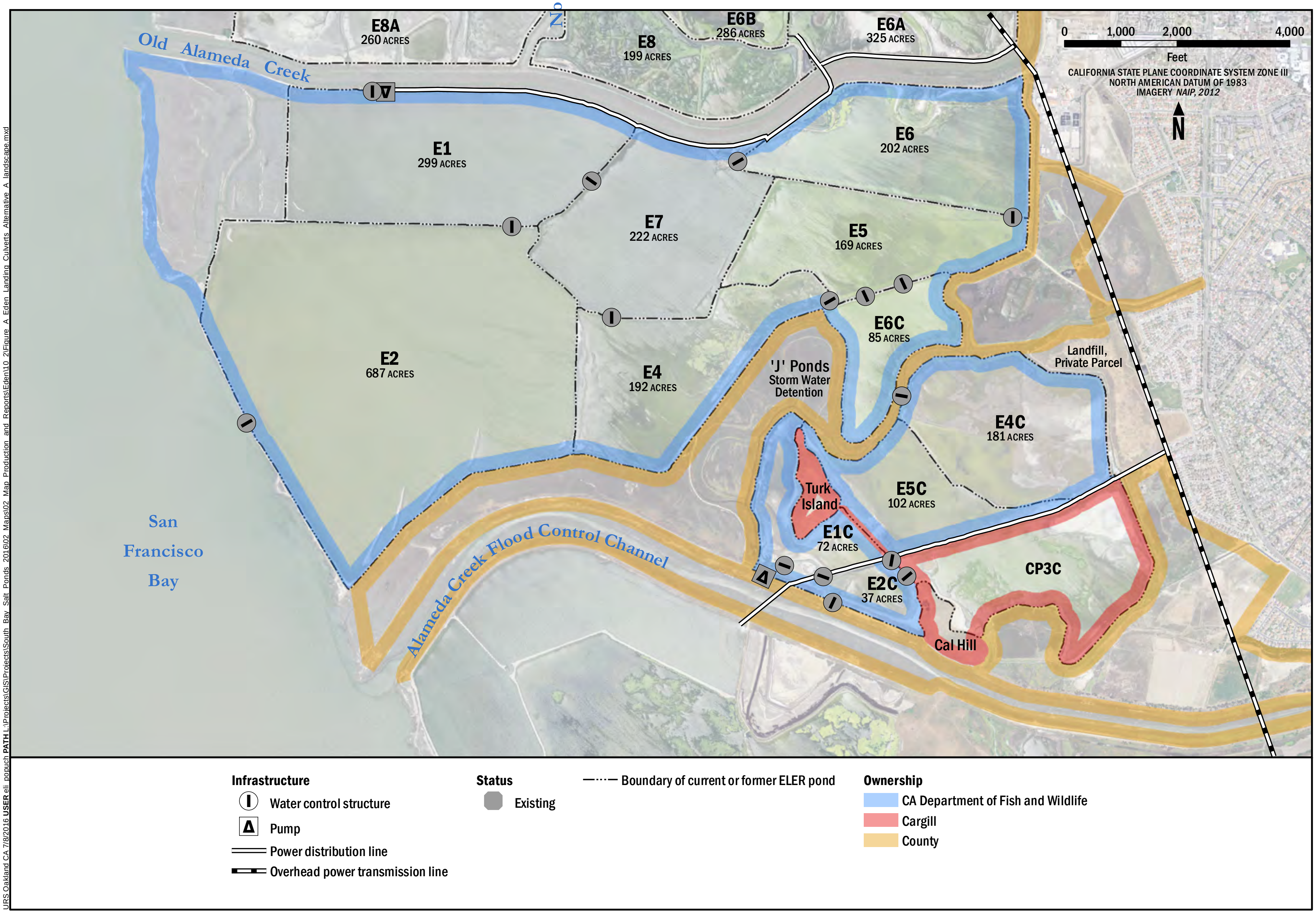
Alternative Eden C



AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

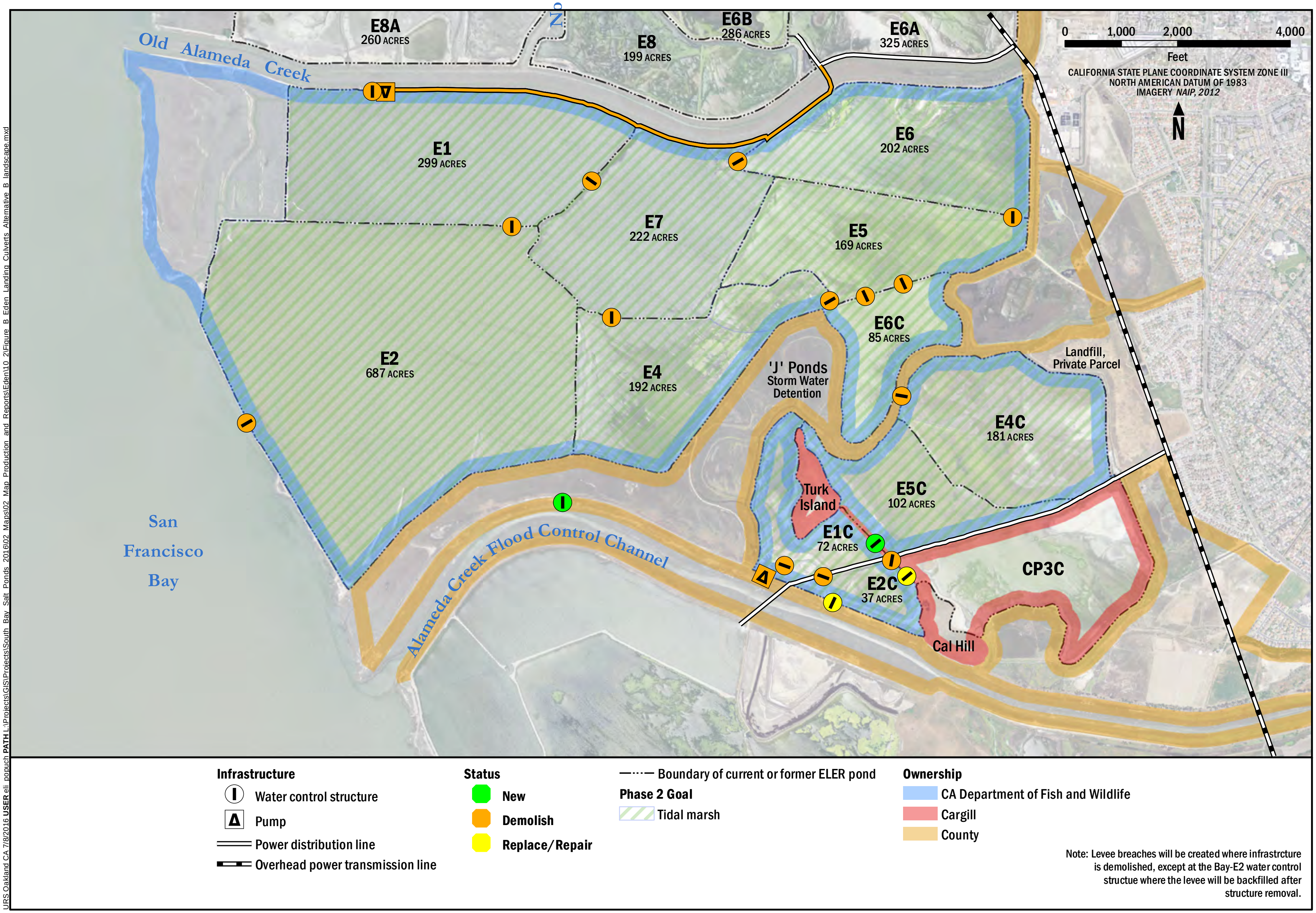
Alternative Eden D



AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

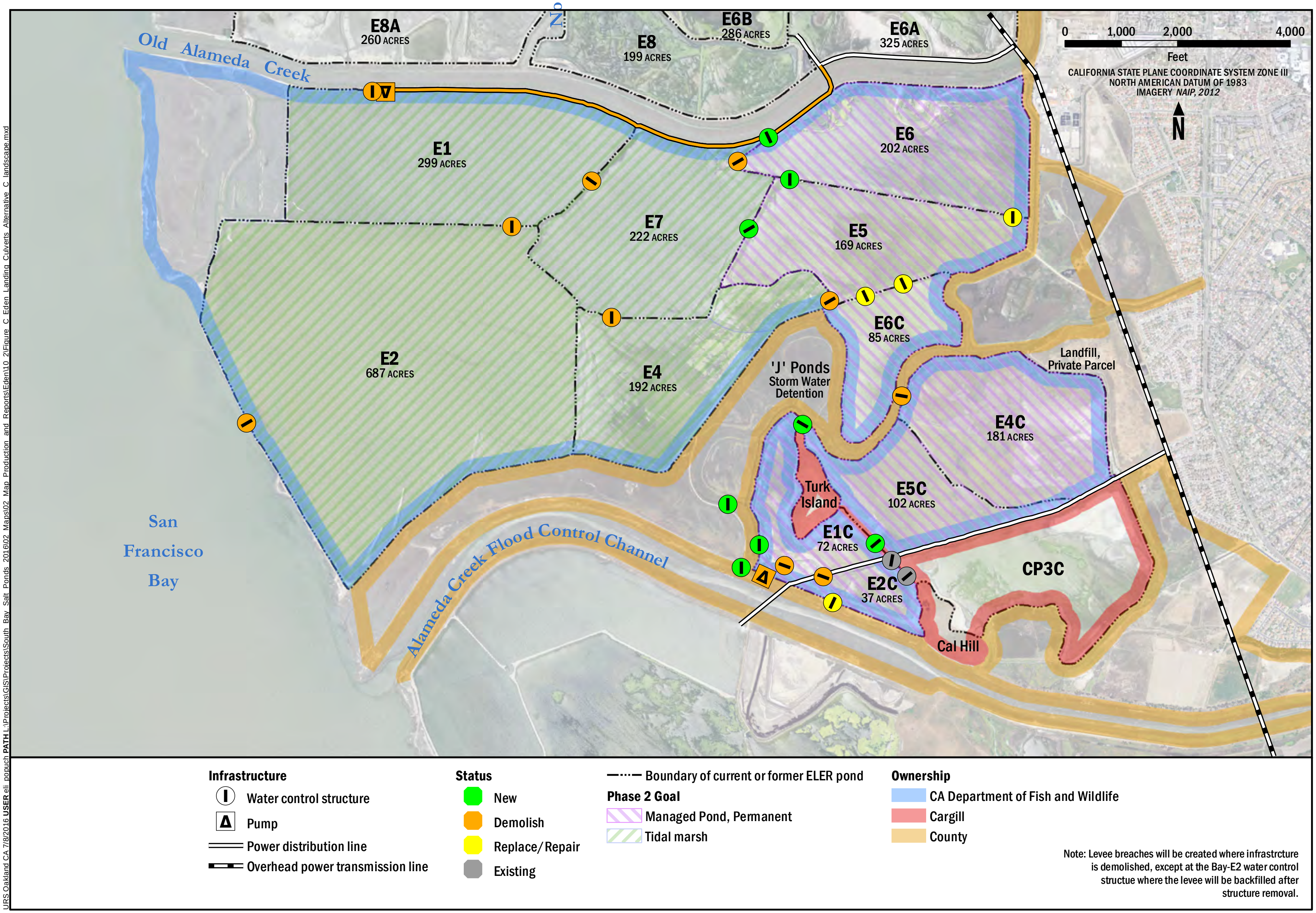
Infrastructure Alternative A



AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

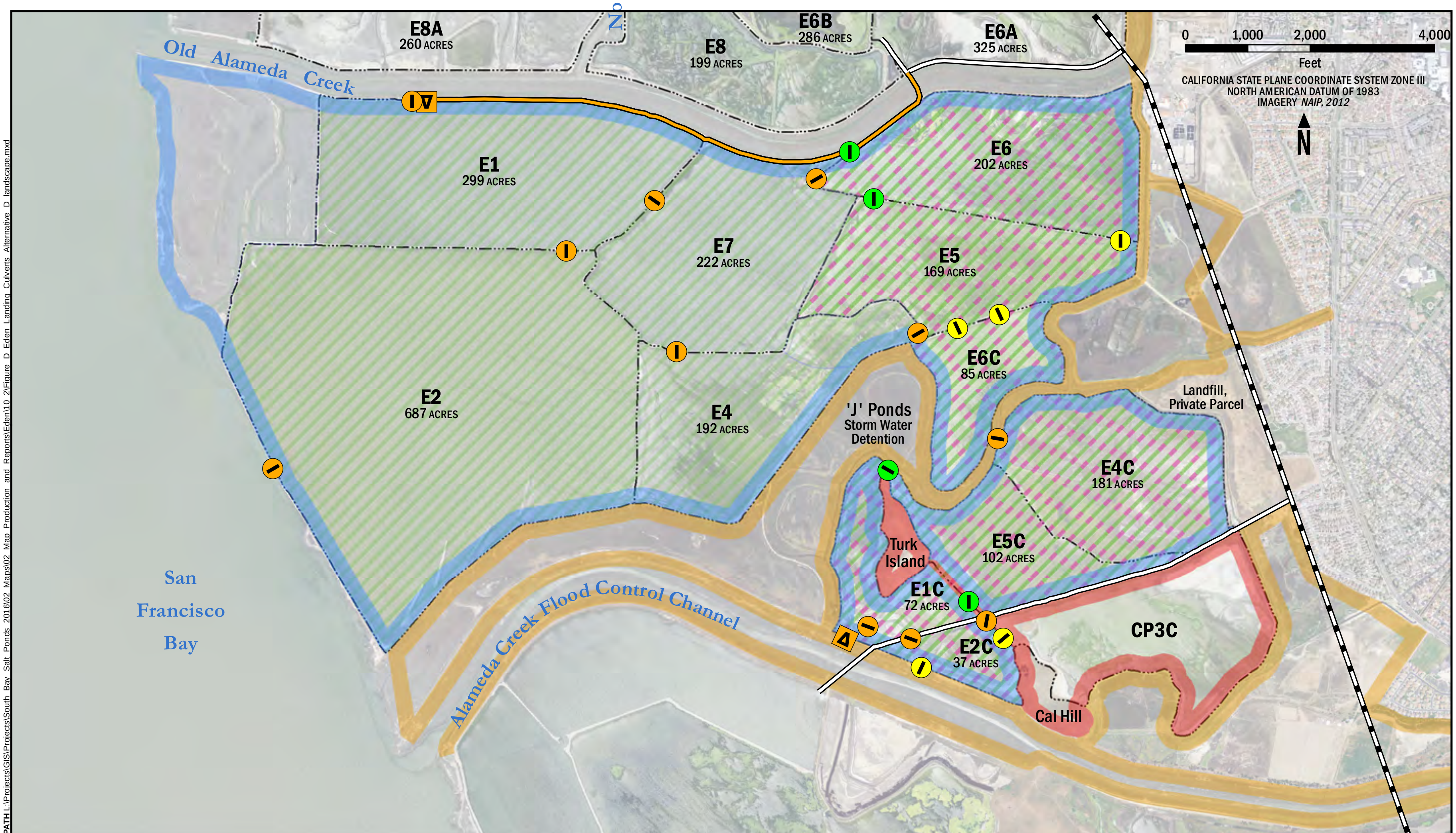
Infrastructure Alternative B



AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Infrastructure Alternative C



Infrastructure
- Water control structure
- Pump
- Power distribution line
- Overhead power transmission line

Status
- New
- Demolish
- Replace/Repair

Boundary of current or former ELER pond

Phase 2 Goal
- Managed Pond, then tidal marsh
- Tidal marsh

Ownership
- CA Department of Fish and Wildlife
- Cargill
- County

Note: Levee breaches will be created where infrastrcture is demolished, except at the Bay-E2 water control structure where the levee will be backfilled after structure removal. New and replaced/repaired water control structures in the Island Ponds will be demolished when the ponds are phased into tidal marsh.

URS Oakland CA 7/8/2016 USER eli_popuch PATH L:\Projects\GIS\Projects\South_Bay_Salt_Ponds_2016\02_Maps\02_Map_Production_and_Reports\Eden\10_2\Figure_D_Eden_Landing_Culverts_Alternative_D_landscape.mxd

AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Infrastructure Alternative D

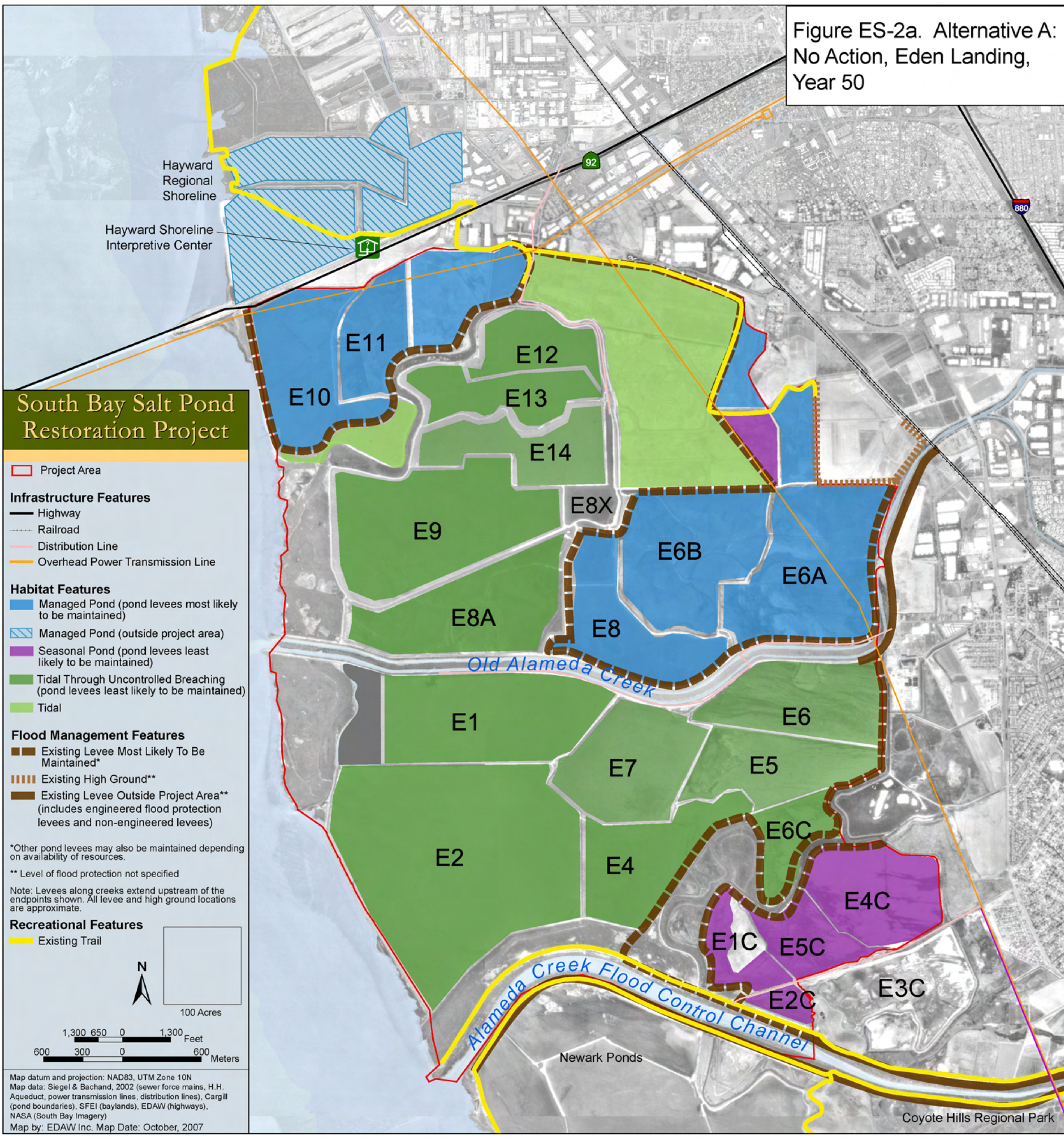


Figure A-6. Programmatic EIS/R Alternative A: No Action

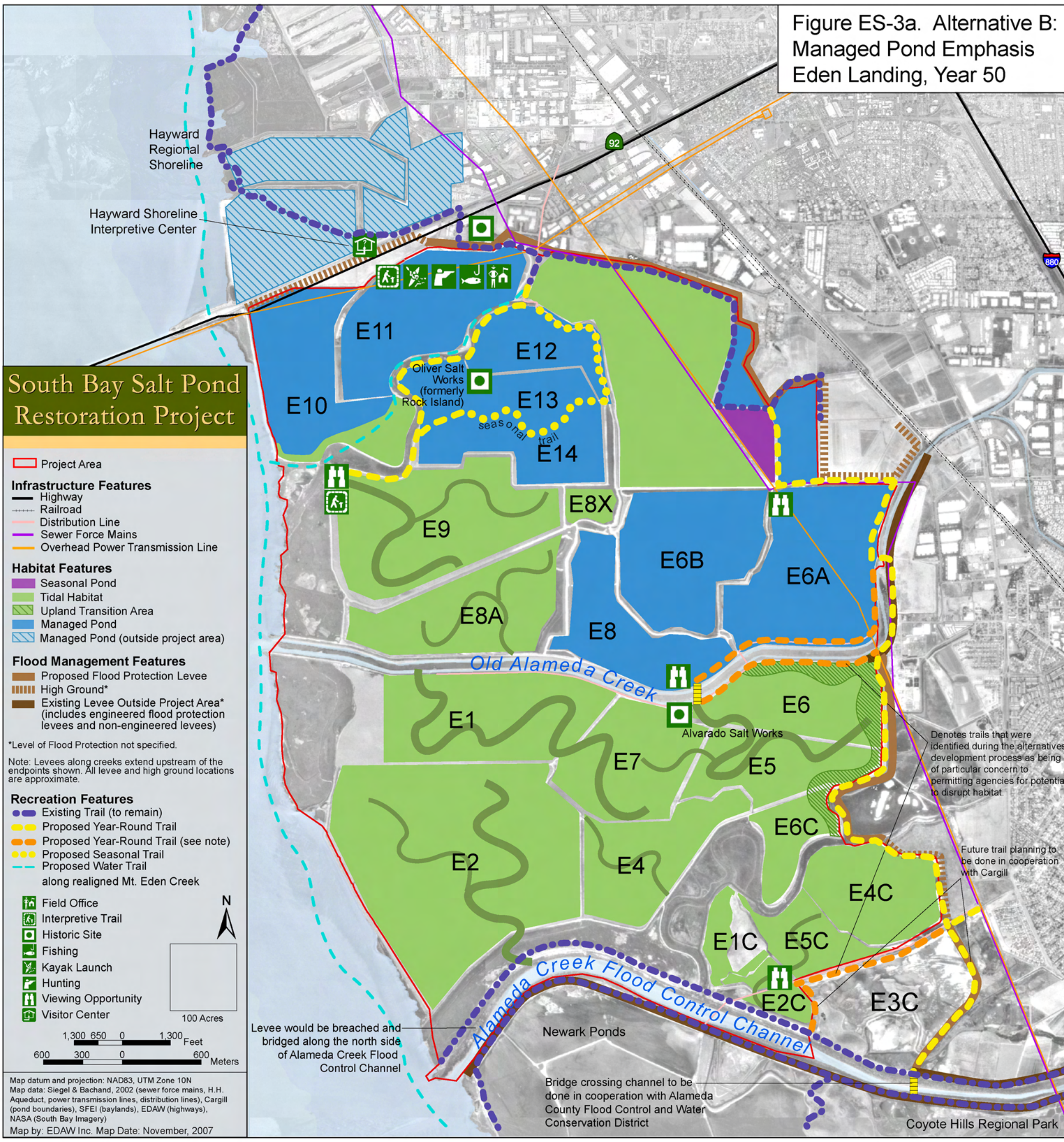


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Figure A-7. Programmatic EIS/R Alternative B: Managed Pond Emphasis

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Figure A-8. Programmatic EIS/R Alternative C: Tidal Habitat Emphasis

Appendix B

Levee Breach Design

Table A.1. External Breach Design: Empirical Relationships

Location	Pond Area (acres)	Avg. Pond Bottom Elev. (ft. NAVD88)	Potential Diurnal Tidal Prism (ac-ft)	Avg. Channel Cross-sectional Area (ft^2)	Bottom Elev. (ft. NAVD88)	Channel Top Width or Breach Length (ft.) (parallel crest)	Applicable Alternatives
OAC/E1 (west)	Note 1				0	30	B, C and D
OAC/E1 (east)	1,375 (E1, E2, E4, E7)	4.9 (E1) 4.8 (E2) 5.6 (E4) 5.2 (E7)	1,000	2,750	-4	380	B, C and D
OAC/E6	445 (E5, E6, E6C)	5.1 (E5, E6) 5.5 (E6C)	280	1,200	-4	160	B
Alameda County Wetlands/E2/E4	Note 2				2.7 or higher	50	B
Alameda County Wetlands/E4	Note 2				2.7 or higher	50	C

Note 1: Not applicable. Breach included due to structure removal and not designed with empirical relationships.

Note 2: Not applicable. Breach included to provide fish passage downstream of a culvert. Not designed with empirical relationships.

Table A.2. Internal Breach Design: Empirical Relationships

Location	Pond Area (acres)	Avg. Pond Bottom Elev. (ft. NAVD88)	Potential Diurnal Tidal Prism (ac-ft)	Avg. Channel Cross-sectional Area (ft^2)	Bottom Elev. (ft. NAVD88)	Channel Top Width or Breach Length (ft.) (parallel crest)	Applicable Alternatives
E1/E2 (west)	680 (E2)	4.8 (E2)	180	900	-4	120	B, C and D
E1/E2 (mid)			180	900	-4	120	B, C and D
E1/E2 (east)			180	900	-4	120	B, C and D
E1/E7	Note 1				-4	50	B, C and D
E2/E7	Note 1				5 (EG)	50	B, C and D
E7/E4	190 (E4)	5.6 (E4)	120	700	-4	100	B, C and D
E2/E4 (north)	Note 1				-4	50	B, C and D
E2/E4 (south)	Note 1				6 (EG)	50	B, C and D
E7/E6 (west)	Note 1				5 (EG)	25	B
E7/E6 (east)	200 (E6)	5.1 (E6)	130	730	-4	100	B
E5/E7	245 (E5, E6C)	5.1 (E6) 5.5 (E6C)	150	780	-4	110	B
E4/E5	Note 1				5 (EG)	50	B
E6/E5 (west)	Note 1				0	50	B
E6/E5 (east)	Note 1				5 (EG)	50	B
E5/E6C	80 (E6C)	5.5 (E6C)	20	230	-4	50	B
E1C/E2C Donut	Note 2				2.4	100	B, C and D
E2C Donut (west)	Note 2				2.4	50	B, C and D
E2C Donut (east)						50	B, C and D
E4C/E5C (mid)	95 (E5C)	6.1 (E5C)	60	410	2.7	50	B and D
E4C/E5C (south)					2.7	50	B and D

Note 1: Not applicable. Breach included to promote water exchange between ponds and not designed with empirical relationships.

Note 2: Not applicable. Culvert causes muted tides; therefore, breaches not designed with empirical relationships.

ATTACHMENT 1. SOUTHERN EDEN LANDING RESTORATION PRELIMINARY DESIGN: 1D AND 2D HYDRODYNAMIC MODELING

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South Bay Salt Pond Restoration Project

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

Coastal Conservancy

U.S. FISH & WILDLIFE SERVICE

MEMORANDUM

TO:	Members of the South Bay Salt Pond Restoration Project Management Team
FROM:	AECOM
DATE:	July 2016
RE:	**Attachment 1. Southern Eden Landing Restoration Preliminary Design: 1D and 2D Hydrodynamic Modeling**

1. INTRODUCTION

This memorandum documents the one- and two-dimensional hydrodynamic modeling performed in support of the Southern Eden Landing Restoration Preliminary Design (AECOM 2016a). The preliminary design is of the South Bay Salt Pond (SBSP) Restoration Project's Phase 2 actions at the southern half of the Eden Landing Ecological Reserve (ELER). For the purposes of this document, these ponds are referred to as the southern Eden Landing Ponds.

The southern Eden Landing Ponds includes 11 ponds that are described in three groups in this memorandum, based on their location within the complex and their proximity and similarity to each other. The groups are as follows and as shown in Figure 1.1:

- The Bay Ponds: Ponds E1, E2, E4, and E7 are the four relatively large ponds closest to San Francisco Bay, bordered to the north by the Old Alameda Creek (OAC) and to the south by

Alameda County-owned property including the Alameda County Wetlands and the Alameda County Flood Control Channel (ACFCC).

- The Inland Ponds: Ponds E5, E6, and E6C are somewhat smaller ponds in the northeast portion of the complex. They are bordered to the north by OAC, to the east by the Union Sanitary District Waste Water Treatment Plant and Cargill owned property (used by the Southern Alameda County Radio Controllers Aircraft Club), and to the south by an Alameda County-owned freshwater outflow channel and diked marsh areas known collectively as the "J-Ponds".
- The Southern Ponds or C-Ponds: Referred to by both names, Ponds E1C, E2C, E4C, and E5C are in the southeastern portion of the complex. They are separated from the Inland Ponds and the Bay Ponds by the J-Ponds.

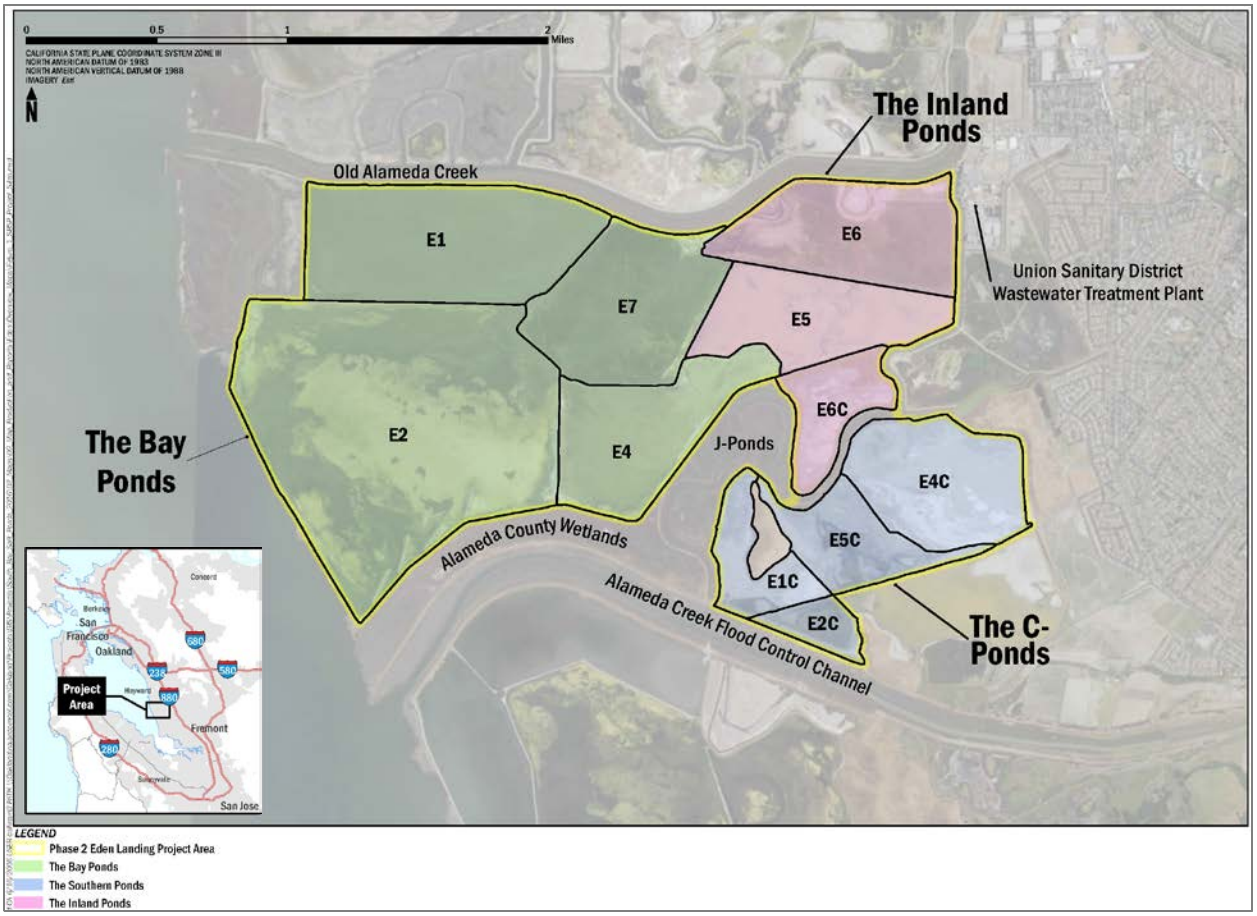

Figure 1.1. Project Vicinity Map

The Phase 2 southern Eden Landing alternatives include one no-action (Alternative Eden A) and three action project alternatives (Alternatives Eden B, C and D) as graphically depicted in Appendix A on Figures A-2, A-3, A-4, and A-5. Each of these alternatives also includes new infrastructure and repair of existing structures as shown in Figures A-6, A-7, A-8, and A-9. Figure 1.2 below shows no-action infrastructure alternative map (Figure A-6) which details existing infrastructure (culverts, pumps, and electrical lines) within southern Eden Landing. Table 1.1 summarizes these existing culverts and pumps and the proposed action. Proposed actions include demolishing or repairing/replacing structures. Demolished materials will be salvaged for re-use elsewhere, or disposed or recycled off-site.

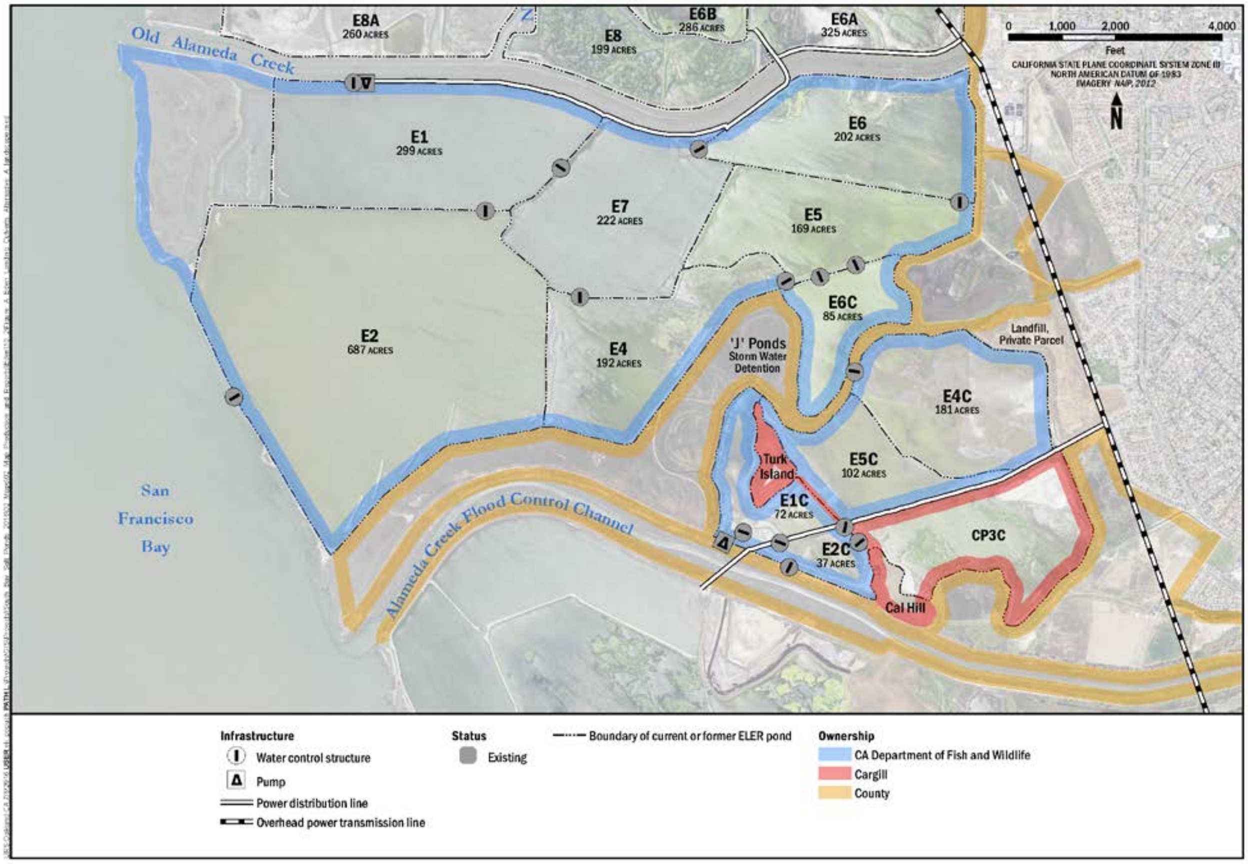

Figure 1.2. Existing Infrastructure

Table 1.1. Existing Water Control Structures

Location	Quantity	Size	Type	Action
E2 - Bay	2	48 in.	Intake/discharge gates	Demolish (backfill levee)
OAC - E1	4	48 in.	(2) Intake/discharge open pipes/combo gates	Demolish
			(2) Intake/discharge slide gates/flap gates	
OAC - E1	1	10,000 gpm	Pump (#1 Baumberg Intake)	
E1 - E2	1	48 in.	Slide gate	
E1 - E7	1	48 in.	Slide gate	
E7 - E4	1	48 in.	Slide gate	
E7 - E6	1	48 in.	Slide gate	
E4 - E5	1	48 in.	Combo gate	
E6 - E5	4	30 in.	Wood gates	Demolish (Alt. B) or Replace/repair (Alt. C & D)
E5 - E6C	2	36 in.	Combo gates	
E6C - E4C	2	30 in.	Siphons (not operable)	Demolish (backfill levee)
E2C - E5C	1	36 in.	Combo gate	
ACFCC - E1C	1	7,660 gpm	Pump (Cal Hill Intake) (not operable)	
ACFCC - E2C	2	48 in.	Intake/discharge combo gates	Replace/repair
E2C - CP3C	1	48 in.	Slide gate	
E2C - E2C donut	1	36 in.	Unknown (open)	Demolish
E1C - E2C donut	1 1	24 in. 10,000 gpm	Unknown (not operable) Pump (Cal Hill Transfer) (not operable)	

2. METHODOLOGY

AECOM developed a two-dimensional hydrodynamic model using MIKE21 to refine the design of restoration features including levee breach and pilot channel dimensions, levee raising and lowering heights and locations, and culvert locations and numbers. A one-dimensional hydraulic model using HEC-RAS was also developed to efficiently analyze culvert sizes for the C-Ponds and Inland Ponds, as HEC-RAS has a more robust culvert routine and the model runtime is minutes instead of hours with MIKE21. Analyses were performed on the three project action alternatives (Alternatives Eden B, C and D). These alternatives are graphically depicted in Appendix A on Figures A-3, A-4, and A-5.

The following sections include a description of the model methodology (model type, domain, restoration feature design criteria, modeling scenarios, and inputs). Because there were no available flow or pond water surface elevation data, neither of the models were calibrated.

2.1 Model Types

<u>MIKE21 FM Model</u>
AECOM used MIKE21 Flexible Mesh Flow Model version 2016 (MIKE21 FM) for this study. MIKE21 FM simulates changes in water levels and velocities in response to tides, wind, and freshwater inflows. It solves the time-dependent, vertically integrated equations of continuity and conservation of momentum in two horizontal dimensions. The equations are solved using a cell-centered finite volume method. Water levels and flows are resolved using a spatial domain comprised of triangles and/or quadrilateral elements. Inputs include topography and bathymetry, structure geometry, bed resistance, structures, and hydrographic boundary conditions (e.g. tides and river discharge). Outputs include water surface elevation, total water depth, velocities, and discharge through structures.

<u>HEC-RAS Model</u>
USACE’s Hydrologic Engineering Center’s River Analysis System (HEC-RAS) was used to develop a model of the Eden Landing managed pond system. Existing and potential culverts were modeled to measure their effectiveness at filling the ponds during typical management activities and flood conditions. As mentioned above, HEC-RAS is the preferred model for culvert design as model runtimes are on the scale of minutes instead of hours with MIKE21, and HEC-RAS allows for more comprehensive culvert design. Inputs include topography and bathymetry, bed resistance, structures, and hydrographic boundary conditions (e.g. tides and river discharge). Outputs include water surface elevation and discharge velocities through structures.

2.2 Site Topography and Project Datum

Table 2.1 lists the three sources of topographic and bathymetric data used in this modeling analysis and the associated preliminary design.

Table 2.1. Topographic and Bathymetric Data

Data Source	Year Collected	Horizontal Datum	Vertical Datum	Projection
USGS 2010 SBSP Project LiDAR	2010	NAD83	NAVD88	UTM-10 10N
USGS 2005 SBSP Project Bathymetry	2003-2004	NAD83	NAVD88	CA State Plane III
USGS 2007 South San Francisco Bay Bathymetry	2005	NAD83	NAVD88	UTM-10 10N

The available site topography is high-accuracy LiDAR from the 2010 USGS San Francisco Coastal LiDAR project (San Francisco, Marin, Solano, Contra Costa, Alameda, San Mateo, Santa Clara counties, California). The LiDAR data was collected between June 11, 2010 and July 11, 2010.

USGS (2005) also conducted a bathymetric survey of the SBSP Project pond complexes between August 2003 and March 2004 using a shallow-water sounding system to measure water depths with a precision of 1 cm. The system was comprised of a single beam echosounder, a differential global positioning system (DGPS) unit, and a laptop computer on a shallow-draft kayak with a trolling motor. Sample depths were converted to elevation based on water surface elevations recorded every 15-20 minutes at the ponds. Transects were made at 100 meter intervals.

The below water elevations in the Bay adjacent to the project site were obtained from 2005 Hydrographic Survey of South San Francisco Bay, California by USGS, published in 2007. These data consisted of xyz data collected using a single beam acoustic sampler.

The digital elevation point files used in the hydrodynamic model were generated by merging the three sets of data using the horizontal spatial reference system of NAD83, CA State Plane III meters and vertical datum NAVD88, meters.

The data from the bathymetric survey of the SBSP pond complexes and the bathymetric survey of the South Bay were inserted into areas with no LiDAR coverage (to prevent overlapping points between the datasets). To reduce the number of LiDAR points for use in CADD and the hydrodynamic model, the LiDAR datasets were down sampled using a “model key point” algorithm. “Model key points” are points selected to represent local topography and are not removed during a point thinning process. This algorithm thins the ground class within a user-specified vertical tolerance. Areas which exhibit a greater variation in the terrain have more model key points than in areas with a smaller variation in terrain (for example a parking lot). The vertical tolerance parameter required for the algorithm mandates that a triangulated irregular network (TIN) surface generated from the model key points would be within the user-specified distance of a TIN surface generated from the original ground points. The algorithm vertical tolerance parameter was set to 6 inches (0.15 meters) for this study.

In general, the project site is comprised of fairly flat pond bottoms separated by levees. Many of the levees have borrow ditches directly adjacent to them. Figure 2.1 depicts the distribution of pond bottom elevations of the three groups of ponds, most of which are between MSL and MHW. About half of the pond bottoms are 1 ½ to 2 feet or more below MHW and less than 10% are higher than MHW. The C-Ponds are the highest group of ponds, followed by the Inland and Bay Ponds.

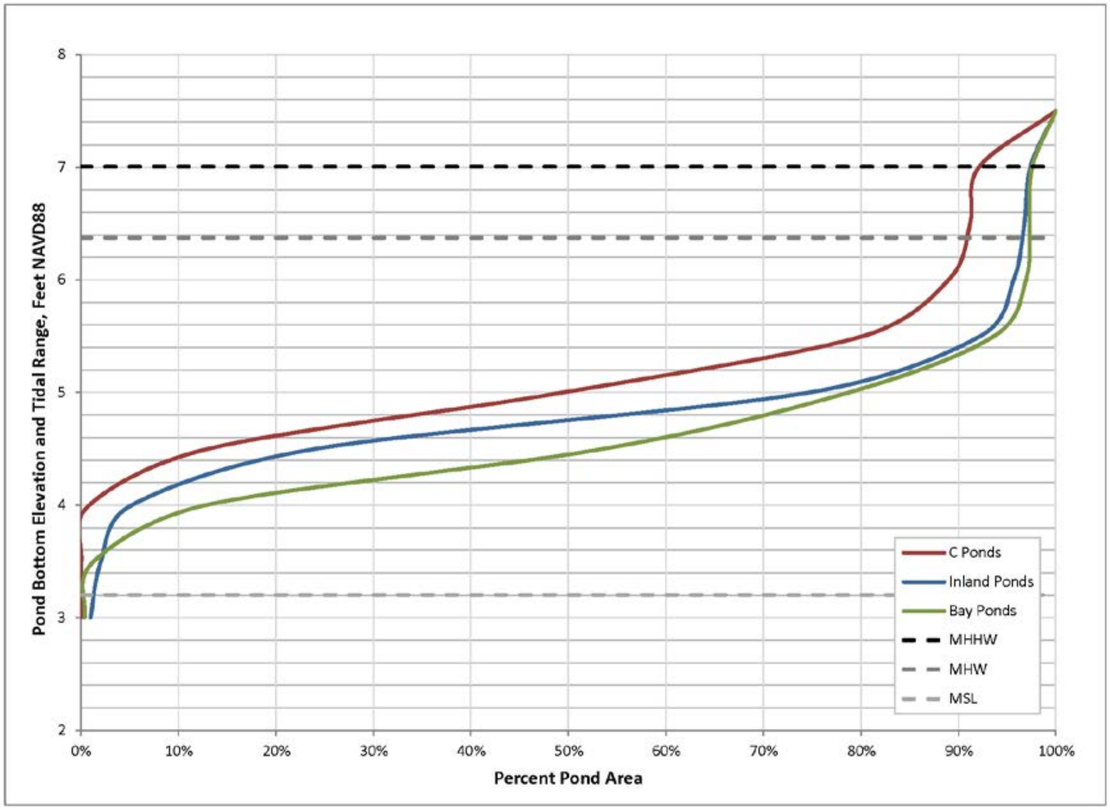

Figure 2.1. Average Pond Group Bottom Elevations

2.3 MIKE21 Model Domain

As mentioned in the previous section, the topographic and bathymetric data used to develop the model domain included three separate data sources. The final elevation grid used as input to the MIKE21 FM model is shown in Figure 2.2. (Please note, all MIKE21 model plan views are shown in metric coordinate systems and units, as the model runs most efficiently in metric.)

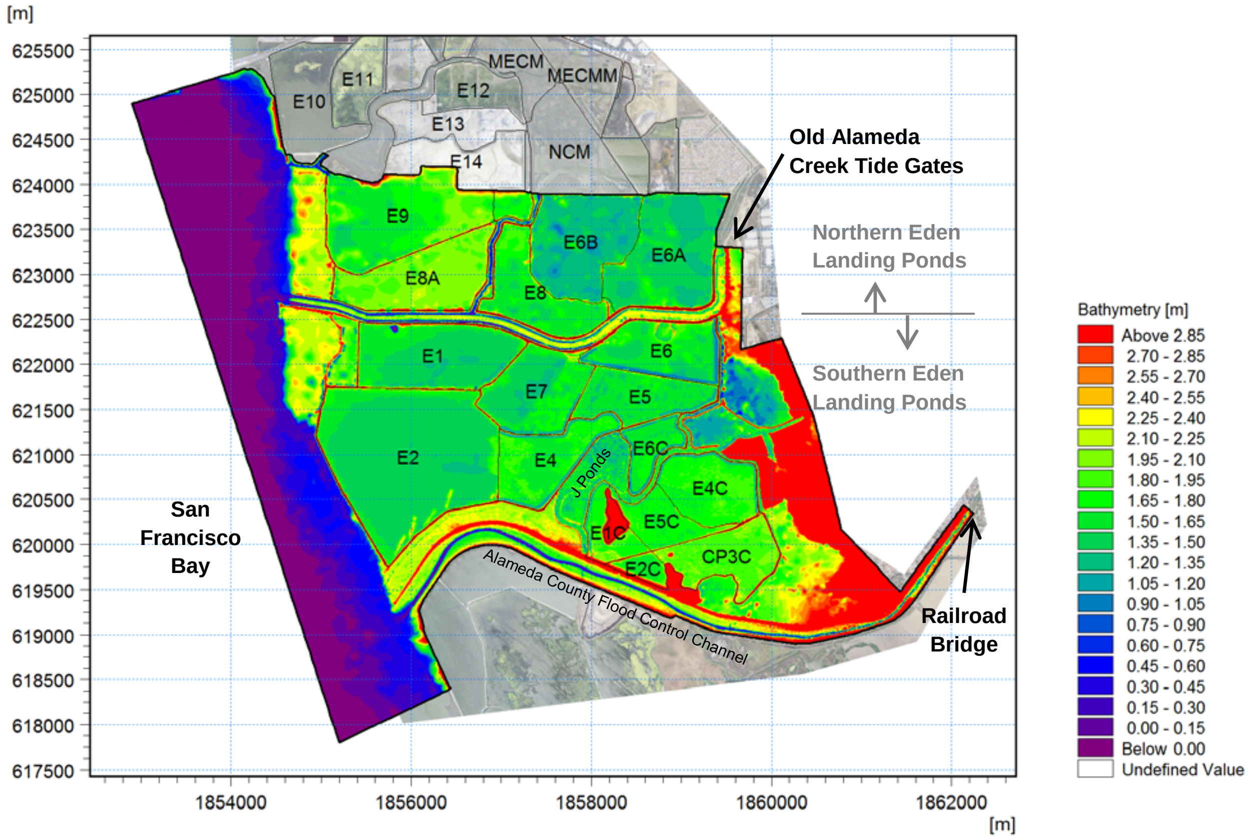

Figure 2.2. Model Elevation Grid (m NAVD88)

The model extent is as shown in Figure 2.2; bounded by the Bay to the west, the northern Eden Landing Ponds to the north, Alameda County property to the east, and ACFCC to the south. Along the OAC, the model extends to the tide gates located approximately 3.5 miles (18,500 feet) upstream from the Bay. Along the ACFCC, the model extends to the point of tidal influence approximately 4.7 miles (25,000 feet) upstream to the railroad bridge. The eastern boundary was determined with iterative modeling, which indicated that all modeled flood waters were contained by relatively high ground to the east. Of the northern Eden Landing Ponds, the three southwestern ponds (E8A, E9, and E8X) were included in the model extent because they were breached in September 2011 (SCC, 2012). The three southeastern managed ponds (E8, E6B, and E6A) were also included in the model, as they are overtopped during the 100-year flood event and therefore provide some storage capacity for the system.

The southern levee of the ACFCC was chosen as the southern extent of the model; however, it is likely overtopped during the 100-year flood event, allowing water to flow into Cargill’s currently-operating salt ponds to the south. This is because, although the southern ACFCC levee is slightly higher than the northern levee near the Bay (by approximately 1 foot), the momentum of the flow will direct the water against the northern levee first, potentially overtopping and breaching it. Therefore, the southern model extent assumption is considered a realistic, conservative approach for determining flood levels in the project area.

The spatial domain of the MIKE21 FM model is represented by a system of triangular sections called a mesh, which is composed of nodes and elements. A “node” is a point in space that has both horizontal coordinates and vertical elevation assigned to it. An “element” is a triangular or quadrilateral area bounded by three or four nodes, varied throughout the mesh, which allows the area of interest to be modeled at variable resolution.

For construction of the MIKE21 FM mesh, the node points from the LiDAR were imported into the MIKE21 FM Mesh Generator utility. The Mesh Generator develops the unstructured grid that is used as the model domain. The elevations of each mesh element were interpolated from the LiDAR point cloud.

The final mesh is shown in Figure 2.3. Denser areas indicate finer mesh. In general the mesh elements range in size from 100 to 5,000 m^2 (approximately 15 to 100 meters tall and wide triangular elements). Smaller elements down to 10 m^2 are located on many of the narrow levee crests. In general, the most impacted ponds (C-Ponds), creeks, and County lands have refined element sizes of 200 m^2. The larger, flatter ponds have element sizes of 1,250 m^2. Time was taken to construct the mesh such that the critical topographic features, such as levee crests and borrow ditches, were accurately captured in the model with connected paths of at least one element.

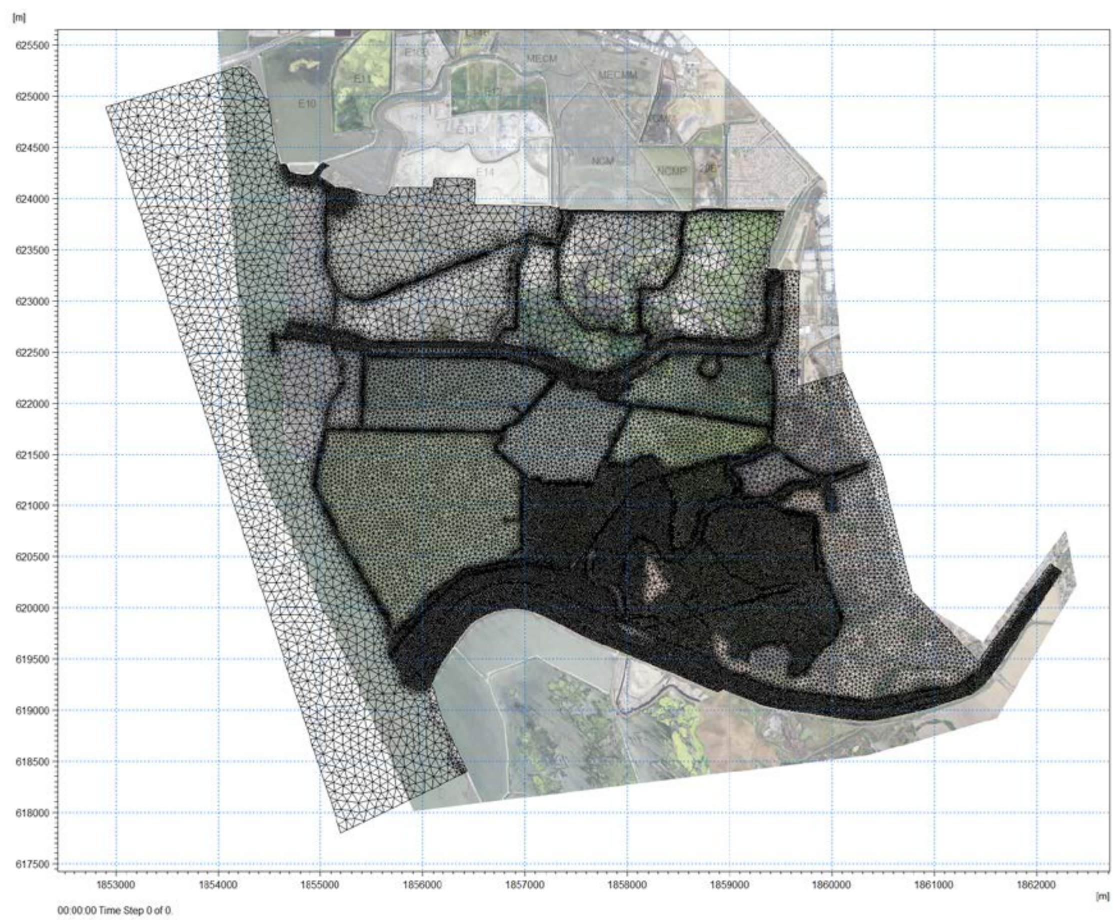

Figure 2.3. Model Mesh

Several modifications to the mesh and elevation grid were made in the Mesh Generator to improve the accuracy of the modeling results. These modifications include:

- The Northern Eden Landing Ponds were breached in September 2011 (SCC, 2012). The 2010 LiDAR data was modified to include levee breaches based on aerial imagery. Levee breach bottom elevations were estimated at about 5 feet NAVD88, similar to the surrounding pond bottom elevations.
- Borrow ditches and small channels visible in aerial imagery were included in the mesh to a greater detail than what was captured with the 100-meter bathymetry transects. Since limited bathymetry was available in these smaller ditches and channels, AECOM used nearby elevations that captured channel depths, and applied those elevations along the visible length of the channels (as determined by historic aerial images).
- Bathymetry was not available for the OAC or ACFCC, however, only the deepest portions of the channels were not captured with the 2010 LiDAR. As described in the results section, the OAC proved to be a major constriction in flow during the restoration scenarios. Because the OAC is comprised of a larger north and smaller south stream, separated by a marsh island in the middle, the smaller south stream was modified to resemble the larger north stream during some model runs. The southern stream in the OAC is anticipated to quickly, naturally increase in size and depth with the restoration project, and therefore this modification is believed to accurately represent the future conditions after restoration.

2.4 Modeling Configurations

Three general layout configurations were modeled to analyze how the different alternative configurations would function given certain boundary conditions. The features within each of these configurations were refined during the modeling analysis, resulting in the final restoration alternatives and modeling configurations as listed below. The habitat transition zones and habitat islands were not included in the analysis since they do not significantly affect the hydrodynamics. Specifics of the design of all of these alternatives can be found in the Preliminary Design Memo (AECOM 2016a).

1. Alternative A (Appendix A, Figure A-2): Existing conditions with all existing culverts closed (see Table 1.1). Given the limited conveyance of the culverts and the short duration of the peak flood (several hours), having the culverts open or closed has limited impact on flood levels; however the slightly more conservative “closed” scenario (resulting in a greater level of flood protection) was chosen of the two options.
2. Alternative B (Appendix A, Figure A-3): Full tidal restoration of the southern Eden Landing Ponds with improvements to the landside levee. The proposed fish passage channel from the ACFCC to Ponds E2 and E4 was not included in this configuration (it was originally included in a different alternative); it was however included in the Alternative C & D configuration described below. Given the relative limited conveyance through the proposed ACFCC culvert in this fish passage channel, (especially during 100-year fluvial and tidal events when levees are overtopped), the inclusion or exclusion of this fish passage channel has minimal, if any, effect on model results.

3. Alternative C & D (Appendix A, Figure A-4 and A-5): Construction of a mid-complex levee, allowing tidal restoration of the Bay Ponds and management of the Inland and C-Ponds. The future phased tidal restoration of the Inland and C-Ponds in Alternative D was assumed to be similar to Alternative B, and was therefore not modeled separately. This Alternative C & D configuration included Alternative B's fish passage culvert and channel from ACFCC to Ponds E2 and E4. Either of the fish passage channels could have been selected for use in the model, as both have limited relative conveyance through the proposed ACFCC culverts as described above.

2.5 Design Criteria of Restoration Features

The modeling objective was to inform the design of restoration features. The prominent design criteria of the restoration features were:

1. Tidal Propagation: Restoration features were designed to create adequate filling and draining of the ponds during tidal cycles. Adequate filling was defined as when the vast majority pond surface was flooded (greater than 6") during a flood tide. Adequate draining was defined as when the vast majority of the pond surface was dry (less than 6" based on model accuracy and data) during an ebb tide.
2. Flood Control: Restoration features were designed to provide at a minimum the same level of tidal and fluvial flood protection as exists under current conditions.

Additional criteria were also taken into consideration, such as limiting adverse erosion or accretion of nearby features such as existing marsh, levees and channels.

2.6 Hydrologic Scenarios

Design criteria were applied to the restoration features during two hydrologic scenarios: a typical tide scenario with no riverine discharge, and a flood scenario with a combination of 10- and 100-year riverine and tidal events. Both are described in detail below.

Tide Scenario: This hydrologic scenario included three weeks of a typical summer tide from May 4, 2015 7:00 AM to June 2, 2015 7:00 AM with no channel discharge. The first week was a "warmup" week for model equilibration, followed by two to three weeks as needed. The ponds initially were started with a water surface elevation of 2.5 feet in the ponds (about half a foot below MSL). The initial water surface elevation in the ponds was chosen to be near MSL, but because the model had a week of warmup, the initial water surface elevation had a minor impact on the modeling results. Figure 2.4 shows the time series of water levels in relation to the local tidal datums obtained from the Redwood City tide gauge (NOAA gauge 9414523), located roughly 7 miles (11 kilometers) west of Eden Landing.

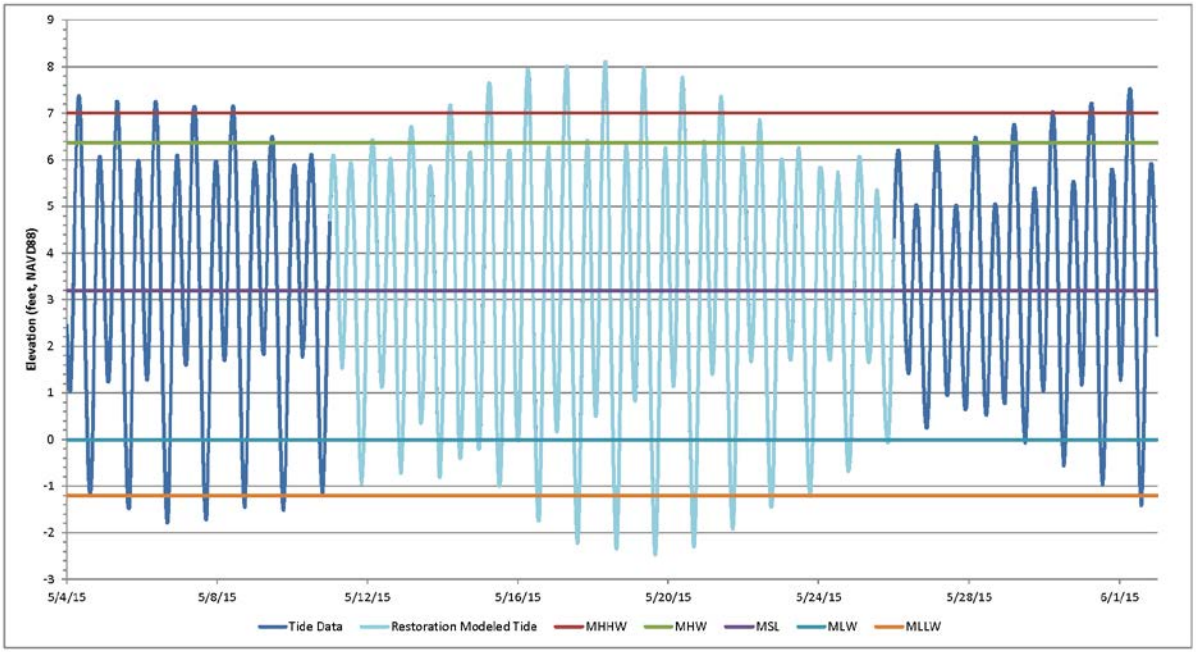

Figure 2.4. Typical Tide used as Input for Model Scenarios (Maximum Elevation 8.1 feet)

The 6 minute daily tide data from the Redwood City gauge were obtained from National Oceanic Atmospheric Administration's Tides and Currents website (NOAA 2016) and converted to NAVD88 using NOAA conversions listed in AECOM 2016. Table 2.2 summarizes the tidal datums for the three NOAA tide gauges near the project site, showing that the mixed-semidiurnal tides are amplified in the South Bay from a MHHW elevation of 6.9 feet at San Mateo Bridge up to 7.2 feet at Dumbarton Bridge and MLLW from -0.8 to -1.4 feet. Sources of conversions from tidal to geodetic (NAVD88) datum are listed in Table 2.2.

Table 2.2. Tidal Statistics for the South Bay

	San Mateo Bridge West, CA Station ID 9414458	**Redwood City, CA Station ID 9414523**	**Dumbarton Bridge, CA Station ID 9414509**
	Feet, NAVD88	Feet, NAVD88	Feet, NAVD88
100-year[1]	10.4	10.7	10.9
10-year[1]	9.3	9.4	9.6
MHHW	6.92	7.10	7.20
MHW	6.29	6.47	6.59
MSL	3.31	3.30	3.27
MTL	3.34	3.28	3.22
NAVD88	0	0.00	0
MLW	0.39	0.10	-0.15
MLLW	-0.80	-1.10	-1.41
NAVD88 Datum Source	Foxgrover et al. 2007	AECOM 2016	NOAA 2016

[1]Extreme still water tide levels from the *San Francisco Bay Tidal Datums and Extreme Tides Study Final Report* (AECOM 2016b).

Flood Scenario: This scenario included the following two combinations of flood events:

1. 100-year tide with 10-year riverine discharge from the OAC and ACFCC (coinciding tide and discharge peaks)
2. 10-year tide with 100-year riverine discharge from the OAC and ACFCC (coinciding tide and discharge peaks)

This is more conservative than recommended in the Alameda County Hydrology and Hydraulics Manual (2003) where for primary facilities the highest of the following scenarios is to be used:

- The FEMA 100-year water surface elevation; or
- The 5-year recurrence peak discharge combined with a 100-year tide elevation in the Bay; or
- The 15-year recurrence peak discharge with a MHHW elevation in the Bay.

These flood scenarios included seven days of a 10- and 100-year tide from May 15, 2015 7:00 AM to May 21, 2015 7:00 AM. Figure 2.5 and Figure 2.6 show the time series of the 10- and 100-year tide levels in relation to the local tidal datums. The 10- and 100-year tides were generated by shifting the typical tide shown in Figure 2.4 (maximum elevation of 8.1 feet) up to the extreme elevations of 9.4 feet and 10.7 feet NAVD88 (AECOM 2016b), respectively.

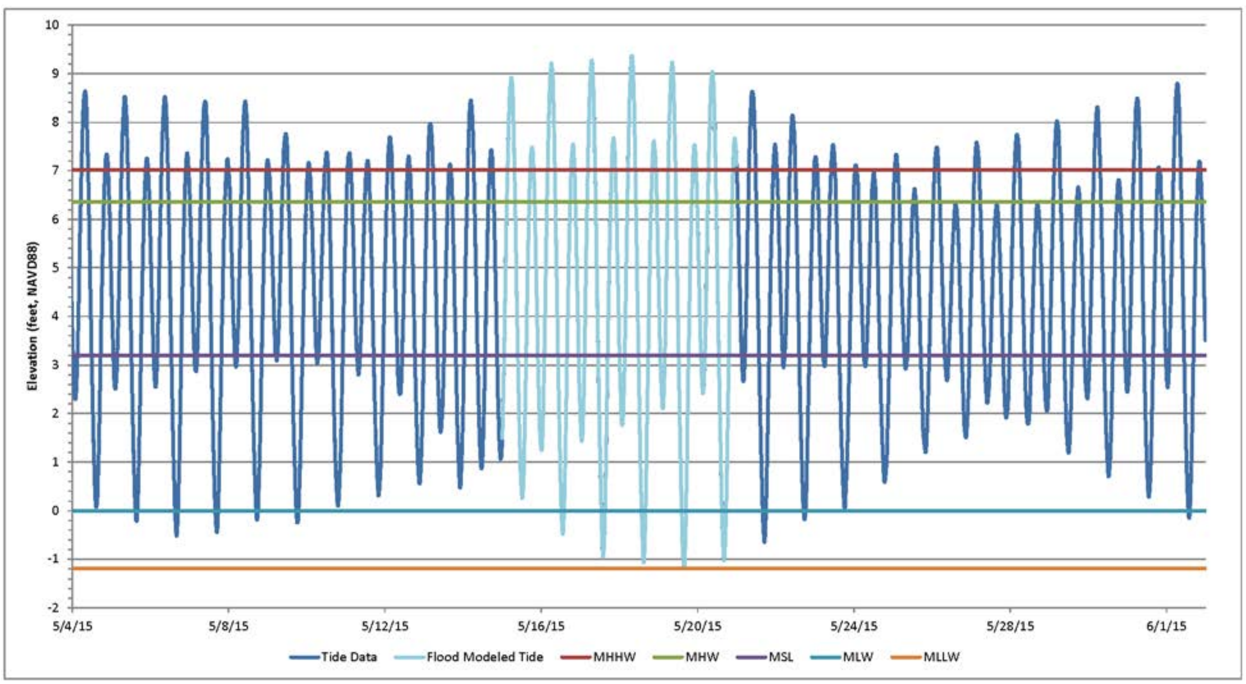

Figure 2.5. 10-year Tide (Extreme Elevation 9.4 feet)

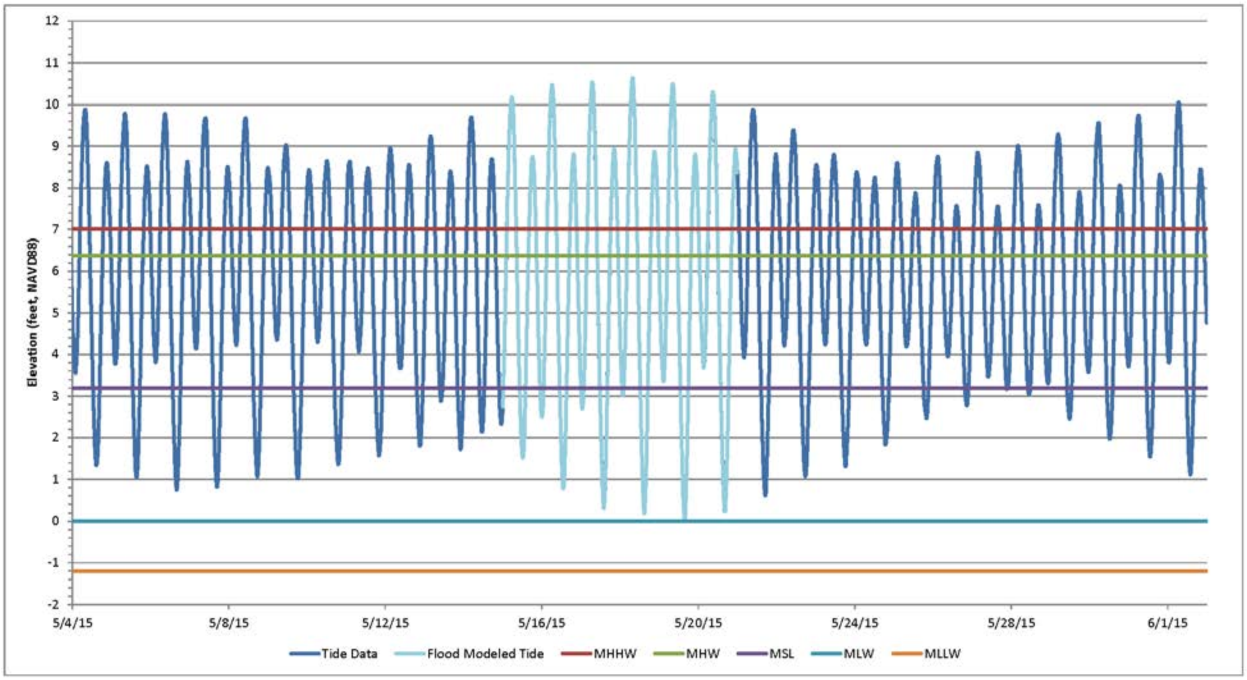

Figure 2.6. 100-year Tide (Extreme Elevation 10.7 feet)

The hydrographs for the 10- and 100-year discharge events from OAC and ACFCC are shown in Figure 2.7. The hydrographs were obtained from DHI (2015). To confirm that the hydrographs represent reasonable approximations to the 10- and 100-year events, HEC-SSP V2.0 was used to analyze 56 years of peak flow data collected in the ACFCC at Union City (USGS # 11180700, located 0.2 mi upstream of Interstate 880 crossing). The analysis resulted in a 100-year peak flow of 30,410 cfs and a 10-year flow of 14,116 cfs, which are consistent with the hydrographs in DHI (2015). Sufficient data were not available for the OAC so the DHI (2015) values were assumed to also be sufficiently accurate for preliminary design.

All flood scenarios had an initial water surface elevation of 6.5 feet NAVD88 throughout the model mesh, conservatively assuming the ponds were starting "full" about a half of a foot below MHHW. This is conservative for all alternatives because the available flood storage in the ponds is minimized. (The internal water level in the pond has no impact on the whether the external levees are overtopped during a flood event; the initial water surface elevation does however have an impact on if the internal levees are overtopped.) If this elevation were to be decreased to MSL, the maximum water surface elevation reached within the ponds (and used to design the levee heights) may decrease. At the 6.5 feet NAVD88 elevation, portions of the low-lying areas east of the complex also began with ponded water; however the *difference* in water surface elevation between existing and restored conditions was used as the indicator of meeting or exceeding existing flood control in this area, not the total water surface elevation. For this reason, these flood criteria results were not sensitive to the initial water surface elevation.

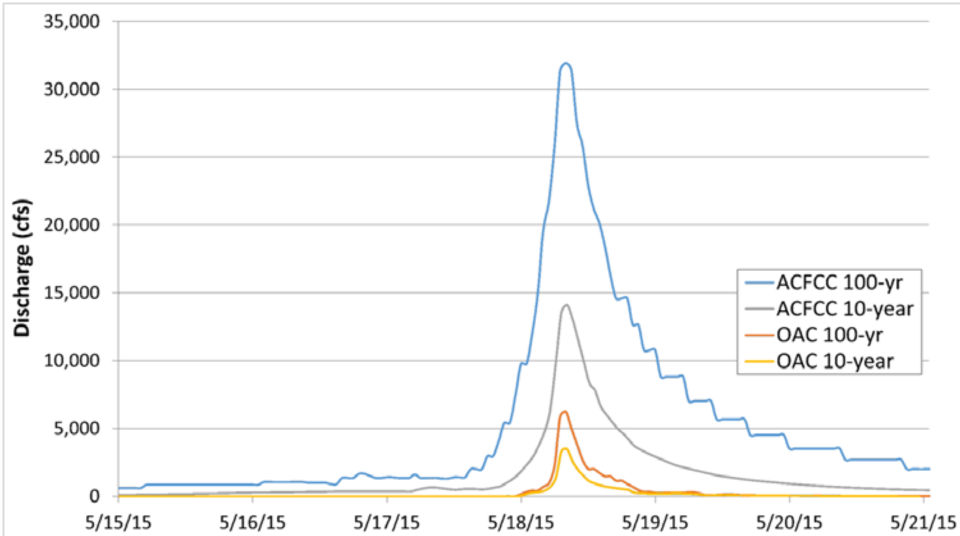

Figure 2.7. 10- and 100-year Discharge Event Hydrographs of ACFCC and OAC

2.7 Bed Resistance

In MIKE21 FM, the bed resistance is specified using a Manning number "M", which is the inverse of the more commonly used Manning's n. Typically the roughness coefficient is used as a calibration parameter, and the lower the Manning's number the higher the roughness. Figure 2.8 shows the chosen Manning's numbers based on vegetation observed or lack thereof in available imagery.

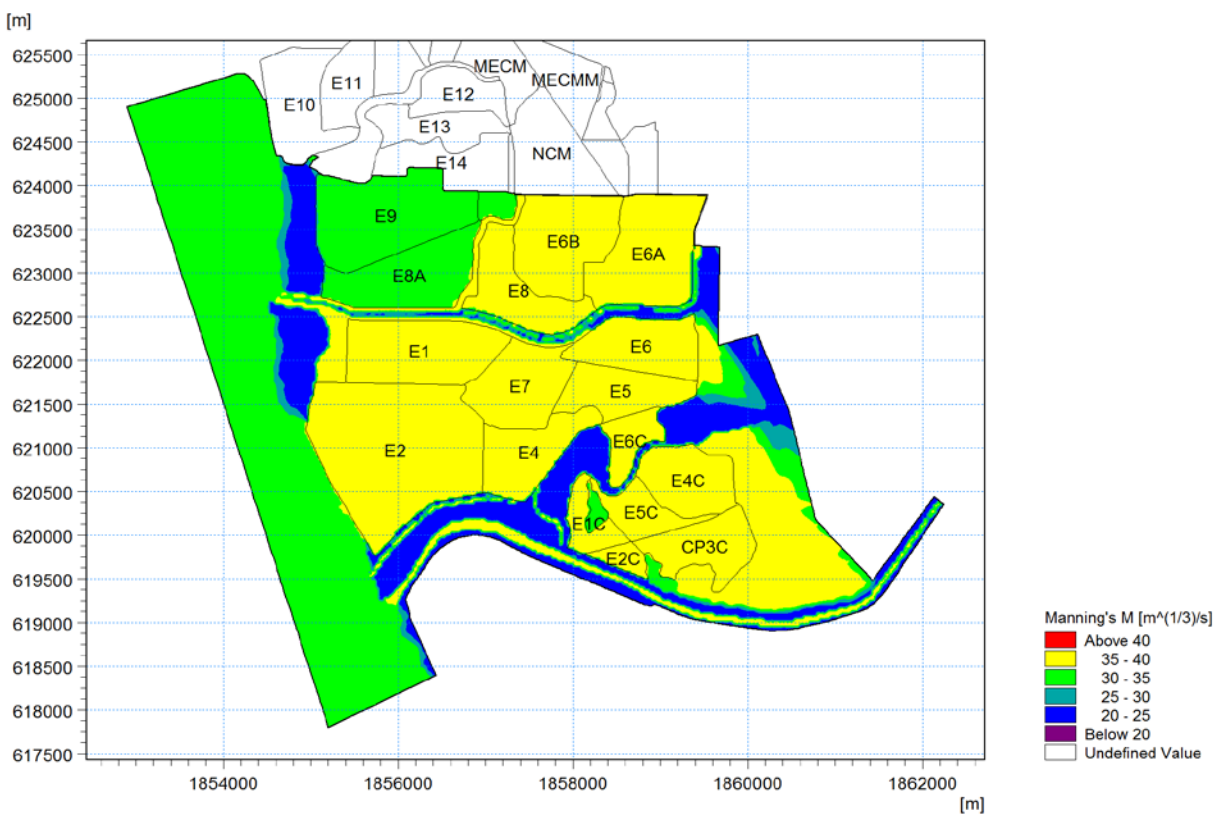

Figure 2.8. Bed Resistance

2.8 Approach

Various locations and quantities of levee breaches, pilot channels, culverts, and levee raising and lowering were modeled to refine the design features. The Preliminary Design Memo (AECOM 2016a) contains details on initial design choices for feature dimensions and locations. For instance, initial levee breach sizes were sized based on empirical hydraulic geometries of historic marshes in San Francisco Bay (PWA et al. 2004), and initial pilot channels were sized and located based on equipment capabilities and cost considerations.

In general, tidal filling and draining criteria were first met with the addition of levee breaches and pilot channels, then flooding criteria were applied to the features and levee raising and lowering design details were determined. The greatest water surface elevation resulting from the two Flood Scenario combinations was used to design the restoration features.

All of the southern Eden Landing Ponds are within areas inundated by the 1% annual chance flood on FEMA's Flood Insurance Rate Maps (FIRMs) due to coastal flooding sources from extreme high tide (as opposed to riverine sources) (see Figure 2.9). None of the existing levees are accredited to meet Federal standards to reduce risk from a 100-year flood. The 1% annual chance Still Water Level (SWL), or flood level not including the effects of waves or tsunamis but including storm surge and astronomical tide, of the ponds is 10 feet NAVD88. FEMA is currently updating its maps, and preliminary results indicate the 1% SWL will increase to 11 and 12 feet within southern Eden Landing pending additional considerations proposed by Alameda County. Because the uncertified levees in and around the pond complex do not influence the 1% SWL in FEMA's typical approach, breaching the existing ponds does not change FEMA's current FIRMs depicting 1% SWL.

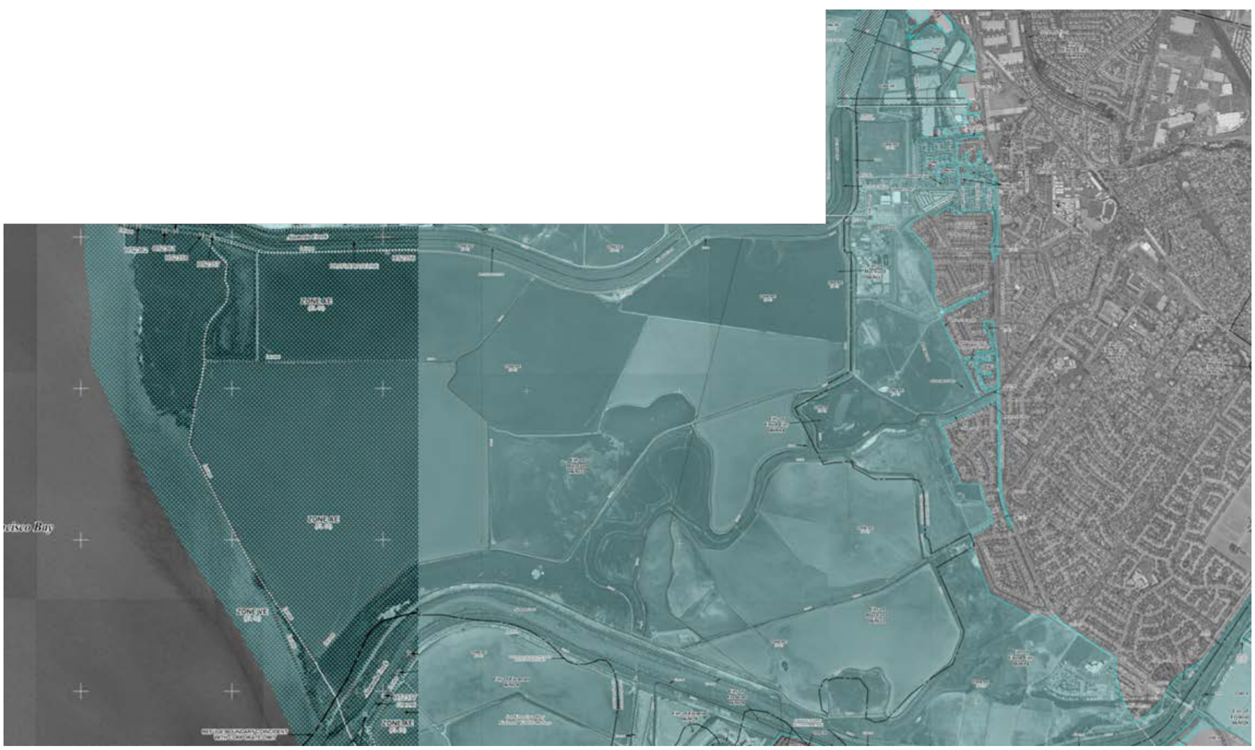

Figure 2.9. Existing FEMA Flood Insurance Rate Map Extent (Effective 2009, pending update)

FEMA also calculates the Total Water Level (TWL), which includes the effects of waves (wave setup and runup) on top of the SWL. All of the levee improvements and habitat transition zones proposed in the restoration design could lower FEMA's calculated TWL, as the TWL does take into consideration berms or levees that knock down waves or reduce fetch lengths.

The Federal levees surrounding the ACFCC are accredited levees, and therefore may need to be unclassified as an "accredited" levee in order to install breaches. Because this process is likely to conflict with the Phase 2 restoration timeline, the restoration design was constrained to installing only gated culverts in the ACFCC Federal levees. Although not ideal for the full tidal restoration alternative for the C-Ponds, additional culverts will improve tidal exchange and maintain or improve the existing flood protection. Restoration Alternatives B and D also included a culvert through the ACFCC Federal levee to allow fish passage from the ACFCC into the Bay Ponds.

Lastly, during model development Dr. David Schoellhamer from the USGS performed an external review of the model and modeling approach. His comments are listed in Appendix B and were incorporated into subsequent versions of the model and analysis.

3. MODEL RESULTS

The following is a summary of the MIKE21 and HEC-RAS modeling results.

3.1 MIKE21 Tide Scenario Results

The extent of tidal waters and total water depth within Alternative B (full tidal restoration) configuration is shown in Figure 3.1 and Figure 3.2 (on the following page) during the spring and neap tides, respectively. During the peak of the spring tide, the majority of the ponds contain ponded water except for the areas of highest elevation. The ponds may not drain completely at low tides during the peak spring tide and may contain ponded water for several days. When the peak tides recede the ponds do not fill as high and they drain more fully. During the neap tide, the majority of the ponds are drained with patches of water remaining in the ponds due to the uneven nature of the pond bottoms. These patches of ponded water are anticipated to shrink in size over time as small channels form in the pond bottoms; the model does not include geomorphic changes such as these.

Figure 3.3 (on the following pages) shows the water surface elevations in the Bay Ponds and channels of the Inland Ponds, which fill up to about 5.6 feet. The ponds receive water from the muted tide in the OAC, also shown in the figure. The majority of the pond bottoms of the Inland Ponds are only flooded during peak tidal elevations, however deeper channels transport water around the ponds. Figure 3.4 shows the water surface elevations in the C-Ponds, which fill up to about 6.3 feet (in E2C). The C-Ponds receive water from the slightly muted tide in ACFCC, also shown in the figure. In general, the ponds become more muted the farther the distance from the connection to ACFCC.

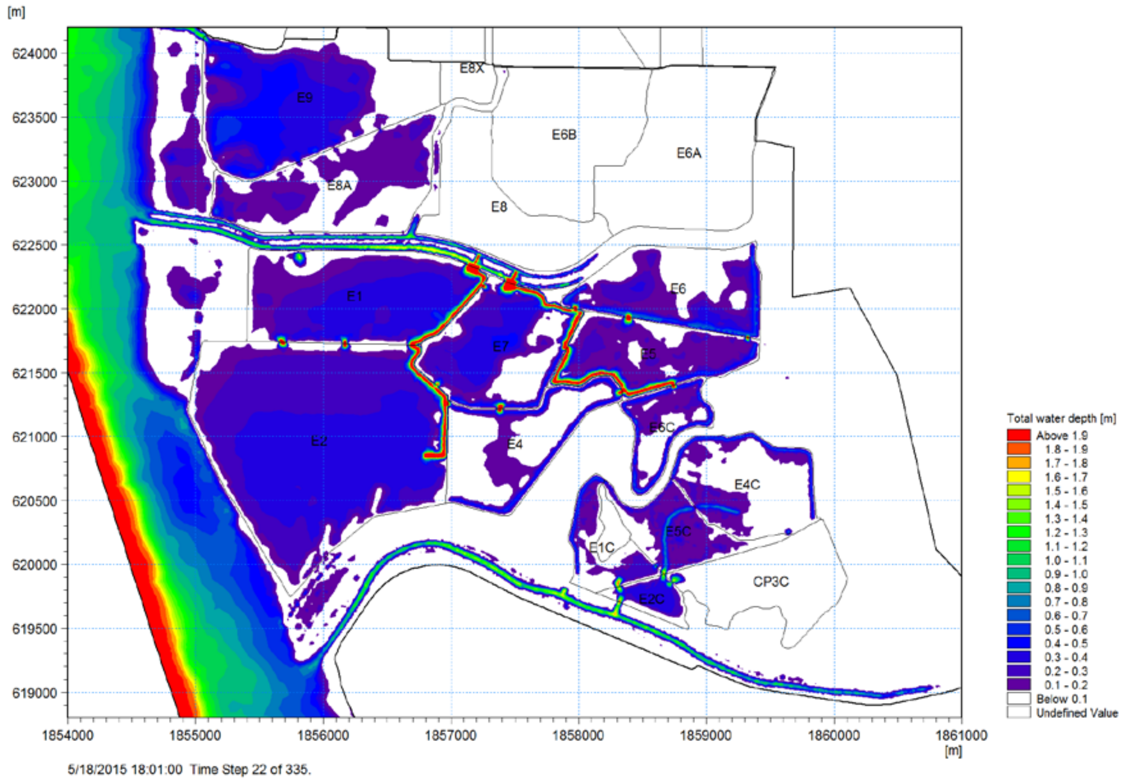

Figure 3.1. Alternative B Total Water Depth during Spring Tide

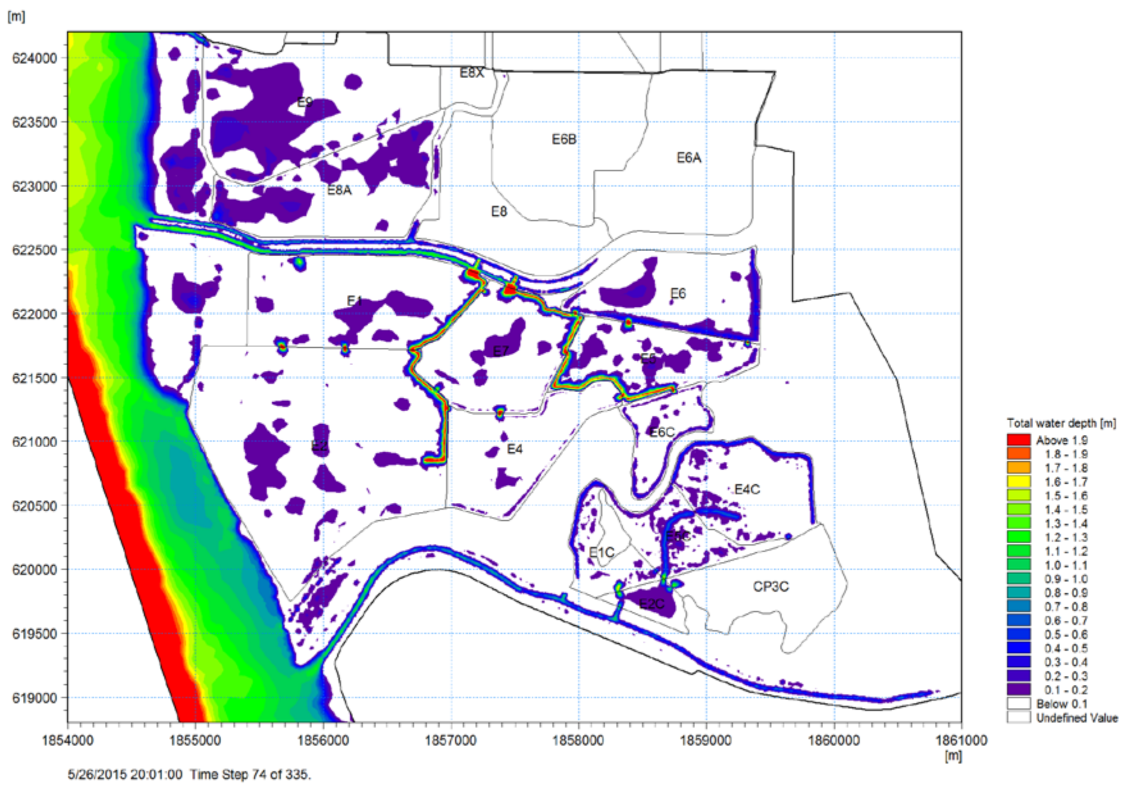

Figure 3.2. Alternative B Total Water Depth during Neap Tide

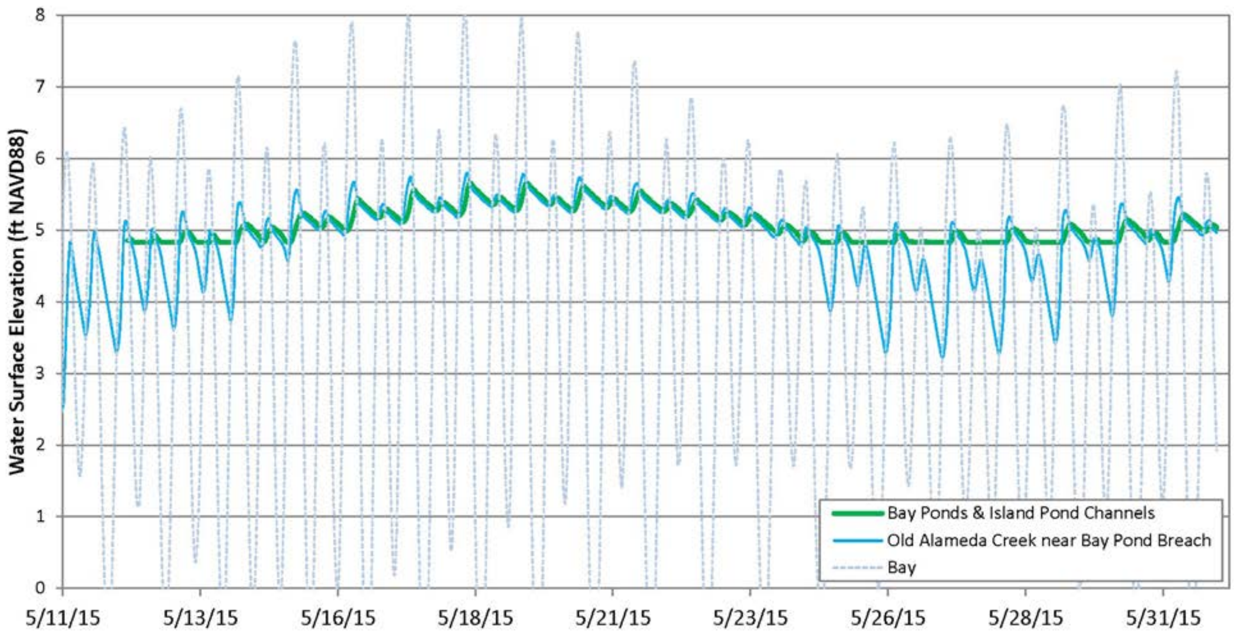

Figure 3.3. Tidal Elevations in the Bay and Island Ponds

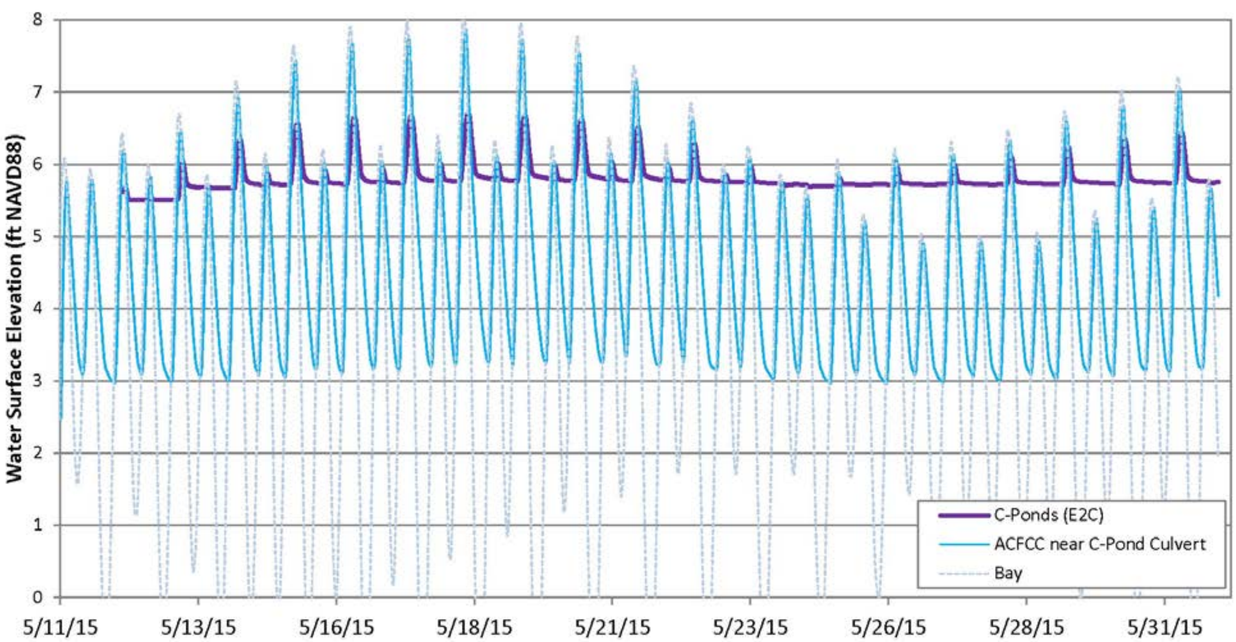

Figure 3.4. Tidal Elevations in the C-Ponds

The major Tide Scenario modeling results include:

- The OAC constricts conveyance into the ponds; therefore increasing the number of breaches above those already included along the OAC would not significantly increase conveyance into the ponds. The OAC is anticipated to scour over time with the restoration project, thereby increasing the tidal prism in the Bay and Inland Ponds.
- "Natural" channels constructed in the center of the wet pond bottoms were modeled, however eliminated due to anticipated construction cost (except for in the C-Ponds where the ponds may be dried sufficiently to support low ground pressure equipment). More economical "borrow ditch" channels were included in the Bay and Inland Ponds where equipment can excavate to the side while on existing levees. Both channel types enhance draining of low depressions in the ponds; without constructed channels, the ponds do not fully drain.
- Because the design is constrained to including a culvert through the ACFCC Federal levee (as opposed to a breach), the channel through the Alameda County Wetlands to Ponds E2 and E4 should only be as large as the volume that may be conveyed through the culvert. Model results show the hydraulic conveyance into the Bay Ponds through this culvert and channel is minimal. Fish habitat and passage is an important goal of this restoration design, therefore this connection culvert and channel remains in the restoration alternatives to predominately support fish passage into the Bay Ponds, as opposed to hydraulic connectivity.
- The C-Ponds are the highest elevation ponds of the southern Eden Landing Ponds, and although the restoration design proposes to double the existing culverts and construct a channel in the pond bottom, the tide will remain muted in the C-Ponds. The proposed additional culverts and channel will increase management flexibility, if the ponds remain managed permanently or temporarily (Alternatives C and D).

3.2 MIKE21 Flood Scenario Results

The results of the Flood Scenarios informed the levee crest elevation design in all three action alternatives and allowed for comparison of pre- and post-project flood levels. For each of the Flood Scenarios and model configurations, maximum water depth was analyzed along the four proposed raised levees found in Alternatives B, C, and D, as well as three areas of potential flooding outside the complex, as listed in Table 3.1 and shown in Figure 3.5.

Table 3.1. Flood Scenario Areas of Analysis

	Flood Scenario Areas of Analysis	Applicable Alternative
Levee Alignments	Inland Ponds Landside Levee	B & D
	C-Ponds Landside Levee	B & D
	Bay Levee	C & D
	Mid Complex Levee	C & D
Areas of Potential Flooding Outside of Complex	J-Ponds	B, C, & D
	Alameda County East Property	B, C, & D
	Alameda County South Property	B, C, & D

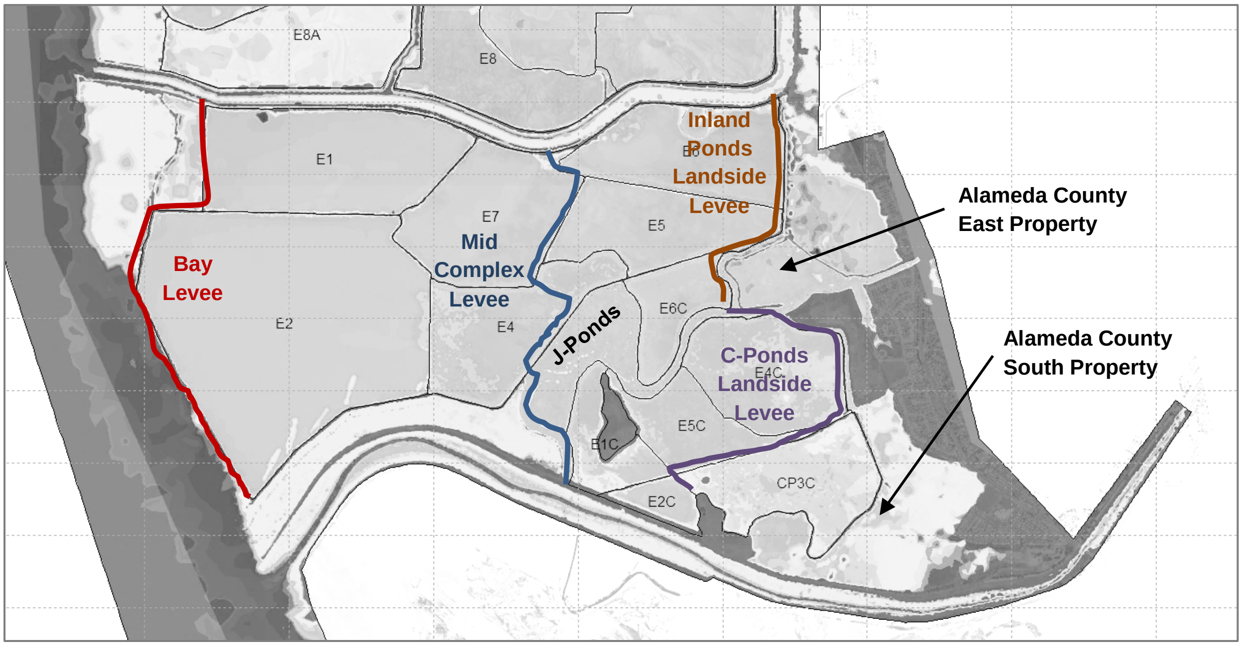

Figure 3.5. Flood Scenario Areas of Analysis for Alternatives A, B, C & D

The following is a summary of the Flood Scenario results in each of these areas of interest, discussed in the context of each model configuration: Alternative A (existing conditions), Alternative B (full tidal restoration), and Alternative C & D (partial tidal restoration and pond management).

Alternative A Configuration (Existing Conditions)

Figure 3.6 and Figure 3.7 show the maximum water surface elevations reached during the 10-year tide and 100-year discharge and the 100-year tide and 10-year discharge Flood Scenarios.

During the 10-year tide and 100-year discharge, the blue arrows in Figure 3.6 indicate the general flow path of the water. The 100-year discharge event overtops the ACFCC levee near the Bay and travels back upstream through the Alameda County Wetlands, J-Ponds, Pond E6C, C-Ponds, and to the Alameda County East Property and South Property.

During the 100-year tide and 10-year discharge, the blue arrows in Figure 3.7 also indicate the general flow path of the water. In this case, the 100-year tide overtops the pond levees via the OAC and Alameda County Wetlands. The Alameda County East Property is flooded by water traveling upstream through the J-Ponds and overtopped levees of Pond E6C (also fed by the J-Ponds). The FEMA FIRMs (see Figure 2.9) project the 100-year tide elevation farther inland than shown in Figure 3.7 because FEMA assumes non-accredited levees do not prevent water from traveling inland.

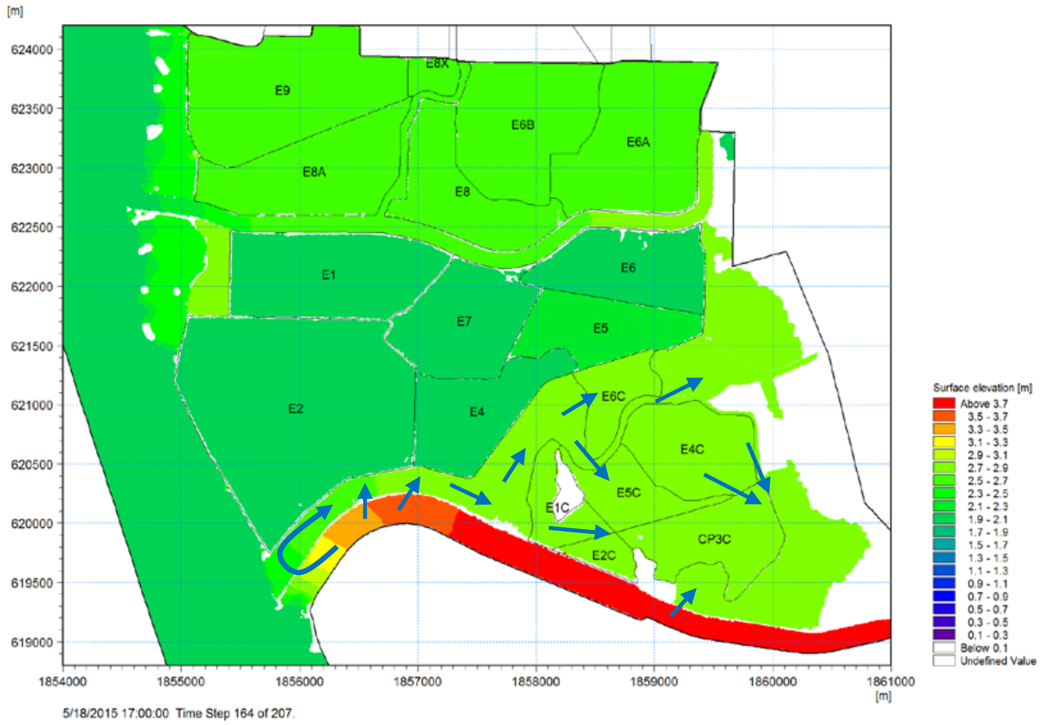

Figure 3.6. Alternative A Existing Conditions, Maximum Water Surface Elevation, Flood Scenario 10-year Tide & 100-year Discharge

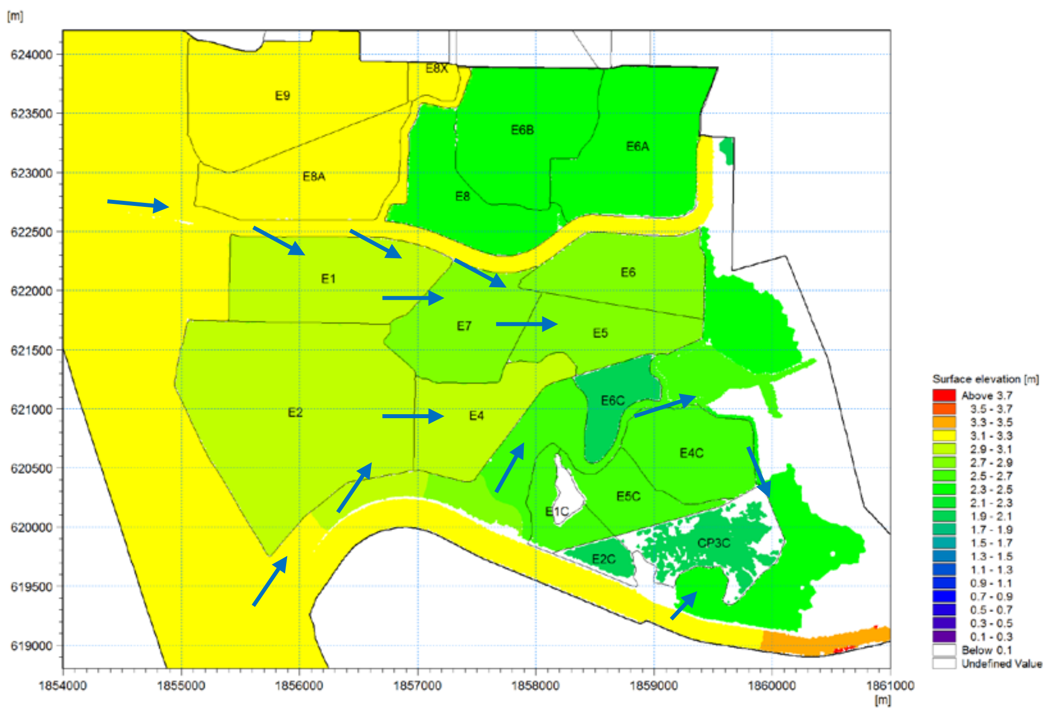

Figure 3.7. Alternative A Existing Conditions, Maximum Water Surface Elevation, Flood Scenario 100-year Tide & 10-year Discharge

The peak water surface elevations near the four proposed levee improvements for the Alternative A configuration (existing condition) are shown in Figure 3.8. Figure 3.8 shows that maximum water surface elevations near most proposed levees are near 9.5 feet, or about 10.2 feet in the case of the Bay Levee. The J-Ponds and Alameda County East and South Properties have a maximum water surface elevation of about 9 to 9.5 feet. In general, the C-Ponds, J-Ponds, and Alameda County Wetlands are most influenced by a large flood discharge down the ACFCC, whereas the Bay Ponds are much more influenced by a large tide. The Inland Ponds generally reach the same maximum water surface elevations during either Flood Scenario.

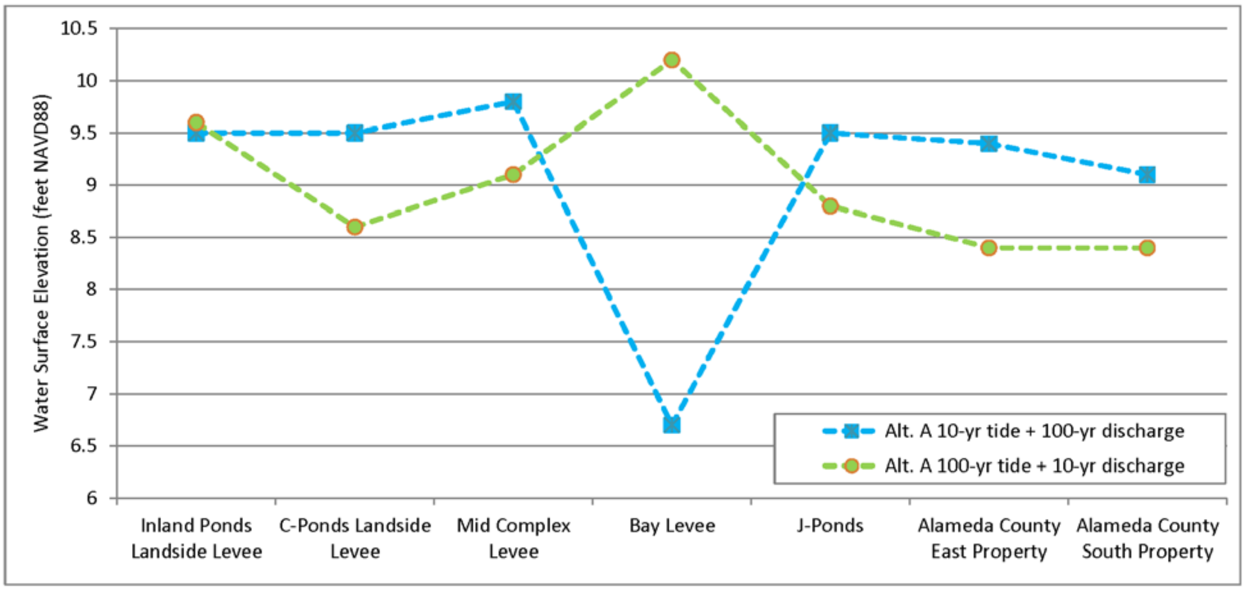

Figure 3.8. Alternative A Existing Conditions, Flood Scenarios, Maximum Water Surface Elevations in Vicinity of Improved Levees

Alternative B Configuration (full tidal restoration)

In the case of the Alternative B configuration, Figure 3.9 and Figure 3.10 (on the following page) show the maximum water surface elevations reached during the 10-year tide and 100-year discharge and the 100-year tide and 10-year discharge Flood Scenarios.

During the 10-year tide and 100-year discharge, the blue arrows in Figure 3.9 indicate the general flow path of the water. The 100-year discharge event overtops the ACFCC levee near the Bay similar to the Alternative A configuration, however with the proposed levee lowering to MHHW along the southern Pond E2 and northern Pond E1 levees, the majority of the water passes into the Bay and Inland Ponds and out through the OAC. With this restoration design, the ponds act as detention during peak discharge events, reducing the maximum water depths and extents experienced in the J-Ponds and Alameda County East and South Properties compared to existing conditions (see Figure 3.6).

During the 100-year tide and 10-year discharge, the blue arrows in Figure 3.10 indicate that the 100-year tide overtops the pond levees via the OAC and Alameda County Wetlands, similar to the Alternative A Configuration. Because the restoration design includes pilot channels, the maximum water surface elevation experienced is of shorter duration because the water can more quickly recede with the outgoing tide. The maximum water surface elevation is slightly increased about half a foot in the Bay Ponds (as one would expect with tidal restoration) due to the 100-year tide entering the Bay Ponds over the lowered levees along the OAC and Alameda County Wetlands; the maximum water surface elevation does however remain below the maximum occurring during the 10-year tide and 100-year discharge hydrologic scenario.

The peak water surface elevations for this configuration compared to existing conditions are summarized in Figure 3.11 (on the following pages). (Please note, in comparison to Figure 3.8, Figure 3.11 does not include the extraction points near the Mid-complex and Bay Levees, as those levee raises are not included in Alternative B and this information was extracted to inform levee height design.)

Within the J-Ponds, Alameda County East and South Properties, the maximum water surface elevations of the Alternative B configuration are all maintained or less than the peak elevation of about 9 to 9.5 feet in these areas. The maximum water surface elevation near the Inland Ponds and C-Ponds landside levees increase less than a half of foot. This slight increase is the driver for improving the Inland and C-Ponds Landside Levees between 2 and 2.5 feet in this Alternative, thereby increasing flood protection beyond existing conditions.

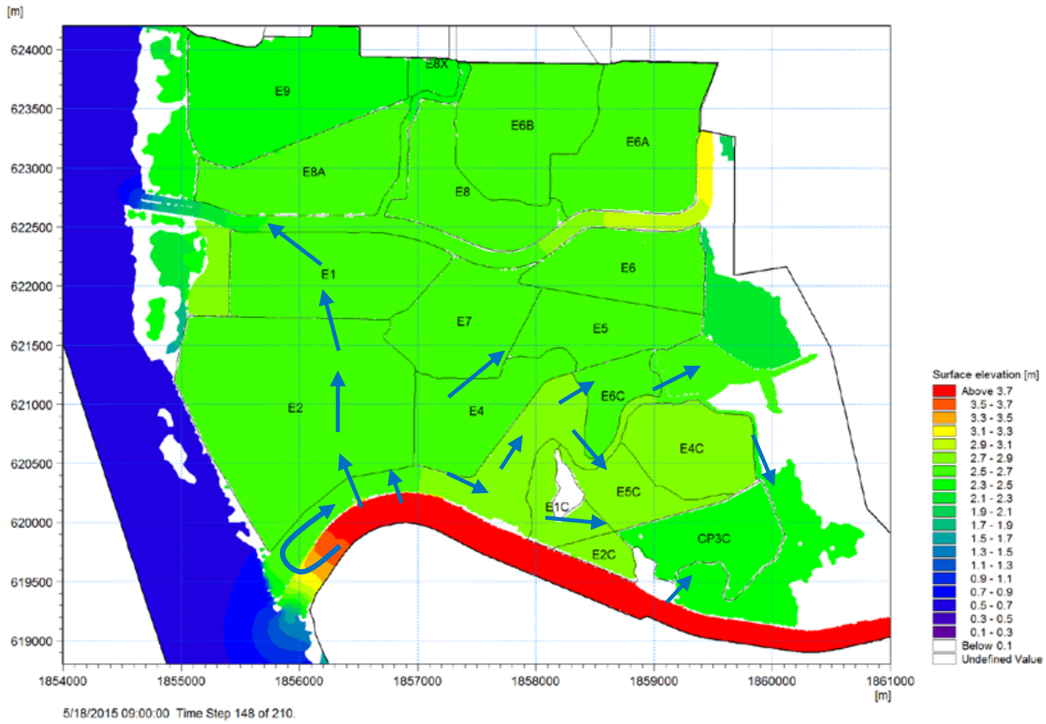

Figure 3.9. Alternative B Tidal Restoration, Maximum Water Surface Elevation, Flood Scenario 10-year Tide & 100-year Discharge

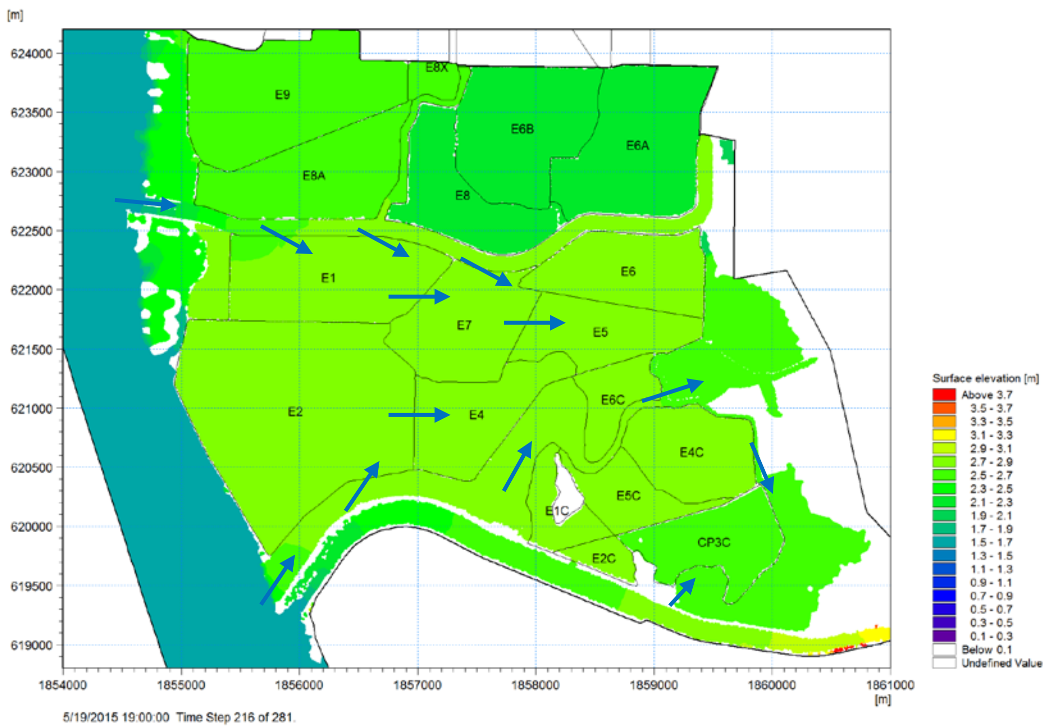

Figure 3.10. Alternative B Tidal Restoration, Maximum Water Surface Elevation, Flood Scenario 100-year Tide & 10-year Discharge

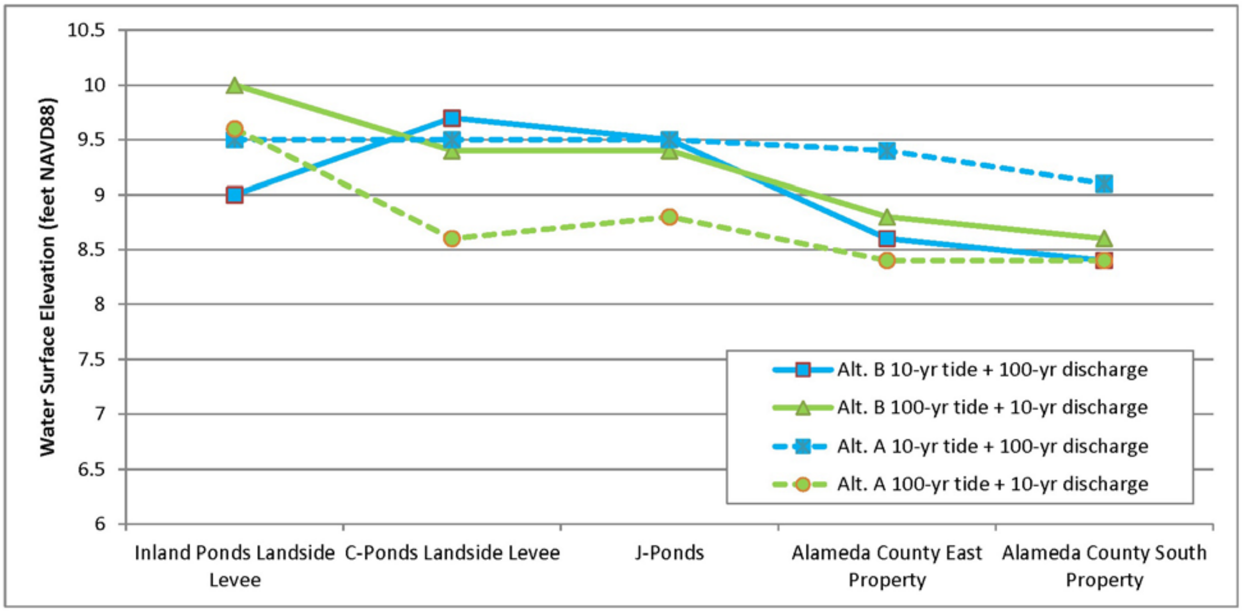

Figure 3.11. Alternative B Tidal Restoration, Flood Scenarios, Maximum Water Surface Elevations in Vicinity of Improved Levees

Additional general results from the Alternative B tidal restoration include:

- If the northern Pond E1 and southern Pond E2 levees were not lowered in Alternative B, the maximum water surface elevation in the J-Ponds increases over two feet, and the water surface elevation in the Alameda County East and South Properties increase about a foot. Levee lowering is an important flood control method necessary in the design to allow for flood waters from the ACFCC to travel through the ponds and out through the OAC.
- A levee breach into the C-Ponds from either the ACFCC or the J-Ponds would result in significantly higher water surface elevations in the C-Ponds compared to existing conditions. A breach in either of these locations allows for the ACFCC large discharge event to travel directly into the C-Ponds, and would require additional levee raising than what is proposed in the Preliminary Design to prevent levee overtopping into Alameda County South Property via Cargill's Pond CP3C.
- To investigate the potential fish passage culvert along ACFCC, a relatively small 3,500 cfs (less than the 10-year event) was discharged from ACFCC during a model run with a dye tracer in it. Dye concentration results indicate water travels from ACFCC through the proposed fish passage culverts and into the Bay Ponds. Little to no tidal water extend up to the fish passage culverts during such an event. The ACFCC discharge enters the Bay and Inland Ponds, indicating that a percentage of juvenile fish traveling with flow would be transported into the Bay and Inland Ponds and then out the OAC.

Alternative C & D Configuration (mid complex levee and phased restoration)

In the case of the Alternative C & D configuration, Figure 3.12 and Figure 3.13 (on the following page) show the maximum water surface elevations reached during the 10-year tide and 100-year discharge and the 100-year tide and 10-year discharge Flood Scenarios.

During the 10-year tide and 100-year discharge, the blue arrows in Figure 3.12 indicate the general flow path of the water. The 100-year discharge event overtops the ACFCC levee near the Bay similar to the Alternative A configuration, however with proposed levee lowering to MHHW along the southern Pond E2 and northern Pond E1 levees, the majority of the water passes into the Bay Ponds, and is blocked by the Mid Complex levee from entering the Inland and C-Ponds, and travels out through the OAC. With this restoration design, the ponds act as detention during peak discharge events, reducing the maximum water surface elevations and extents experienced in the Inland Ponds, C-Ponds, J-Ponds and Alameda County East and South Properties compared to existing conditions (see Figure 3.6).

During the 100-year tide and 10-year discharge, the blue arrows in Figure 3.13 indicate that the 100-year tide overtops the pond levees via the OAC and Alameda County Wetlands, similar to the Alternative A Configuration. The Mid Complex Levee prevents the high tide from entering the all ponds and properties east of the Bay Ponds.

The peak water surface elevations for this configuration compared to existing conditions are summarized in Figure 3.14 (on the following pages). The maximum water surface elevations in the J-Ponds and Alameda County East and South Properties are reduced between 0.5 to one foot compared to the peak flood elevation. The water surface elevation at the Mid Complex Levee increases from about 9.7 to 10.4 feet, and the Bay Levee water surface elevation remains about the same compared to Alternative A existing conditions. The Mid Complex Levee is not overtopped, and therefore the increase in water surface elevation at this location is anticipated as all the water previously allowed to flood the Inland Ponds, J-Ponds, C-Ponds, and Alameda County Properties is now contained only within the Bay Ponds.

Additional general results from the Alternative C & D partial tidal restoration and managed pond configuration include:

- The maximum water surface elevations in the OAC and ACFCC near the model extents do not increase in Alternative C & D compared to Alternative A (existing conditions). The same is true for the Northern Eden Landing Ponds, which reach a maximum water surface elevation of about 8 feet, which does not flood into the property immediately behind the existing Pond E6A levee.

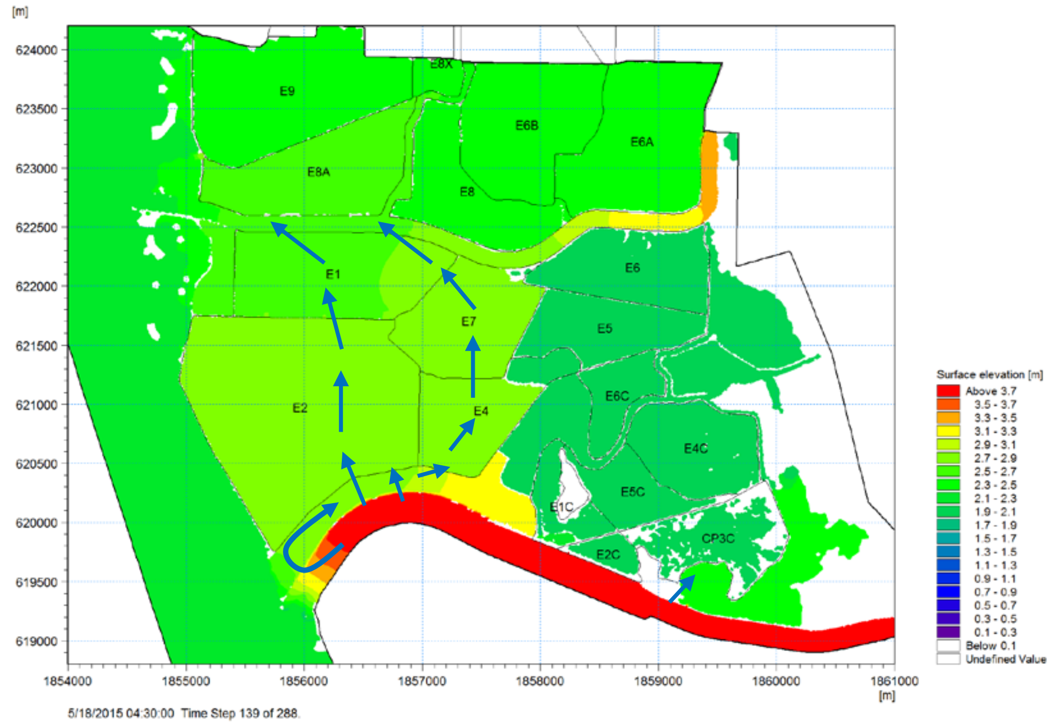

Figure 3.12. Alternative C & D Partial Tidal Restoration and Managed Ponds, Maximum Water Surface Elevation, Flood Scenario 10-year Tide & 100-year Discharge

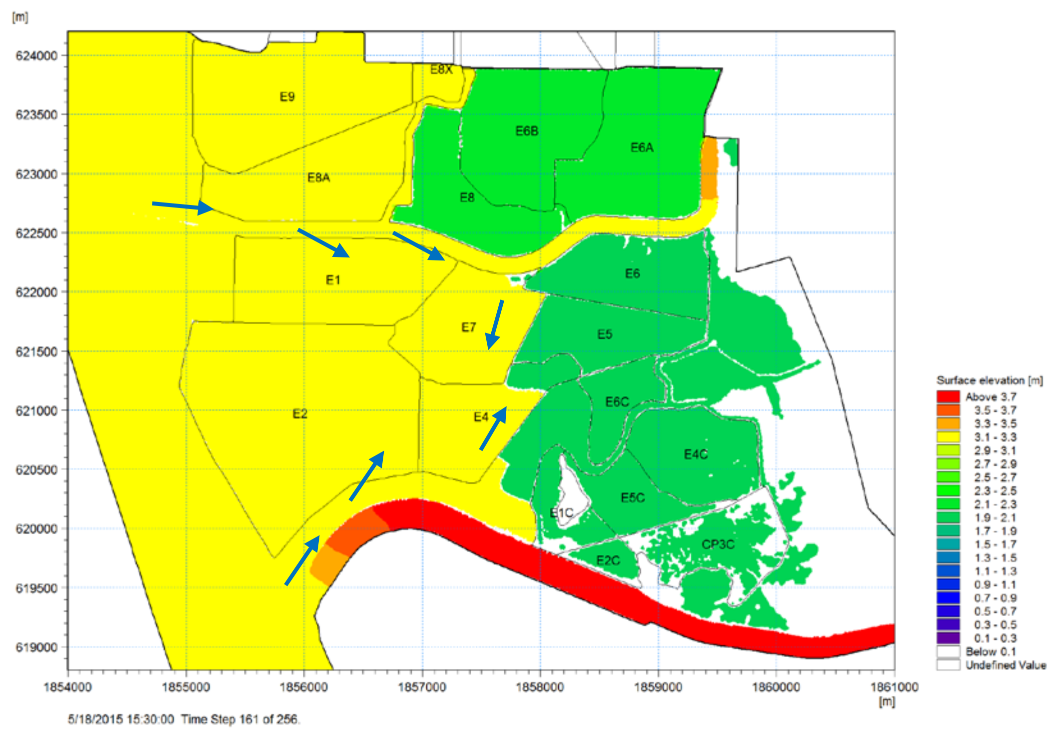

Figure 3.13. Alternative C & D Partial Tidal Restoration and Managed Ponds, Maximum Water Surface Elevation, Flood Scenario 100-year Tide & 10-year Discharge

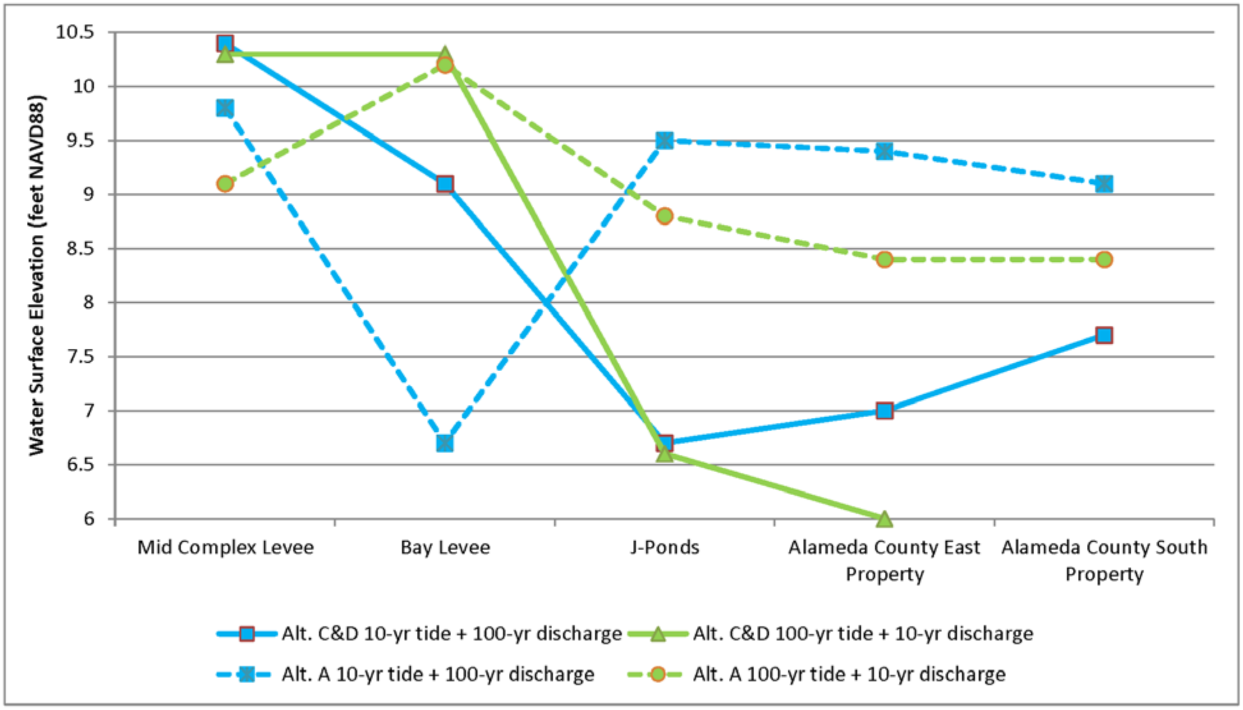

Figure 3.14. Alternative C & D Tidal Restoration and Pond Management, Flood Scenarios, Maximum Water Surface Elevations in Vicinity of Improved Levees

Flood Scenario Conclusions

Based on results from all Flood Scenarios, a consistent 12 foot NAVD88 levee improvement elevation was included in the Preliminary Design for all proposed levee improvements to provide over 1.5 feet of freeboard at all locations. Further analysis may allow the Inland and C-Ponds Landside Levees to be reduced to 11 feet NAVD88, however the higher elevation, greater volume, and larger environmental impact is appropriate to assume at this stage in the design. The Bay Levee may also be eliminated from improvement if habitat value is added elsewhere, as the Bay Levee currently provides wave protection; no flood protection. Of note, these maximum water surface elevations do not include wave setup and runup, therefore a freeboard is recommended.

Table 3.2. Preliminary Design Levee Improvement Elevations

	Max. Water Surface Elev. (feet NAVD88)			Freeboard	Preliminary Design Elevation
	Alt. A	Alt. B	Alt. C & D	(feet)	(feet NAVD88)
Inland Ponds Landside Levee	9.6	10.0	-	2.0	12.0
C-Ponds Landside Levee	9.5	9.4	-	2.5	12.0
Mid Complex Levee	9.8	-	10.4	1.6	12.0
Bay Levee	10.2	-	10.3	1.7	12.0

3.3 HEC-RAS Water Control Structure Results

New water control structures will facilitate the controlled movement of water between the ponds. The number, location, sizes, and operation of these water control structures differs by Alternative. Below is a summary of the results obtained from the HEC-RAS modeling analysis performed on the Inland and C-Ponds. Proposed water control structures (new and existing) are shown in Table 3.3, as well as Appendix A Figures A-7, A-8, and A-9. Additional information can be found in the Eden Landing Preliminary Design (AECOM 2016a).

Table 3.3. Design Criteria of Water Control Structures

<table>
<tr><th>Location</th><th>(Number), Size, Type</th><th>Length (ft.)</th><th>Existing Invert Elev. (ft. NAVD88)</th><th>Design Invert Elev. (ft. NAVD88)</th><th>Purpose</th><th>Applicable Alternatives</th></tr>
<tr><td>ACFCC/E2C (existing)</td><td>(2) 48 in. dia. HPDE/CMP</td><td>170</td><td>2.7</td><td>-</td><td rowspan="10">Hydraulic connectivity (Alt. B) or Pond management (Alt. C and D)</td><td rowspan="3">B, C and D</td></tr>
<tr><td>ACFCC/E2C</td><td>(2) 48 in. dia. HPDE/CMP</td><td>170</td><td>-</td><td>2.7</td></tr>
<tr><td>E1C/E5C (S)</td><td>(2) 48 in. dia. HPDE/CMP</td><td>60</td><td>-</td><td>2.7</td></tr>
<tr><td>E1C/E5C (N)</td><td>(1) 48 in. dia. HPDE/CMP</td><td>50</td><td>-</td><td>2.7</td><td>C and D</td></tr>
<tr><td>E2C/CP3C (existing)</td><td>(1) 48 in. dia. HPDE/CMP</td><td>60</td><td>Unknown</td><td>-</td><td>B and D</td></tr>
<tr><td>OAC/E6</td><td>(2) 48 in. dia. HPDE/CMP</td><td>150</td><td>-</td><td>0</td><td rowspan="5">C and D</td></tr>
<tr><td>E6/E5 (W)[1]</td><td>(1) 48 in. dia. HPDE/CMP</td><td>40</td><td>-</td><td>0</td></tr>
<tr><td>E6/E5 (E)[1] (existing)</td><td>(1) 48 in. dia. HPDE/CMP</td><td>40</td><td>-</td><td>0</td></tr>
<tr><td>E5/E6C (W)[2] (existing)</td><td>(1) 36 in. dia. HDPE/CMP</td><td>60</td><td>Unknown</td><td>0</td></tr>
<tr><td>E5/E6C (E)[2] (existing)</td><td>(1) 36 in. dia. HDPE/CMP</td><td>60</td><td>Unknown</td><td>0</td></tr>
<tr><td>ACFCC/E2&E4 via Alameda County Wetlands</td><td>(1) 6 ft. x 6 ft. concrete box or (3) 48 in. diam. HDPE/CMP</td><td>200</td><td>-</td><td>2.7</td><td>Fish passage</td><td>B</td></tr>
<tr><td>E7/E5</td><td>(1) 48 in. dia. HPDE/CMP</td><td>50</td><td>-</td><td>0</td><td>Culvert redundancy</td><td rowspan="4">C</td></tr>
<tr><td>ACFCC/Alameda County Wetlands</td><td>(1) 6 ft. x 6 ft. concrete box or (3) 48 in. diam. HDPE/CMP</td><td>200</td><td>-</td><td>2.7</td><td>Fish passage</td></tr>
<tr><td>Alameda County Wetlands/E1C</td><td>(1) 48 in. dia. HPDE/CMP</td><td>30</td><td>-</td><td>2.7</td><td>Fish passage/pond management</td></tr>
<tr><td>Alameda County Wetlands/J-Ponds</td><td>(1) 48 in. dia. HPDE/CMP</td><td>50</td><td>-</td><td>2.7</td><td>Detention basin management</td></tr>
</table>

Note 1: E6/E5 (W) and (E) could be combined into a single set of culverts to reduce costs as opposed to two separate culverts.

Note 2: E5/E6C (W) and (E) could be combined into a single set of culverts to reduce costs as opposed to two separate culverts.

3.3.1 Inland Ponds

In Alternatives C and D (the managed pond alternatives), two culverts will connect the OAC and Pond E6. One culvert could provide the desired conveyance over a longer period, however redundancy in the system is desired. The water level in the Inland Ponds may be increased up to the high tide level in the OAC by operating the combination gate on the inside of Pond E6 as a tide gate, and leaving open the outside gate on the OAC end.

Figure 3.15 shows the water surface elevations in the Inland Ponds with the proposed culverts for Alternatives C and D listed in Table 3.3. The results in the figure indicate sufficient capacity to convey water between the ponds.

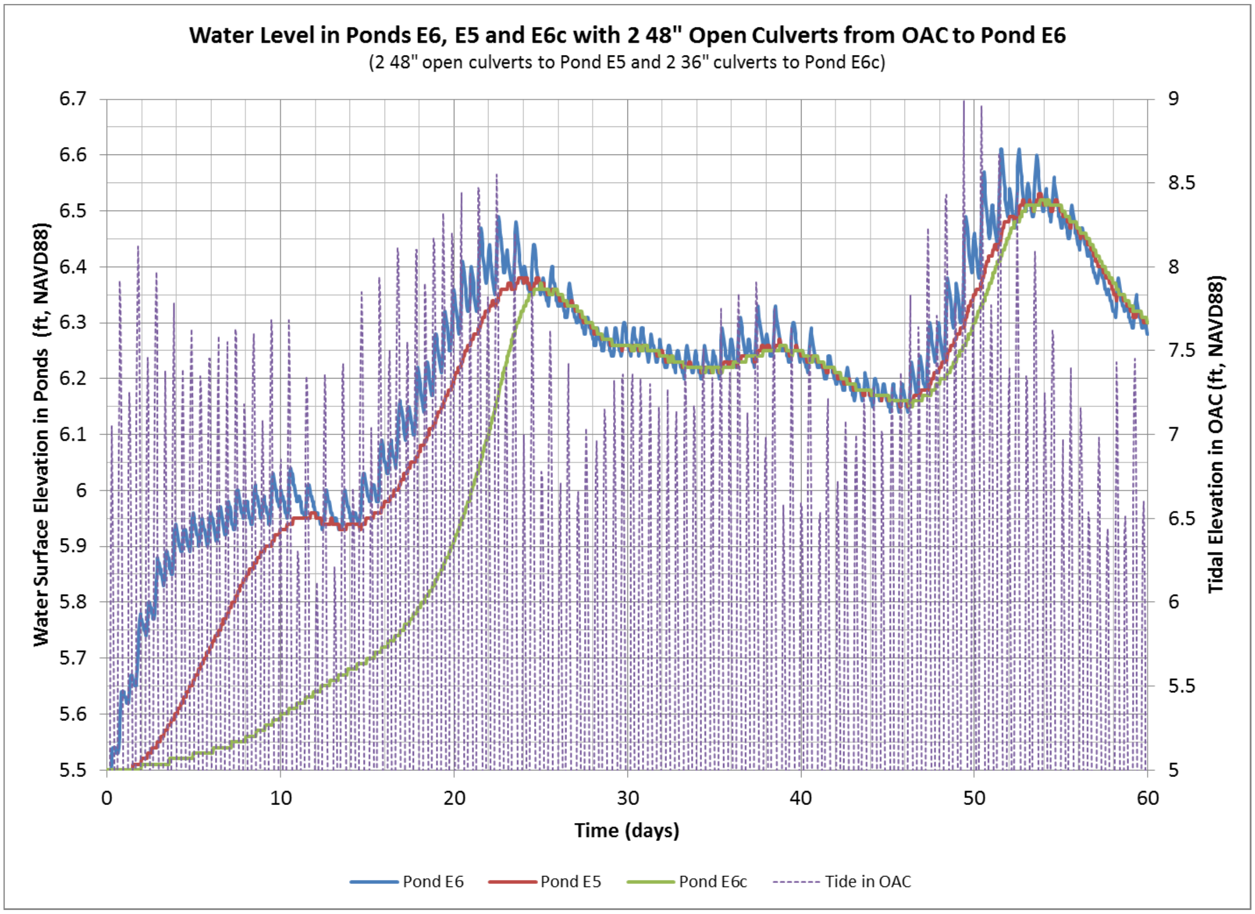

Figure 3.15 Water Surface Elevations in Inland Ponds with Proposed Water Control Structures

Figure 3.16 shows the predicted water surface elevations in the OAC near the Pond E6 culverts relative to the Bay tides. When the OAC is flowing during rain events, the limited conveyance capacity of the OAC causes water surface elevations in the OAC to rise. With a 10 cfs base flow in the OAC, the low tide in the OAC just outside the Inland Ponds is about one to two feet higher than that experienced in the Bay. With a higher base flow of about 100 cfs, the low tide in the OAC is about three to four feet higher than the low tide in the Bay. After the breach is constructed connecting the OAC and Pond E1

(Alternatives B, C and D), the OAC is anticipated to scour and increase its conveyance capacity; however the OAC reach from Pond E1 to the culvert at Pond E6 is not anticipated to scour.

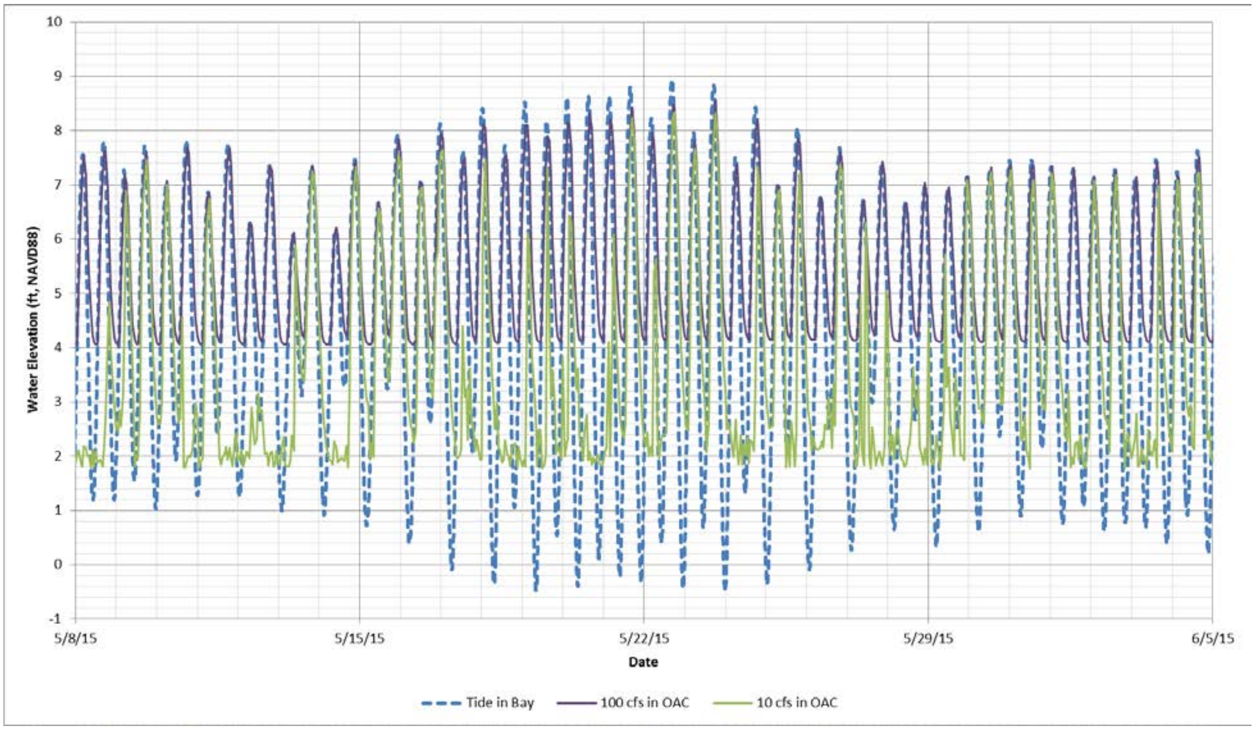

Figure 3.16 Tidal Elevations in the Bay and OAC (near Pond E6)

3.3.2 C-Ponds

Presently there are two 48 inch gates culverts connecting Pond E2C to the ACFCC. Adding two more culverts raises the maximum water level in the ponds by about a half a foot in Pond E2C and about 0.1 feet in Ponds E5C and E4C. This assumes that a 48 inch culvert is installed between Ponds E1C and E5C.

4. LIMITATIONS

This memorandum summarizes a modeling study based on information available at the time and our professional judgment pending future analyses. Future design decisions or additional information may change the findings, and corresponding professional judgments presented in this report. In the event that conclusions or recommendations based on the information in this memorandum are made by others, such conclusions are not the responsibility of AECOM, or its subconsultants, unless we have been given an opportunity to review and concur with such conclusions in writing

5. REFERENCES

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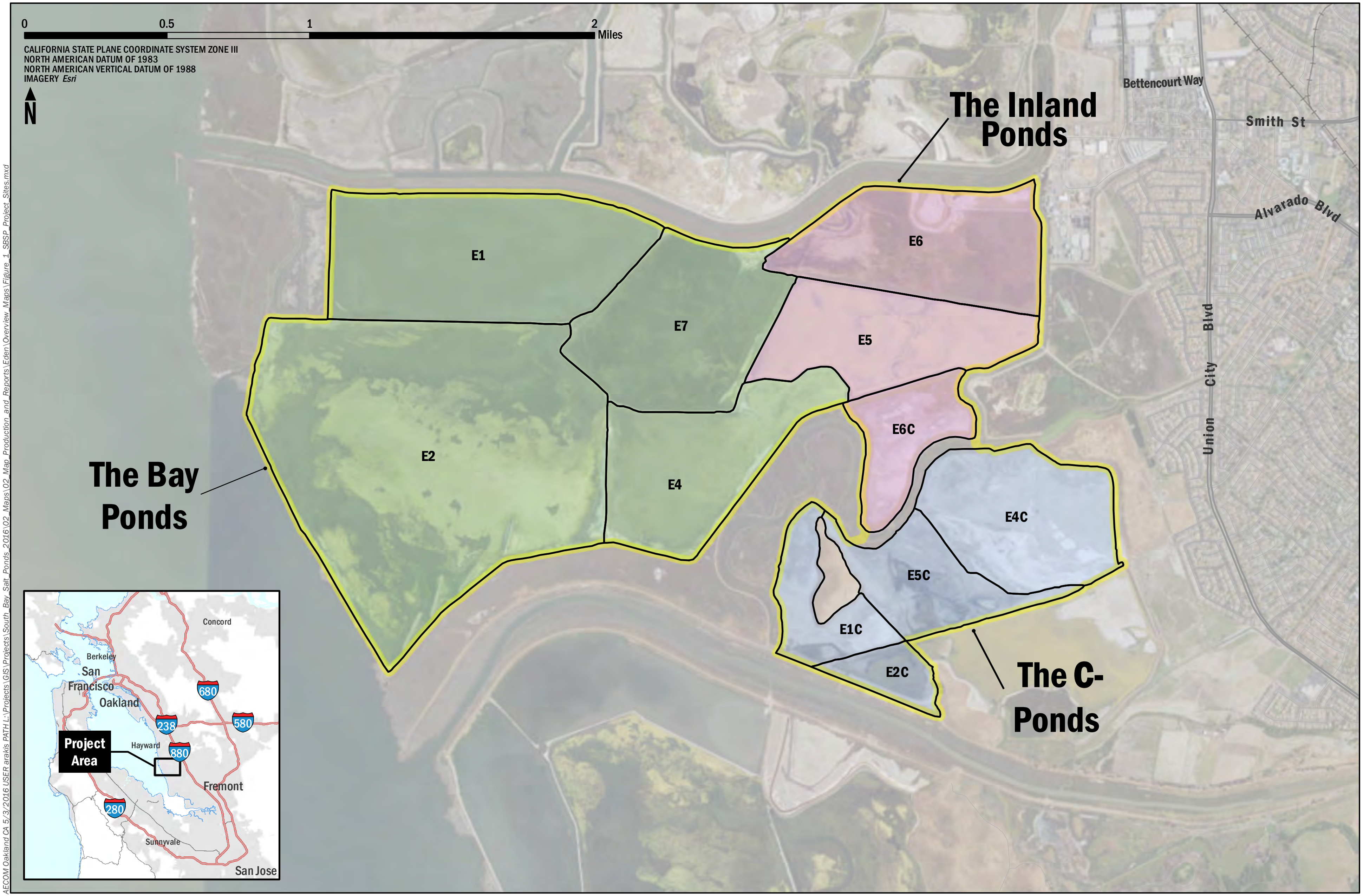
Appendix A

Eden Landing Figures



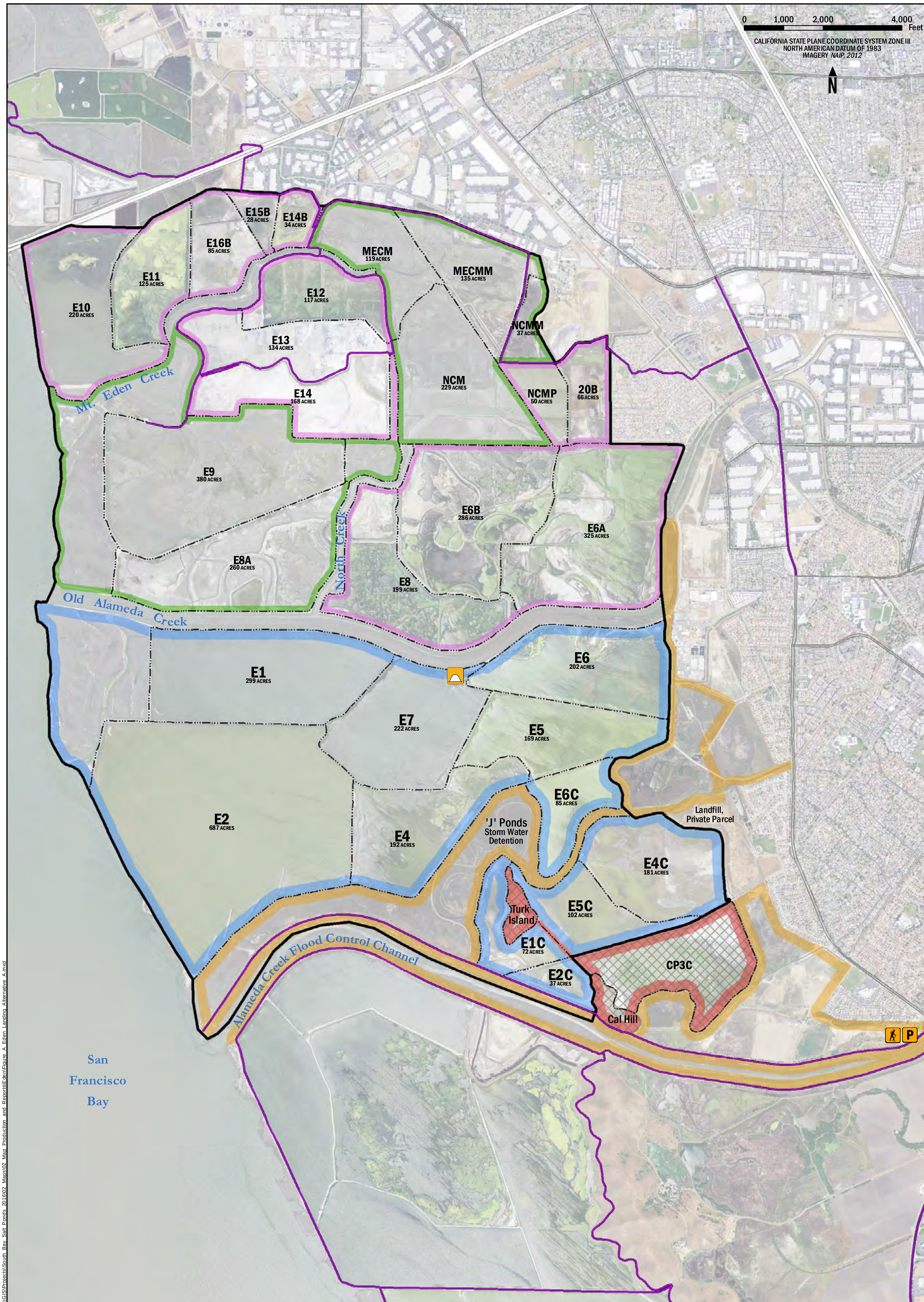
LEGEND

- Phase 2 Eden Landing Project Area
- The Bay Ponds
- The C Ponds
- The Inland Ponds

AECOM

South Bay Salt Pond Restoration Project
Eden Landing Phase 2: Project Area

Figure A-1
Eden Landing Phase 2: Project Area



Existing Alvarado Salt Works
Existhing Trailhead
Existing Parking lot
Existing trail
Boundary of current or former ELER pond

Phase 2 Project area

Phase 1
Enhanced managed pond
Tidal marsh

Ownership
CA Department of Fish and Wildlife
Cargill
County

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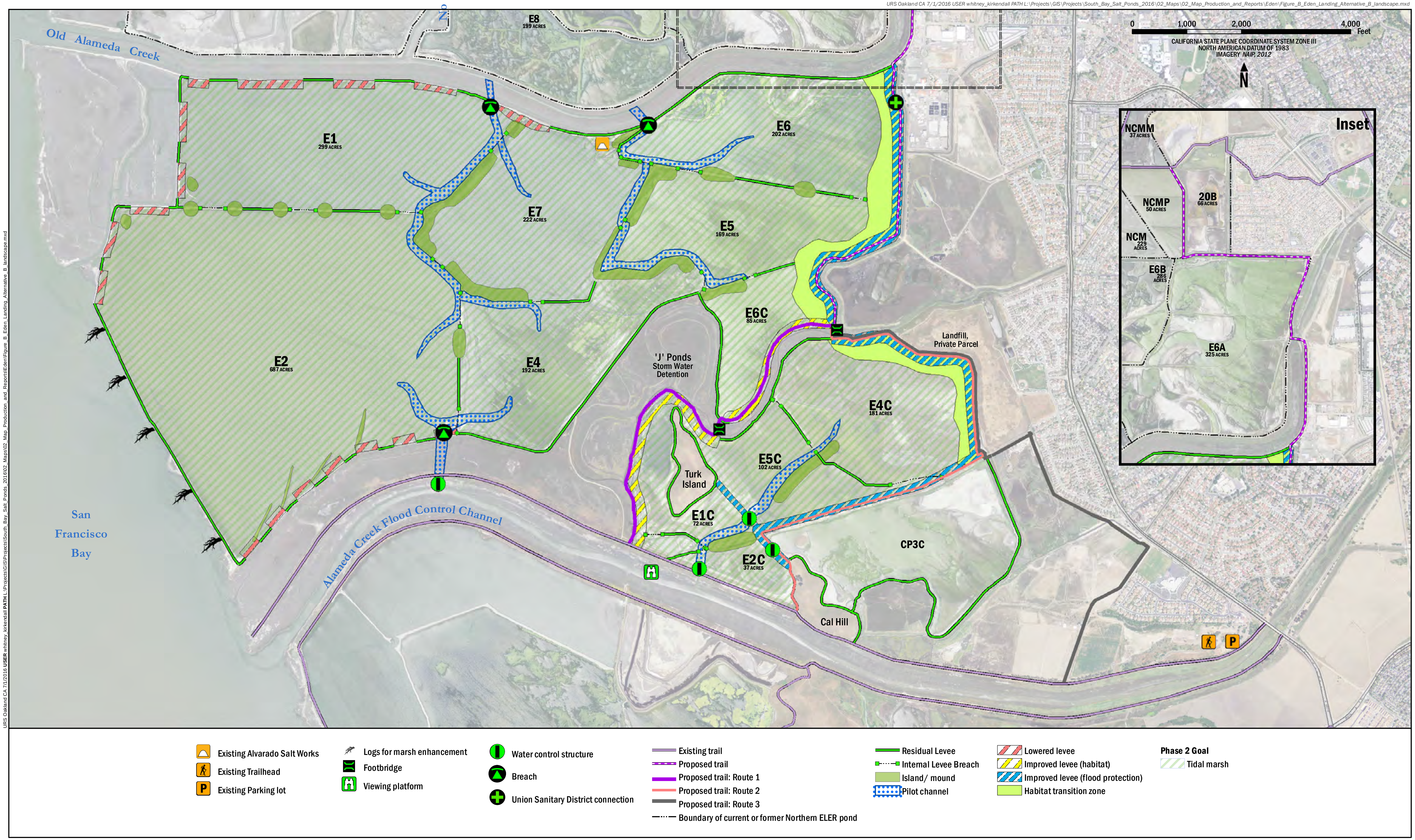
AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Alternative Eden A



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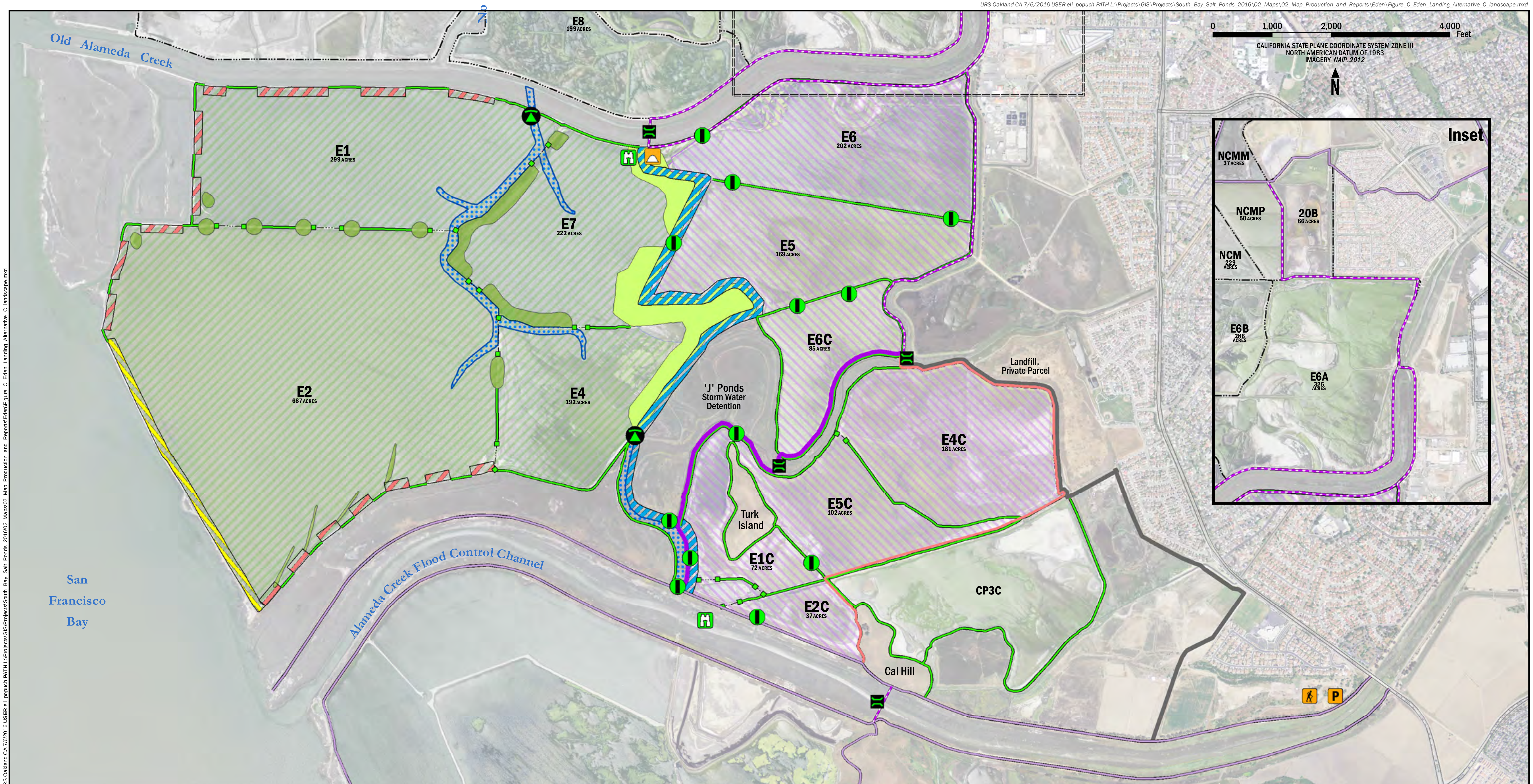
South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Alternative Eden B

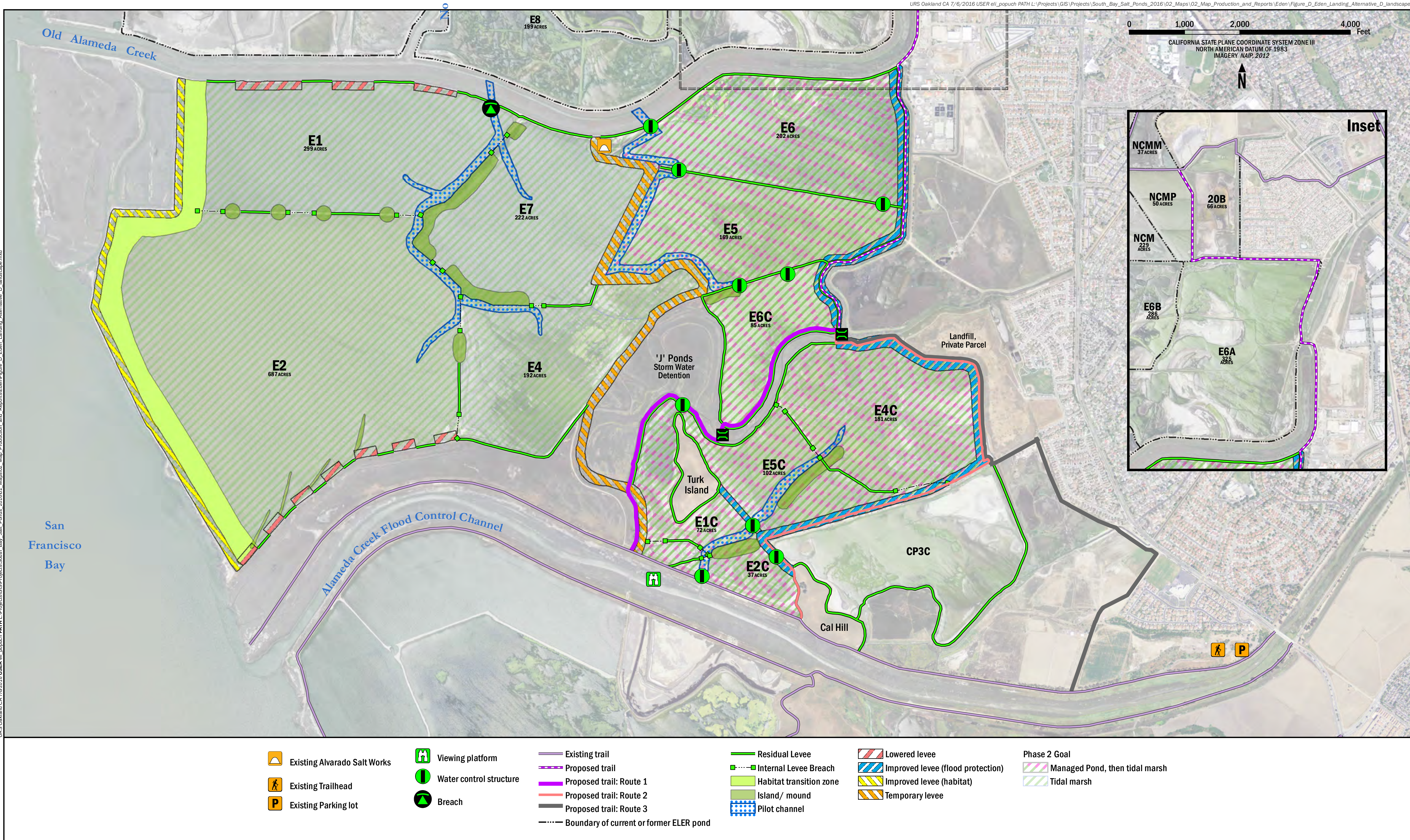


Existing Alvarado Salt Works
Existing Trailhead
Existing Parking lot
Footbridge
Viewing platform
Water control structure
Breach
Existing trail
Proposed trail
Proposed trail: Route 1
Proposed trail: Route 2
Proposed trail: Route 3
Boundary of current or former ELER pond
Residual Levee
Internal Levee Breach
Island/ mound
Pilot channel
Lowered levee
Improved levee (flood protection)
Improved levee (habitat)
Habitat transition zone
Phase 2 Goal
Managed Pond, Permanent
Tidal marsh

AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Alternative Eden C



AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Alternative Eden D

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Infrastructure
- Water control structure
- Pump
- Power distribution line
- Overhead power transmission line

Status
- Existing

Boundary of current or former ELER pond

Ownership
- CA Department of Fish and Wildlife
- Cargill
- County

AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Infrastructure Alternative A

Infrastructure

- Water control structure
- Pump
- Power distribution line
- Overhead power transmission line

Status

- New
- Demolish
- Replace/Repair

Boundary of current or former ELER pond

Phase 2 Goal

- Tidal marsh

Ownership

- CA Department of Fish and Wildlife
- Cargill
- County

Note: Levee breaches will be created where infrastrcture is demolished, except at the Bay-E2 water control structue where the levee will be backfilled after structure removal.

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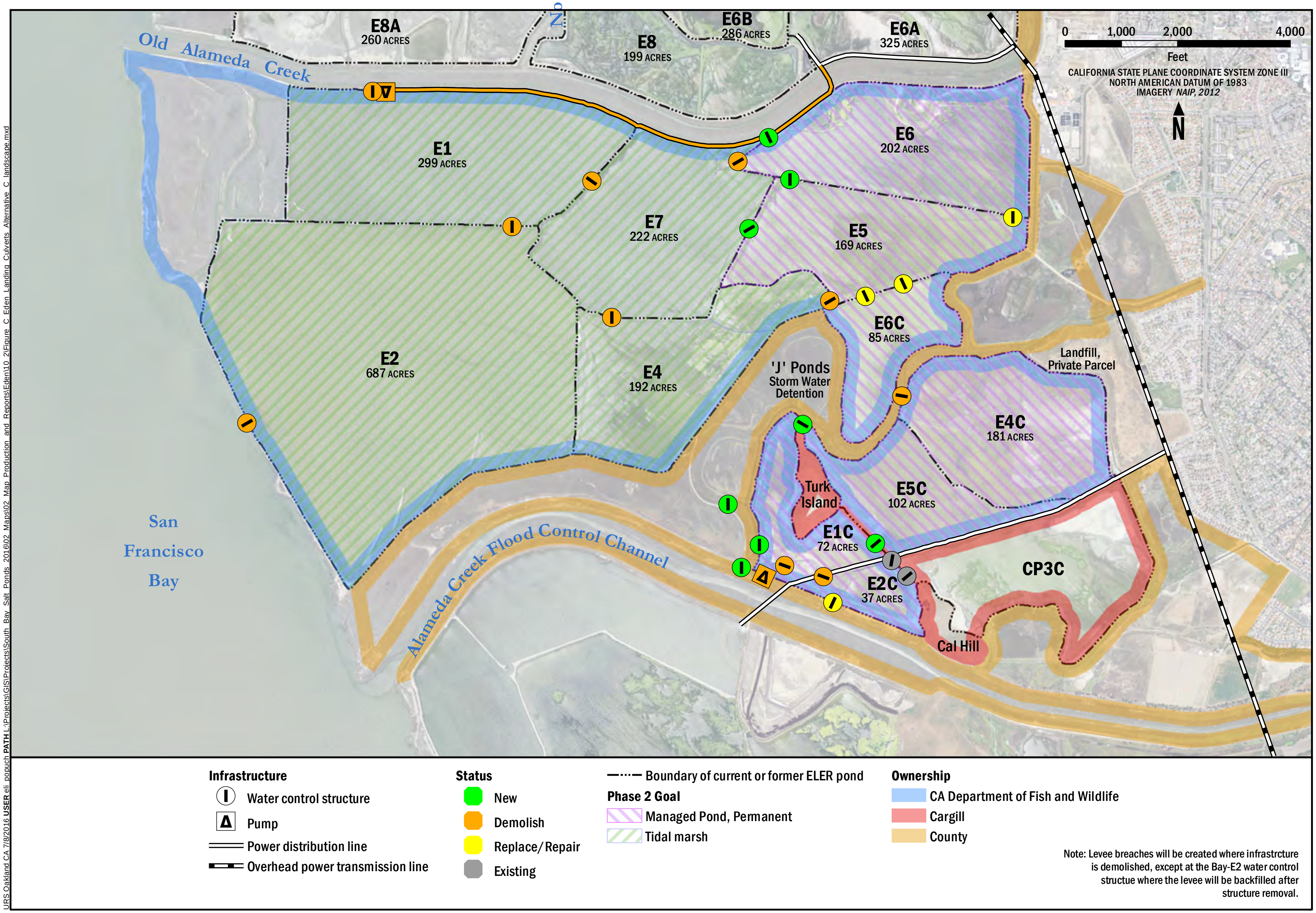
AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

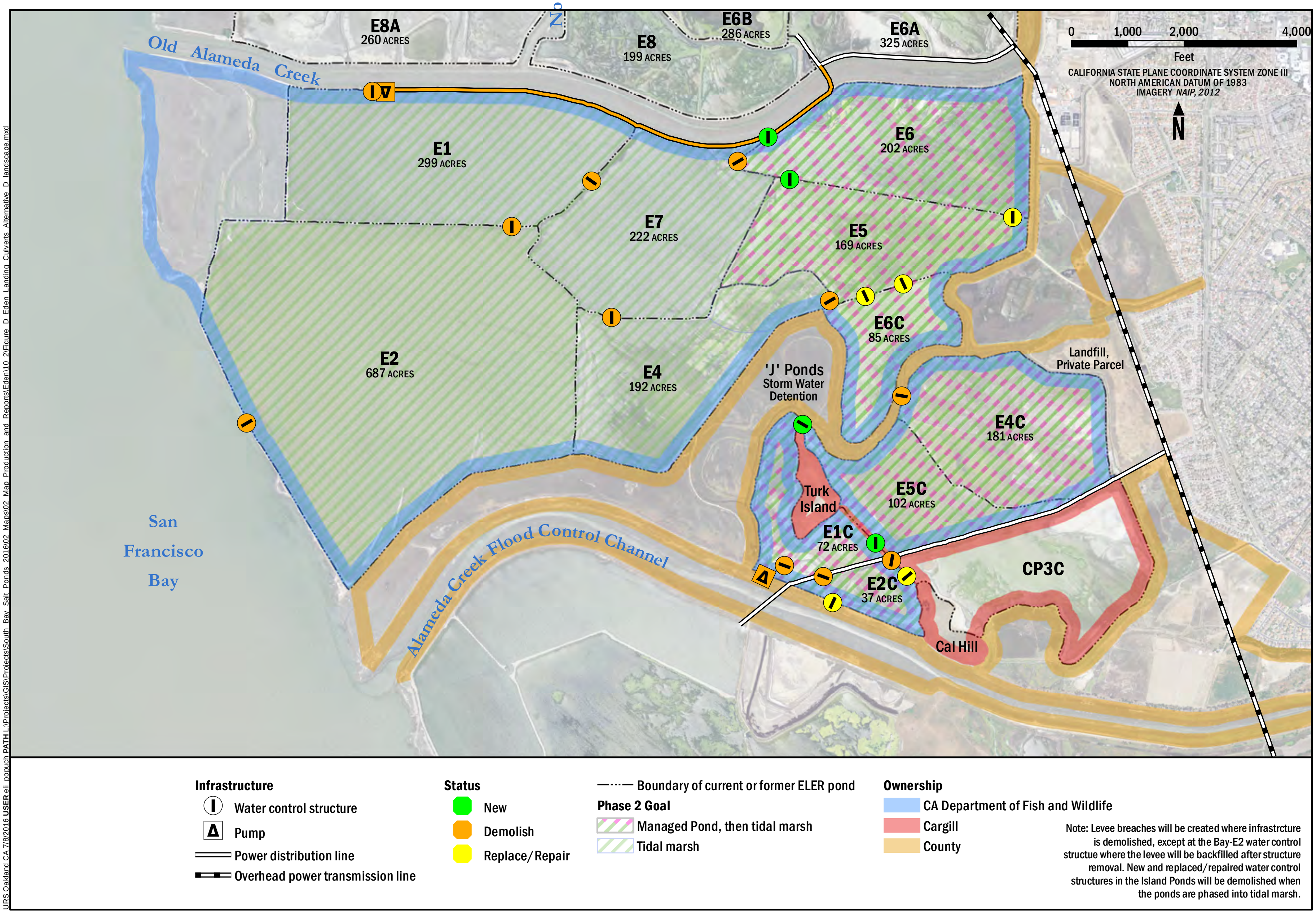
Infrastructure Alternative B



AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Infrastructure Alternative C



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South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Infrastructure Alternative D

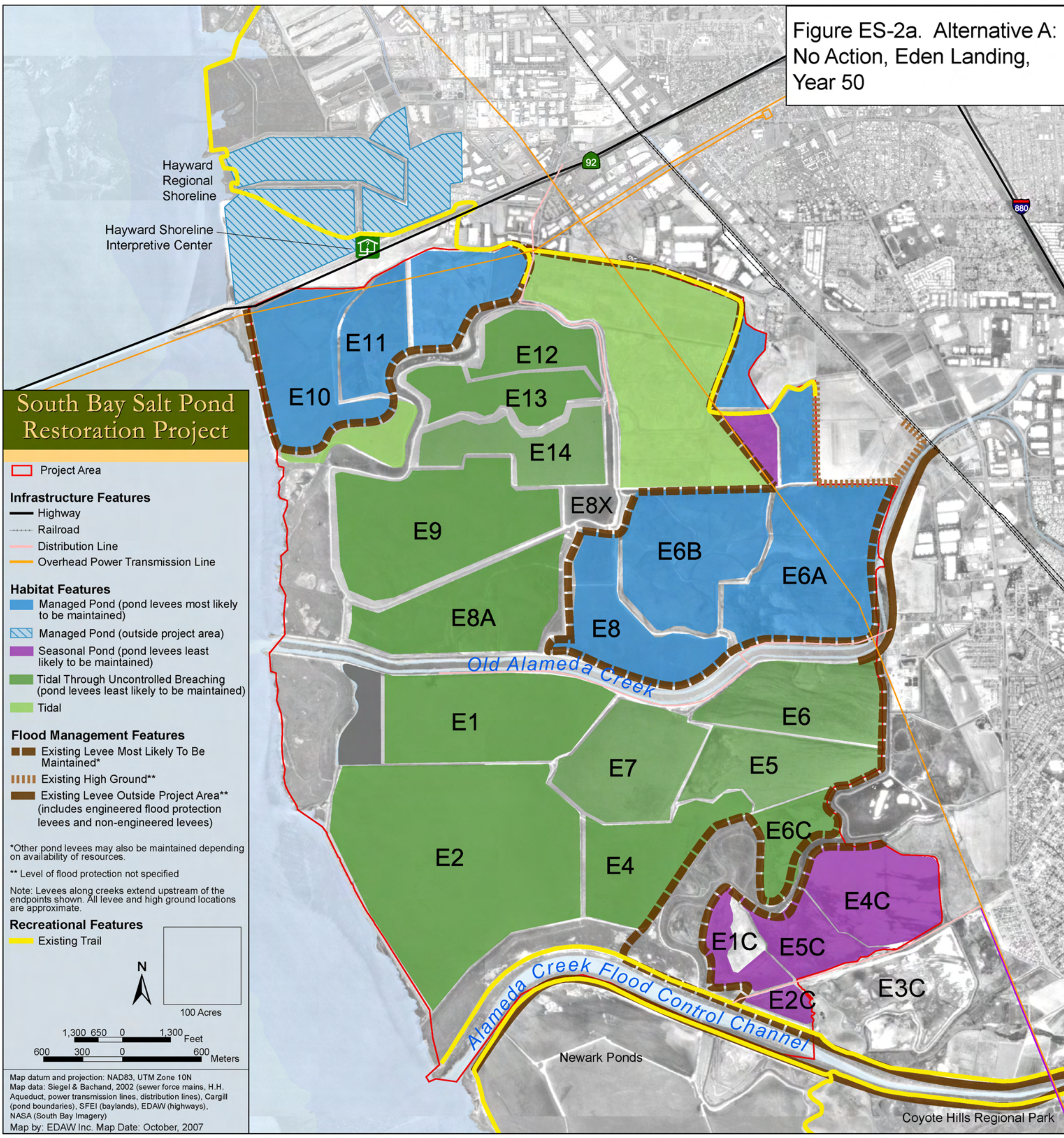

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Figure A-6. Programmatic EIS/R Alternative A: No Action

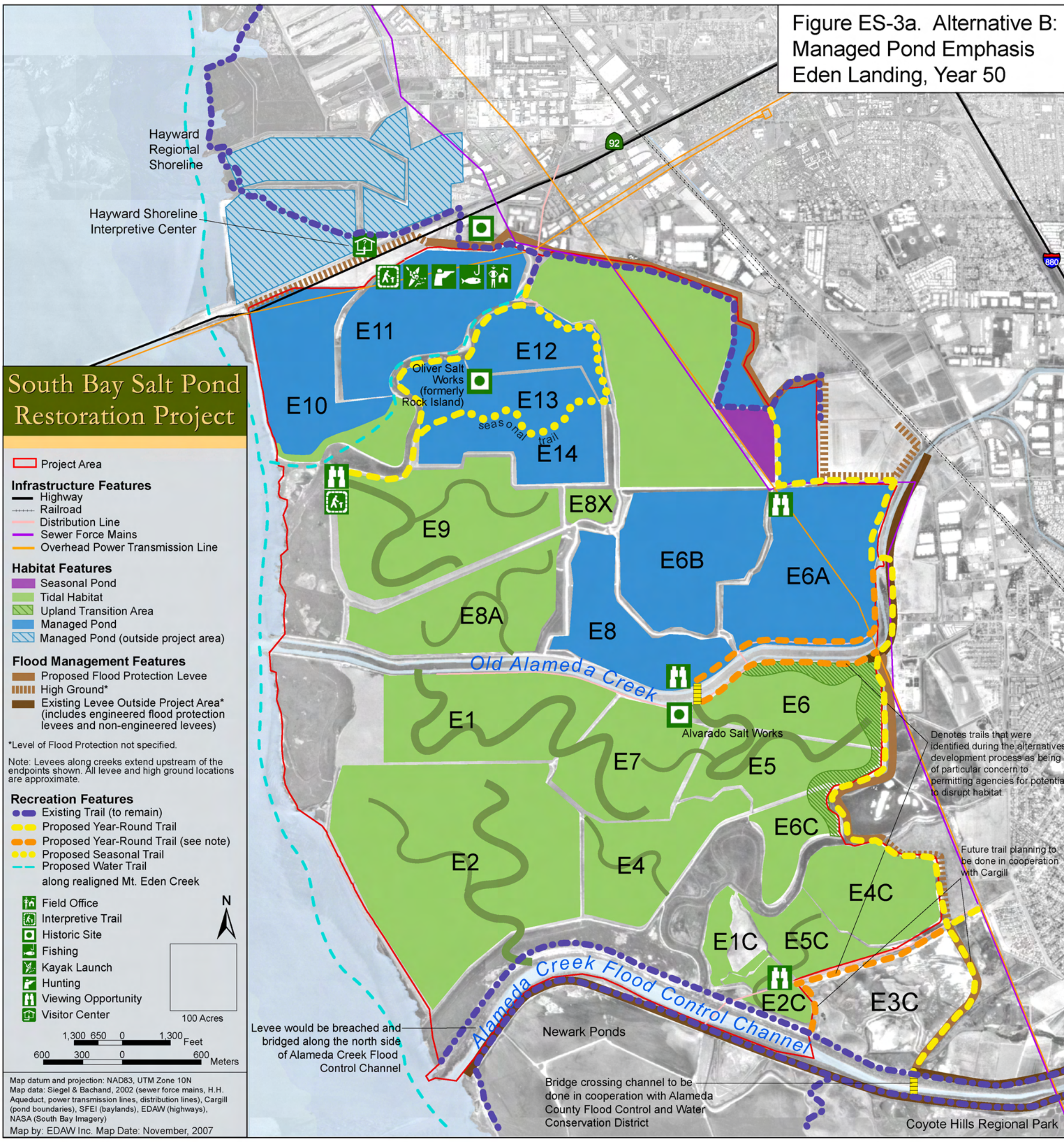

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Figure A-7. Programmatic EIS/R Alternative B: Managed Pond Emphasis

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Figure A-8. Programmatic EIS/R Alternative C: Tidal Habitat Emphasis

Appendix B

David Schoellhamer (USGS) comments on AECOM modeling of Eden Landing Ponds

David Schoellhamer comments on AECOM modeling of Eden Landing Ponds

March 18, 2016

On March 17, 2016, Phil Mineart and Megan Collins of AECOM presented their modeling of the Eden Landing Ponds to me via a webinar. The objective of the modeling at this 10% design stage is to conceptually determine how to obtain water levels in the ponds that meet management objectives without increasing flood risk. AECOM is applying the MIKE21 model, a commonly used model that simulates depth-averaged flow varying in time and varying horizontally. This is an appropriate model for the task and overall the modeling is appropriate for the task. Specific comments follow.

- Accurate bathymetry data are essential and they have utilized the latest and best data available.
- Boundary conditions of Bay tides and the 100-year flood are also essential and well-defined. For flood simulations they have aligned the arrival of the flood peak with a high tide which is a good conservative approach. Perhaps now or a later design stage the effect of sea level rise on the flood scenario should be considered. *[AECOM insert: The SBSP Project's approach is to maintain existing flood protection and work with external partners as practicable to improve existing conditions. Designing for sea level rise would improve existing conditions, and is therefore not an incorporated component of the Eden Landing design at this time.]*
- There is no water level data that I know of that could be used for model calibration. Ideally, such data would exist and be used to calibrate the model. Fortunately water level is the easiest model variable to predict (compared to velocity, salinity, sediment, water quality), the model domain is small, bathymetry is well-defined, and the boundary conditions are well-defined. So lack of data adds uncertainty to the model but is not a fatal flaw.
- The management objective for restoration is to maximize pond area that is wetted and dried during a tidal cycle. A different management objective would likely lead to a different restoration design.
- AECOM will double check that there is no overtopping of the levee on the landward side of the model domain that protects an urban area. *[AECOM insert: The model extent was expanded to the east to capture the full flood extent.]*
- The model does not consider bathymetric change created by restoration actions. The simulation of a scoured OAC was a good idea to test what could happen with increased tidal prism and potential scour. OAC at the E7 breach (I am 90% sure I have the right one) has a mid-channel marsh island. The E7 breach to the south channel could increase scour there. The south channel would then take more tidal prism, reducing tidal flows in the north channel that could lead to deposition there (similar to deposition in Steinberger Slough when the Port of Redwood City was deepened). The north channel presently takes most of the flood flow, so deposition in it would have the potential to make flooding worse. AECOM proposed making a cut in the mid-channel island at the E7

breach to try to better balance the increased flow in the north and south channels, which makes sense to me.   I expect this would also improve wetting and drying of E7. I also expect it would reduce erosion of seaward fringe marsh in OAC along the south channel and so the cut may preserve some seaward marsh and may not result in a net loss of marsh. *[AECOM insert: OAC island cuts are proposed for external breaches connecting Ponds E1 and E7 to the OAC.]*

ATTACHMENT 2. EDEN LANDING GEOTECHNICAL INVESTIGATION AND ANLYSES

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Memorandum

To	State Coastal Conservancy	Pages 5
Subject	Eden Landing Geotechnical Investigation and Analyses	
From	Seth Gentzler, PE, Project Manager Kanax Kanagalingam, PE, GE, Benjamin Choy, PE	
Date	November 8, 2016	

This memorandum presents geotechnical data collected from the recent AECOM geotechnical field investigation and results of the geotechnical analyses performed for the conceptual restoration design of the southern half of the Eden Landing Ecological Reserve (ELER).

1.0 AECOM Geotechnical Investigation

In June 2016, AECOM planned and executed a subsurface field investigation in order to collect geotechnical field data, and to perform laboratory testing on the samples collected during the investigation. The investigation consisted of six soil borings, B-01-through B-06. Table 1 summarizes the approximate locations of these borings and the boring depths. Figure 1 shows the locations of these boring on the project vicinity map. The field investigation was performed between June 20 and 22, 2016.

Pitcher Drilling Company of East Palo Alto, California drilled the exploratory borings using a truck-mounted Failing 1500 drill rig. The borings were advanced using rotary wash drilling techniques to depths ranging from 56.5 to 63 feet. An AECOM geologist on site during drilling, visually classified the soils encountered during the drilling, and logged the borings. The draft boring logs are included as Attachment 1. The borings were backfilled with a neat cement-bentonite grout in accordance with the appropriate county permits.

Samples were collected at five foot intervals using a split-spoon sampler during standard penetration testing (SPT), a 2.5-inch Modified California (ModCal) sampler, or a 2.8-inch Shelby tube sampler. The sampler utilized in the field was determined based on the encountered materials.

Samples collected during the exploration were transferred to Cooper Testing Laboratories in Palo Alto, California for testing. Tests were performed on select samples and included moisture content and density, sieve analysis, Atterberg limits, unconsolidated-undrained triaxial tests (TXUUs), consolidated-undrained triaxial tests (TXCUs) with pore pressure measurements, and consolidation tests. The geotechnical laboratory test results are presented in Attachment 2.

2.0 Geotechnical Analyses

As part of the restoration of the southern half of the ELER, existing levees in the Eden Landing pond complex are proposed to be raised to a design crest elevation of 12 feet (NAVD88). Based on hydrodynamic modeling results, the proposed raise is expected to provide equal or better flood protection compared to existing conditions. Based on the subsurface soil conditions and the levee geometry after the proposed raise, representative levee cross sections were selected for geotechnical analyses.

The details of the representative analysis sections, material characterization, analysis procedures, and the results of the analyses are discussed in the following sections.

2.1 Representative Analysis Sections and Material Characterization

The selected representative analysis cross sections and their idealized soil profiles are shown on Figures 2 and 3. The section shown on Figure 2, named as Section A, represents the existing levees that will be raised by about 2 feet. Section A represents the majority of the levees that will be raised as part of the ELER restoration. The section shown on Figure 3, named as Section B, represents a relatively short levee section where the levees will be raised by about 4 feet to meet the design crest elevation of 12 feet. This section is located along the Mid-Complex Levee between approximate Stations 81+00 and 115+00. Considering the thickness of the soft bay mud (as described below) at the project site, the levee side slopes of 4H:1V were assumed for the geotechnical evaluation.

The idealized profiles and material properties for the analyses were developed based on the geotechnical data collected from the recent AECOM investigation, available historical data collected by others (Geo/Resource Consultants, INC. 2008, AMEC 2010, Wood Rodgers, CE&G and GEI 2011), past similar projects, and engineering judgement. In general, the existing levees are underlain by a soft compressible Young Bay Mud (YBM). The YBM is underlain by stiff old bay clay (OBC). The thickness of the YBM at the project site ranges from 15 to 35 feet. The idealized soil profile modeled the YBM as a 30-foot–thick layer underlying the existing levee. It is recommended that a more comprehensive field investigation program shall be performed to refine the subsurface conditions for final design.

Since the source of the new levee fill material is not yet determined, conservative strengths were assigned to the new levee fill in performing the slope stability analysis. It is recommended that a test fill be constructed to confirm that the strengths and densities assumed in this analysis are attainable. Due to the difficulty in working with the YBM, it is recommended that the levee test fill be constructed near the site of the future levee in an area with similar subsurface conditions as the foundations for the future levees. Depending on the results of the test fill, modifications of the design may be warranted. For now, the strengths assigned to the levee fill in this analysis are judged to be sufficiently conservative to achieve in the field.

Table 2 summarizes the idealized soil profile and the material parameters selected for the settlement and stability analyses.

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2.2 Analysis Procedures

The stability of the levees was analyzed for two cases: the end of construction case and the long-term steady state seepage during a potential high water event. Rapid drawdown was judged to not be applicable since the tidal fluctuations would not allow the levees to fully saturate.

As the levee raises will, in general, be constructed over soft compressible YBM, one dimensional settlement analysis was performed for the selected representative sections using the geometry determined to be stable for the target design crest elevation. Slope stability analysis was then performed with the levee crest height selected at a higher elevation to approximately compensate for the estimated settlement.

As provided in Table 2, the soft YBM layer was modeled using undrained shear strength. For the end of construction case, the undrained shear strength was first estimated using the current effective stresses and the undrained strength ratio (Su/σ_v') of 0.27, and then modeled using a depth-dependent strength model. For the long term steady state case, the undrained strength was modeled directly using the undrained strength ratio to represent the long term consolidated stress conditions. In both cases the lower bound of the undrained strength was limited to 200 psf.

Finite element seepage analyses were performed using SEEP/W (2012 Version 8.15), a two-dimensional, finite element analysis software program developed by GEO-SLOPE International, Ltd. SEEP/W analyzes groundwater seepage and excess pore water pressure dissipation conditions in porous materials, such as soil and rock. Slope stability analyses were completed using SLOPE/W (2012 Version 8.15), a slope stability analysis program also developed by GEO-SLOPE International, Ltd. Pore water pressures calculated in SEEP/W analyses, assuming steady-state seepage conditions, were imported and used in the static slope stability.

2.3 Analysis Results and Discussion

2.3.1 Section A

The anticipated settlement of the raised levee crest was first estimated by performing a settlement analysis on Section A with the design crest elevation of 12 feet. The estimated immediate settlement is on the order of 1-inch, and the consolidation settlement is on the order of 17-inches. The consolidation settlement is expected to occur over 20 to 85 years. In order to compensate for the consolidation settlement the constructed crest elevation will be 13.4 feet, which is assumed to be sufficient to maintain the levee crest at or above elevation of 12 feet. It is noted that along the alignment of the levee, differential settlement is likely to occur due to differences in the subsurface materials.

Slope stability analyses were performed on the levee section with the increased crest height (elevation 13.4 feet). The results of the stability analyses are summarized in Table 3, and in Figures 4 and 5. The section calculated a factor of safety of 1.2 for end of construction, and 1.3 for long term stability. Based on the results of the slope stability analyses performed as part of the 30 percent design of the levees at Alviso and Ravenswood Pond Complexes (not included in this memorandum), the calculated factors of safety were judged to be adequate for both the end of construction and long term conditions. Based on these analysis results, 4H:1V or flatter side slopes and the construction crest elevation of 13.4 feet are recommended for the levee construction.

2.3.2 Section B

Similar to Section A, the anticipated settlement of the raised levee crest was first estimated by performing a settlement analysis on Section B with the design crest elevation of 12 feet. The estimated immediate settlement is on the order of 2-inches, and the consolidation settlement is on the order of 36-inches. The consolidation settlement is expected to occur over 20 to 85 years. In order to compensate for the consolidation settlement, the proposed constructed crest elevation will be 15 feet, which is assumed to be sufficient to maintain the levee crest at or above elevation of 12 feet. It is noted that along the alignment of the levee, differential settlement is likely to occur due to differences in the subsurface materials.

Slope stability analyses were performed on the levee section with the increased crest height (crest elevation 15 feet). The results of the stability analyses showed that the factor of safety calculated for the end of construction case was judged to be not adequate for construction.

Three alternatives were considered for raising the levee to provide a long term crest elevation at 12 feet or above:

(1) Construct to elevation 15 feet with flattened side slopes of 5H:1V,
(2) Excavation and replacement of the top 10 feet thick soft YBM and construct to elevation 15 feet with 4H:1V side slopes, and
(3) Staged construction with first stage construction to elevation 12 feet following by periodic maintenance to keep crest at elevation 12 feet.

The factors of safety calculated for the end of construction stability of both (1) and (2) did not meet the assumed adequate factors of safety of 1.2 for end of construction case. The alternative involving the excavation and replacement of deeper than 10-foot thick soft YBM is considered to be an expensive alternative, and therefore not considered for evaluation. The results of analysis for staged construction are summarized in Table 3, and in Figures 6 and 7. The section with the crest elevation at 12 feet calculated a factor of safety of 1.2 for end of construction, and 1.4 for long term stability. The calculated factors of safety for this scenario were judged to be adequate for construction.

Based on these analysis results, 4H:1V or flatter side slopes and the construction crest elevation of 12 feet are recommended for the levee construction. In addition to the alternatives discussed above, an alternate levee alignment closer to nearby existing levees could also be considered for Section B.

3.0 Limitations

This memorandum was developed in accordance with the standard of care commonly used as state-of-practice in the engineering profession. Standard of care is defined as the ordinary diligence exercised by fellow practitioners in this area performing the same services under similar circumstances during the same period. No warranty is either expressed or implied that actual encountered site and subsurface conditions will conform exactly to the conditions described herein; nor is it expressed or implied that this memorandum's recommendations will be sufficient for all construction planning aspects of the work. The conclusions presented in this memorandum are professional opinions based on the indicated project criteria and data available at the time this report was prepared.

The conclusions presented in this memorandum are intended only for the purpose, site location, and project indicated. The recommendations made in this report are based on the assumption that the subsurface soil and groundwater conditions do not deviate appreciably from those disclosed in the site-specific exploratory borings, including those performed by others. Additional borings are recommended for final design.

4.0 References

Geo/Resource Consultants, INC., 2008. Geotechnical Investigation Report, SBSP Eden Landing Ponds E8A, E9, and E8X Phase 1 Action Tidal Restoration/ New E10 Levee, Report.

AMEC, 2010. Geotechnical Study, South Bay Salt Pond Restoration Project, Eden Landing Restroations, Ponds E8/E9 and E12/13, Report.

Wood Rodgers, CE&G and GEI, 2011. Alameda County Category 1 Levee Evaluation, Flood Control Zone 5, Site Plan and Exploration Data.

TABLES

Table 1 AECOM Boring Locations and Depths

Boring	Location	Approximate Latitude	Approximate Longitude	Depth (ft)
B-01	Eden Landing – near Pond E6/E7	37.590270°	-122.116008°	61.5
B-02	Eden Landing – Pond E2	37.573452°	-122.137606°	56.5
B-03	Eden Landing – Pond E6C	37.584964°	-122.091962°	61.5
B-04	Eden Landing – Pond E6C/J Ponds	37.575561°	-122.103004°	61.5
B-05	Eden Landing – Pond E5C	37.572686°	-122.088808°	63
B-06	Eden Landing – Pond E2C	37.568414°	-122.105628°	61.5

Table 2 Idealized Soil Profile and Material Properties Used for Analyses

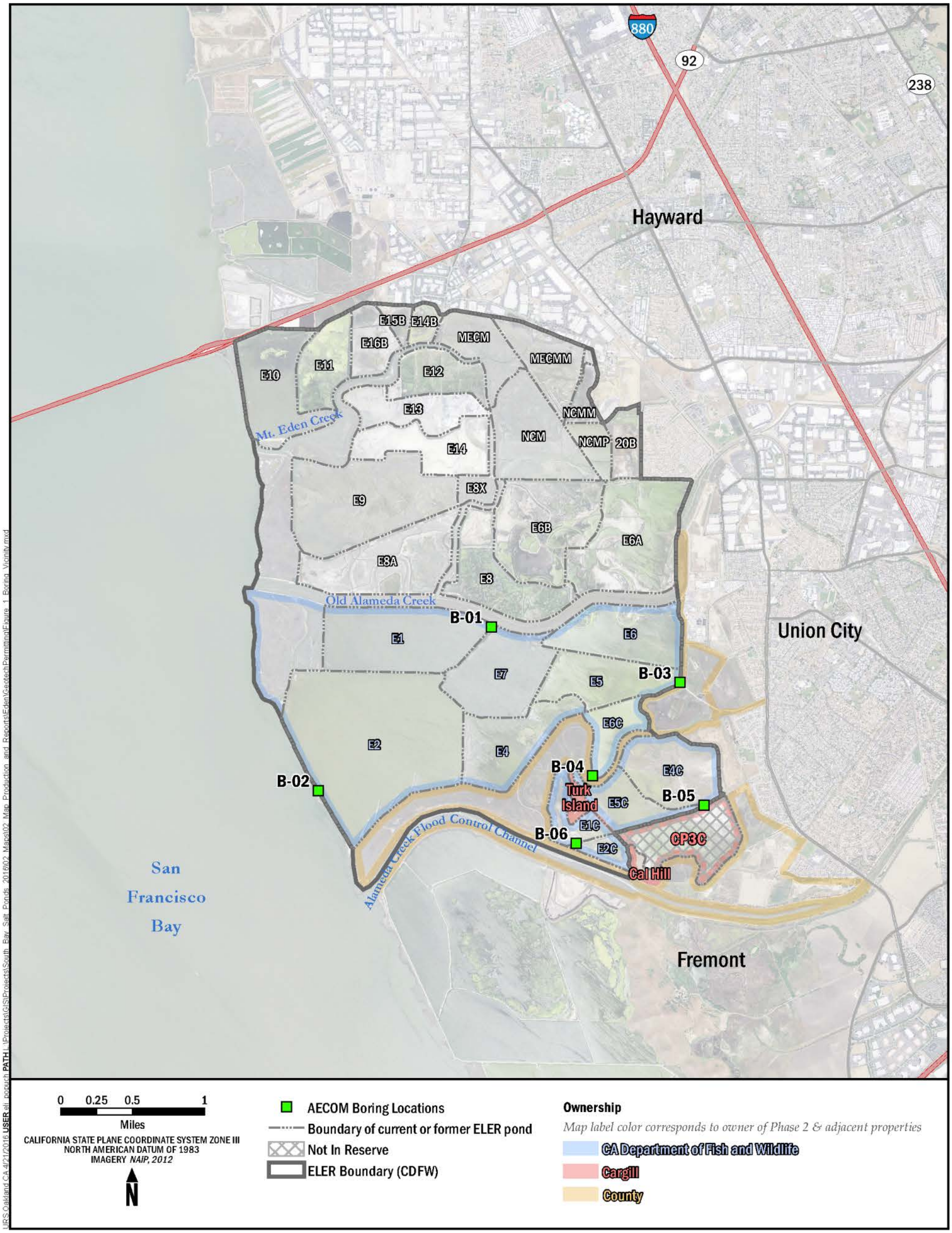
Material Layer	Elevation Below Levee Centerline (ft)				Unit Weight (pcf)	Soil Strength Parameters					Settlement Analysis Parameters			
	Section A		Section B											
	Top	Bottom	Top	Bottom		c' (psf)	ϕ' (deg.)	Su (psf)	Su/σ_v'	Su,min (psf)	OCR	Cc	Cr	e_0
New Fill	12.0	10.3	12	7.6	125	100	32	-	-	-	-	-	-	-
Existing Fill	10.3	5.3	7.6	5	120	50	28	-	-	-	-	-	-	-
Young Bay Mud (YBM)	5.3	-24.8	5	-25	95	-	-	-	0.27	200	1.2	1.1	0.2	2.5
Old Bay Clay (OBC)	-24.8	-50.0	-25	-50	120	-	-	1000	-	-	3.0	0.3	0.1	0.8

Table 3 Slope Stability Analysis Results for Sections A and B

Slope Stability Analysis Case	Analysis Water Surface Elevation (ft)		Assumed Adequate Factor of Safety[3]	Calculated Factor of Safety	
	Assumed Waterside[4]	Assumed Landside		Section A[1]	Section B[2]
End of Construction	10.5	Dry	1.2	1.2	1.2
Long Term Steady State	10.5	Dry	1.3	1.3	1.4

Notes: [1]Crest elevation 13.4 ft, [2] Crest elevation 12 ft.
[3]Assumed factors of safety are based on the results of the slope stability analyses performed as part of the 30 percent design of the levees at Alviso and Ravenswood Pond Complexes (not included in this memorandum).
[4]Assumed based on 100-yr flood level and regional typical tidal high water.

FIGURES



AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

FIGURE 1. VICINITY MAP

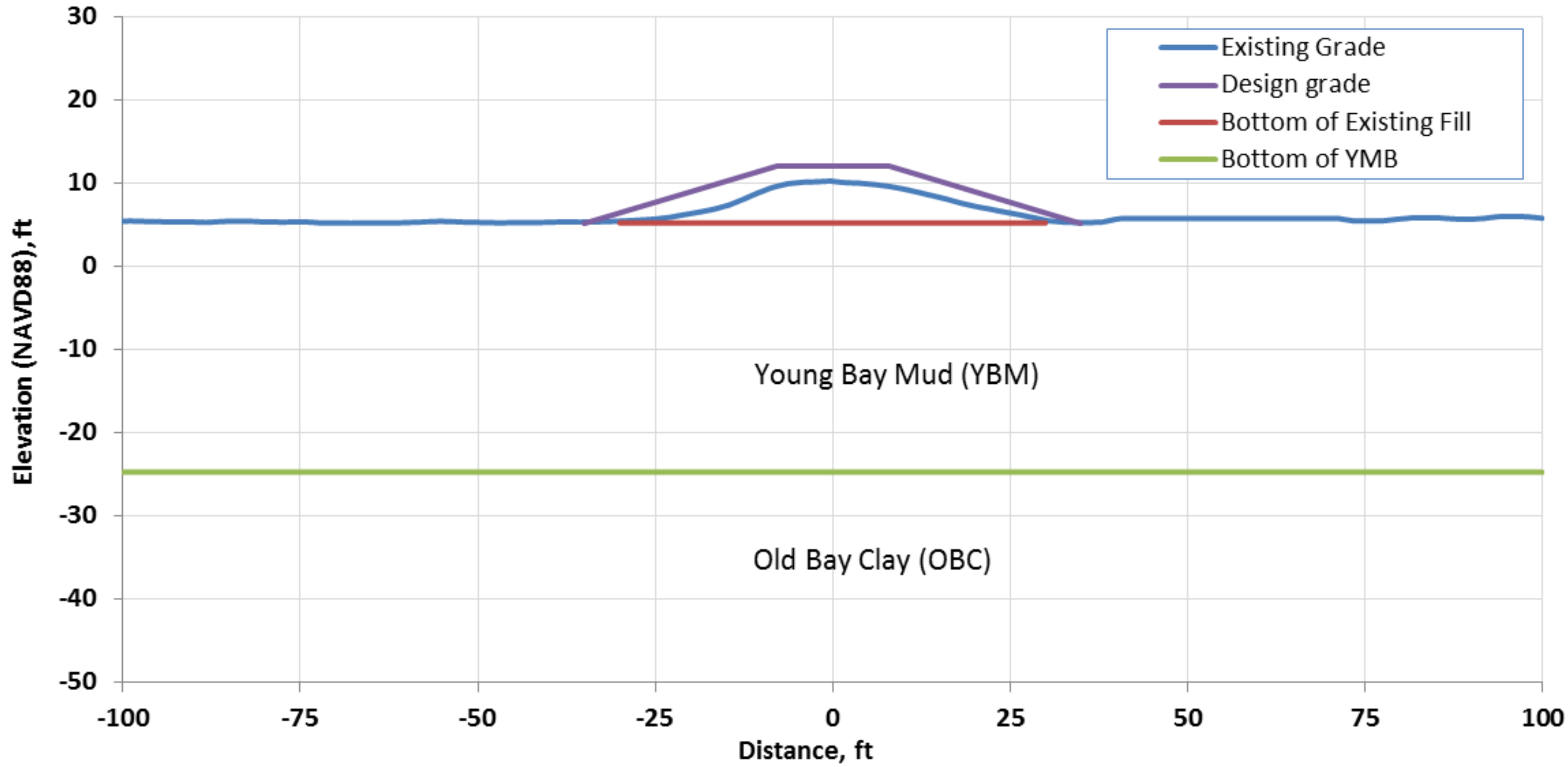


Figure 2 Idealized Cross Section – Section A

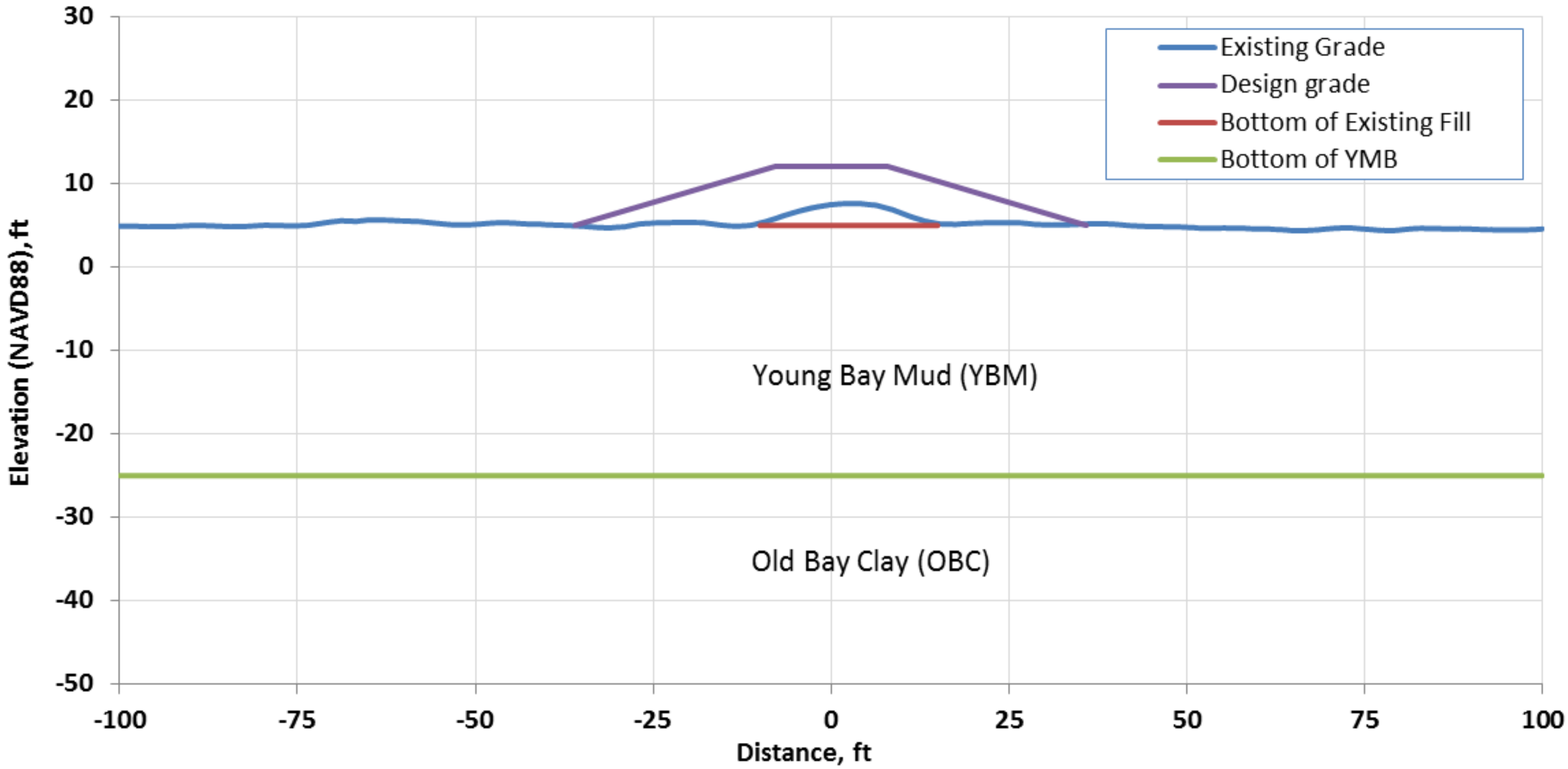


Figure 3 Idealized Cross Section – Section B

Name: Existing Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 50 psf Phi': 28 ° Phi-B: 0 °
Name: Clay-OBM Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 1,000 psf Phi': 0 ° Phi-B: 0 ° Constant Unit Wt. Above Water Table: 125 pcf
Name: YBM-shallow (for EOC Run- Sumin=200psf) Model: Mohr-Coulomb Unit Weight: 95 pcf Cohesion': 200 psf Phi': 0 ° Phi-B: 0 °
Name: New Fill Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 100 psf Phi': 32 ° Phi-B: 0 °
Name: YBM -deep ff (for EOC Run- Su=200-265 psf) Model: S=f(depth) Unit Weight: 95 pcf C-Top of Layer: 200 psf C-Rate of Change: 8.8 (lbs/ft²)/ft C-Maximum: 265 psf
Name: YBM -deep below ext levee (for EOC Run- Su=200-340 psf) Model: S=f(depth) Unit Weight: 95 pcf C-Top of Layer: 200 psf C-Rate of Change: 8.8 (lbs/ft²)/ft C-Maximum: 340 psf

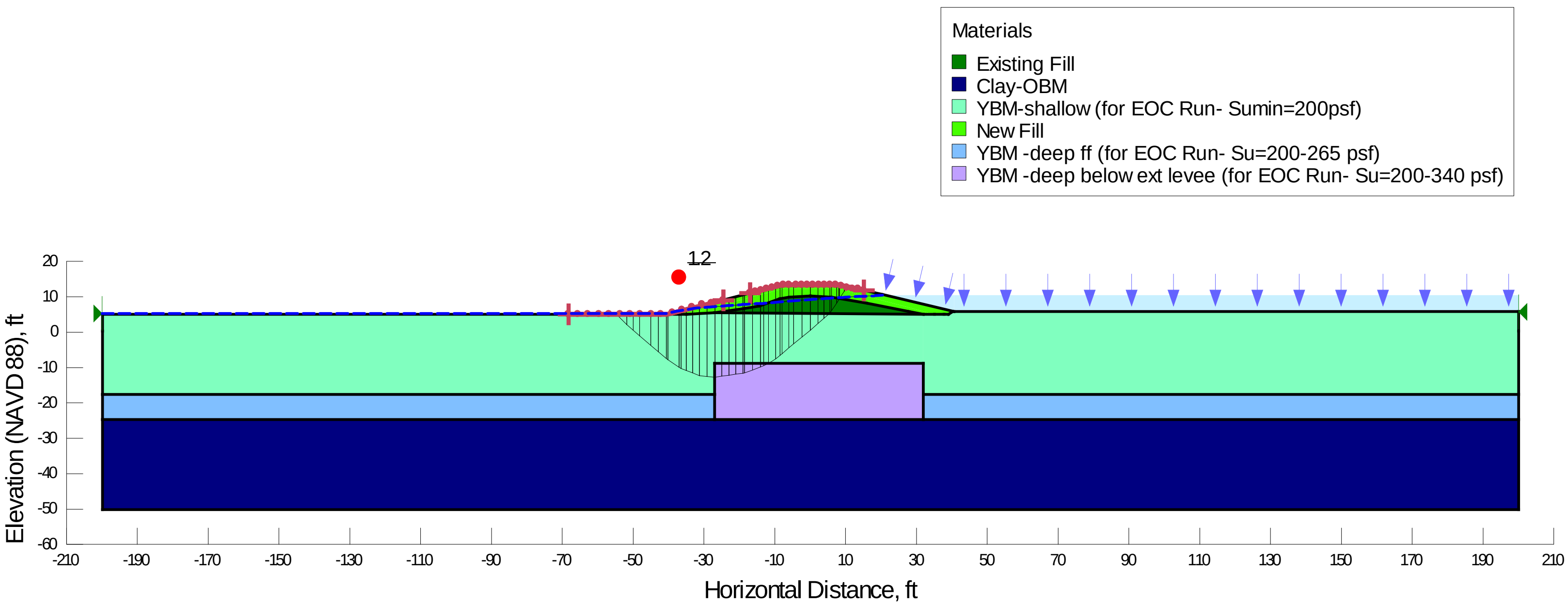


Figure 4 End of Construction Stability - Section A

Name: Existing Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 50 psf Phi': 28 ° Phi-B: 0 °
Name: Clay-OBM Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 1,000 psf Phi': 0 ° Phi-B: 0 ° Constant Unit Wt. Above Water Table: 125 pcf
Name: YBM Model: S=f(overburden) Unit Weight: 95 pcf Tau/Sigma Ratio: 0.27 Minimum Strength: 200 psf
Name: New Fill Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 100 psf Phi': 32 ° Phi-B: 0 °

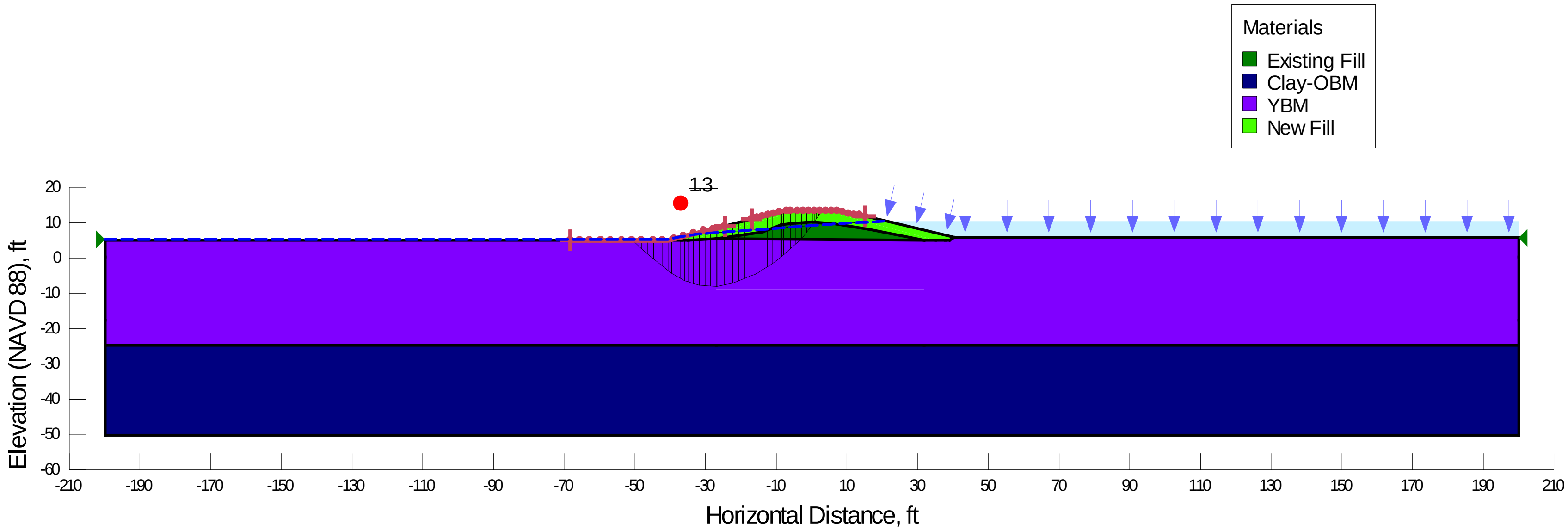


Figure 5 Long Term Steady State Stability - Section A

Name: Existing Fill   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion': 50 psf   Phi': 28 °   Phi-B: 0 °   Piezometric Line: 1
Name: Clay-OBM   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion': 1,000 psf   Phi': 0 °   Phi-B: 0 °   Constant Unit Wt. Above Water Table: 125 pcf   Piezometric Line: 1
Name: YBM-shallow (for EOC Run- Sumin=200psf)   Model: Mohr-Coulomb   Unit Weight: 95 pcf   Cohesion': 200 psf   Phi': 0 °   Phi-B: 0 °   Piezometric Line: 1
Name: New Fill   Model: Mohr-Coulomb   Unit Weight: 125 pcf   Cohesion': 100 psf   Phi': 32 °   Phi-B: 0 °   Piezometric Line: 1
Name: YBM -deep (for EOC Run- Su=200-265 psf)   Model: S=f(depth)   Unit Weight: 95 pcf   C-Top of Layer: 200 psf   C-Rate of Change: 8.8 (lbs/ft²)/ft   C-Maximum: 265 psf   Piezometric Line: 1

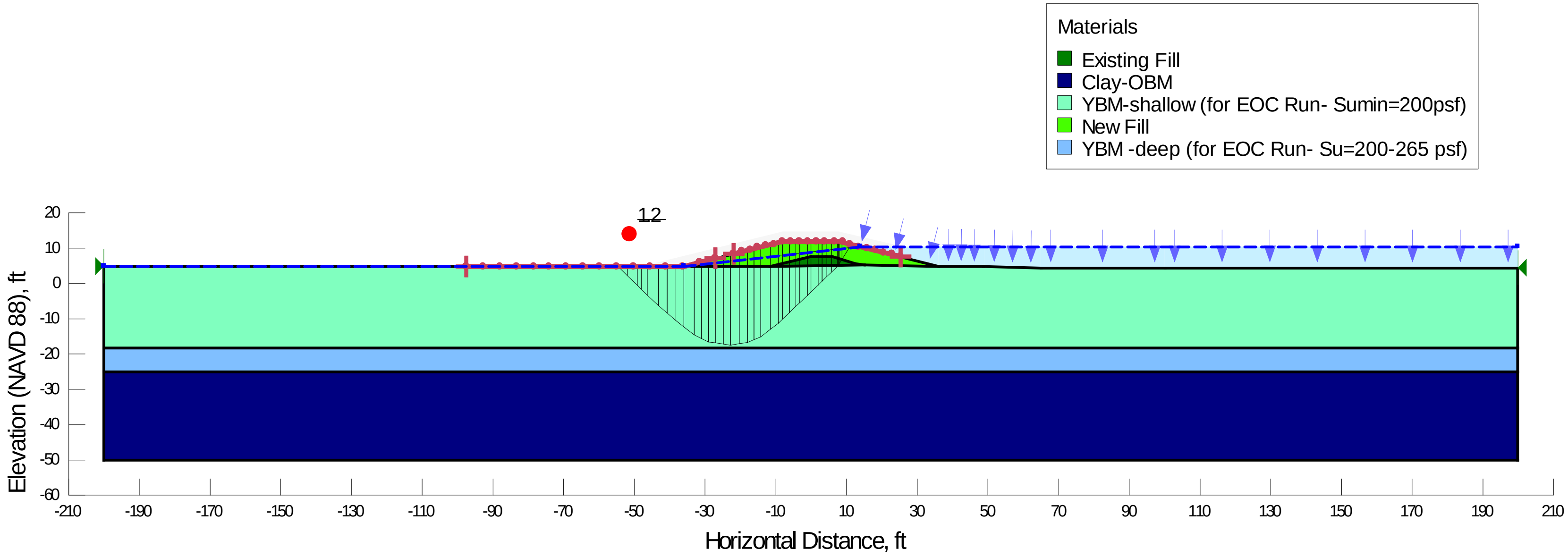


Figure 6 End of Construction Stability - Section B

Name: Existing Fill   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion': 50 psf   Phi': 28 °   Phi-B: 0 °   Piezometric Line: 1
Name: Clay-OBM   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion': 1,000 psf   Phi': 0 °   Phi-B: 0 °   Constant Unit Wt. Above Water Table: 125 pcf   Piezometric Line: 1
Name: YBM   Model: S=f(overburden)   Unit Weight: 95 pcf   Tau/Sigma Ratio: 0.27   Minimum Strength: 200 psf   Piezometric Line: 1
Name: New Fill   Model: Mohr-Coulomb   Unit Weight: 125 pcf   Cohesion': 100 psf   Phi': 32 °   Phi-B: 0 °   Piezometric Line: 1

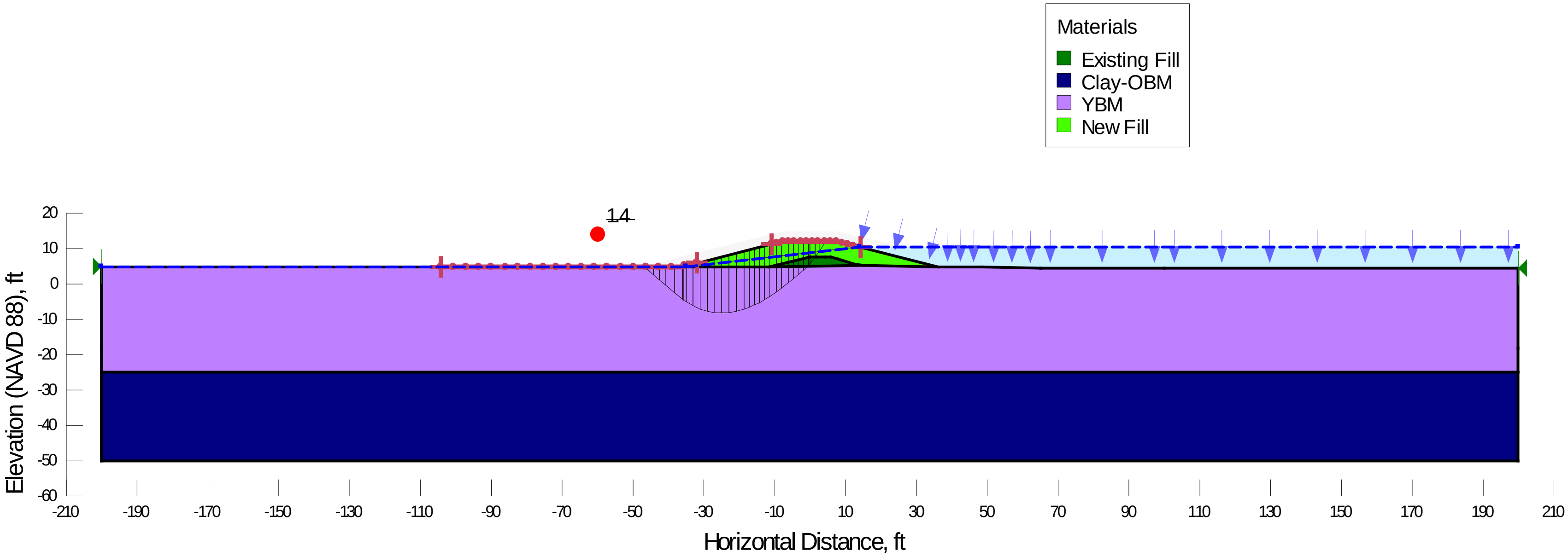


Figure 7 Long Term Steady State Stability - Section B

ATTACHMENT-1

Project: SBSP, Eden Landing
Project Location: South Bay
Project Number: 60423372

Key to Log of Boring

Sheet

Elevation feet	Depth, feet	SAMPLES: Type	SAMPLES: Number	SAMPLES: Sampling Resistance	SAMPLES: Recovery, %	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS
1	2	3	4	5	6	7	8	9	10	11	12

COLUMN DESCRIPTIONS

1 **Elevation:** Elevation in feet referenced to specified datum.

2 **Depth:** Depth in feet below the ground surface.

3 **Sample Type:** Type of soil sample collected at depth interval shown; sampler symbols are explained below.

4 **Sample Number:** Sample identification number.

5 **Sampling Resistance:** Number of blows required to advance driven sampler 12 inches beyond first 6-inch interval, or distance noted, using a 140-lb hammer with a 30-inch drop; or down-pressure for pushed sampler.

6 **Recovery:** Percentage of driven or pushed sample length recovered; "NA" indicates data not recorded.

7 **Graphic Log:** Graphic depiction of subsurface material encountered; typical symbols are explained below.

8 **Material Description:** Description of material encountered; may include density/consistency, moisture, color, and grain size.

9 **Water Content:** Water content of soil sample measured in laboratory, expressed as percentage of dry weight of specimen.

10 **Dry Unit Weight:** Dry weight per unit volume of soil measured in laboratory, expressed in pounds per cubic feet (pcf).

11 **Unconfined Compressive Strength:** Unconfined compressive strength of soil sample measured in laboratory, expressed in psf.

12 **Remarks and Other Tests:** Comments and observations regarding drilling or sampling made by driller or field personnel. Other field and lab test results, using the following abbreviations:

LL	Liquid Limit (from Atterberg Limits test), percent
PI	Plasticity Index (from Atterberg Limits test)
SA	Sieve analysis, percent passing #200 sieve
WA	Wash on #200 sieve, percent passing #200 sieve
UC	Unconfined compressive strength (qu), psf
CONS	Consolidation test
TX-UU	Unconsolidated undrained triaxial compression test, peak deviator stress and confining pressure, psf
TX-CU	Consolidated undrained triaxial compression test
PP	Pocket penetrometer

TYPICAL MATERIAL GRAPHIC SYMBOLS

POORLY GRADED SAND (SP)

POORLY GRADED SAND WITH SILT (SP-SM)

SILTY SAND (SM)

CLAYEY SAND (SC)

WELL-GRADED SAND (SW)

LEAN CLAY (CL)

FAT CLAY (CH)

SILTY CLAY (CL)

POORLY GRADED GRAVEL (GP)

POORLY GRADED GRAVEL WITH SILT (GP-GM)

SILT (ML)

CLAYEY SILT (ML)

TYPICAL SAMPLER GRAPHIC SYMBOLS

Standard Penetration Test (SPT) unlined split spoon

Modified California (2.5-inch OD) with brass liners

California (3-inch OD) split barrel

Shelby tube (3-inch OD, thin-wall, fixed head)

Pitcher barrel with Shelby tube liner

Bulk (5-gallon bucket)

OTHER GRAPHIC SYMBOLS

First water encountered at time of drilling and sampling (ATD)

Static water level measured after drilling and sampling completed

Change in material properties within a lithologic stratum

Inferred or transitional contact between lithologies

GENERAL NOTES

1. Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive; actual lithologic changes may be gradual. Field descriptions may have been modified to reflect results of lab tests.

2. Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced. They are not warranted to be representative of subsurface conditions at other locations or times.

Figure A-1

Report: GEO_10B1_OAK_KEY; File: 20161103_EDEN_BORINGS.GPJ; 11/4/2016 keyKP44

Project: SBSP, Eden Landing
Project Location: South Bay
Project Number: 60423372

Log of Boring B-01

Date(s) Drilled	**6/21/2016**	Logged By	**Stacy Ball**	Checked By	
Drilling Method	**Mud Rotary**	Drill Bit Size/Type	**6-inch OD Core Barrel/ 6-inch OD Auger/ 4.75-inch OD Drag bit**	Total Depth of Borehole	**61.5 feet**
Drill Rig Type	**Failing 1500**	Drilling Contractor	**Pitcher Drilling Co.**	Surface Elevation	**feet (NAVD88)**
Groundwater Level(s)		Sampling Method(s)	**SPT, Modified California, Shelby**	Hammer Data	**140 lb/30-inch drop Auto Hammer**
Borehole Backfill	**Neat Cement Grout**	Location		Coordinates	**N 2041436.29 E 6093467.52**

Elevation feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resistance, blows / foot	SAMPLES Recovery, %	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS
	0						SILTY CLAY (CL-ML), medium stiff, Olive brown (2.5Y 4/4), moist, medium plasticity				
							ELASTIC SILT (MH), soft to medium stiff, very dark grayish brown (2.5Y 3/2), wet, high plasticity [Young Bay Mud]				set casing at 3.5 feet
	5										mud rotary
			1		95		At 6.5 feet, as above except black (2.5Y 2.5/1)				50 to 75 psi
	10		2		80		At 11.5 feet, as above except very dark gray (2.5Y 3/1)				50 to 85 psi
	15		3		95						consolidation test 50 to 75 psi
	20		4	0 0 0	100		- grades to medium stiff				PP: 0.5 tsf PP: 0.75 tsf
							- color changes to dark greenish gray (gley 4/5GY)				
	25		5	0 0 0	100		- trace find sand				PP: 0.5 tsf
	30										

Project: SBSP, Eden Landing
Project Location: South Bay
Project Number: 60423372

Log of Boring B-01

Elevation feet	Depth, feet	Type	Number	Sampling Resistance, blows / foot	Recovery, %	Graphic Log	MATERIAL DESCRIPTION -	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS -
	30		6	0 0 0	100						PP: 0.75 tsf
							FAT CLAY (CH), very stiff to hard, dark greenish gray (gley 3/10Y). At 33.5 feet, shells and sand transition				
	35		7	5 14 20	70						PP: 4.25 tsf
							- grades to light olive brown with white and yellowish brown mottling				
	40		8	7 9 12	55		FAT CLAY with fine Sand (CH), very stiff, high plasticity				PP: 3.25 tsf
							- becomes stiff				
	45		9	0 4 4	70		- becomes soft to medium stiff				PP: 2.0 tsf
											driller notes soil becomes sandy, soft
	50		10	1 2 9	60		Poorly-Graded SAND with CLAY (SP-SC), very loose to loose, olive brown (2.5Y 4/3), fine grained sand.				
			SPT-1	1 3 8							
	55		11	5 4 3	100		LEAN CLAY with Sand (CL), medium stiff, olive brown (2.5Y 4/3), fine grained sand.				
							SILTY CLAY (CL-ML), stiff, olive brown (2.5Y 4/3).				
	60		12	3 6 7	60						PP: 1-1.5 tsf
											End of boring at a depth of 61.5 feet; Grout boring with portland cement
	65										

Project: SBSP, Eden Landing **Project Location: South Bay** **Project Number: 60423372**	**Log of Boring B-02** Sheet 1 of 2

Date(s) Drilled	**6/21/2016**	Logged By	**Stacy Ball**	Checked By	
Drilling Method	**Mud Rotary**	Drill Bit Size/Type	**6-inch OD Core Barrel/ 6-inch OD Auger/ 4.75-inch OD Drag bit**	Total Depth of Borehole	**56.5 feet**
Drill Rig Type	**Failing 1500**	Drilling Contractor	**Pitcher Drilling Co.**	Surface Elevation	**feet (NAVD88)**
Groundwater Level(s)		Sampling Method(s)	**Modified California, Shelby**	Hammer Data	**140 lb/30-inch drop Auto Hammer**
Borehole Backfill	**Neat Cement Grout**	Location		Coordinates	**N 2035422.39 E 6087103.51**

Elevation feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resistance, blows / foot	SAMPLES Recovery, %	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS
	0						LEAN CLAY (CL) with trace fine sand, medium stiff, very dark grayish brown (10YR 3/2), medium to high plasticity fines.				
											set casing at 3.5 feet
	5						ELASTIC SILT (MH), soft, dark greenish gray (gley 3 10Y), medium to high plasticity fines [Young Bay Mud]				mud rotary at 5 feet
			1		95						weight of hammer to 50 psi
	10										50 psi
			2		95						
	15										50 psi
			3		95						
	20						- with shells				50 psi ICU triaxial test PP: 0 tsf ICU triaxial test
			4		95						
							- increasing fine sand				
	25		5	0 0 0	80						PP: 0-0.25 tsf
	30										

Elevation feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, blows / foot	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS
	30		6	0 0 0	90						PP: 0 tsf
	35		7	0 0 0							
	40		8	6 17 22	50		LEAN CLAY (CL), very stiff, dark greenish gray (gley 4 10G), medium to high plasticity fines. - gravel at tip of sample				PP: 2.75 tsf PP: 3.25 tsf
	45		9	7 12 12	55		- color changes to olive brown (2.5Y 4/4)				PP: 3.25 tsf PP: 5.5 tsf
	50		10	0 0 4	75		- soft to medium stiff, light olive brown (2.5Y 5/4)				PP: 1.25 tsf
	55		11	4 7 8			- becomes stiff to very stiff, - becomes low to medium plasticity SILT (ML)				PP: 1.75 tsf PP: 2.0 tsf End of boring at a depth of 56.5 feet; Grout boring with portland cement
	60										
	65										

Project: SBSP, Eden Landing
Project Location: South Bay
Project Number: 60423372

Log of Boring B-03

Date(s) Drilled	**6/20/2016**	Logged By	**Stacy Ball**	Checked By	
Drilling Method	**Mud Rotary**	Drill Bit Size/Type	**6-inch OD Core Barrel/ 6-inch OD Auger/ 4.75-inch OD Drag bit**	Total Depth of Borehole	**61.5 feet**
Drill Rig Type	**Failing 1500**	Drilling Contractor	**Pitcher Drilling Co.**	Surface Elevation	**feet (NAVD88)**
Groundwater Level(s)		Sampling Method(s)	**SPT, Modified California, Shelby**	Hammer Data	**140 lb/30-inch drop Auto Hammer**
Borehole Backfill	**Neat Cement Grout**	Location		Coordinates	**N 2037620.45 E 6099203.59**

Elevation feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, blows / foot	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS
	0						LEAN CLAY (CL), medium stiff, brown (7.5YR 4/2), medium to high plasticity fines.				
							- some organics, dark grayish brown (10YR 4/2) with dark red mottling (2.5YR 3/6)				set casing at 3.5 feet
	5		1		85		ELASTIC SILT (MH), soft to medium stiff, dark greenish gray (gley 3/1 10Y), high plasticity fines [Young Bay Mud]				mud rotary at 5 feet ICU triaxial test 50-85 psi water at a depth of 8 feet on 6-12-16
	10		2		35						75-85 psi sample started to slip out, contractor pushed it back in shelby tube
	15		3		80						50-85 psi
	20		4		50		SILTY CLAY (CL-ML), very stiff, dark greenish gray (gley 4/2 10Y).				PP: 2.75 tsf 50-125 psi, and refusal at a depth of 21.5 feet
	25		5	3 3 2	65		- becomes stiff with fine sand, dark greenish gray (gley 3/10Y)				PP: 1.5 tsf
	30										

Project: SBSP, Eden Landing
Project Location: South Bay
Project Number: 60423372

Log of Boring B-03

Elevation, feet	Depth, feet	Type	Number	Sampling Resistance, blows / foot	Recovery, %	Graphic Log	MATERIAL DESCRIPTION -	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND - OTHER TESTS -
	30		6	0 2 2	75						UU Triaxial test PP: 1.5 tsf
	35		7	0 0 0	? -		- little organics -				PP: 1.25 tsf
	40		8	3 5 5	65 -		SILTY CLAYEY SAND (SC-SM), loose, dark greenish gray - (gley3/10Y), fine-grained sand				
							SILTY CLAY (CL-ML) with fine Sand.				
	45		9	2 5 5	65 -		- becomes soft to medium stiff -				PP: 1.25 tsf
							SILTY CLAY (CL-ML), very stiff, olive gray (5Y 5/2) with light olive brown (2.5Y 5/4)				
	50		10	4 7 8	65						PP: 2.75 tsf end of the day resume drilling
	55		11	15 22 19			Well-Graded SAND with Silty Clay and Gravel (SW-SC), dense, dark grayish brown (2.5Y 4/2) with multi color gravel, gravel up to 1/2", well graded.				
							Well-Graded GRAVEL with Sand (GW), loose, multi color.				
	60		12	4 5 4	partial		SILTY CLAY with Sand (CL-ML), medium stiff to stiff, light olive brown (2.5Y 5/4).				End of boring at a depth of 61.5 feet; Grout boring with portland cement
	65										

DRAFT

Log of Boring B-04

Project: SBSP, Eden Landing
Project Location: South Bay
Project Number: 60423372

Date(s) Drilled	**6/20/2016**	Logged By	**Stacy Ball**	Checked By	
Drilling Method	**Mud Rotary**	Drill Bit Size/Type	**6-inch OD Core Barrel/ 6-inch OD Auger/ 4.75-inch OD Drag bit**	Total Depth of Borehole	**61.5 feet**
Drill Rig Type	**Failing 1500**	Drilling Contractor	**Pitcher Drilling Co.**	Surface Elevation	**feet (NAVD88)**
Groundwater Level(s)		Sampling Method(s)	**SPT, Modified California, Shelby**	Hammer Data	**140 lb/30-inch drop Auto Hammer**
Borehole Backfill	**Neat Cement Grout**	Location		Coordinates	**N 2036016.57 E 6097143.01**

Elevation feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resistance, blows / foot	SAMPLES Recovery, %	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS
	0						LEAN CLAY (CL), medium stiff, dark grayish brown (2.5Y 4/2) with brown mottles, medium plasticity fines.				Native Fill
											set casing at 3.5 feet
							- organics				
	5		1	0 0 0	100		ELASTIC SILT (MH), soft to medium stiff, dark greenish gray (gley 5/1 10Y), medium to high plasticity [Young Bay Mud]				mud rotary at 5 feet PP: 0.5 tsf
							- becomes moist to very moist, organics				
							- transitions to soft				
	10		2		95						weight of bar (50 psi) 15 minutes wait for sample expansion
	15		3		90						50 psi; last 6" with 75 psi
							Poorly-Graded SAND (SP), fine-medium grained, shells and gravel.				
	20		4	3 5 8	40		LEAN CLAY with Silt (CL), medium stiff to stiff, mottled yellowish brown (10YR 5/4) and greenish gray (gley 6/5 BG), medium plasticity.				PP: 2.5 tsf
							SILTY CLAY (CL-ML), medium stiff to stiff, dark greenish gray (gley 3/1 10Y), medium to high plasticity				
	25		5	0 4 4	65						
	30										

DRAFT

Elevation feet	Depth, feet	Type	Number	Sampling Resistance, blows / foot	Recovery, %	Graphic Log	MATERIAL DESCRIPTION -	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS -
	30		6	2 7 7	80						UU Triaxial test PP: 1.5 tsf
	35		7	0 5 9	?		- with brown mottling				PP: 0.75 tsf PP: 3.0 tsf
							SILTY SAND (SM), medium dense, grayish brown.				
	40		8	7 8 8	75						
							SILTY CLAY (CL-ML), medium stiff, very dark gray (2.5Y 3/1).				
	45		9	3 7 18	85						PP: 0.75 tsf
							Poorly-Graded SAND with SILT (SP-SM), very loose, fine-grained sand, dark olive gray (5Y 3/2).				
			SPT-9	0 1 2	?						
							- clay lens				
	50						SILTY SAND (SM) with Well-Graded GRAVEL lenses (GW), medium dense, very dark grayish brown, fine to medium multi colored gravel up to 1/4".				
			10	9 22 17	95						PP: 1.5 tsf
			SPT-10	8 11 25	95?						
							Well-Graded SAND with Gravel (SW), medium dense, dark grayish brown (2.5Y 4/2), multi colored gravel.				
	55		SPT-11	7 14 12	65						
							- becomes dense				
	60		SPT-12	17 24 24							Grout inspection at 1 PM
											End of boring at a depth of 61.5 feet; Grout boring with portland cement
	65										

DRAFT

Report: GEO_10B1_OAK; File: 20161103_EDEN_BORINGS.GPJ; 11/4/2016 04

Project: SBSP, Eden Landing	Log of Boring B-05
Project Location: South Bay	Sheet 1 of 2
Project Number: 60423372	

Date(s) Drilled	**6/22/2016**	Logged By	**Stacy Ball**	Checked By	
Drilling Method	**Mud Rotary**	Drill Bit Size/Type	**6-inch OD Core Barrel/ 6-inch OD Auger/ 4.75-inch OD Drag bit**	Total Depth of Borehole	**63.0 feet**
Drill Rig Type	**Failing 1500**	Drilling Contractor	**Pitcher Drilling Co.**	Surface Elevation	**feet (NAVD88)**
Groundwater Level(s)		Sampling Method(s)	**SPT, Modified California, Shelby**	Hammer Data	**140 lb/30-inch drop Auto Hammer**
Borehole Backfill	**Neat Cement Grout**	Location		Coordinates	**N 2034043.71 E 6098580.55**

Elevation feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resistance, blows / foot	SAMPLES Recovery, %	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS
	0						SILTY CLAY (CL-ML), medium stiff, Olive brown (2.5Y 4/4) and olive gray (5Y 4/2) with reddish brown mottling, moist, medium to high plasticity fines.				
							ORGANIC SILT (OH) with trace fine sand, very soft, black (7.5YR 2.5/1), medium plasticity with organics [Young Bay Mud]				set casing to 3.5 feet
	5		1		50						mud rotary at 5 feet PP: 0 tsf 50-75 psi
							- becomes dark gray (5Y 4/1)				
	10		2		90		- becomes medium stiff				50,125,185 psi
							SILT with Sand (ML), stiff, light olive brown with gray (2.5Y 5/3 with 2.5Y 5/1) and dark yellowish brown mottling				PP: 1.5 tsf
	15		3	2 3 3	70						PP: 1.25 tsf
							SILT (ML), stiff, dark gray (2.5Y 4/1), medium to high plasticity fines				
	20		4		90						50-95 psi
	25		5		90						50-100 psi PP: 1.75 tsf
	30										

Project: SBSP, Eden Landing
Project Location: South Bay
Project Number: 60423372

Log of Boring B-05

Elevation feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, blows / foot	Recovery, %	Graphic Log	MATERIAL DESCRIPTION -	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS -
	30		6	0 5 7	70						PP: 1.5 tsf
							FAT CLAY (CH) with trace fine sand, stiff, dark gray, high plasticity fines.				
	35		7	0 4 4	40		- becomes very stiff, with white and dark yellowish brown mottling				PP: 3.0 tsf
	40		8	6 12 17	40						PP: 3.75 tsf PP: 3.0 tsf
	45		9	8 21 26	40		- becomes very stiff to hard				PP: 3.0 tsf PP: 4.5 tsf
							Well-Graded GRAVEL with Sand (GW), very dense, olive brown (2.5Y 4/4) with multi colored sand and gravel, coarse sand.				
							Well-Graded SAND with SILT and GRAVEL (SW-SM), very dense, olive brown (2.5Y 4/4) with multi colored sand and gravel, coarse sand.				
	50		10	18 25 30	80						losing circulation , add bentonite
	55		11	17 18 15	0		- becomes dense				sample - slough?
											caving back up to 55 feet
	60		12	20 22 36							
			SPT-12	11 22 21							
											End of boring at a depth of 63 feet; Grout boring with portland cement
	65										

Project: SBSP, Eden Landing
Project Location: South Bay
Project Number: 60423372

Log of Boring B-06

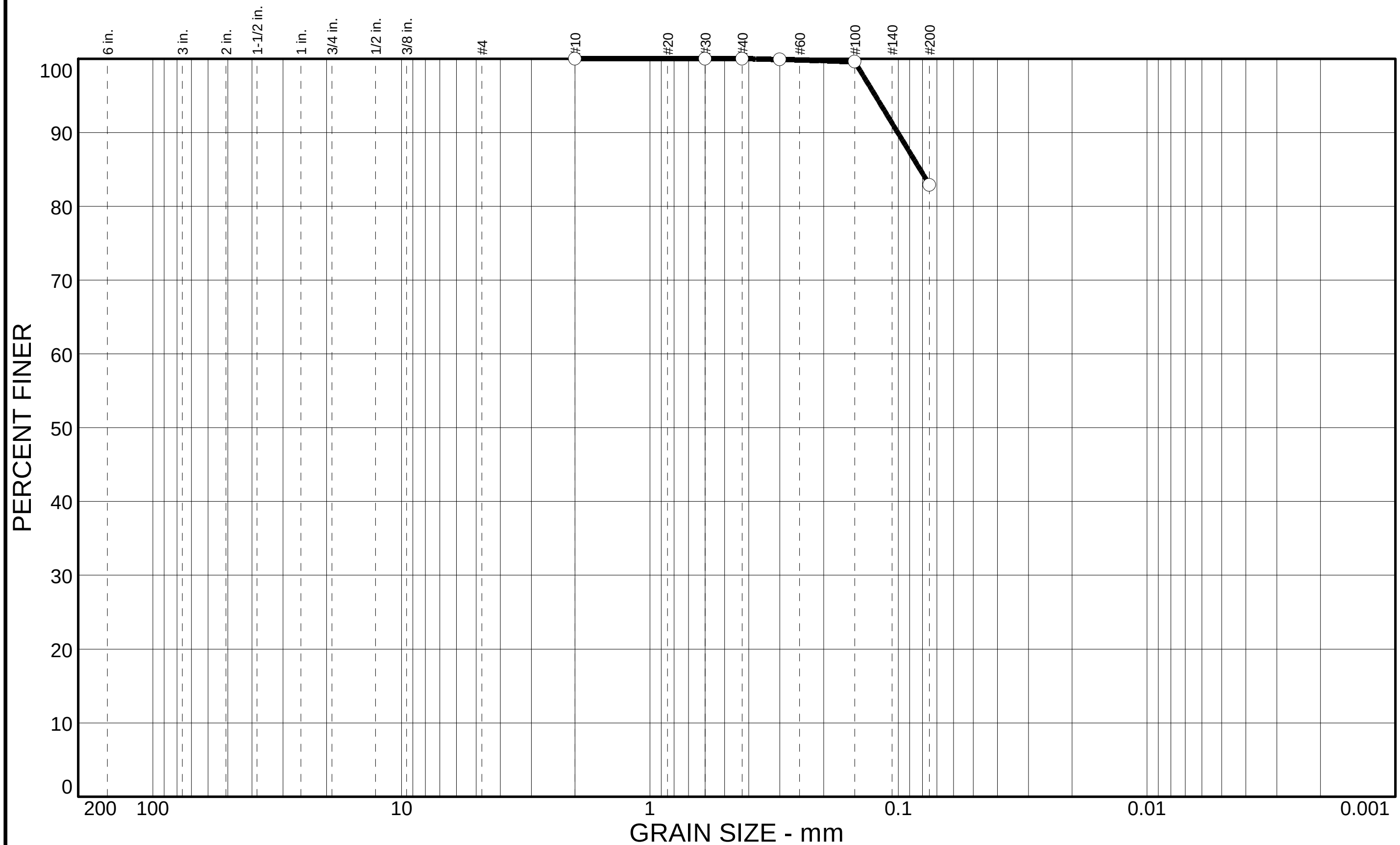
Date(s) Drilled	**6/22/2016**	Logged By	**Stacy Ball**	Checked By	
Drilling Method	**Mud Rotary**	Drill Bit Size/Type	**6-inch OD Core Barrel/ 6-inch OD Auger/ 4.75-inch OD Drag bit**	Total Depth of Borehole	**61.5 feet**
Drill Rig Type	**Failing 1500**	Drilling Contractor	**Pitcher Drilling Co.**	Surface Elevation	**feet (NAVD88)**
Groundwater Level(s)		Sampling Method(s)	**SPT, Modified California, Shelby**	Hammer Data	**140 lb/30-inch drop Auto Hammer**
Borehole Backfill	**Neat Cement Grout**	Location		Coordinates	**N 2033102.70 E 6096899.46**

Elevation feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, blows / foot	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS
	0						SILTY CLAY with sand and gravel (CL-ML), very stiff, dark brown (7.5Y 3/4), moist				
							FAT CLAY to ORGANIC CLAY(CH-OH), medium stiff, black, moist, high plasticity fines, petroleum smell, greasy.				
											set casing to 3.5 feet
	5						ORGANIC SILT (OH), soft, very dark grayish brown (10YR 3/2), medium plasticity fines [Young Bay Mud]				mud rotary at 5 feet
			1		90						50 psi
											PP: 0.25 tsf
							- becomes very soft, very dark gray (10YR 3/1), medium to high plasticity fines, no visible organics				
	10										
			2								weight of bar (300 lbs) PP: 0.0 tsf
	15										
			3								consolidation test weight of bar (300 lbs)
							ORGANIC SILT with Sand (OH), very soft, very dark gray (10YR 3/1), low to medium plasticity fines with organics, shells.				
	20										
			4				ELASTIC SILT (MH), very soft, very dark gray, medium to high plasticity.				weight of bar (300 lbs) PP: 0.75 tsf
	25										weight of bar (50 psi)
			5		90						
											PP: 0.75 tsf
							- becomes stiff				
	30										

Elevation feet	Depth, feet	Type	Number	Sampling Resistance, blows / foot	Recovery, %	Graphic Log	MATERIAL DESCRIPTION -	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS -
	30		6		60		LEAN CLAY with Sand (CL), hard, olive brown (2.5Y 4/3).				UU Triaxial test 75 to 200 psi, and refusal for pushing at 52 feet consolidation test PP: 2.0 tsf
	35		7	0 4 5			SILTY SAND TO SANDY SILT (SM-ML), loose, olive brown (2.5Y 4/3).				
			SPT-7	1 2 3							
	40		8	2 3 5							
							- becomes very dark gray (2.5Y 3/1)				
	45		9	7 12 12			- becomes medium dense				
							SILTY CLAY (CL-ML), very stiff.				PP: 3.0 tsf
							- becomes black (2.5Y 2.5/1)				
	50		10	4 8 12			SANDY SILT TO SILTY SAND(ML-SM), medium dense, fine sand.				
			SPT-10	2 5 9							
							SILTY SAND with Gravel (SM), dense, olive brown (2.5Y 4/4), fine to coarse sand, multi colored fine gravel.				
	55		11	14 20 22							
							SILTY SAND (SM), medium dense, olive brown and dark olive brown (2.5Y 4/3 and 2.5Y 3/3), fine grained sand.				
	60		12	6 9 14							
											End of boring at a depth of 61.5 feet; Grout boring with portland cement
	65										

ATTACHMENT-2

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			17.1	82.9					

SIEVE inches size	PERCENT FINER ○		
	GRAIN SIZE		
D_{60}			
D_{30}			
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#10	100.0		
#30	100.0		
#40	100.0		
#50	99.9		
#100	99.6		
#200	82.9		

SOIL DESCRIPTION
○ Light Olive Brown CLAY w/ Sand

REMARKS:
○

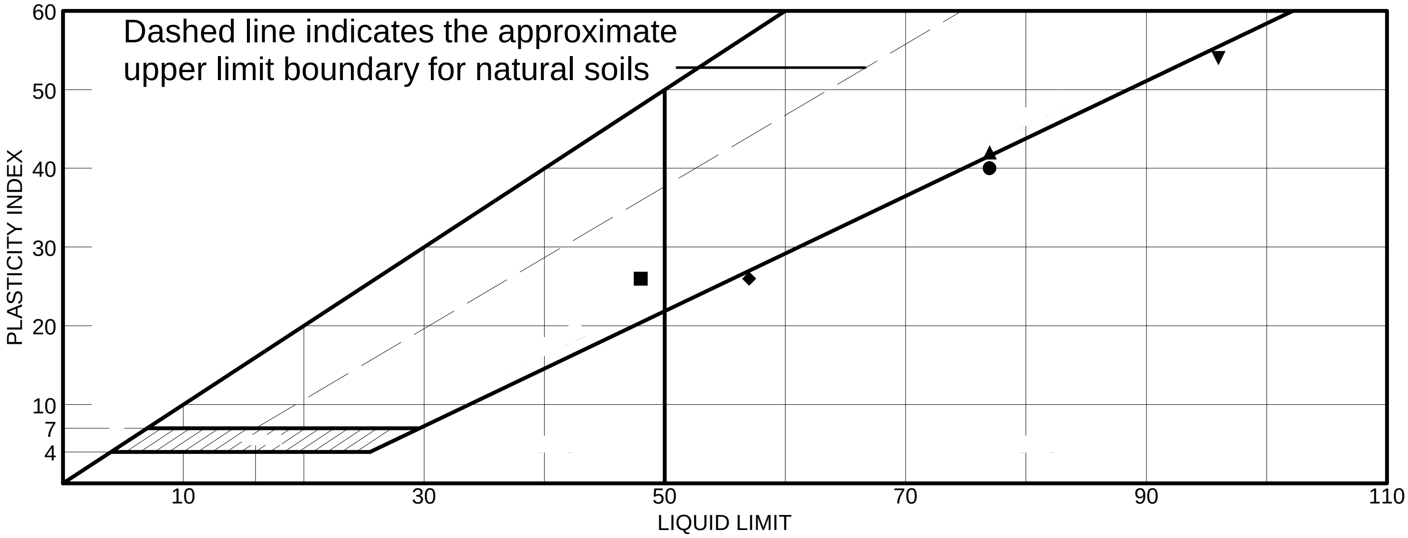
○ Source: B-06-7 Elev./Depth: 35'

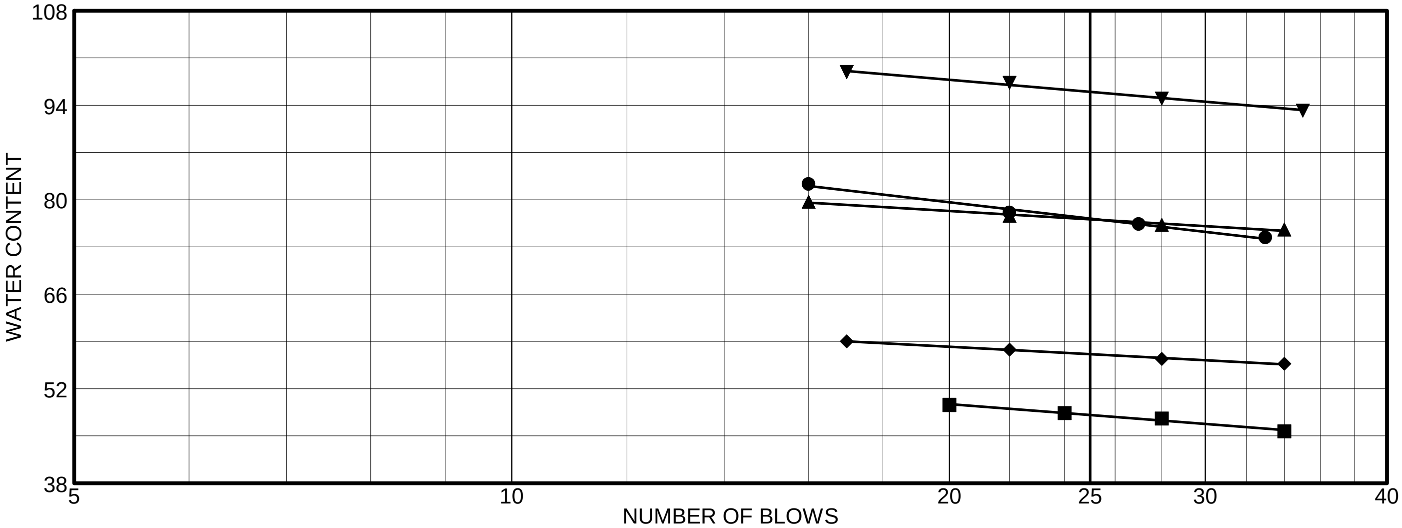
COOPER TESTING LABORATORY

Client: AECOM
Project: Eden Landing - 60423372

Project No.: 020-209 Figure

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Gray Elastic SILT (Bay Mud)	77	37	40			
■	Greenish Gray Lean CLAY w/ shells	48	22	26			
▲	Greenish Gray Fat CLAY	77	35	42			
◆	Greenish Gray Elastic SILT (Bay Mud)	57	31	26			
▼	Greenish Gray Elastic SILT (Bay Mud)	96	42	54			

Project No. 020-209 **Client:** AECOM

Project: Eden Landing - 60423372

● **Source:** B-01-3 **Elev./Depth:** 15-17.5'

■ **Source:** B-01-7 **Elev./Depth:** 35-36'

▲ **Source:** B-02-2 **Elev./Depth:** 10-12.5'

◆ **Source:** B-02-4 **Elev./Depth:** 20.5-23(Tip-1/2")

▼ **Source:** B-03-1 **Elev./Depth:** 5-7.5(Tip-1")

Remarks:

●

■

▲

◆

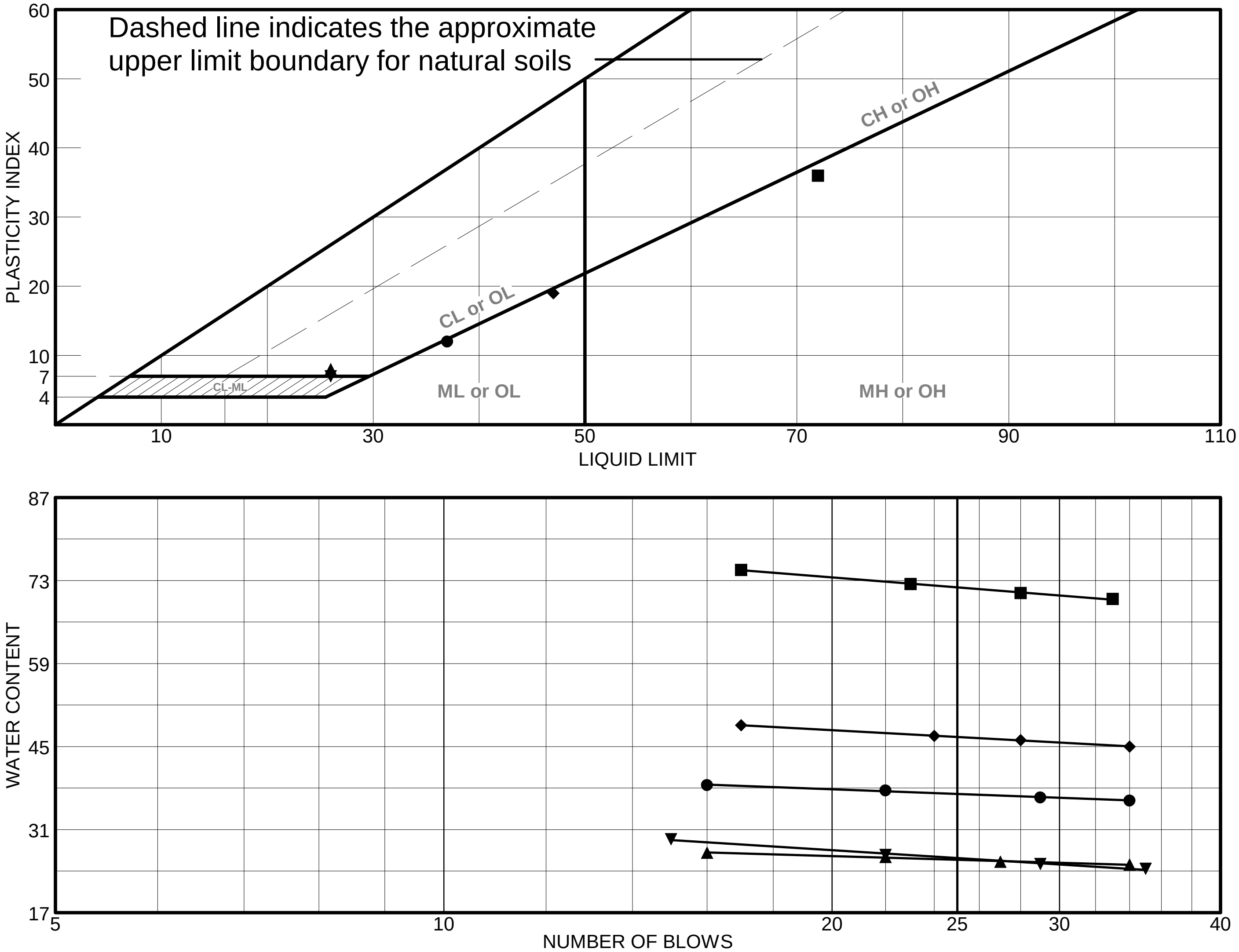
▼

LIQUID AND PLASTIC LIMITS TEST REPORT

COOPER TESTING LABORATORY

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Bluish Gray SILT	37	25	12			
■	Bluish Gray Elastic SILT	72	36	36			
▲	Light Greenish Gray Sandy Lean CLAY	26	18	8			
◆	Bluish Gray SILT	47	28	19			
▼	Dark Gray Silty, Clayey SAND w/ shell fragments	26	19	7			

Project No. 020-209 **Client:** AECOM

Project: Eden Landing - 60423372

● **Source:** B-03-4 **Elev./Depth:** 20-21.5'

■ **Source:** B-04-2 **Elev./Depth:** 10-12.5'

▲ **Source:** B-05-2 **Elev./Depth:** 10-12.5(Tip-1")

◆ **Source:** B-05-4 **Elev./Depth:** 20-22.5'

▼ **Source:** B-06-3 **Elev./Depth:** 15-17.5(Tip-8")

Remarks:

●

■

▲

◆

▼

LIQUID AND PLASTIC LIMITS TEST REPORT

COOPER TESTING LABORATORY

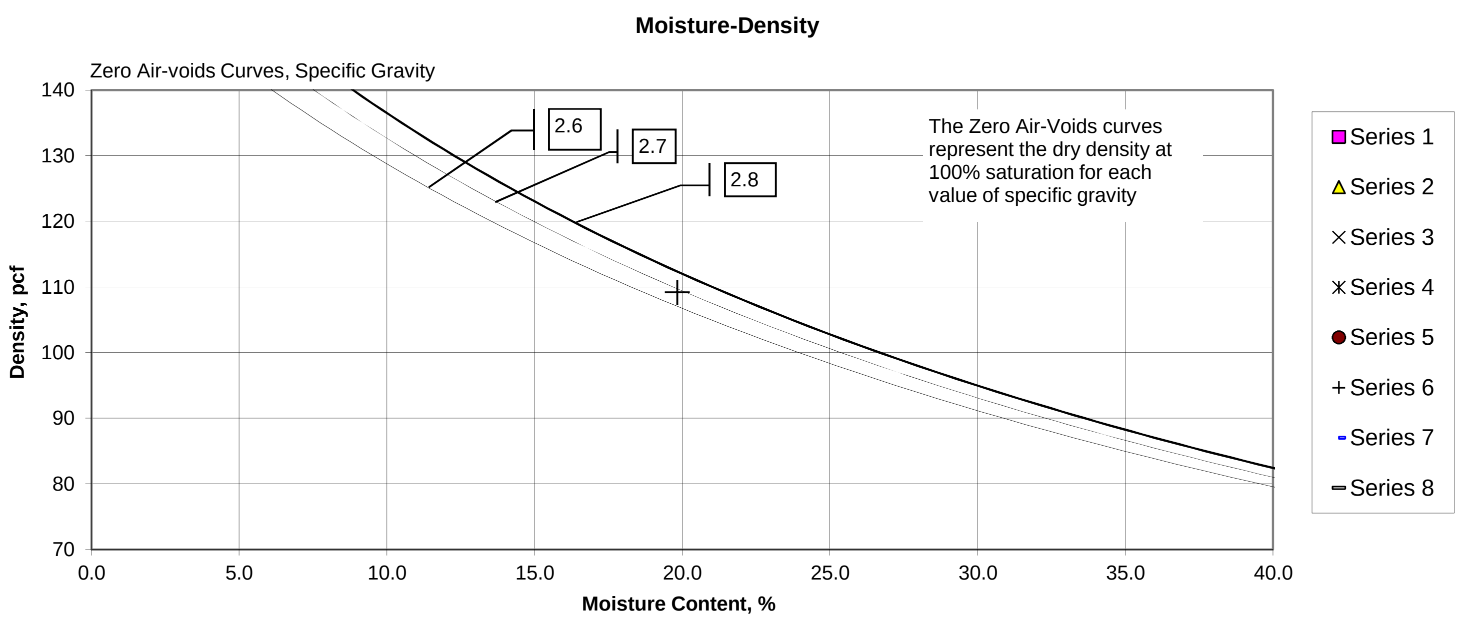
Figure

Moisture-Density-Porosity Report
Cooper Testing Labs, Inc. (ASTM D7263b)

CTL Job No:	020-209	**Project No.**	60423372	**By:**	RU
Client:	AECOM	**Date:**	08/05/16		
Project Name:	Eden Landing	**Remarks:**			

Boring:	B-01	B-02	B-03	B-04	B-05	B-05		
Sample:	7	2	4	2	4	2		
Depth, ft:	35-36	10-12.5	20-21.5	10-12.5	20-22.5	10-12.5(Tip-1")		
Visual Description:	Greenish Gray Lean CLAY w/ shells	Greenish Gray Fat CLAY	Bluish Gray SILT	Bluish Gray Elastic SILT	Bluish Gray SILT	Light Greenish Gray Sandy Lean CLAY		
Actual G_s								
Assumed G_s						2.70		
Moisture, %	55.7	81.2	30.1	86.3	40.5	19.8		
Wet Unit wt, pcf						130.8		
Dry Unit wt, pcf						109.1		
Dry Bulk Dens.pb, (g/cc)						1.75		
Saturation, %						98.1		
Total Porosity, %						35.3		
Volumetric Water Cont,Θw,%						34.6		
Volumetric Air Cont., Θa,%						0.7		
Void Ratio						0.55		
Series	1	2	3	4	5	6	7	8

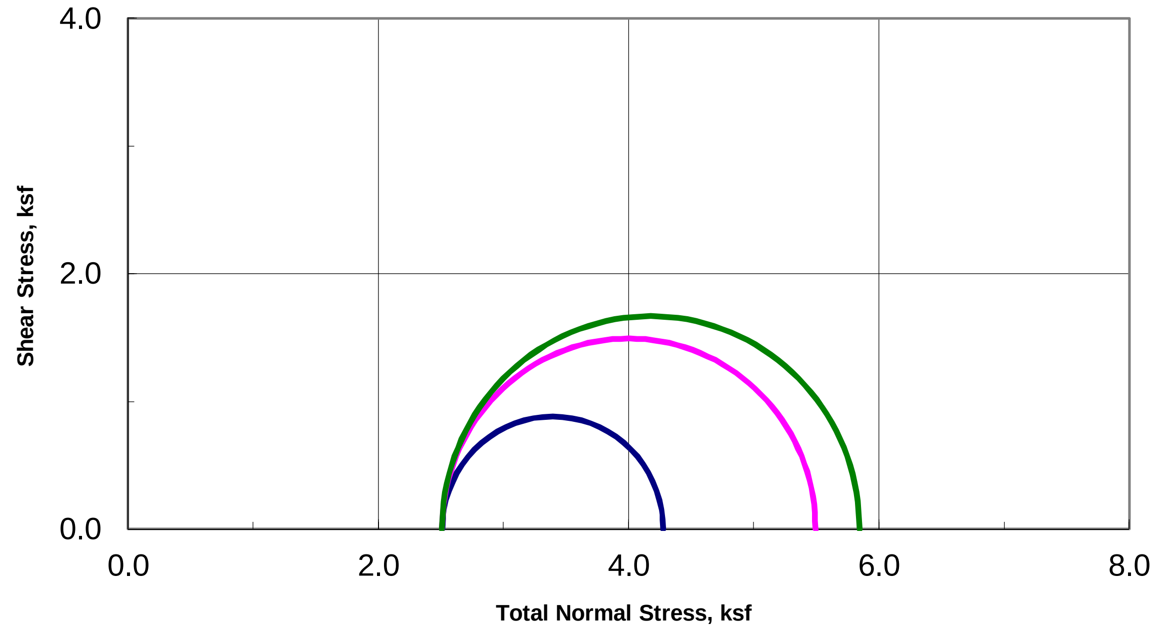
Note: All reported parameters are from the as-received sample condition unless otherwise noted. If an assumed specific gravity (Gs) was used then the saturation, porosities, and void ratio should be considered approximate.

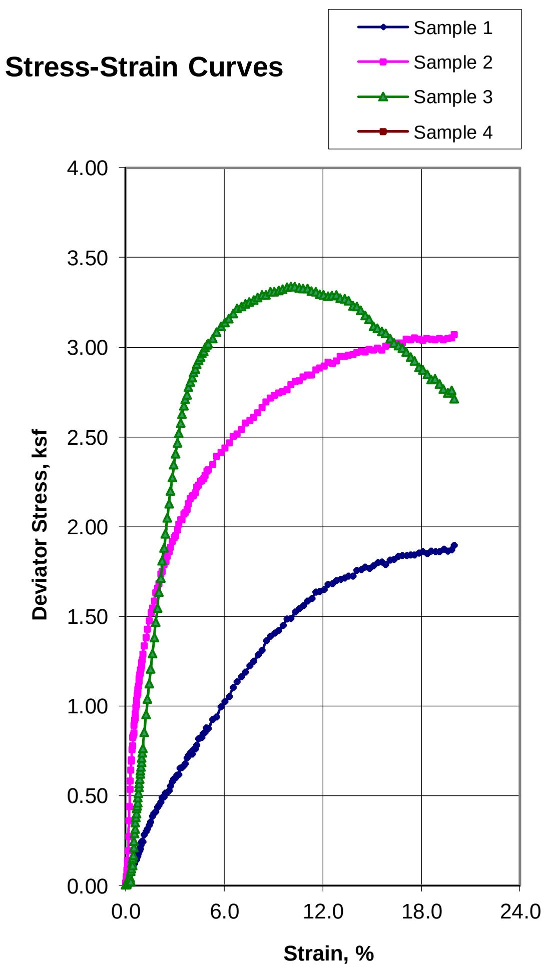


Cooper Testing Labs, Inc.
937 Commercial Street
Palo Alto, CA 94303

Unconsolidated-Undrained Triaxial Test

ASTM D2850





Sample Data				
	1	2	3	4
Moisture %	34.4	28.1	28.0	
Dry Den,pcf	87.3	94.8	95.3	
Void Ratio	0.931	0.777	0.769	
Saturation %	99.9	97.6	98.3	
Height in	4.98	4.98	6.07	
Diameter in	2.41	2.41	2.87	
Cell psi	17.4	17.4	17.4	
Strain %	15.00	15.00	10.31	
Deviator, ksf	1.766	2.987	3.337	
Rate %/min	1.00	1.00	1.00	
in/min	0.050	0.050	0.061	
Job No.:	**020-209**			
Client:	**AECOM**			
Project:	**Eden Landing - 60423372**			
Boring:	B-03-6	B-04-6	B-06-6	
Sample:				
Depth ft:	30-31.5	30	30-32(Tip-4")	

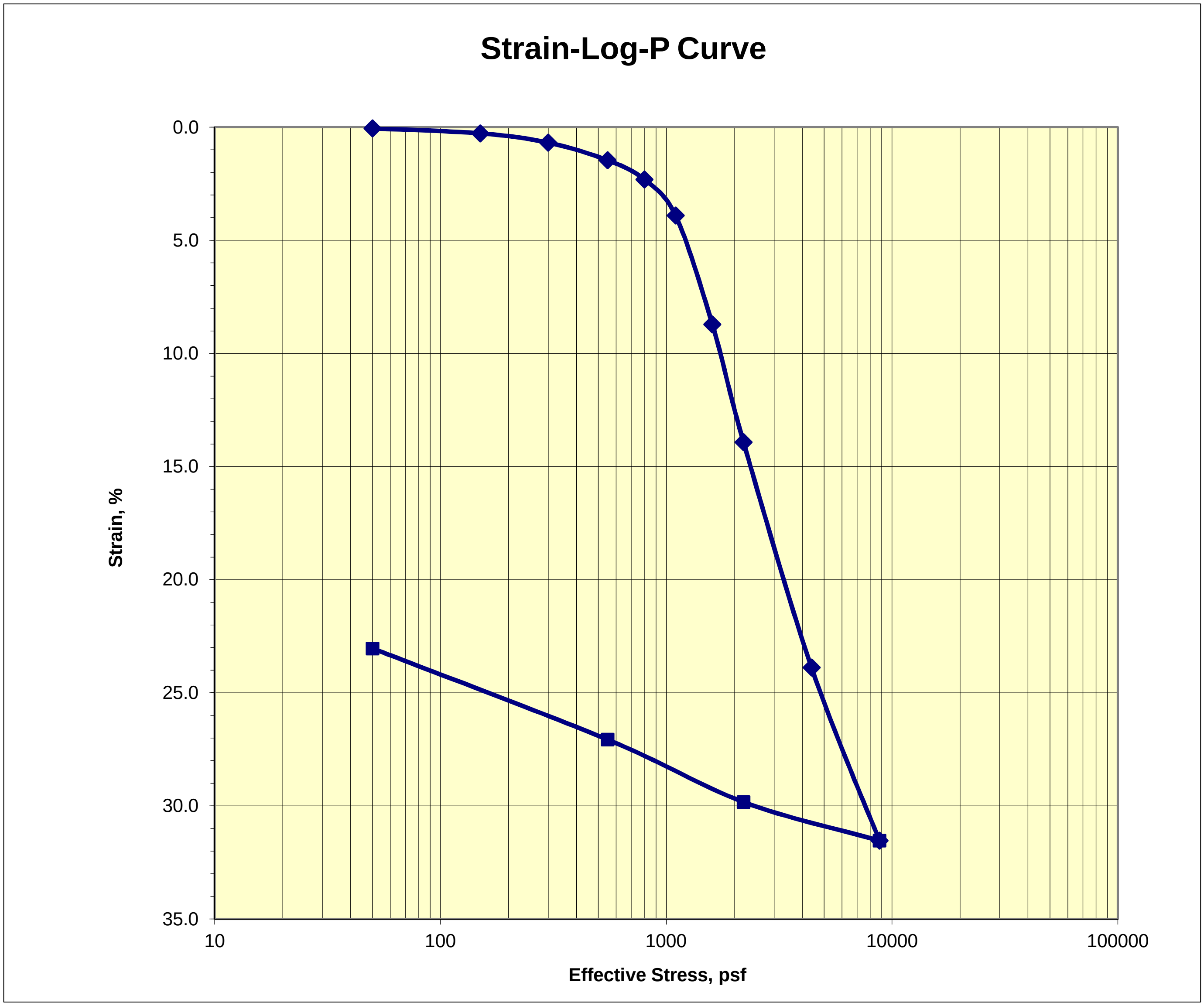
Visual Soil Description	
Sample #	
1	Gray CLAY
2	Gray CLAY
3	Olive Gray CLAY
4	

Remarks:

Note: Strengths are picked at the peak deviator stress or 15% strain which ever occurs first per ASTM D2850.

Consolidation Test
ASTM D2435

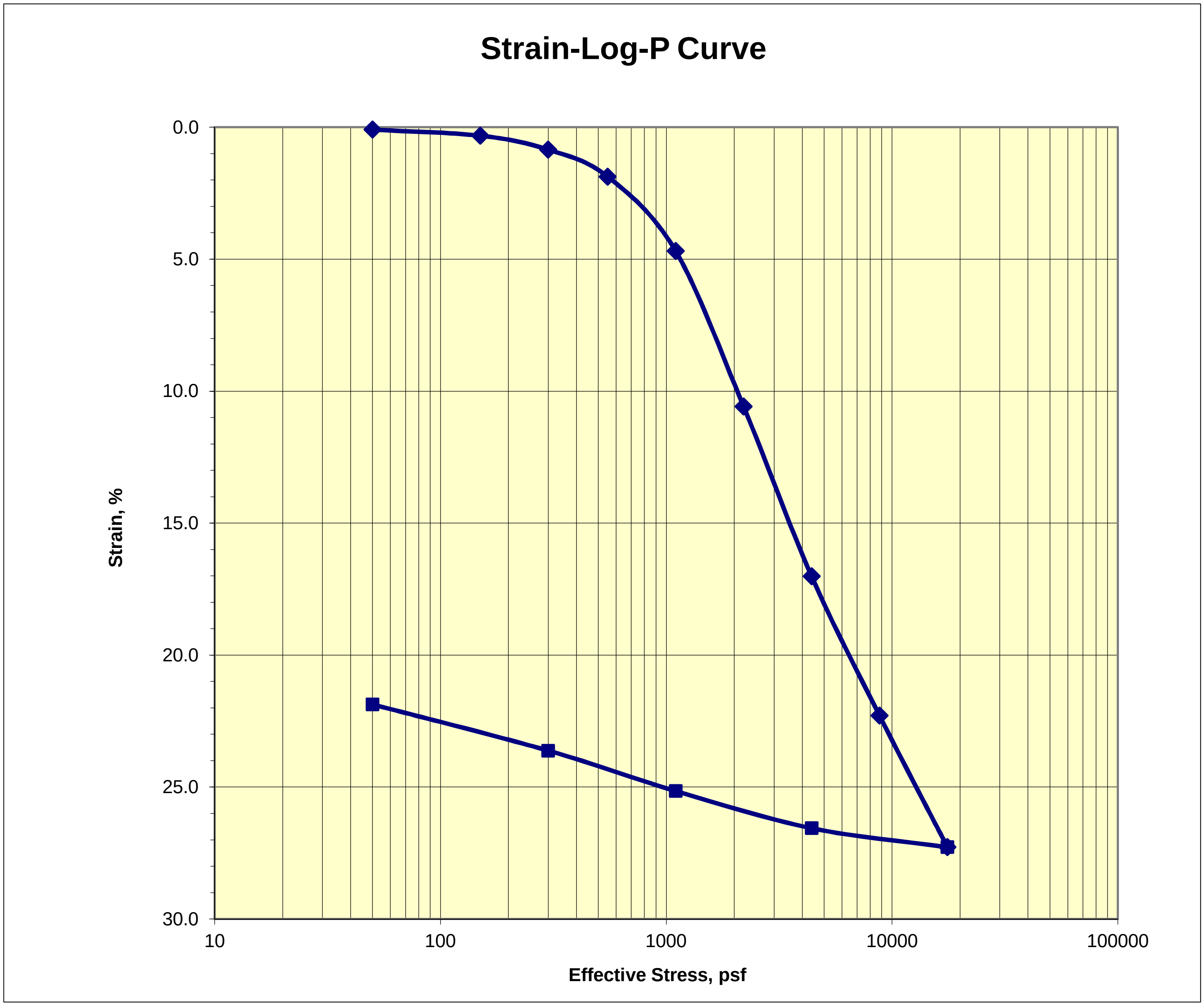
Job No.:	020-209	**Boring:**	B-01-3	**Run By:**	MD
Client:	AECOM	**Sample:**		**Reduced:**	PJ
Project:	60423372	**Depth, ft.:**	15-17.5(Tip-9")	**Checked:**	PJ/DC
Soil Type:	Gray Elastic SILT (Bay Mud)			**Date:**	8/9/2016



Assumed Gs 2.7	Initial	Final
Moisture %:	90.2	60.3
Dry Density, pcf:	49.0	64.1
Void Ratio:	2.438	1.628
% Saturation:	99.9	100.0

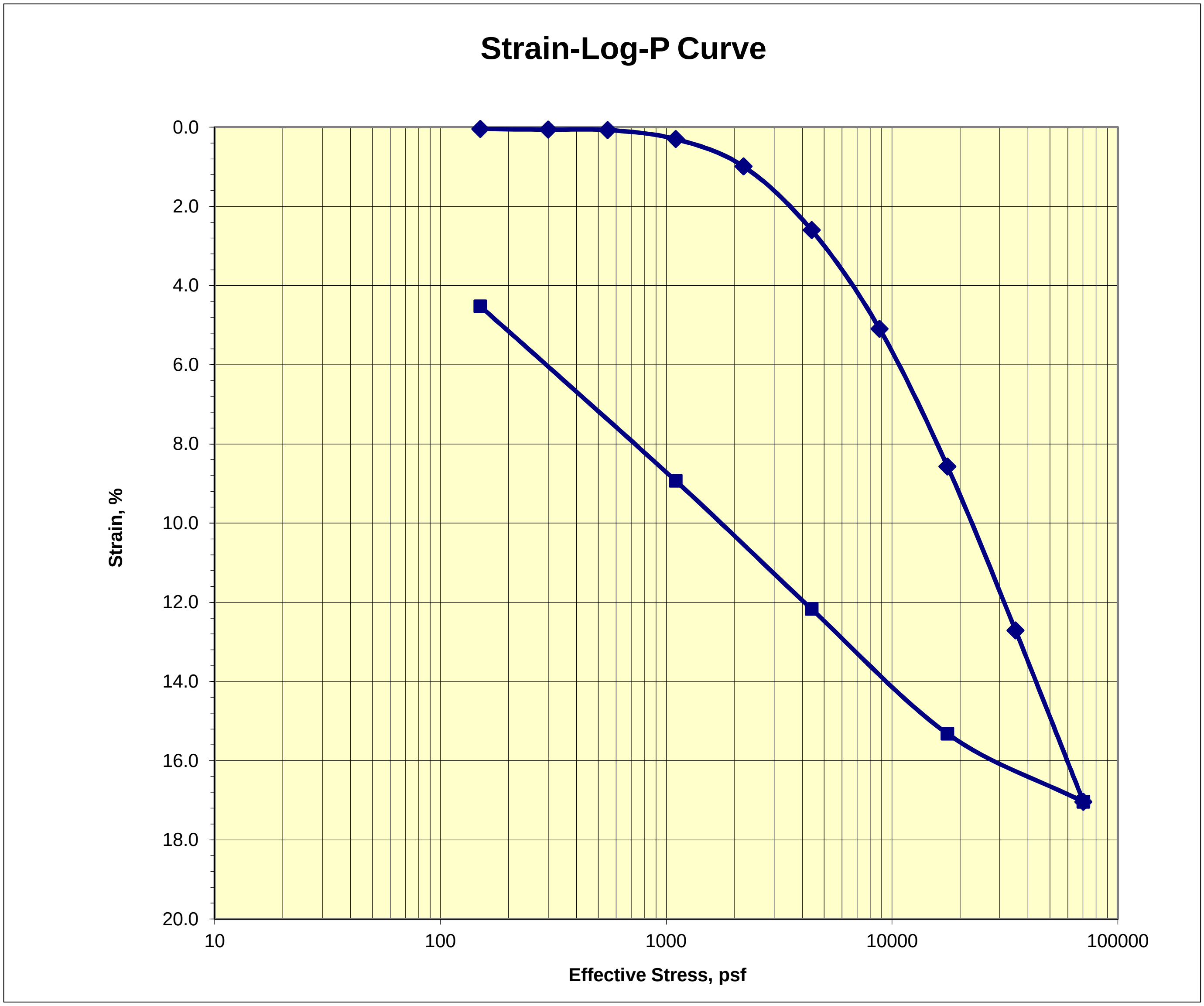
Consolidation Test
ASTM D2435

Job No.:	020-209	**Boring:**	B-06-3	**Run By:**	MD
Client:	AECOM	**Sample:**		**Reduced:**	PJ
Project:	60423372	**Depth, ft.:**	15-17.5(Tip-7")	**Checked:**	PJ/DC
Soil Type:	Dark Gray Silty, Clayey SAND w/ shell fragments			**Date:**	8/9/2016



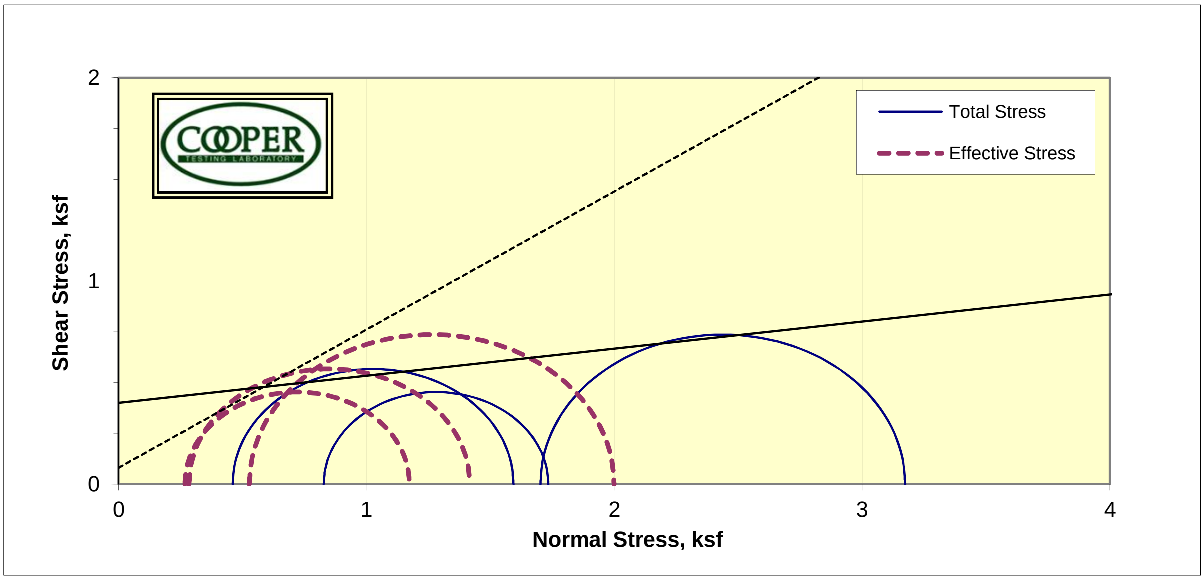
Assumed Gs 2.7	Initial	Final
Moisture %:	50.3	31.1
Dry Density, pcf:	71.3	91.6
Void Ratio:	1.364	0.840
% Saturation:	99.6	100.0

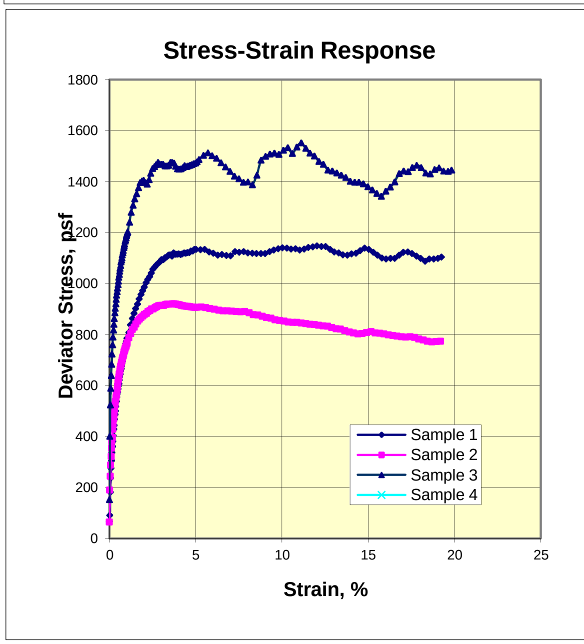
Job No.:	020-209	**Boring:**	B-06-6	**Run By:**	MD
Client:	AECOM	**Sample:**		**Reduced:**	PJ
Project:	60423372	**Depth, ft.:**	30-32(Tip-3")	**Checked:**	PJ/DC
Soil Type:	Olive CLAY			**Date:**	8/9/2016



Assumed Gs 2.75	Initial	Final
Moisture %:	28.3	26.3
Dry Density, pcf:	95.2	99.5
Void Ratio:	0.804	0.725
% Saturation:	96.7	100.0

Triaxial Consolidated Undrained with Pore Pressure
ASTM D4767





Sample:	1	2	3	4
MC, %	74.6	71.2	65.6	
DD, pcf	53.8	57.0	59.6	
Sat. %	94.6	98.4	97.0	
Void Ratio	2.130	1.954	1.827	
Diameter in	2.87	2.87	2.87	
Height, in	6.11	6.10	6.10	
	Final			
MC, %	75.1	65.9	53.8	
DD, pcf	55.6	60.6	68.7	
Sat. %	100.0	100.0	100.0	
Void Ratio	2.028	1.779	1.452	
Diameter, in	2.83	2.80	2.71	
Height, in	6.10	6.05	5.92	
Cell, psi	62.9	66.0	71.4	
BP, psi	59.7	60.3	59.6	
	Effective Stresses At:			
Strain, %	5.0	5.0	5.0	
Deviator ksf	1.133	0.906	1.472	
Excess PP	0.176	0.560	1.174	
Sigma 1	1.418	1.175	2.000	
Sigma 3	0.285	0.268	0.528	
P, ksf	0.851	0.721	1.264	
Q, ksf	0.567	0.453	0.736	
Stress Ratio	4.979	4.379	3.787	
Rate in/min	0.0001	0.0001	0.0001	

Total C	0.4	ksf
Total phi	7.6	degrees
Eff. C	0.1	ksf
Eff. Phi	34.2	degrees

©

Job No.:	020-209	**Date:** 8/12/2016
Client:	AECOM	BY:DC
Project:	Eden Landing - 60423372	
Sample 1)	B-03-1 @ 5-7.5(Tip-1")	Greenish Gray Elastic SILT (Bay Mud)
Sample 2)	B-02-4 @ 20.5-23(Tip-7")	Greenish Gray Elastic SILT (Bay Mud)
Sample 3)	B-02-4 @ 20.5-23(Tip-1/2")	Greenish Gray Elastic SILT (Bay Mud)
Sample 4)		

The strength of sample #2 was the lowest and is shown in order as the second Mohr circle. Interestingly the pore pressure responded as it should have when comparing to the other samples. It is assumed that the strengths didn't plot as expected because sample #1 was a different boring and depth than samples #2 & #3.

APPENDIX E

PRELIMINARY DESIGN MEMORANDUM OF DREDGED MATERIAL PLACEMENT AT SOUTHERN EDEN LANDING

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MEMORANDUM

TO: Members of the South Bay Salt Pond Restoration Project Management Team

FROM: AECOM

DATE: March 24, 2017

RE: **Preliminary Design Memorandum of Dredged Material Placement at Southern Eden Landing**

1. EXECUTIVE SUMMARY

The former salt production ponds of southern Eden Landing are subsided two to three feet below mean higher high water (MHHW), the approximate target elevation for tidal mid-marsh growth. The State Coastal Conservancy (SCC) and California Department of Fish and Wildlife (CDFW) are proposing to restore the ponds to tidal habitat and/or managed ponds, as described in the Southern Eden Landing Restoration Preliminary Design Memorandum (AECOM 2016a). Prior to breaching the ponds to restore tidal influence, dredged material may be placed in the ponds to raise the pond bottoms to the target elevation of MHW (6.5 feet NAVD88), as well as create habitat transition zones which would otherwise require a significant amount of material import via truck. This memorandum is a conceptual design for dredged material placement at southern Eden Landing (the Project) to inform the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) clearance.

Southern Eden Landing (the Site) is located within the Eden Landing Ecological Reserve (ELER), near the eastern end of the San Mateo Bridge, adjacent to the San Francisco Bay (the Bay). The Site spans 2,210 acres and is comprised of 11 fairly flat pond bottoms separated by former salt production levees. CDFW currently manages water levels within the ponds with pumps and water control structures connected to the Bay and adjoining creeks. The ponds are described in three groups: the Bay Ponds (1,408 acres immediately adjacent to the Bay), the Inland Ponds (440 acres located landward of the Bay Ponds), and the C-Ponds (362 acres located south of the Inland Ponds).

The Site has the capacity to support beneficial reuse of up to 6.0 million cubic yards (MCY) of dredged material to create approximately 1,848 acres of tidal habitat in the Bay and Inland Ponds; the C-Ponds are not being considered for dredged material placement because they have relatively high pond bottom elevations not necessitating large volumes of dredged material, and the ponds are relatively far from the offloading facility. This estimate of 6.0 MCY of dredged material import includes anticipated consolidation of the dredged material and settlement of the pond bottoms, and is based on reaching a target pond bottom elevation of MHW (6.5 feet NAVD88). Minor levee improvements requiring approximately 10,000 CY of fill would provide adequate freeboard for the dredged material placement operation. If the low-lying portions of existing levees are not improved, the volume of beneficial reuse is reduced to 4.0 MCY, and the final pond bottom elevations would be on average 6.0 feet NAVD88, ranging between about 5.5 and 6.5 feet NAVD88. An additional 100,000 CY of dredged material could be utilized to create habitat transition zones (otherwise referred to as gradual-sloped horizontal levees), which vary in size and location by restoration alternative. Given the relatively shallow placement depth in the ponds, only material meeting the Regional Water Quality Control Board (RWQCB) wetland cover suitability criteria would be accepted for placement at the Site.

Dredged material would be sourced from dredging projects around the Bay which typically provide a range of fine and coarse material, although fines would likely be predominant. Dredging projects wishing to dispose of material at the Site would obtain permits to dredge and transport their material to the Project's deep-water transfer point located in the Bay. The Project would seek permits to station an offloader in the Bay, to offload, pump and place the material via pipeline from the offloading facility to the Site. One potential federal dredging project currently on hold, the Redwood City Harbor Navigation Improvement Project, could potentially pump directly to the offloading facility location and not require use of a hydraulic offloader, only supplemental booster pumps (HydroPlan et al. 2015).

The offloading facility would be located in the deep water channel approximately 3 miles offshore from the Site. It would be comprised of a hydraulic offloader, landing barges, temporary mooring piles, delivery vessels, a feed water system, and slurry pipeline. The feed water system would be comprised of an intake pump and fish screen, and would supply water into the delivery vessel (scow or hopper) to create a slurry that the hydraulic offloader (i.e. transfer pump) would pump shoreward via pipeline. The offloading facility would be less than 30,000 square feet in size and approximately 30 temporary mooring piles 18 to 36 inch in diameter would be driven to secure the offloader, landing barges, delivery vessels, and supporting equipment.

The pipeline transporting the slurry from the offloading facility to the Site would be 24 to 36 inches in diameter and manufactured of steel or high density polyethylene (HDPE). It would be submerged from the offloading facility to shore, identified with appropriate signage and lighting according to U.S. Coast Guard requirements. The pipeline would consist of the following approximate lengths: 500 feet floating, 16,000 feet submerged, 14,400 feet primary on shore, and 16,000 feet secondary on shore. Secondary pipeline lengths include diversions from the primary pipeline to prevent material mounding and support habitat transition zone construction. The minimum, maximum, and average pumping distance would be approximately 16,500 feet, 34,000 feet, and 23,700 feet, respectively, depending on pond discharge location. Up to two booster pumps would be located along the pipeline route; potentially one in the Bay, depending on the hydraulic offloader’s pumping capacity.

Existing water control structures would be utilized where possible to manage the slurry placed within the ponds; however up to eight water control structures could be modified or added to maximize the residence time in the ponds and promote settling of solids prior to decant discharge into the Bay. M&N (2015) estimated an average annual range of dredged sediment delivery to the Site ranging from 0.9 to 1.8 MCY depending on the market-driven delivery optimization schedule. Assuming an average offloading rate similar to that experienced at the Hamilton Wetlands Restoration Project, the Bay and Inland Ponds have the capacity to receive the 0.9 to 1.8 MCY of dredged sediment in one year, without discharging decant back to the Bay. When discharge does become necessary, water would be returned to the Bay at either the Bay-front levee of Pond E2, or into Old Alameda Creek (OAC) from one of the northern ponds (Ponds E1, E7, or E6). Discharges back to the Bay would meet Waste Discharge Requirements (WDR) as measured at the specified sampling location, typically 100 feet from the discharge location. Turbidity WDRs typically specify a maximum allowable increase (measured in Nephelometric Turbidity Units) of five units or less for background levels less than 50 units, and an increase of 10% or less for background levels greater than 50 units.

Mobilization and site preparation to receive dredged material would span approximately nine months. The Site may receive dredged material between three to seven years, depending on the pace of the dredged material delivery to the Site. Decommissioning and demobilization would occur over approximately 4.5 months after dredged material placement is complete. The offloading facility and booster pumps may be powered by diesel or electric, depending on cost and regulatory emission requirements. Diesel power could prove more economical if the project duration falls under approximately five years, and electric power could prove more economical if the project durations spans longer than approximately five years.

After completion of the placement of dredged material, the other selected restoration, flood control, and recreational features [as described in the Restoration Preliminary Design Memorandum, (AECOM

2016a)] would be constructed to complete Phase 2. The EIR/S is currently being prepared and will be completed in the fall of 2017. Preliminary restoration design was completed in 2016. Preliminary design of dredged material placement, permitting of the selected project, and 100% design would follow in 2018 and the beginning of 2019. Construction could begin as early as the summer of 2019.

2. INTRODUCTION

This memorandum documents the preliminary design of dredged material placement at the southern half of the Eden Landing Ecological Reserve (ELER), owned and operated by the California Department of Fish and Wildlife (CDFW). This design is in support of the South Bay Salt Pond (SBSP) Restoration Project's Phase 2 at the southern Eden Landing Ponds (the Site), and is intended to supplement the Southern Eden Landing Restoration Preliminary Design Memorandum (AECOM 2016a). Refer to the Restoration Preliminary Design Memorandum for additional site-specific information.

2.1 Purpose

The purpose of this memorandum is to inform the CEQA and NEPA approval processes for placing dredged material at the Site. It is also a basis for the next, more detailed design phase in support of the regulatory agency permitting process.

2.2 Project Background

The ELER, and the southern Eden Landing Ponds within it, is near the eastern end of the San Mateo Bridge, south of State Route 92 as it passes through the City of Hayward in Alameda County. The Phase 2 actions at southern Eden Landing are focused on the ponds south of the Old Alameda Creek (OAC) and north of the federally constructed Alameda Creek Flood Control Channel (ACFCC).

The southern Eden Landing Ponds includes 11 ponds, which are described in three groups based on their location within the complex and their proximity and similarity to each other. The groups are as follows and as shown in Figure 2.1:

- The Bay Ponds: Ponds E1, E2, E4, and E7
- The Inland Ponds: Ponds E5, E6, and E6C
- The C-Ponds (also referred to as the Southern Ponds): Ponds E1C, E2C, E4C, and E5C

The goal of the Phase 2 actions is to restore the various pond complexes to a mixture of tidal habitat and managed ponds.

2.3 Limitations

This memorandum provides a preliminary design for dredged material placement which is based on information available at the time and professional judgment pending future detailed engineering analyses. Future design decisions or additional information may change the findings, and corresponding professional judgments presented in this memo. Additional detailed design will be necessary prior to construction. In the event that conclusions or recommendations based on the information in this memorandum are made by others, such conclusions are not the responsibility of AECOM, or its subconsultants.

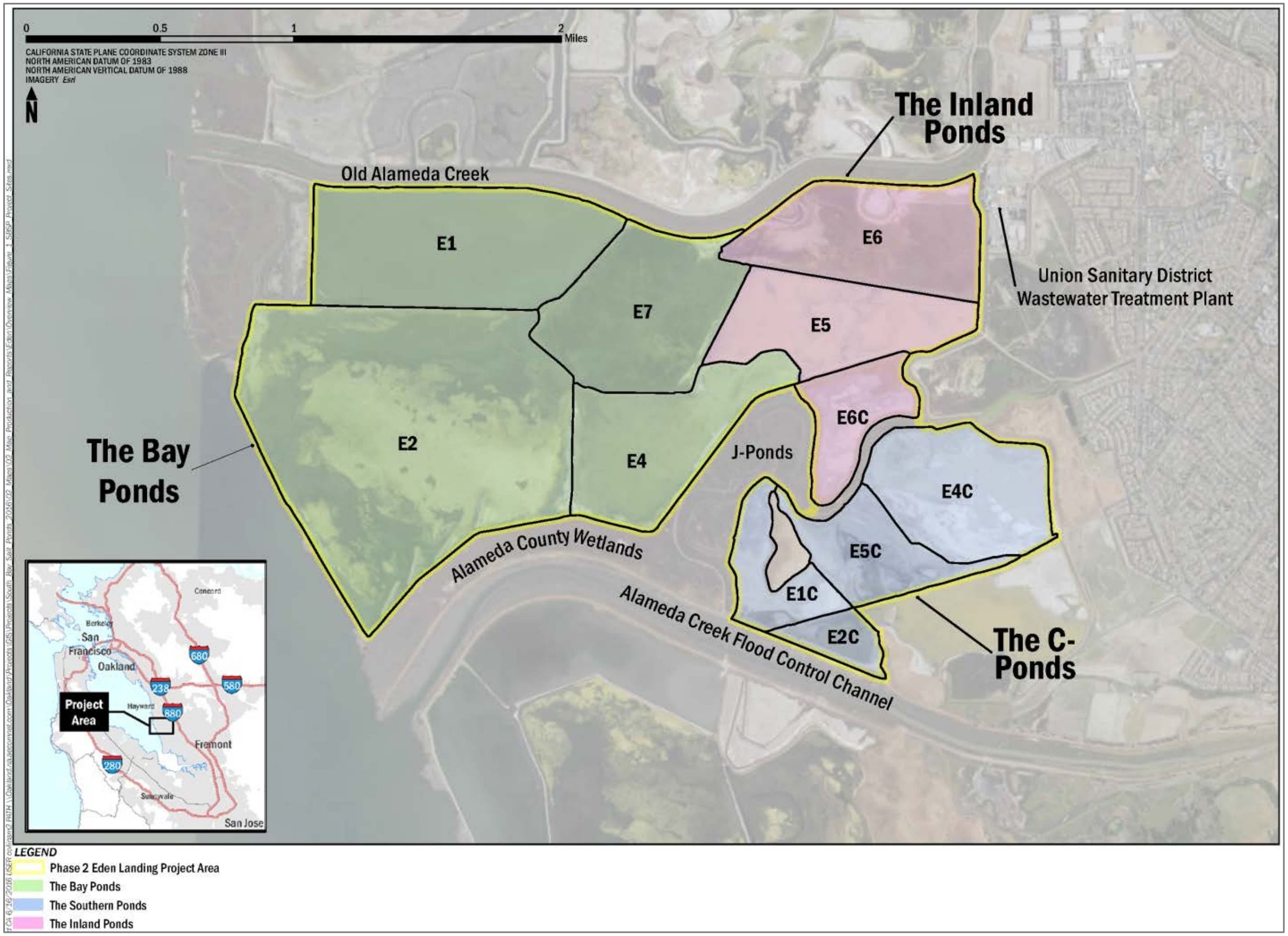

Figure 2.1. Project Area

3. AVAILABLE DATA

3.1 Water Levels

The Redwood City tide gauge (NOAA gauge 9414523), located approximately 7 miles (11 kilometers) west of Eden Landing, was used to represent tidal water elevations at Eden Landing. The 6 minute daily tide data were obtained from National Oceanic Atmospheric Administration's (NOAA) Tides and Currents website (NOAA 2016) and converted to the North American Vertical Datum of 1988 (NAVD88) using NOAA conversions listed in the San Francisco Bay Tidal Datums and Extreme Tides Study Final Report (AECOM 2016b). Table 3.1 summarizes the tidal datums for the three NOAA tide gauges near the project site, showing that the mixed-semidiurnal tides are amplified in the South Bay from a MHHW elevation of 6.9 feet at San Mateo Bridge up to 7.2 feet at Dumbarton Bridge and MLLW from -0.8 to -1.4 feet, respectively. Sources of conversions from tidal to geodetic (NAVD88) datum are listed in Table 3.1.

Table 3.1. Tidal Datums and Extreme Still Water Tide Levels in South Bay

	San Mateo Bridge West, CA Station ID 9414458	**Redwood City, CA Station ID 9414523**	**Dumbarton Bridge, CA Station ID 9414509**
	Feet, NAVD88	Feet, NAVD88	Feet, NAVD88
100-year[1]	10.4	10.7	10.9
10-year[1]	9.3	9.4	9.6
MHHW	6.92	7.10	7.20
MHW	6.29	6.47	6.59
MSL	3.31	3.30	3.27
MTL	3.34	3.28	3.22
NAVD88	0	0.00	0
MLW	0.39	0.10	-0.15
MLLW	-0.80	-1.10	-1.41
NAVD88 Datum Source	Foxgrover et al. 2007	AECOM 2016b	NOAA 2016

[1]Extreme still water tide levels from the *San Francisco Bay Tidal Datums and Extreme Tides Study Final Report* (AECOM 2016b).

3.2 Pond Statistics

In general, the project site is comprised of fairly flat pond bottoms separated by levees. Many of the levees have borrow ditches on the pond side, directly adjacent to the levee. Table 3.2 provides the pond perimeters, acreages, average bottom elevations, and minimum, external levee crest elevations. In general, the internal pond levees are of lower elevation than the surrounding complex perimeter levees. Of note, Pond E2 and E4 are connected with two large breaches and a deteriorating levee, while all other ponds within the Bay and Inland Ponds are separated with existing levees and water control structures.

Table 3.2. Pond Statistics

Pond	Pond Group	Perimeter (ft.)	Area (Acre)	Avg. Pond Bottom Elev. (ft. NAVD88)	Min. External Existing Levee Crest Elev. (ft. NAVD88)	Notes
E1	Bay Ponds	15,801	297	4.8	8.5	Dredged Material Placement Proposed
E2		22,485	692	4.8	9.5	
E7		12,709	217	4.9	9.0	
E4		14,261	202	5.6	9.5	
E6	Inland Ponds	14,046	183	5.1	9.0	
E5		13,682	172	5.3	9.0	
E6C		9,417	85	5.5	9.0	
E1C	C-Ponds	10,254	65	5.8	9.0	No Dredged Material Placement Proposed
E2C		5,682	32	5.2	7.5	
E5C		12,485	97	5.4	9.0	
E4C		10,406	168	5.7	9.0	

3.3 Existing Water Control Structures

Existing water control structures are detailed in Table 3.3 and shown in Figure 3.1. Some existing water control structures may be used during the placement of dredged material, depending on their invert elevations. Further phases of design would confirm and/or determine existing invert elevations and suitability for use during dredged material placement.

Table 3.3. Existing Water Control Structures

Location	Quantity	Size	Invert Elev. (ft. NAVD88)	Type
E2 - Bay	2	48 in.	1.7	Intake/discharge combo gates
OAC - E1	2	48 in.	1.7	Intake/discharge open pipes/combo gates
	2			Intake/discharge slide gates/flap gates
OAC - E1	1	10,000 gpm	-	Pump (#1 Baumberg Intake)
E1 - E2	1	48 in.	1.7	Slide gate
E1 - E7	1	48 in.	2.2	Slide gate
E7 - E4	1	48 in.	-	Slide gate
E7 - E6	1	48 in.	-	Slide gate
E4 - E5	2	48 in.	0.7	Combo gates
E6 - E5	4	30 in.	0.7	Wood gates
E5 - E6C	2	36 in.	2.7	Combo gates
E6C - E4C	2	30 in.	-	Siphons (not operable, but flows depending on water surface elevations)
E2C - E5C	1	36 in.	2.7	Combo gate
ACFCC - E1C	1	7,660 gpm	-	Pump (Cal Hill Intake) (not operable)
ACFCC - E2C	2	48 in.	2.7	Intake/discharge combo gates
E2C - CP3C	1	48 in.	-	Slide gate
E2C - E2C donut	1	36 in.	-	Unknown (open)
E1C - E2C donut	1 1	24 in. 10,000 gpm	- -	Unknown (not operable) Pump (Call Hill Transfer) (not operable)

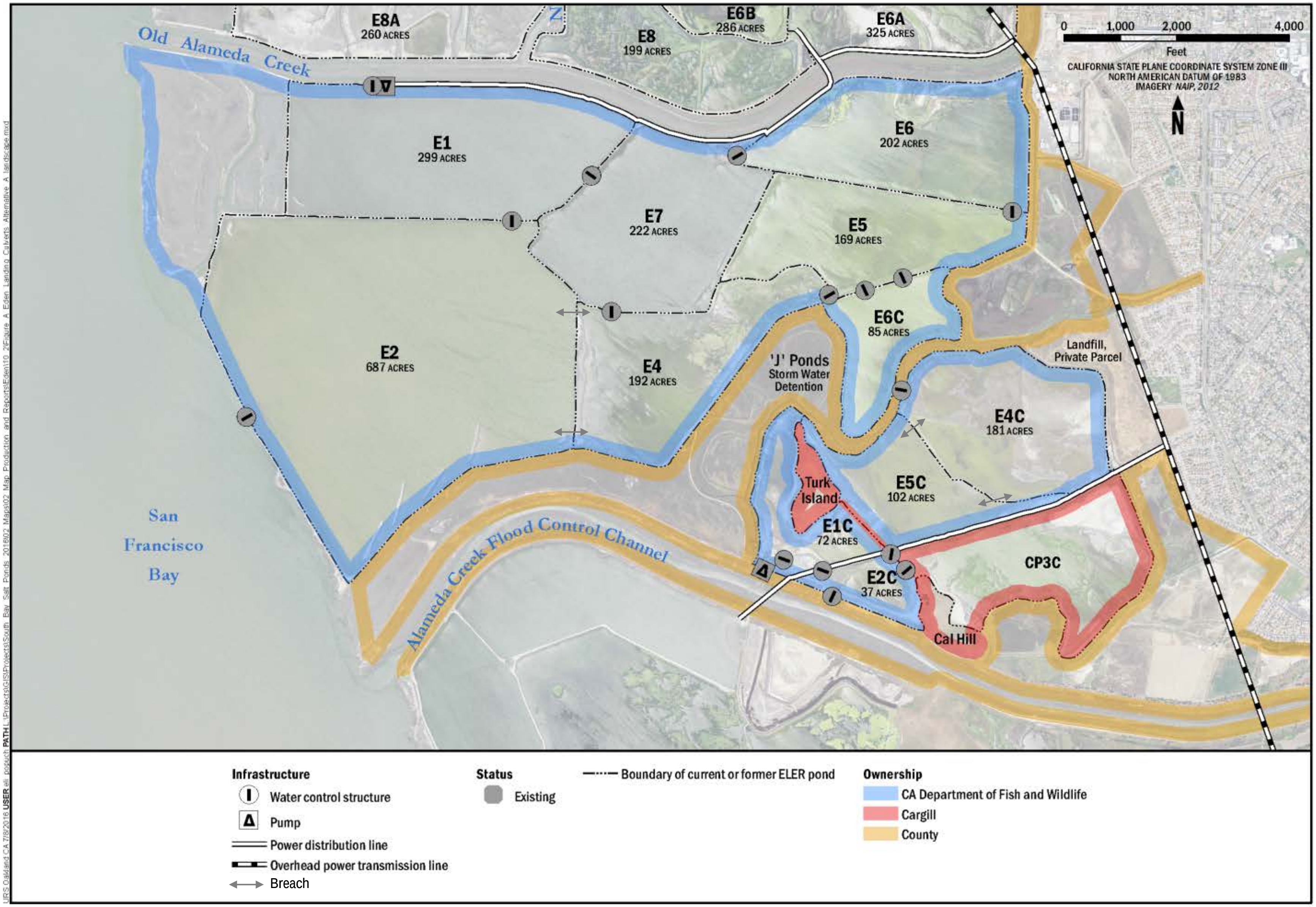

Figure 3.1. Existing Infrastructure

4. PRELIMINARY DESIGN ANALYSIS

The preliminary dredge material design elements of the Eden Landing ponds are discussed in the sections below.

4.1 Material Placement Volumes

If existing levees are utilized as-is, approximately 4.0 MCY of dredged material may be imported and placed in the Bay and Inland Ponds to raise the bottom elevations to an average 6.0 feet NAVD88. This assumes a two-foot freeboard between the maximum slurry elevation and levee crest, a minimum of half a foot of slurry depth during placement (near the end of material placement), and about half a foot to one foot of dredged material consolidation settlement (of the dredged material itself and of the young bay mud beneath the one to two feet of placed material).

If portions of existing levees are improved to a minimum of 10 feet NAVD88, the Bay and Inland Pond bottoms may be raised to the target elevation of MHW (6.5 feet NAVD88) with the placement of 6.0 MCY. Similar assumptions as stated above were assumed. Approximately 10,000 CY would be need from onsite upland areas and to improve levees to 10 feet NAVD88.

Total material volume estimates are summarized in Table 4.1.

Table 4.1. Dredged Material Placement Volumes

Pond Group	Pond	Placement Volume (CY) using existing levees (pond bottoms raised to avg. 6.0 ft. NAVD88)		Placement Volume (CY) with improved levees to 10 ft. (pond bottoms raised to 6.5 ft. NAVD88)		Volume (CY) to improve perimeter levees to 10 ft.	
Bay Ponds	E1	477,000	3,294,000	1,052,000	4,725,000	800	5,600
	E2	2,003,000		2,449,000		0	
	E7	443,000		723,000		2,900	
	E4	371,000		501,000		1,900	
Inland Ponds	E6	334,000	697,000	571,000	1,265,000	0	4,400
	E5	255,000		477,000		0	
	E6C	108,000		217,000		4,400	
C-Ponds	No dredged material placement						
	Total		**3,991,000**		**5,990,000**		**10,000**

*Volumes to raise Pond E7 and E4 levees to 10 feet NAVD88 are for raising the eastern internal levees if the Bay Pond were to receive phased placement of dredged material. If the Bay and Inland Ponds were to receive dredged material in the same phase, the internal Pond E7 and E4 levees would not need to be improved.

These estimated volumes are based on the average pond bottom estimates and minimum existing levee crest elevations as listed in Table 3.2. The two feet of freeboard between the maximum slurry elevation and levee crest is included to provide allowances for wind waves generated within the ponds and to provide time for release of captured precipitation. The young bay mud currently comprising the bottom of the ponds is anticipated to have consolidation settlement on the order of approximately one inch over one year, four inches over seven years, and six inches over 20 years with the placement of approximately two feet of dredged material.

The C-Ponds are not being considered for dredged material placement for the following reasons:

- Flood Protection: Hydrodynamic modeling of large flood events indicated that raising the exterior C-Pond levees to 12 feet NAVD88 could cause an increase in water surface elevation within the C-Ponds and nearby properties (AECOM 2016a). This would decrease existing de-facto flood protection. Raising the levees to 10 feet NAVD88, as opposed to 12 feet, is anticipated to result in similar (but slightly less) flood protection. A reduction in flood protection is not in-line with project goals, and thereby existing levees should not be raised to receive dredged material slurry in the C-Ponds. The lowest existing levees' elevations are approximately 7.5 to 9 feet NAVD88.
- Pond Bottom Elevation/Minimal Placement Volume: The C-Pond bottoms range in elevation between 5 and 6 feet NAVD88, relatively high compared to the other ponds. Because the C-Ponds are currently tidally muted and will remain tidally muted with the proposed restoration design, the target placement elevation is approximately half a foot below the Bay's 6.5 feet MHW elevation. This leaves only approximately a half of foot of placement capacity in the C-Ponds (resulting in the placement of about 443,000 CY total) to reach the target elevation. This could occur through natural sedimentation processes with tidal action over a relatively short time compared to the other ponds.
- Separated Hydraulic System: The C-Ponds are not currently hydraulically connected to the Bay or Inland Ponds, and would require construction of a slurry pipeline across Alameda County Property to connect them. Likely a separate permitted discharge point would be required into the ACFCC, so decant water could be returned to the Bay by gravity. These property ownership and construction challenges could potentially be overcome, but given the limited volume capacity of the C-Ponds, managing these challenges may not be warranted or cost effective.

Dredged material will be placed over approximately 1,848 acres, while levee improvements would occur over up to 23 acres if all levees surrounding the Bay and Inland Ponds were improved to 10 feet NAVD88. Raising the levees to higher elevations (such as 11 feet NAVD88) was investigated, however material needs would exceed available upland material and would require material import or excavation from borrow ditches. Due to the anticipated cost and possibly detrimental higher elevation effects on desired habitat, levee improvements above 10 feet NAVD88 were eliminated from consideration from the project.

Three action alternatives are described in the Restoration Preliminary Design Memorandum (AECOM 2016a). Alternative B (full tidal restoration) and Alternative D (phased tidal restoration) may receive dredged material in the Bay and Inland Ponds. Alternative C (tidal restoration of the Bay Ponds; Inland Ponds to remain as managed ponds), may receive dredged material only in the Bay Ponds, as the Inland Ponds will remain as managed ponds. The anticipated dredged material placement volumes for each action alternative are summarized in Table 4.2. The placed volume depends on if the levees are improved or not to receive material up to the target pond bottom elevation.

Table 4.2. Total Dredged Material Placement Volumes in Bay & Inland Ponds by Alternative

Feature	Alt. B[1]	Alt. C[2]	Alt. D[1]
Raise pond bottoms to 6.0 ft on average using existing levees	3,991,000	3,294,000	3,991,000
Raise pond bottoms to MHW (6.5 ft) with improved levees	5,990,000	4,725,000	5,990,000
Construct Restoration Habitat Transition Zones (net material needed with restoration project assumptions as listed in AECOM 2016a)	83,000	46,000	96,000[3]
Total to avg. 6.0 ft. (CY)	**4,074,000**	**3,340,000**	**4,087,000**
Total to 6.5 ft. MHW (CY)	**6,073,000**	**4,771,000**	**6,086,000**

[1]Dredged material placement in Bay and Inland Ponds
[2]Dredged material placement in Bay Ponds
[3]An additional 49,000 CY of dry material would be imported for levee improvement as part of the restoration project; volume not included here because onsite drying and reuse of dredged material is not proposed for levee improvements.

In addition to placing dredged material on the pond bottoms, dredged material may be utilized to construct habitat transition zones for the three action restoration alternatives, also described in the Restoration Preliminary Design Memorandum (AECOM 2016a). Table 4.2 includes the volume required for construction of habitat transition zones and levee features for each alternative. In general, the restoration features add up to an additional 100,000 CY of dry fill that could be sourced from dredged material, although this number varies by alternative.

Because the restoration design includes channel excavation, the dredged material placed within the ponds will increase the amount of excavation required during the restoration design. This additional excavation volume is listed in Table 4.3 for each alternative assuming the pond bottoms are raised to MHHW. The additional material excavated for the channels would be utilized to create additional island habitats (similar to other excavated channel material). A range of 2 to 4 feet of placed dredged material was assumed (as some of the channels are located in existing borrow ditches), a channel width of 15 to 30 feet, as well as a 30% bulking factor and 20% volume contingency [similar to the Restoration Preliminary Design Memorandum (AECOM 2016a) volume estimates].

Table 4.3. Additional Material Excavation and Placement Required with Dredged Material Placement by Restoration Alternative

Additional Channel Excavation Volume (CY)			
	Alt. B	**Alt. C**	**Alt. D**
Bay Ponds	53,000 CY	53,000 CY	53,000 CY
Inland Ponds	45,000 CY	0 CY	43,000 CY

4.2 Material Sources

Dredged material would be sourced from dredging projects around the Bay; the nearest ongoing project being the Redwood City Federal Maintenance Dredging Project that dredges approximately 430,000 CY on average every 3 years [Moffatt & Nichol (M&N) 2015]. M&N (2015) identified potential federal and non-federal projects that could place material at the Site, the largest sources being Oakland Inner and Outer Harbors, Redwood City Harbor, and numerous ports. In general, material from the Oakland Inner and Outer Harbor is comprised of 30% clay, 30% silt, and 40% sand (M&N 2015). The federal channel at Redwood City Harbor is comprised of predominately silt and clay with less than 2% sands and gravels (HydroPlan et al. 2015). In general, the Site would likely receive both fine and coarse material, thereby requiring secondary pipeline routes (described in the next section) to transport sandy materials throughout the ponds and reduce the amount of mechanical spreading at the slurry outlet.

4.3 Preliminary Design Components

4.3.1 Overview

Preliminary design components are summarized in Table 4.4, the majority of which are shown in Figure 4.1. The following sections describe each design component.

Table 4.4. Dredged Material Placement Design Summary

	Approximate Dimensions/Capacity	Approximate Footprint (SF)	Purpose/Notes
Offloading Facility	-	28,220 SF total	-
Hydraulic Offloader	160 ft long x 50 ft wide	8,000 SF	Transport slurry material from delivery vessels to disposal location via pressure pipeline. May vary in size and pumping capacity.
Piles	10 to 30 piles, 18 to 36 inches in diameter	220 SF	Secure offloading equipment. The number and length of piles depends on the selected equipment, mooring configuration and local geology.
Landing Barges	(2x) 200 ft. long x 50 ft. wide	20,000 SF	Secure delivery vessels while being offloaded. May vary in size.
Support Equipment	Variable	-	Includes Fuel/Water Barge, Crew/Survey Boat, Work Tug, etc.
Pipeline	24 to 36 inch steel and HDPE	140,700 SF total	Transport material from the offloader to the Site.
Floating	500 ft.	1,500 SF	Max. pumping dist. = 34,000 ft. Avg. pumping dist. = 23,700 ft. Total of 46,900 ft. of pipe.
Submerged	16,000 ft.	48,000 SF	
Shore (Primary)	14,400 ft.	43,200 SF	
Shore (Secondary)	16,000 ft.	48,000 SF	
Booster Pumps	-	12,200 SF total	Up to two in-line boosters would increase the pumping capacity of the offloader.
Floating or Jack-up Barge Booster	120 ft. x 60 ft. with (4) piles or spuds	7,200 SF	Requires approximately 8 feet of water depth.
Shore Booster	100 ft. x 50 ft. concrete pad	5,000 SF	-
Site Preparation	-	-	-
Improve Levees to 10 ft. NAVD88	Up to 10,000 CY (with phased Bay & Inland Pond placement)	Up to 23 AC	Allows for greater slurry containment and material placement up to 7.1 ft. NAVD88.
Water Control Structures	Up to eight new construction and two discharge weirs	-	Manage dredged material slurry and decant water.
Power	-	-	Either diesel or electric would provide power to equipment.
Diesel	Large diesel generator barge	2,000 SF	Power offloading facility.
Electric • Substation	120 ft. long x 100 ft. wide	12,000 SF	Transform voltage from high to low and distribute power to equipment.
• Overhead Line	17,700 ft.	-	
• Submarine Cable	16,000 ft.	-	

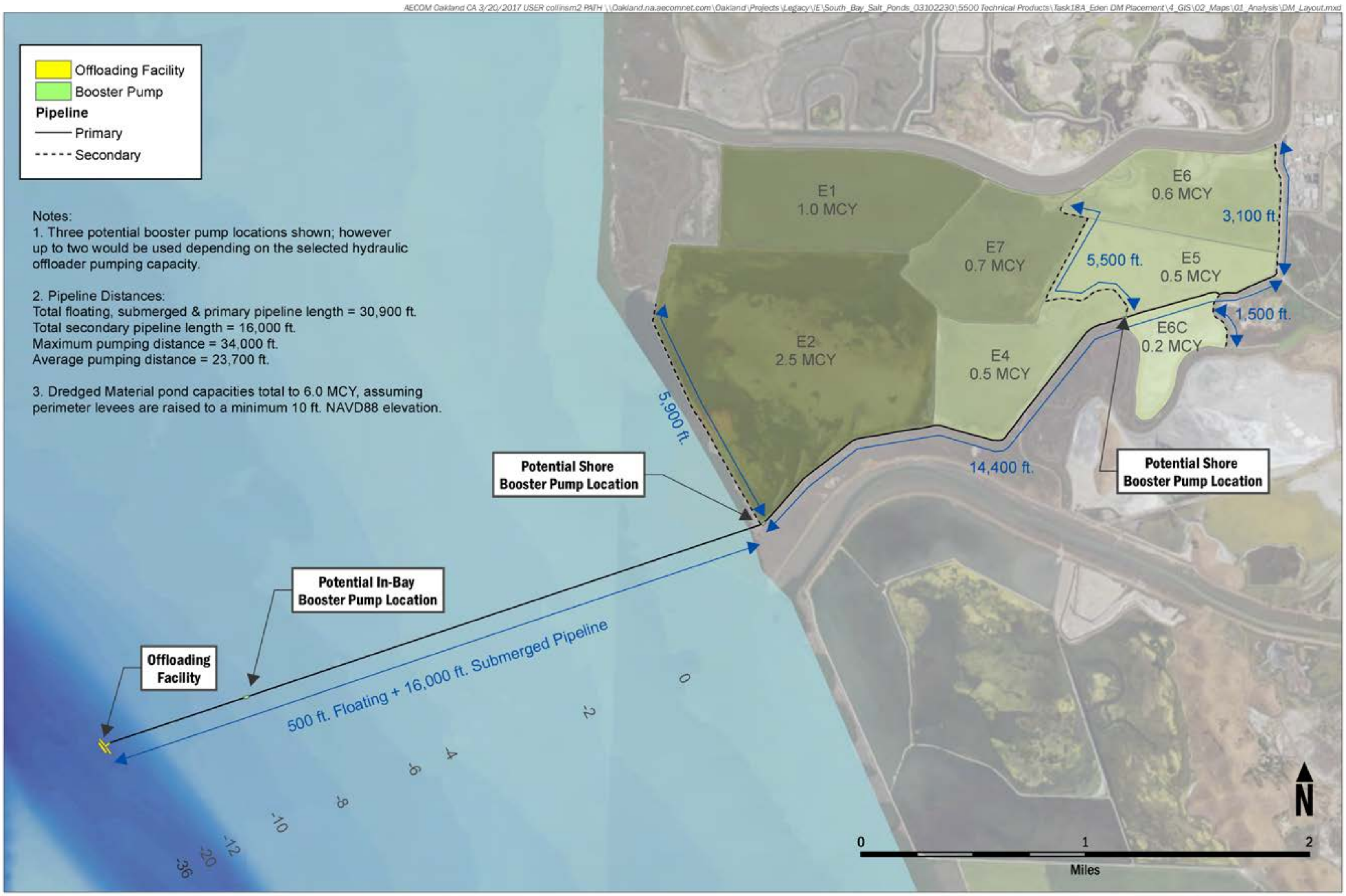

Figure 4.1. Dredged Material Design Components

4.3.2 Offloading Facility

The offloading facility would offload material from barges and scows and transport the material via pipeline to the Site for placement. The offloading facility would be comprised of an hydraulic offloader, temporary mooring dolphins, landing barges, an auxiliary feed water pump, pipelines, delivery vessels, and support equipment. Support equipment would include barges, tug boats, crew boats, and site security. All materials and equipment would contain the appropriate signage and navigation lighting in accordance with U.S. Coast Guard requirements. Material barges or scows (delivery vessels) would range in capacity from 800 to 6,000 CY and would draft up to 18 feet. Given the required water depth for the delivery vessels and offloading equipment, the offloading facility would be positioned approximately 3 miles offshore, past the mudflats and shallow depths bordering the Site. Figure 4.2 shows the deep water channel in where the offloading facility would be located at depths of approximately -35 feet NAVD88.

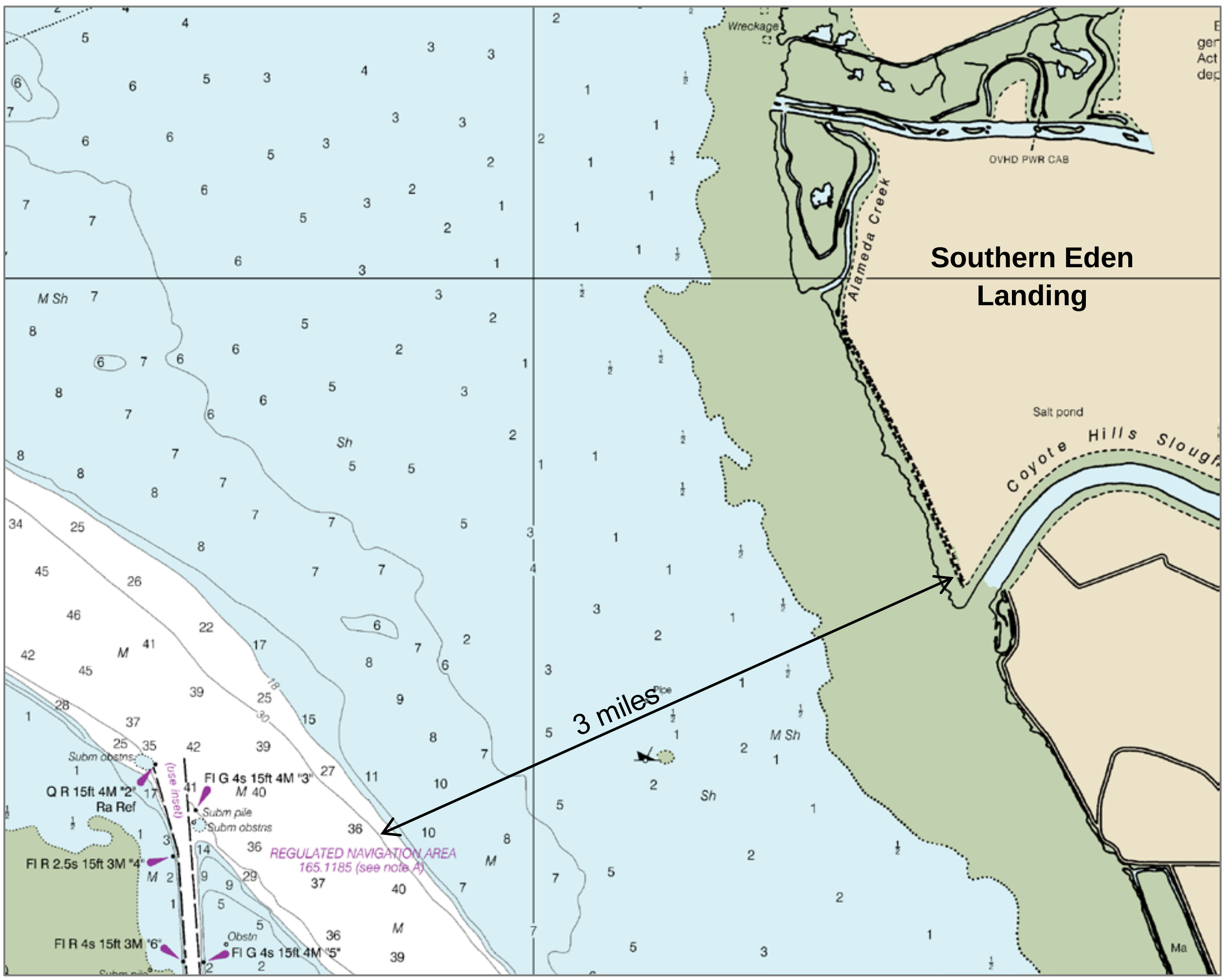

Figure 4.2. NOAA Nautical Chart 18651 San Francisco Bay Southern Part, Soundings in Feet at MLLW

Depending on the material type and selected equipment, an offloading facility and booster pump system (described in the following sections) could be sized to pump material a range of distances, ranging from within the inner pond levee nearest the bay (approximately 3 miles) to the farthest inland extent of the ponds (approximately 6 miles). Most likely a hydraulic offloader with approximately 24 inch suction and discharge, 120 feet long by 50 feet wide (6,000 square feet), would provide the main pumping capacity to place material at the Site. An auxiliary feed water system would slurry the dredged material in scows by agitation with water jets, allowing the hydraulic offloader to suction the slurry through the snorkel and transport the material via pipeline to shore. The hydraulic offloader would be held in position with 10 to 30 steel pipe piles securing the offloading facility. An example of an offloading facility is provided in Figure 4.3.

Figure 4.3. Offloading Facility

Source: HydroPlan et al. 2015

Less likely are the following offloader equipment options:

- Submersible Dredge Pump & Boosters: A submersible dredge pump could be mounted on an excavator secured to a flat-deck barge. This equipment setup would likely have less pumping capacity than a hydraulic offloader, therefore material would be transported at a slower production rate and potentially an additional in-line booster pump may be required. The barge would be held in position with two temporary pile anchors (spuds) 18 to 24 inches in diameter.
- Hopper Dredge Pump-Off: Most Bay Area projects are dredged mechanically or by hopper dredges without pump-out capability (M&N 2015); a hopper dredge pump-off system (with an in-line booster pump within the Bay) is possible but not likely.
- Hydraulic Dredge Pipeline Connection: A continuous pipeline from Redwood City Harbor could transport sediment slurry to the Site, in which case no offloader would be needed. A

pipeline connection would be secured at the transfer point, and booster pumps would be required to support the slurry transport.

Regardless of the material transport system, the slurry would contain approximately 10% to 40% solids by volume. Feed water would be sourced from a screened intake located at the offloader in the deep water channel, similar to the approach taken at the Hamilton Wetlands Restoration Project and the Cullinan Ranch Restoration Project (2016 Richmond Maintenance Dredging Episode). Fish screens would comply with NMFS and CDFW design guidelines to protect species of concern. A recirculation line from the decant water at the Site to the offloading facility, similar to the operation considered for Cullinan Ranch, is not cost effective given the distance from the Site to the offloading facility. For the same reason, a groundwater extraction system to supply slurry water, as utilized at Montezuma Wetlands Restoration Project, is not appropriate for this Site.

4.3.3 Pipeline

A network of approximately 46,900 feet of pipeline would be installed to transport sediment slurry from the hydraulic offloader to and around the Site. As shown in Figure 4.1, the pipeline would be comprised of approximately 500 feet of floating pipeline (located near the offloader, booster pumps, and shore), 16,000 feet of submerged pipeline, 14,400 feet of primary shore pipeline, and 16,000 feet of secondary shoreline pipeline. Secondary shore pipeline could support the spread of material throughout the ponds and allow for sand mounding along the proposed habitat transition zone locations. The final pipeline routing and pipeline extent would be determined during detailed design.

The floating, submerged and shore pipelines would range in size from 24 to 36 inches in diameter and would be comprised of steel and/or HDPE. Submerged pipeline would be anchored on the Bay bottom with precast concrete pipe weights to reduce navigation hazards and vulnerability to wind and wave action, and would be identified with signs and lights per US Coast Guard guidelines. Portions of the submerged pipeline may be floated above the shallow mudflats if there is a concern of water flow around the pipeline during low tide. The outboard levee would be minimally graded to transition the pipeline from the mudflats to the levee. The onshore pipeline would be secured with stakes on existing levees currently utilized for maintenance access, or on levee shoulders as necessary to sustain equipment access. Existing vegetation on levees would be avoided where possible. Abrupt pipeline turns would be supported with concrete blocks as necessary. The pipeline would undergo repair and replacement due to typical wear and tear over the project length. The type of pumped material (sand and gravel versus silt and clay) would influence the frequency of repair and replacement.

4.3.4 Booster Pump

Given the distance from the offloading facility to the point of discharge at the Site, one or more in-line booster pumps would be required and would be located along the discharge line to increase the pumping production rate and facilitate delivery of the slurry to the Site. Typically boosters are needed every two to five miles and may allow for an additional pumping distance of about two miles. The specific locations of the booster pumps depend on the pumping capacity of the selected offloader and desired discharge location at the Site. For instance, two boosters may be required if slurry is pumped to the northeast corner of the Inland Ponds (approximately 6.1 miles).

Booster pumps may be located along the pipeline in the Bay and/or on pond levees. If located within the Bay, a floating or jack-up booster pump barge may be pile-secured depending on water depth and wind/wave action (see Figure 4.4 for example of a jack-up booster). A jack-up booster pump may be held in place with up to four spuds, while a floating booster pump barge would be secured with approximately 4 piles (each 24 to 36 inches in diameter). Both booster pumps require at least 8 feet of water depth for crew changes with a skiff and provision of fuel, and typically range in size from 3,500 to 7,200 square feet.

Source: Great Lakes Dredge & Dock, 2017 Source: Hammerwold, date unknown

Figure 4.4. Jack-up Booster (left) and Shore Booster Pump (right)

If located on land, a booster pump may be utilized at multiple locations depending on pumping distance and material type. A booster pump station would be approximately 5,000 square feet in size and would likely require temporary placement of material within the ponds for adequate space and access around the equipment (see Figure 4.4 for an example of a shore booster pump).

4.3.5 Site Preparation

4.3.5.1 Improved Levees

As described in Section 4.1, levees could be improved to an elevation of 10 feet NAVD88 to provide sufficient slurry capacity to reach the target pond bottom elevation of MHW. Up to 10,000 CY of material would be sourced from onsite existing levees that are currently above the target elevation of 10 feet NAVD88. The southern levee of Pond E2 and northern levees of Ponds E1 and E7 are proposed for levee lowering. Material would not be sourced from levees proposed for improvement in the preliminary restoration design, so as to avoid lowering and raising the same levees in different phases of the overall project. Table 4.5 shows that the material would be sourced from approximately 5,500 linear feet of relatively high levees, and be used to improve 20,400 linear feet of levees identified for improvement.

Table 4.5. Lengths of Levee Improvement and Material Sources

	Levee Improvement Locations (ft.)	Material Source Locations (ft.)
Bay Ponds	13,400	5,500
Inland Ponds	7,000	0
C-Ponds	0	0
Total	**20,400**	**5,500**

The Restoration Preliminary Design Memorandum (AECOM 2016a) included a geotechnical investigation and analyses. Using information from these analyses, a representative cross section of an existing levee was analyzed for slope stability with slurry up to the levee crest of elevation 10 feet NAVD88. The preliminary resulting factor of safety was 1.3 or greater, which is considered adequate for stability.

4.3.5.2 Site Slurry Capacity and Time to Discharge Decant Water

The Bay and Inland Ponds may receive up to about 6.0 MCY of dredged material to raise the pond bottoms (assuming the perimeter levees are raised to 10 feet NAVD88). With the perimeter levees raised to 10 feet NAVD88, the Bay and Inland Ponds could contain up to 5,565 acre-feet of slurry (at one time if filled to capacity) given the current pond bottom elevations and a freeboard of approximately two feet.

M&N (2015) estimated an average annual range of dredged sediment delivery to the Site ranging from 0.9 to 1.8 MCY depending on the market-driven delivery optimization schedule. Assuming an average offloading rate similar to that experienced at the Hamilton Wetlands Restoration Project, the Bay and Inland Ponds have the capacity to receive the 0.9 to 1.8 MCY annual delivery range (slurried) without discharging decant water back to the Bay.

In later design phases, discharge structures would be designed to allow for decant water release at an appropriate flow rate given anticipated offloading pump rates. Consideration would be given to have adequate capacity for a design rain event as well.

4.3.5.3 Water Control Structures

Existing water control structures are believed to be sufficient to manage the dredged material slurry. However, depending on their invert elevation, location within the ponds, and the selected slurry discharge point within the ponds, additional water control structures may temporarily be built to manage the dredged material slurry. Up to eight new or replaced water control structures would allow for controlled exchange between all Bay and Inland Pond levees, likely no larger than approximately two 48” HDPE pipes per structure. The structures would be temporary, designed to span the approximated time period (less than 10 years) to receive the desired amount of dredged material.

Additionally, up to two decant discharge structures would be constructed at locations described in the next section.

4.3.5.4 Receiving Water Discharge Locations

After solids settlement in the ponds, the resulting decant water will be returned to the Bay or sloughs via one or more permitted discharge locations. Typically discharge locations are selected to maximize the distance from the slurry pipe outlet, or in zones of low velocity such as corners of rectangular-shaped cells. The receiving water body is also a consideration, such as discharging directly into the Bay or into a smaller creek where velocities may suspended creek bed sediments.

Because the location of the slurry pipe outlet may change with material type and volume placed, multiple discharge locations may be considered along the levees between Pond E2 and the Bay, and Ponds E1, E6 and OAC, as shown in Figure 4.5. Likely no more than two locations would be utilized during different phases of dredged material placement. Decant discharge structures typically have stop logs or variable height weirs on the upstream side to allow for the controlled decant of the ponded water on the downstream side; therefore existing water control structures would likely have to be modified to discharge decant water.

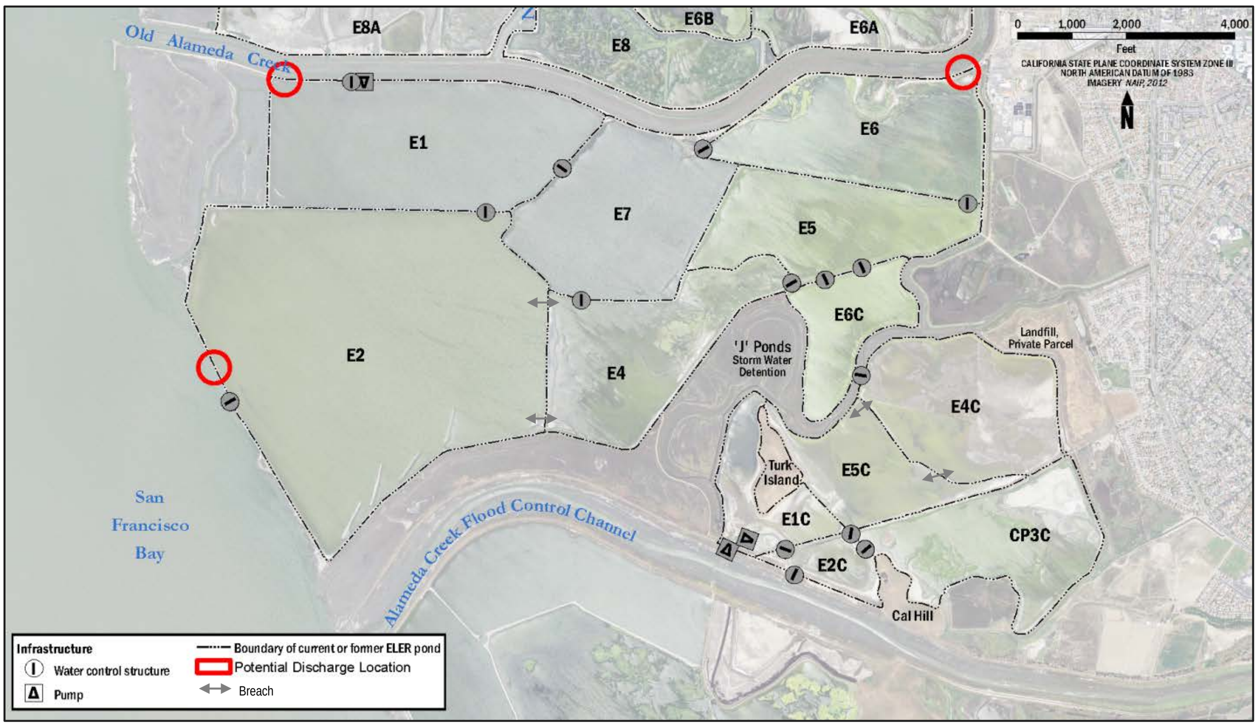

Figure 4.5. Potential Discharge Locations

Similar to other Bay Area beneficial reuse sites, the Project would meet water quality standards in the receiving water as defined in project-specific Waste Discharge Requirements (WDR). Both the Montezuma (RWQCB 2012) and Cullinan (RWQCB 2010) WDRs contain the following receiving water limitation for turbidity (in Nephelometric Turbidity Units):

> If the receiving water background is less than 50 units, an incremental increase of 5 units is allowed, as measured from 100 feet from the discharge location. If the receiving water background is greater than or equal to 50 units, an incremental increase of 10% of background is allowed, as measured from 100 feet from the discharge location.

4.3.6 Power

The offloading facility and booster pumps may be powered by diesel or electric, depending on cost and regulatory emission requirements. Both diesel and electric power options are described below, however only one would be utilized during the Project. Diesel power could prove more economical if the project duration falls under approximately five years, and electric power could prove more economical if the project spans more than approximately five years.

4.3.6.1 Diesel

If diesel were to be selected to power project equipment, a large diesel generator barge would be moored near the offloading facility in the deep-water channel. Booster pumps and onshore equipment would have individual diesel generators that would be maintained by land- and water-based crews. As M&N (2015) suggested, the Project could use low emission (Tier III) engines, install selective catalytic reduction systems, or purchase air quality credits to offset emissions and allow the Project to comply with CEQA annual emission limits. Although not recognized in CEQA emissions analysis, restoration of 1,848 acres of marsh (instead of disposal at SF-DODS 55 nautical miles offshore) results in overall carbon sequestration benefits.

4.3.6.2 Electric

To supply electricity to project equipment, significant electrical infrastructure would be constructed, requiring a large upfront capital investment. M&N (2015) estimated this cost to be between $9 and $12 million. Recent AECOM estimates for an electrical dredge project in southern California estimated a substation alone to be between $4 and $6 millon. Depending on the length and power usage of a project, these upfront costs could be outweighed by the cost savings of electric over diesel power for longer projects (greater than about five years). Placement of dredged material at Eden Landing may fall between three and seven years, as described in more detail in Section 4.5.

Electrical infrastructure necessary to bring power to the offloading facility and booster pumps would include a substation, overhead transmission line, and submarine power cables. The nearest high voltage transmission line for a power drop to a substation is the Grant-Newark overhead double circuit 138kV line located immediately east of the Site, as shown in Figure 4.6. The existing line rating, spare capacity and any necessary upgrades required to interconnect to the PG&E system are unknown at this time. During the early design phase, a detailed electric load study will be required to estimate the total project connected and operating load.

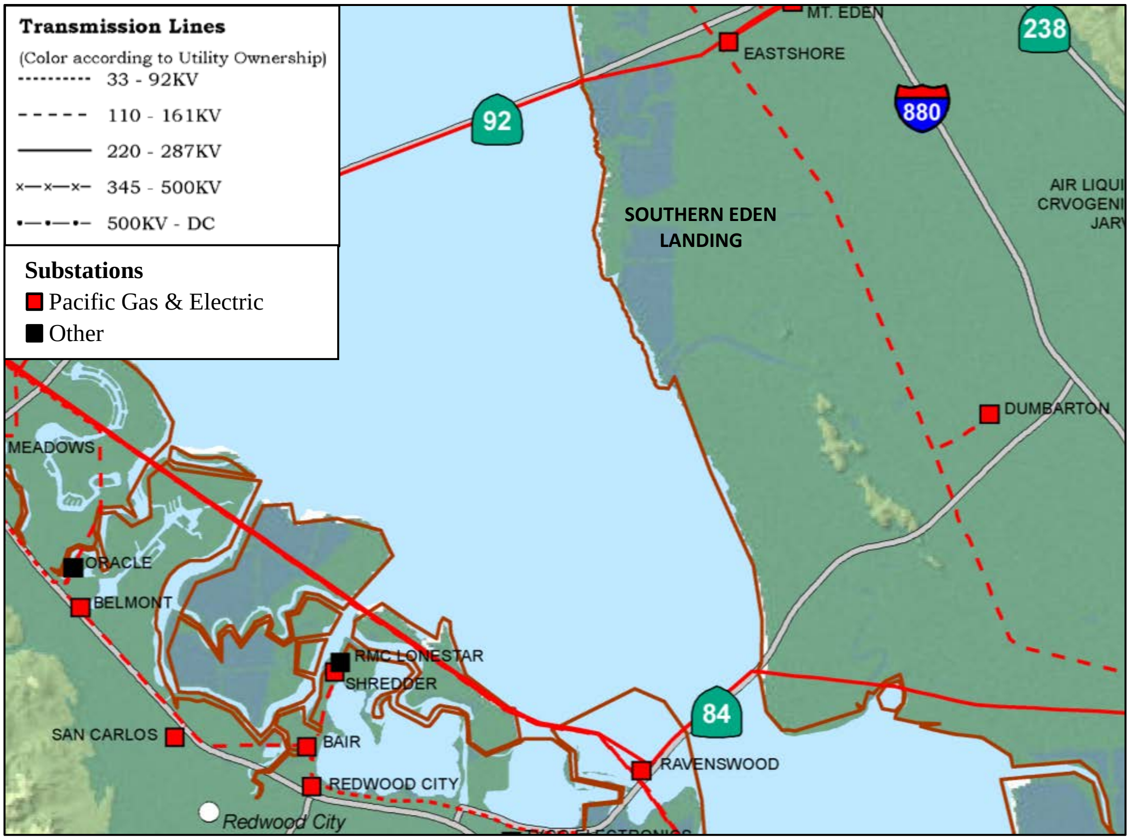

Figure 4.6. Existing Transmission Lines and Substations
Source: California Energy Commission 2015

More details on the electrical infrastructure are listed below:

- **Electric Substation**: Construction of an electric substation would be required to interface with the PG&E power system and transform the voltage from 138kV to 12.47kV, and to provide distribution power to project equipment including booster pumps, the offloading facility, and any other balance of plant loads. Additional transformers and electrical equipment would be required at pump locations to transform the voltage to a useable voltage, likely 2300V or 4140V. The substation site would also include a small unmanned control building/enclosure to house auxiliary controls and protective relay systems. The substation would be supported by a large concrete pad (with foundation piles) and would encompass an area approximately 12,000 square feet in size, similar to that constructed at the Hamilton Wetlands Restoration Project as shown in Figure 4.7. The ideal location of a substation is nearest the equipment on a Bay front levee, which would require temporary placement of material within the ponds for adequate space and access around the equipment. Alternatively, the substation could be located within the Site on a levee (potentially near a shore booster pump), or near the high voltage line on Union Sanitary District property.
- **Overhead transmission line:** The project interconnection will consist of a 138kV line segment extending from the existing PG&E transmission line to the new project 138kV substation. Tubular steel pole structures approximately 70 to 100 feet in height will be required to support

overhead transmission conductors and shield wires. The PG&E line will be looped into the new project substation where the voltage will be transformed to a lower voltage that is suitable for the project distribution system. From the high voltage line near the Union Sanitary District property, approximately 17,700 feet (3.4 miles) of overhead power cables would be installed to reach the shore's edge at the southwest corner of Pond E2.

- **MV Submarine power cables** would carry electric power from the shore's edge to the potential in-bay booster pump and offloading facility. The submerged power cables, as shown in Figure 4.7, would be laid on the Bay bottom and would extend approximately 16,000 feet (3 miles) offshore to the offloading facility.

Figure 4.7. Electrical Substation and Submarine Power Cable used at Hamilton Wetlands Restoration Project
Source: Hammerwold, date unknown

In the next design phase, a Load Interconnection application would need to be filed with PG&E to tie into the existing Grant to Newark 138kV line. PG&E would perform a System Impact Study and Facilities Study that will identify the impact the project will have on the existing power system, system modifications required to interconnect the additional load, and associated costs. This process can take between 6 to 12 months, and would therefore need to be performed early in the design.

Given the interconnection voltage is classified as "transmission" level, the Project would need to be assessed against California Independent System Operator (CAISO) Controlled Grid Reliability Criteria and comply with the CAISO Tariff (accessible at www.caiso.com). The Project would also likely have to file with the Federal Aviation Administration (FAA), in accordance with CFR Title 14 Part 77.9, as the proposed overhead cable structures would be in proximity to navigation facilities and may impact that assurance of navigation signal reception (per Obstruction Evaluation / Airport Airspace Analysis at https://oeaaa.faa.gov/oeaaa).

4.4 Review of Conceptual Cost Analysis

M&N (2015) performed a feasibility study of material sourcing and determined that placement of dredged material at the Site could be cost competitive with existing disposal and placement sites in the Bay Area. The key assumptions listed in M&N (2015) included 7.2 MCY dredged material capacity in the Bay, Inland, and C-Ponds; various material delivery schedules; diesel power, no electric power; and approximately $2-$3/CY for site preparation totaling approximately $19 million. M&N (2015) identified the overall project cost and annual cost to be driven by the dredged material delivery schedule, as opposed to the offloading and placement production rates. This indicates that if the selected restoration project allows for dredged material placement in only the Bay Ponds [i.e. Alternatives C and D (AECOM 2106)], the Project would still potentially be cost competitive to disposal at SF-DODS if it received 1.5 or 1.8 MCY per year [i.e. “optimized” and “super optimized” delivery schedules identified in M&N (2015)]. If the Site were to only receive about 0.9 MCY per year [i.e. the “non-optimized” delivery schedule in M&N (2015)], then placement at the Site would likely not be cost competitive with disposal at SF-DODS.

Two potential projects led by the USACE, the Redwood City Harbor Navigation Improvement Project and the WIIN Pilot Project, have the potential to increase the certainty in dredged material delivery, and keep beneficial reuse costs competitive with other disposal options.

Although currently on hold due to unavailable cost-competitive beneficial reuse sites, the Redwood City Harbor Navigation Improvement Project could provide a substantial volume [1.7, 3.9 or 7.6 MCY (HydroPlan et al. 2015)] for placement at the Site. Because this material would be delivered within a short delivery schedule, the downtime operating costs of the Site would be minimized and the Site could be cost competitive with other Bay Area disposal and placement locations.

Federal navigation projects in the Bay Area produce the majority of the annual dredge volume available for beneficial reuse. If the USACE were to invest in a beneficial reuse site and provide a level of certainty that material would be placed at such a site, downtime equipment costs could be minimized at that site. The “Water Infrastructure Improvements for the Nation Act” (WIIN Act, or WRDA 2016) includes creation of a USACE pilot program to increase beneficial reuse of dredged material. The Bay may be selected as one of the ten regions in which to conduct a pilot study, and in turn southern Eden Landing could be selected as the region’s pilot location. The timing however may not align with the restoration progress required of the SBSP Restoration Project.

Since the completion of the M&N (2015) Feasibility Study, two additional events could increase cost competitiveness of beneficial reuse in the Bay Area. Recently, smaller dredge equipment has been utilized to conduct federal navigation maintenance dredging and placement at an in-Bay beneficial reuse site. By utilizing smaller, less-costly scows, projects can improve efficiencies and reduce construction and operation costs (compared to utilizing ocean disposal dump scows). Also, more dredging projects are utilizing NMFS’s (2015) Programmatic Biological Opinion; allowing dredgers to operate outside the typical dredging window if all material is placed at a beneficial reuse site. By reducing equipment downtime, operation and maintenance costs are reduced. More projects may also utilize equipment while in the Bay Area, reducing mobilization and demobilization costs.

4.5 Construction Implementation

Construction will be implemented by procuring the services of a general contractor with experience in performing dredged material offloading activities, marine pile driving, levee improvements, and working within and near tidal waters and bay mud. Primary land access to the Site would be as described in the Restoration Preliminary Design Memorandum (AECOM 2016a) and access throughout the pond complex would be via former salt pond levee maintenance roads. The offloading facility, in-bay booster pump, and floating and submerged pipeline would be floated into position at high tides.

The following equipment would likely be used to construct the Project. This equipment list does not include smaller items such as fuel service, maintenance service, personal vehicles, small tools and equipment.

- Hydraulic Offloader
- Booster Pumps
- Floating Barges with Pile Drivers and Cranes
- Equipment Barges / Cable Reel Barges
- Work Tugs
- Crew/Survey Boats
- Amphibious Low Ground Pressure (LGP) Dozers
- Excavators
- Dozers
- HDPE Pipe Fusers
- Impact/Vibratory Hammers
- Dump Trucks
- Flatbed Trucks
- Concrete Trucks
- Water Trucks
- Bucket Trucks
- Compactors
- Pumps
- Generators

Assuming construction is performed in the Bay and on shore concurrently (un-phased throughout the site) the sequence of construction tasks and approximate durations are summarized in Table 4.6.

Table 4.6. Construction Tasks and Durations

Construction Task	Approximate Duration
1. Mobilization	0.5 month
2. Site Preparation 2.1. Pile Installation 2.2. Submerged Pipeline Installation 2.3. In-water Equipment Installation of Offloader, Landing Barges, Floating Pipeline, Support Equipment, and Booster Pump 2.4. Clear & Grub Levees 2.5. Levee Improvements (cut, haul, fill) 2.6. Various Water Control Structures 2.7. Shore Booster Pump Installation 2.8. Shore Pipeline Installation 2.9. Substation 2.10. Overhead Transmission Line 2.11. Submarine Power Cables	7.5 months
3. Dredged Material Placement 3.1. Material Offloading & Placement 3.2. Habitat Transition Zones 3.3. Offseason demobilization, equipment storage, & mobilization	<u>Alternatives B and D</u>: Approx. 10 months of 24-hour days over 3 to 7 years depending on material delivery schedule <u>Alternative C</u>: Approx. 9 months of 24-hour days over 3 to 6 years depending on material delivery schedule
4. Decommissioning 4.1. In-water Equipment Demobilization of Offloader, Barges, Floating Pipeline, Support Equipment, and Booster Pump 4.2. Demolish Piles 4.3. Demolish Submerged Pipeline 4.4. Demolish Shore Booster Pump 4.5. Demolish Shore Pipeline 4.6. Demolish Water Control Structures 4.7. Demolish Substation 4.8. Demolish Overhead Transmission Line 4.9. Demolish Submarine Power Cables	4 months
5. Demobilization	0.5 month

The construction schedule will be driven by construction work windows, weather conditions, and contractor means and methods. As listed in Table 4.6, mobilization and site preparation construction would span approximately 8 months, and would be regulated by work windows described in more detail below. This construction duration assumes an electrical system would be constructed (as opposed to a diesel power system).

In-water construction work (e.g. dredging and pile work) would be restricted by dredging work windows, which span from June 1st through November 30th to protect Steelhead (*Oncorhynchus mykiss*) in South Central and South San Francisco Bay. On-shore construction activities in bird nesting areas could be limited or subject to buffer zones during the following periods listed for each species:

- March 1 to September 15 for Western Snowy Plover (*Charadrius alexandrinus nivosus*)
- February 1 to September 1 for Terns, Avocets, and Stilts
- February 1 to September 1 or earlier (as allowed) for Ridgway's Rail (*Rallus obsoletus*).

After site preparation is concluded, dredged material may be placed at the Site as material becomes available. Most dredging projects occur during the dredging work window, between June 1st and November 30th; however material could potentially be received year-around as the offloading and placement of dredged material is not constrained by this dredging work window. With NMFS's (2015) Programmatic BO that allows dredging outside this work window when the material is beneficially reused, Eden Landing has the opportunity to receive dredged material when other disposal sites are unable to accept material without further consultation with NMFS.

M&N (2015) assumed four to eight years of material acceptance at the Site based on a site capacity to receive 7.2 MCY. Assuming the Site's capacity is reduced by about 1 MCY with the elimination of the C-Ponds, the anticipated period of material acceptance could range from about three to seven years for Restoration Alternatives B and D depending on the amount of material delivered to the Site. For Restoration Alternative C, the anticipated period of material acceptance could range from three to six years. In all alternatives, sediment delivery vessels could come once a day to once every few hours. Decommissioning of equipment and onsite structures would be up to about four months, with a few weeks to demobilize the remaining equipment.

Following demobilization of the dredged material placement equipment, the restoration project as described in the Restoration Preliminary Design Memorandum (AECOM 2016a) would be performed. This work includes channel excavation, levee lowering and raising, habitat island creation, internal and external levee breaching, water control structure removal/modification, habitat transition zone construction, and recreational trail and bridge construction. The final equipment and sequencing will be developed by the selected contractor based on the contractor's detailed work plan.

The Phase 2 Eden Landing Restoration Project is anticipated to have a final EIR/S in the fall of 2017. Preliminary design of the restoration elements was completed in 2016. Preliminary design of dredged material placement, permitting of the selected project, and 100% design would follow in 2018 and the beginning of 2019. Construction could begin as early as the summer of 2019.

5. References

AECOM 2016a. Southern Eden Landing Restoration Preliminary Design Memorandum. October 2016.

AECOM 2016b. San Francisco Bay Tidal Datums and Extreme Tides Study Final Report. February 2016.

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Moffatt & Nichol (M&N) 2015. South Bay Salt Pond Restoration Project. Beneficial Reuse Feasibility Study. Prepared for the State Coastal Conservancy. January 2015.

NMFS 2015. National Marine Fisheries Service. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion. Long Term Management Strategy For the Placement of Dredged Material in the San Francisco Bay Region. July 9, 2015.

NOAA 2016. National Oceanic and Atmospheric Administration. Tides and Currents Datums webpage. http://tidesandcurrents.noaa.gov/

RWQCB 2010. California Regional Water Quality Control Board San Francisco Bay Region Order No. R2-2010-0108 Waste Discharge Requirements and Water Quality Certification for: U.S. Fish and Wildlife Service Cullinan Ranch Restoration Project.

RWQCB 2012. California Regional Water Quality Control Board San Francisco Bay Region Order No. R2-2012-0087 Updated Waste Discharge Requirements, Water Quality Certification, and Rescission of Order No. 00-061 for: Montezuma Wetlands LLC, Montezuma Wetlands Restoration Project, Solano County.

APPENDIX F

SIGNED MEMORANDUM OF UNDERSTANDING

UNITED STATES FISH & WILDLIFE SERVICE AND THE CALIFORNIA STATE HISTORIC PRESERVATION OFFICER

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MEMORANDUM OF AGREEMENT
BETWEEN THE U.S. FISH & WILDLIFE SERVICE
AND THE
CALIFORNIA STATE HISTORIC PRESERVATION OFFICER
REGARDING
THE SOUTH BAY SALT POND RESTORATION PROJECT
INCLUDING RESTORATION OF FORMER INDUSTRIAL SALT PONDS TO TIDAL SALT MARSH AND OTHER WETLAND HABITATS, INCLUDING THE FORMER SALT WORKS SITES WITHIN THE ALVISO UNIT ON THE DON EDWARDS SAN FRANCISCO BAY NATIONAL WILDLIFE REFUGE AND CALIFORNIA DEPARTMENT OF FISH AND GAME'S, EDEN LANDING ECOLOGICAL RESERVE; ALAMEDA AND SANTA CLARA, COUNTIES, CALIFORNIA

WHEREAS, the South Bay Salt Pond Restoration Project (SBSPRP) is an extensive project that includes approximately 20,000 acres of former industrial salt pond complexes along the shoreline of the San Francisco Bay, south of the San Mateo Bridge. The salt ponds were part of a vast system of salt ponds previously operated by Cargill Salt. In 2003 the Alviso and West Bay salt pond complexes were transferred to the U.S. Fish and Wildlife Service and included in the Don Edwards San Francisco Bay National Wildlife Refuge (DESFBNWR). The Baumberg salt pond complex, now knows as the Eden Landing Ecological Reserve, is owned and managed by the California Department of Fish and Game (CDFG). The SBSPRP is partially on federal property, will require a federal permit, and will use federal funding. Restoration activities will change the salt ponds to salt marsh which alters their function and open water appearance, both of which are contributing characteristics of the historic landscape and has the potential to affect a historic property (Undertaking) (Figure 1 in Attachment 1); and

WHEREAS, the U.S. Fish and Wildlife Service (USFWS) has determined, in consultation with the California State Historic Preservation Officer (SHPO), that the former salt works and evaporative salt industry ponds associated with the Alviso Unit of the DESFBNWR and property owned and managed by the CDFG known as the Eden Landing Ecological Reserve (ELER) are eligible for inclusion in the National Register of Historic Places under Criteria A (historic property) as historic landscapes, including the six eligible archaeological sites identified within the ELER as defined in 36 CFR Part 800, the regulation implementing Section 106 of the National Historic Preservation Act (NHPA) of 1966 (16 U.S.C. 470f). The SHPO concurred with the evaluation on October 12, 2010; and

WHEREAS, the USFWS has determined that altering the former industrial salt ponds in the Alviso and ELER complexes by replacing the controlled flow of water with a tidally influenced marsh environment will adversely affect the character defining elements of the ponds by affecting their function and appearance and may adversely affect the archaeological sites by changing the water system (Adverse Effect); and

WHEREAS, the USFWS has consulted with the SHPO pursuant to 36 CFR Part 800 regarding the Undertaking's adverse effects on historic properties and the USFWS has notified the Advisory Council on Historic Preservation (Council) of the adverse effect pursuant to 36 CFR 800, implementing Section 106 of the National Historic Preservation Act, as amended, 16 U.S.C. 470f (NHPA). The Council has declined to participate in a letter dated December 3, 2010; and

WHEREAS, a portion of the project is on land owned by the CDFG. The USFWS and CDFG have consulted regarding this project and have executed a Memorandum of Understanding (MOU) that determines that the USFWS is the lead agency and defines the relationship and responsibilities of each agency. The CDFG is a consulting party with obligations that are associated with the resolution of the adverse effect, thus they have been invited to concur in this MOA (800.6(c)(3); and

WHEREAS, the USFWS has consulted with interested parties and tribes. The SBSPRP includes a wide variety of partners and agencies. Communication with and input from stakeholders in the community and interested organizations continues to be achieved using public meetings and workshops, a website, a newsletter, press releases, and presentations, to ensure that the public remains informed about the project status and is involved in the planning and implementation process. The USFWS consulted with tribes and tribal members provided by the California Native American Heritage Commission. Consultation was also accomplished through contacts during the public outreach efforts. The Hayward County Historical Society and parties that expressed an interest will continue to be updated as the project is implemented; and

NOW, THEREFORE, the USFWS and the SHPO agree that if the Undertaking proceeds, the Undertaking shall be implemented in accordance with the following stipulations in order to take into account the effects of the Undertaking on a historic property and to satisfy the requirements of Sections 106 and 110(b) of the NHPA, and further agree that these stipulations shall govern the Undertaking and all of its parts until this Memorandum of Agreement (MOA) expires or is terminated.

STIPULATIONS

The USFWS and by extension through the MOU, CDFG shall ensure that the following stipulations are implemented:

I. Area of Potential Effect

A. The Area of Potential Effect (APE) is depicted in Figures 2 and 3 (Attachment 1) and includes the Alviso Historic District and ELER Historic District that are located in the southern end of San Francisco Bay. The ELER encompasses 6612 acres divided into 23 ponds. The Alviso Unit encompasses 9677 acres divided into 28 ponds. Within the APE, activities will focus on restoring the salt ponds to naturally functioning, tidally influenced salt marsh which requires breeching levees and opening ponds to the tides, building levees between the newly restored tidal marsh areas and local communities, and restoring habitat features. Additionally, archaeological resources within the ELER Historic Landscape that are contributing elements of the landscape may be affected by fluctuating water levels

B. If modifications to the Undertaking take place subsequent to the execution of this MOA that necessitate the revision of the APE, USFWS will consult with the SHPO to facilitate mutual agreement on the subject revisions. If USFWS and SHPO cannot reach an agreement, then the parties will resolve the dispute in accordance with Stipulation III.B of this document. Should the USFWS and SHPO reach mutual agreement on the proposed revisions the USFWS will submit a final map of the revision no later than 30 days following such an agreement.

II. Mitigation of Project Effects to Historic Properties

The USFWS has consulted with the SHPO and has developed a historic properties treatment plan (Attachment 2) that will be implemented, prior to and during the SBSPRP. The mitigation plan follows the *Secretary of the Interior's Standards for the Treatment of Historic Properties* and includes the following elements:

A. Recordation of Historic Properties: The Alviso and ELER salt pond complexes are considered historic landscape districts. The USFWS consulted with the Regional Coordinator for the HALS program at the National Park Service regarding the requirements for photo documentation and recordation of the landscape that is commensurate with the level of adverse effect. NPS-HALS program staff responded with guidance on the requirements for recordation, therefore all recordation and photography documentation requirements will be in accordance with this guidance. The HALS documentation will be submitted to the NPS for transmittal to the Library of Congress. Copies of the HALS documentation will also be maintained at the DESFBNWR, USFWS Cultural Resources Team office, CDFG, and the Hayward County Historical Society.

B. Interpretation of Solar Salt Industry: Interpretive materials will be developed, including at least one interpretive panel and pamphlet that describes the solar salt industry process and landscape features that were associated with the evaporative salt industry. A draft of the interpretive materials will be shared with SHPO and interested parties for review and comment. The panel will be installed within the ELER. The timeline for completing the interpretive materials is based on the pace of the restoration project but is estimated to be within 5 years of the date of this agreement

C. Archaeological Resources: Archaeological resources within the ELER that are contributing elements of the historic landscape will be treated according to the Treatment Plan (Attachment 2). Generally, sites will be protected *in situ*.

However, sites that are affected by fluctuating water levels will be documented with photography, GPS mapping, and limited subsurface testing of features and selective surface collection. The sites will then be monitored once a year at a low tide event or summer dry season for five consecutive years from the signing of this MOA. Monitoring will continue until the restoration work is completed. No additional affects are anticipated from the restoration work once the salt marsh habitat has been reestablished, at that point monitoring will cease. If any site appears to be accessible to vandals or the structure of the site changes due to vandalism, then a more substantial data collection procedure will be instituted. There is also the potential for new discoveries to occur and these will be managed by recordation and data collection procedures outlined in the Historic Properties Treatment Plan (Attachment 2).

III. Administrative Provisions

A. Standards

1. Professional Qualifications: All activities prescribed in Stipulations I and II of this MOA shall be carried out under the authority of USFWS by or under the direct supervision of a person or persons meeting at a minimum the *Secretary of the Interior's Professional Qualifications Standards* (48 FR 44738-3, September 29, 1983) in the appropriate disciplines.

B. Dispute Resolution

1. Should the SHPO object to the manner in which the terms of this MOA are implemented, to any action carried out or proposed with respect to implementation of the MOA, or to any documentation prepared in accordance with and subject to the terms of this MOA, the USFWS shall immediately consult with the SHPO for no more than 30 days to resolve the objection. If the objection is resolved through such consultation, the action subject to dispute may proceed in accordance with the terms of that resolution. If, after initiating such consultation, the USFWS determines that the objection cannot be resolved through consultation, the USFWS shall forward all documentation relevant to the objection to the Council, including the USFWS proposed response to the objection, with the expectation that the Council will within 45 days after receipt of such documentation:

    a. Advise the USFWS that the Council concurs in the proposed response to the objection, whereupon the USFWS will respond to the objection accordingly; or

b. Provide the USFWS with recommendations, which the USFWS will take into account in reaching a final decision regarding its response to the objection; or

c. Notify the USFWS that the objection will be referred for comment to the Council pursuant to 36 CFR 800.7, and proceed to refer the objection and comment. The USFWS shall take the resulting comment into account in accordance with 36 CFR 800.7(c)(4) and Section 110 (1) of the NHPA.

2. Should the Council not exercise one of the above options within 45 days after receipt of all pertinent documentation, the USFWS may assume the Council's concurrence in its proposed response to the objection.

3. The USFWS shall take into account any Council recommendation or comment provided in accordance with this stipulation with reference only to the subject of the objection. The USFWS responsibility to carry out all actions under this MOA that are not the subjects of the objection will remain unchanged.

4. At any time during implementation of the measures stipulated in this MOA should an objection pertaining to such implementation be raised by a member of the public, the USFWS shall notify the SHPO and take the objection into account, consulting with the objector and, should the objector so request, with the SHPO to address the objection. The time frame for such consultation shall be reasonably determined by the USFWS.

5. The USFWS shall provide to the SHPO, the Council when Council comments have been issued hereunder, and any parties that have objected pursuant to paragraph B.4., above, with a copy of its final written decision regarding any objection addressed pursuant to this stipulation.

6. The USFWS may authorize any action subject to objection under this stipulation to proceed after the objection has been resolved in accordance with the terms of this stipulation.

C. Amendments

Either signatory may propose that this MOA be amended, whereupon the signatories will consult for no more than 30 days to consider such amendment. The amendment process shall comply with 36 CFR 800.6(c)(1) and 800.6(c)(7). This MOA may be amended only upon the written agreement of the signatories. If it is not amended, this may be terminated by either signatory in accordance with Stipulation D., below.

D. Termination

1. If this MOA is not amended as provided for in paragraph C. of this stipulation, or if

either signatory proposes termination of this MOA for other reasons, the signatory proposing termination shall in writing notify the other signatory, explain the reasons for proposing termination, and consult with the other signatory for at least 30 days to seek alternatives to termination. Should such consultation result in an agreement on an alternative to termination, then, the signatories shall proceed in accordance with the terms of that agreement.

2. Should such consultation fail, the signatory proposing termination may terminate this MOA by promptly notifying the other signatory in writing. Termination hereunder shall render this MOA null and void. If this MOA is terminated hereunder and if the USFWS determines that the Undertaking will nonetheless proceed, then the USFWS shall either consult in accordance with 36 CFR 800.6 to develop a new MOA or request the comments of the Council pursuant to 36 CFR Part 800.

E. Duration of the MOA

Unless terminated pursuant to paragraph D. of this MOA, or unless it is superseded by an amended MOA, this MOA will be in effect until the USFWS, in consultation with the SHPO, determines that all of its stipulations have been satisfactorily fulfilled. The duration of this MOA will not exceed seven (7) years, because of the restoration phases that require up to five years to complete, unless the signatory parties agree to an extension. Upon a determination by USFWS that all of the terms of this MOA have been satisfactorily fulfilled, this MOA will terminate and have no further force or effect. The USFWS will promptly provide the SHPO and CDFG with written notice of its determination and of the termination of the MOA. Following provision of such notice, this MOA will be null and void.

F. Effective Date

This MOA will take effect when it has been executed by both the USFWS and the SHPO. Execution of this MOA by the USFWS and the SHPO, its transmittal by the USFWS to the Council in accordance with 36 CFR 800.6(b)(1)(iv) and subsequent implementation of its terms, shall evince pursuant to 36 CFR 800.6(c), that this MOA is an agreement with the Council for purposes of Section 110(1) of the NHPA, and shall further evince that the USFWS has afforded the Council an opportunity to comment on the Undertaking and its effects on historic properties, and that the USFWS has taken into account the effects of the Undertaking on historic properties. The CDFG is a concurring party to the MOA as represented by their signature.

U.S. FISH and WILDLIFE SERVICE

By: G. Mendel Stewart Date: 5/25/12

Mendel Stewart, Project Leader, San Francisco Bay NWR Complex, Region 8

CALIFORNIA STATE HISTORIC PRESERVATION OFFICER

By: milford wayne donaldson Date: 28 JUN 2012

Mr. Milford Wayne Donaldson, FAIA: California State Historic Preservation Officer

Concurring Party
CALIFORNIA DEPARTMENT OF FISH AND GAME

By: Scott Wilson Date: 6/12/12

Mr. Scott Wilson, Acting Regional Manager, Bay Delta Region

Attachments:
Attachment 1: Figure 1. Project Location Map.
Figure 2. Alviso Unit APE.
Figure 3. ELER APE.

Attachment 2: Historic Properties Treatment Plan

South Bay Salt Pond Restoration Project

Alviso Unit APE Map

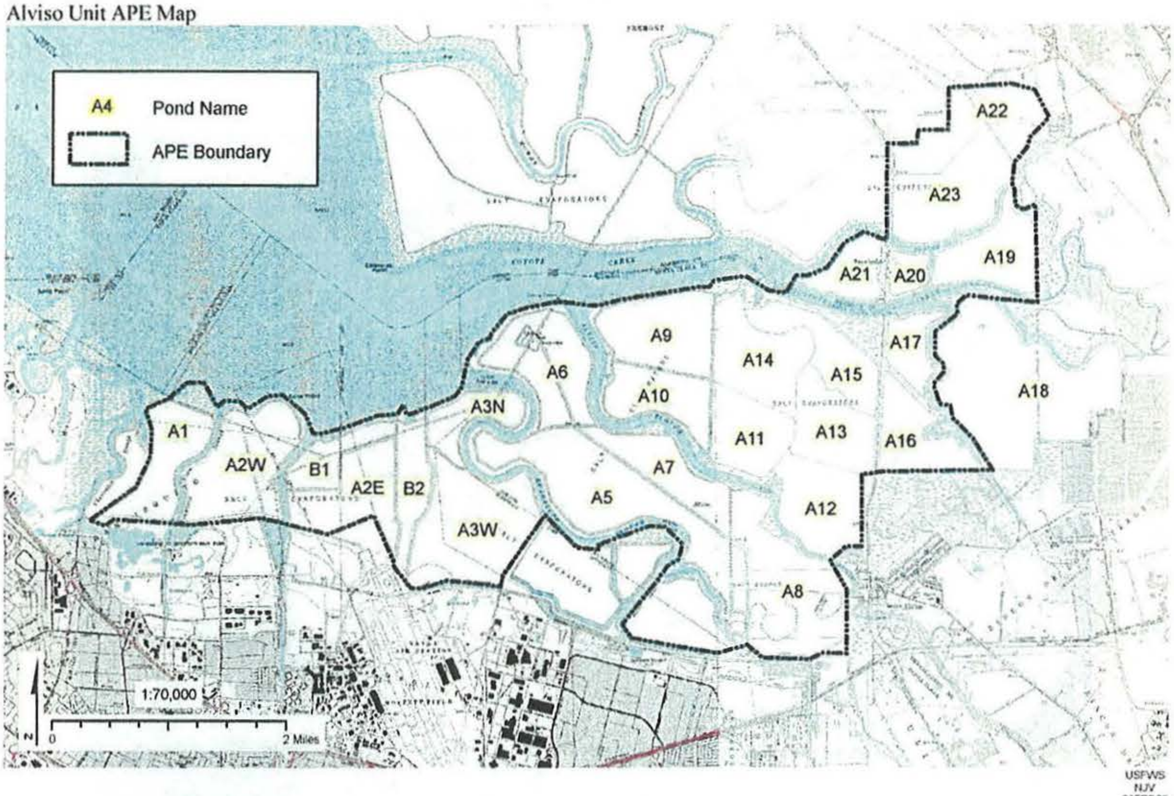

Figure 2. Alviso Unit APE.

South Bay Salt Pond Restoration Project
Eden Landing Unit APE Map

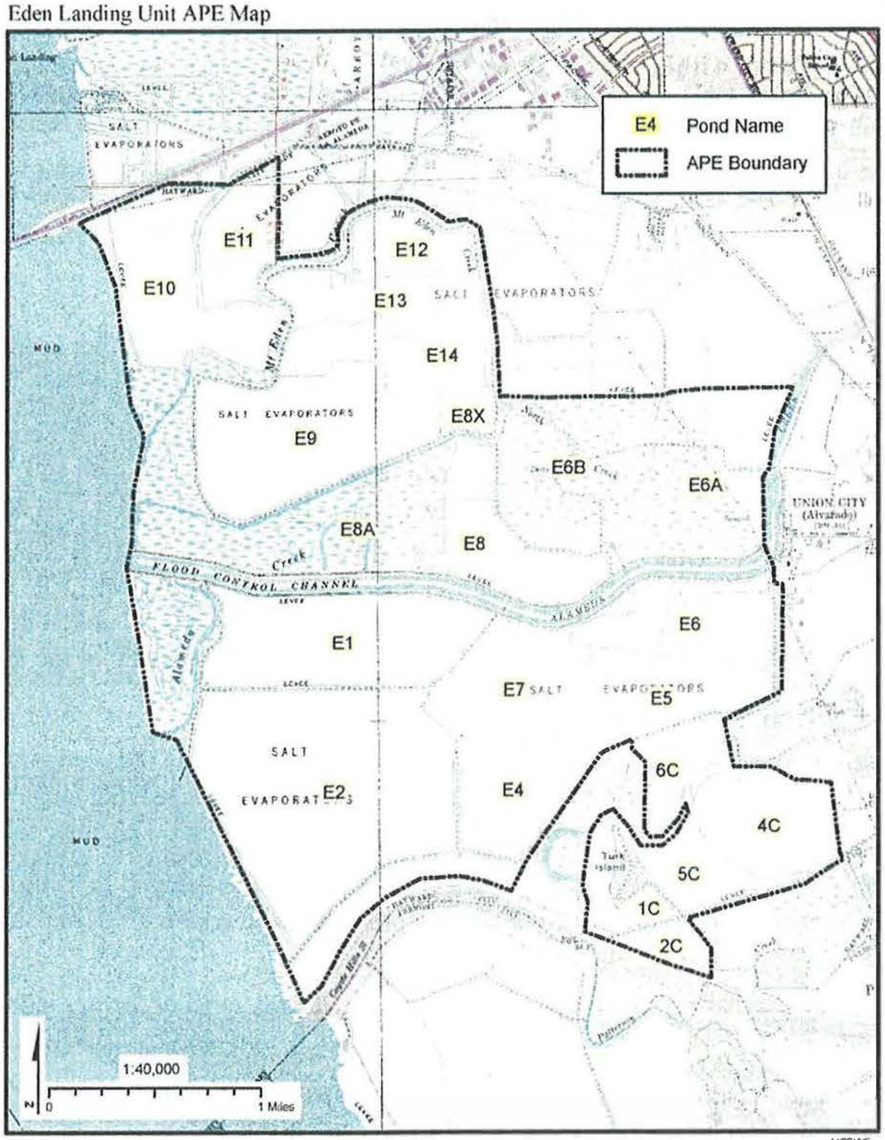

Figure 3. ELER APE.

ATTACHMENT 2.

U.S. Fish and Wildlife Service Project #FWS040721A
Historic Properties Treatment Plan
for the
Salt Works within the South Bay Salt Pond Restoration Project at the
Alviso Unit, Don Edwards San Francisco Bay National Wildlife Refuge,
and the
Eden Landing Ecological Reserve, California Department of Fish and Game
Alameda and Santa Clara counties, California
January 14, 2011/revised May 4, 2012

Introduction

The South Bay Salt Pond Restoration Project (SBSPRP) will restore the former industrial salt production ponds in South San Francisco Bay to a more natural mix of tidal wetland habitats and managed ponds. The restoration comprises former salt ponds located at the southern end of San Francisco Bay. The SBSPRP encompasses property managed by the U.S. Fish and Wildlife Service (USFWS) and the California Department of Fish and Game (CDFG). The agencies are working together along with the California State Coastal Conservancy (Conservancy) and U.S. Army Corps of Engineers (USACE) and other project partners. The SBSPRP is composed of three noncontiguous units, including the Eden Landing Ecological Reserve (ELER or Eden Landing) on the east side of the Bay near the San Mateo bridge; the Alviso unit at the southern end of the bay; and the West Bay-Ravenswood unit located on the west side of the Bay near the Dumbarton Bridge (Figure 1).

In 2010 the salt works at the Alviso Unit and ELER were evaluated and determined to be eligible to the National Register of Historic Places (NRHP) as historic landscapes that encompass a range of condensing ponds, archaeological resources, and features associated with solar salt production and processing. This historic properties treatment plan has been developed to mitigate for the adverse effects associated with converting the salt ponds back to a native salt marsh habitat.

Undertaking

The SBSPRP is an extensive project that includes nearly 20,000 acres of former industrial salt ponds that were part of a vast system of salt ponds previously operated by Cargill Salt. The USFWS is the lead agency for complying with the National Historic Preservation Act. The Alviso Unit is managed by the USFWS and the ELER salt ponds are owned and managed by the CDFG. The SBSPRP is partially on federal property, will require a federal permit, and will use federal funding. Restoration activities will change the salt ponds to salt marsh which alters their function and open water appearance, both of which are contributing characteristics of the historic landscape and has the potential to affect a historic property

South Bay Salt Pond Restoration Project

Project Overview and APE Map

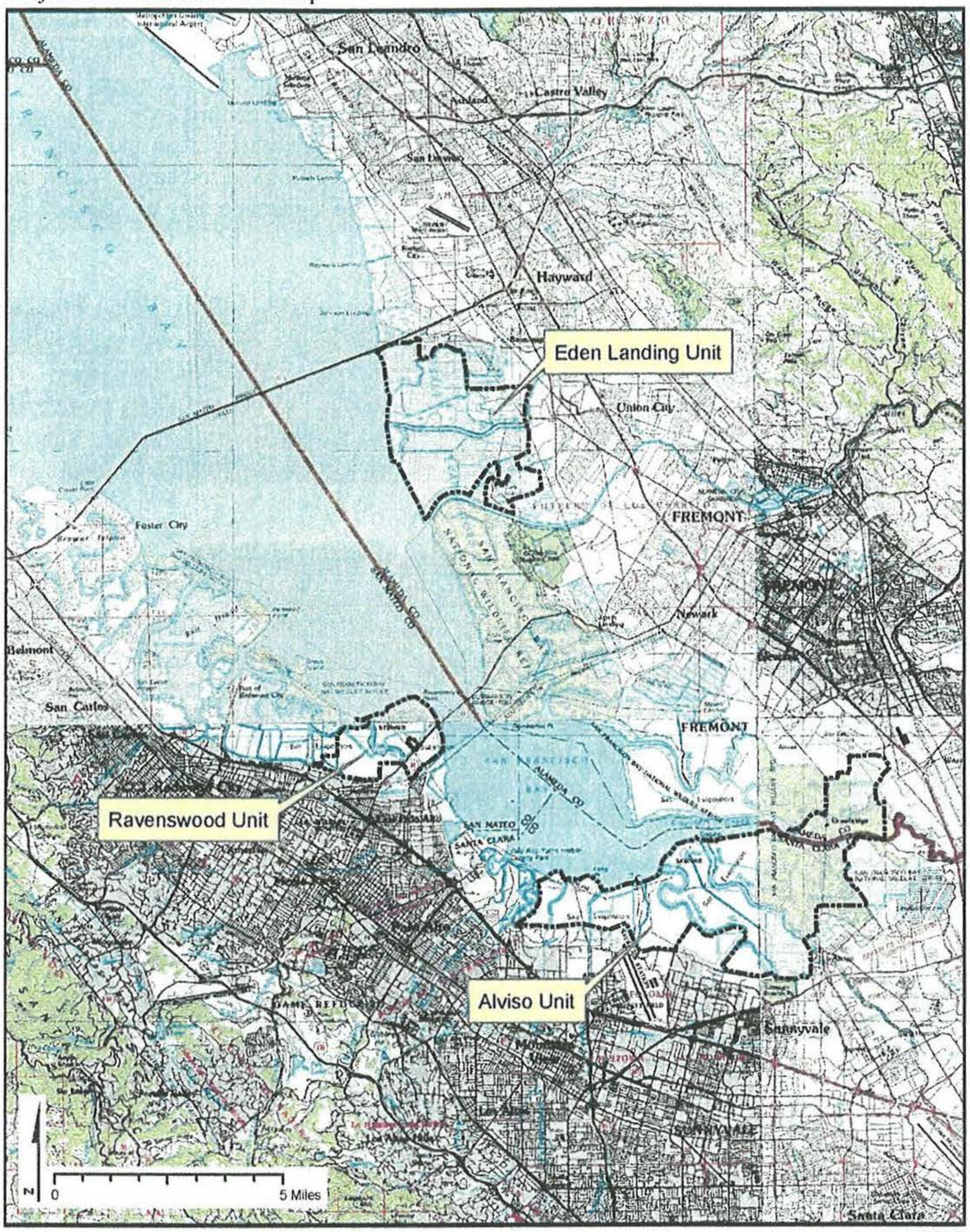

Figure 1. Project location map.

Area of Potential Effects
The Area of Potential Effect (APE) is depicted on Figure 1 and includes the Alviso Historic District and ELER Historic District that are located in the southern end of San Francisco Bay (See Figures 2 and 3). The ELER encompasses 6612 acres divided into 23 ponds, in Alameda County. The Alviso Unit encompasses 9677 acres divided into 28 ponds, within Alameda and Santa Clara counties. Within the APE, activities will focus on restoring the salt ponds to naturally functioning, tidally influenced salt marsh which requires breeching levees and opening ponds to the tides, building levees between the newly restored tidal marsh areas and local communities, and restoring habitat features. Additionally, archaeological resources within the ELER Historic Landscape that are contributing elements of the landscape may be affected by fluctuating water levels

The Alviso Unit is drained, from east to west, by Mud Slough, Coyote Creek, Alviso Slough, Guadalupe Slough, Stevens Creek, Mtn View Creek, and Charleston Slough. The boundaries of the Alviso Salt Works Historic Landscape are established by legal ownership and natural features. The Eden Landing Unit is drained by Mt. Eden, North, and Old Alameda Creeks, the Alameda Federal Flood Control Channel marks the southern boundary of the district. The boundaries of the Eden Landing Salt Works Historic Landscape are established by legal ownership and natural features.

Alviso Salt Works Eligibility to the National Register of Historic Places:
The Alviso Salt Works Historic Landscape meets eligibility standards under criterion A because it is associated with the twentieth century period of industrialization when one operator created a vast network of evaporation ponds to produce the large amount of brine necessary to meet production demands. The SHPO has concurred with the eligibility determination (Donaldson to Mruz, October 12, 2010). Interpreting the Alviso Salt Works landscape offers a different view of the salt industry than the Eden Landing area. The Alviso Salt Works clearly reflects the industrial zenith and development of huge tracks of salt marsh for salt brine production. The large exterior levees and vast ponds are the signature features of the Alviso Unit solar salt landscape.

Alviso Salt Works Historic Properties Description
The history of solar salt production in Alviso dates from the 1920s. In Alviso, the salt industry did not develop from small, family-owned salt farms, but rather, began as an industrial-level enterprise. Only two salt companies, the Alviso Salt Company (that included Continental Salt and Chemical Company) and Schilling's Arden Salt Company are associated with the Alviso unit. Both companies appear to have built levees, developed salt ponds, and harvested salt from these lands during the 1920s. Arden acquired Alviso Salt in 1929, including its plant near the town of Alviso. Leslie Salt became the sole operator after 1936, until Cargill's acquisition in 1978 (EDAW 2005:14).

The Alviso Salt Works is characterized by vast evaporation ponds, large levees, and robust water control devices. The pattern of spatial organization has changed only slightly from the 1950s when the operation was controlled by the Leslie Salt Company. The Alviso Unit was developed for brine production there were no crystallizing ponds or processing plants within the unit.

One archaeological site, one townsite, and a bridge have been recorded within the Alviso Salt Works, none of which are related to salt production (Table 1). Only two of the three resources within the Alviso Salt Works are potentially eligible properties but they do not contribute to the Alviso Salt Works Historic Landscape. The town of Drawbridge (P-01-003291) and site CA-ALA-338 (P-01-002057) have been reviewed but no formal determination of eligibility has been completed. Site CA-ALA-338 was originally noted in 1909 by Nels C. Nelson as a shell-midden mound site. The site location has been re-visited, but no evidence of the site was identified (Busby 2008; Valentine 2009). Site CA-ALA-338 appears to have been completely destroyed by salt pond development.

The town of Drawbridge (P-01-003291) was a small community of cabins that were used for duck hunting and weekend retreats. The isolated location also attracted bootleggers, gamblers, and prostitution in the 1920s and 1930s. Leslie's salt plant diked off parts of the east and west marshes at the southern end of San Francisco Bay, leaving Drawbridge in isolation and causing the ground to subside (Morrow 1984; EIS/EIR 2007 Report). Environmental conditions for the island have not improved since the 1940s and most of the cabins are in serious decline, are threatened by vandalism, or are sinking into the marsh. The community was essentially abandoned by the 1950s with the last resident staying until 1978 when the Don Edwards San Francisco Bay NWR was established. Drawbridge is within the refuge boundaries but a corridor through the center of the island and town is on land owned by the Southern Pacific Railroad and private entities. Access to the island requires permission from the Southern Pacific Railroad to cross on their tracks. Because the Service does not own or manage the primary corridor of the town which is within 50 ft of the tracks along with safety concerns with the access on an active railroad track, the deteriorated condition of the buildings, and the problem of continued subsidence of the island have sidelined a proactive preservation approach and implementation of a 1980s plan to open the site to visitors (Morrow 1984:136-137).

The Coyote Slough bridge was constructed in 2001 as a replacement of an earlier bridge and is ineligible to the NRHP.

Table 1. Recorded cultural resources within the Alviso Works Historic Landscape.

Trinomial Site No.	Primary Site No.	Treatment	Eligibility To the NRHP	Description
CA-ALA-338	P-01-002057	N/A	Unevaluated	Disturbed remnants of shell midden; no surface evidence.
	P-01-003291	Monitor	Unevaluated	Drawbridge townsite
	P-01-010205/P-43-001578	N/A	No	Coyote Slough Bridge-installed in 2001.

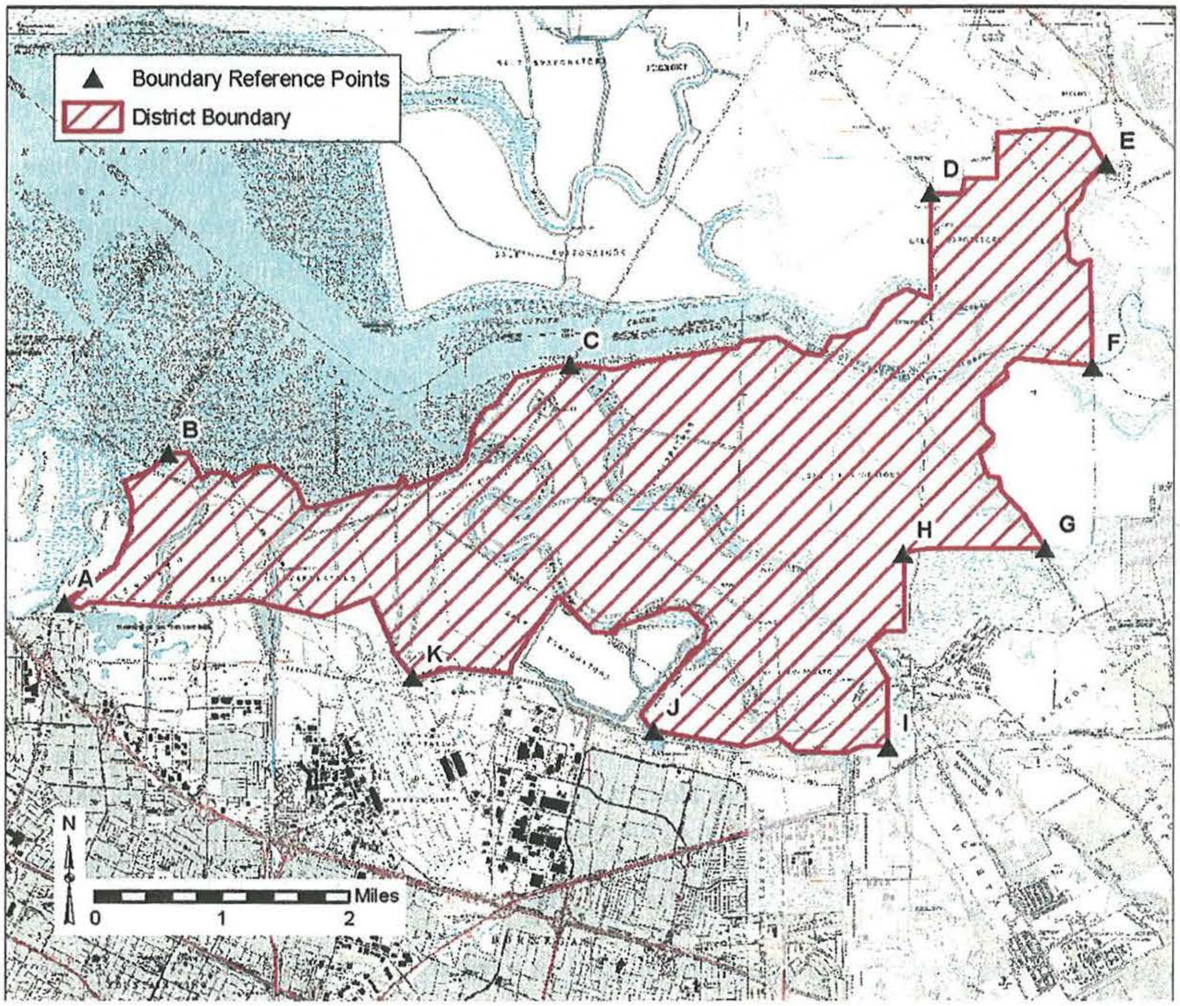

Figure 2. Alviso Salt Works Historic Landscape – Project APE.

Eden Landing Salt Works Eligibility to the National Register of Historic Places:
The Eden Landing Salt Works meets eligibility criteria A and D as defined by the National Register of Historic Places (NRHP) as a historic landscape. The SHPO has concurred with the eligibility determination (Donaldson to Mruz, October 12, 2010). Character defining elements of the historic landscape are the perimeter levees, interior pond divisions, archaeological sites associated with the family-owned processing plants and landings, and the Archimedes screw pumps. The overall Eden Landing Salt Works Historic Landscape provides an opportunity to interpret the evolution of the solar salt industry.

Eden Landing Historic Properties Description

The San Francisco Bay solar salt industry had its beginnings in the Eden Landing area. The initial salt production operations were small, family-owned parcels of less than 50 acres. There were nearly 30 different salt works located within the Eden Landing area between 1850 and 1910. One of the largest salt operations was the Union Pacific Salt Company which was in continuous production from 1872 to 1927. The Oliver Salt Company was among the few nineteenth century salt producers that continued operation into the 1920s. Between 1910 and 1930 the industry began consolidating as the market demand for salt increased beyond the capacity of the small producers. In 1930 the number of operators dropped from 28 to only five; and by the 1940s Leslie became the only major operator (EDAW 2005:14). "The Leslie-California Salt Company purchased the Oliver Salt works in 1931" (Ver Planck 1958:110). The small ponds have been altered to meet modern large-scale production needs.

Eleven cultural resources have been recorded within the Eden Landing Salt Works Historic Landscape, all of which are related to the historic period of salt manufacturing (Table 2). Four sites have been determined eligible, five sites have been determined ineligible, and one site is unevaluated. And, one architectural resource, the Archimedes Screw Windmills has been determined to be a contributing element of the Eden Landing Salt Works historic landscape.

Table 2. Recorded cultural resources within the Eden Landing Salt Pond Historic Landscape.

Trinomial Site No.	Primary Site No.	Treat ment	Eligibility To the NRHP	Description
CA-ALA-489H, -501H	P-01-000217	Monitor and data collection	Yes	Eden Landing historic shipping station (warehouses, wharves, associated developments)
CA-ALA-494H	P-01-000210	Interpret, monitor	Yes	Oliver Salt Co. piling and foundations
-	P-01-010740	Interpret, monitor	Yes	Archimedes Screw Windmills
CA-ALA-495H	P-01-000211	N/AA	No	Location of former Rocky Point Saltworks – no surface remains.
CA-ALA-496H	P-01-000212	Monitor	Yes	Pilings and foundation of former Union Pacific Salt (ca. 1872-1927)
CA-ALA-497H	-	N/A	No	Peterman's Salt Works -- no surface remains
CA-ALA-498H	P-01-214	N/A	No	Salt works, not relocated
CA-ALA-499H	P-01-215	N/A	No	Modern refuse scatter
-	PF-1	Monitor	Yes	Whisby Salt Works refuse scatter
-	P-01-010834	N/A	No	Union City Alvarado Salt Ponds
-	FWS-07-12-1	Monitor, data collection	Yes	J. Quigely Alvarado Salt Works, domestic refuse scatter

Edens Landing Salt Works Historic Landscape

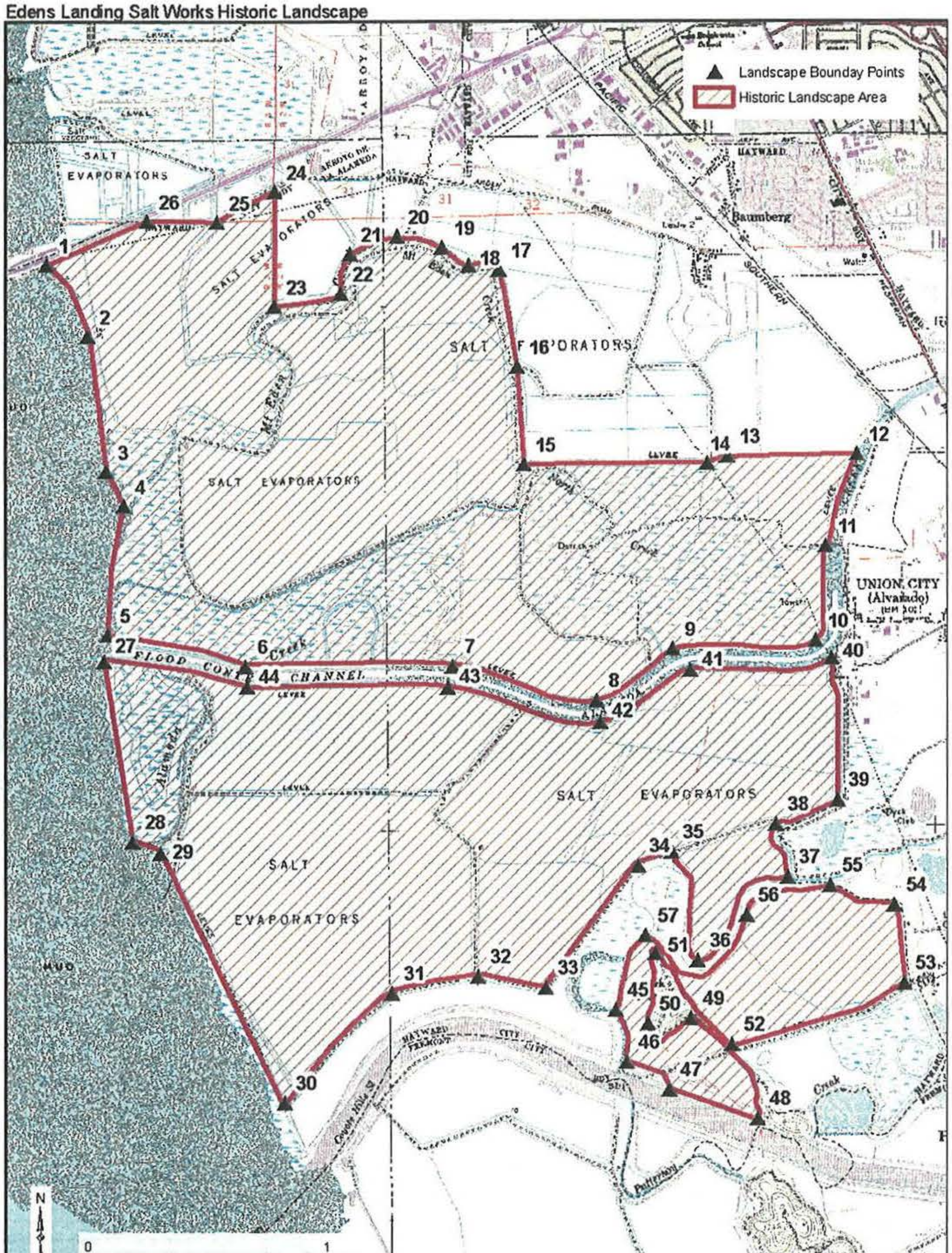

Figure 3. Eden Landing Salt Works Historic Landscape – Project APE.

Character Defining Features of the Alviso and Eden Landing Salt Works Historic Landscape

Character defining features of the Salt Works includes the landscape of levees, open-water ponds, water control structures, roads, and remnant wooden features, and archaeological sites. The initial evaporation ponds were built adjacent to the bay while secondary ponds were larger and protected from inundation from open bay water. Pickling and crystallizing ponds are relatively small and close to the salt processing plant and transportation corridor. The landscape features are engineered but lack distinctive qualities of individual workmanship or materials. The features are important because of their interrelationship and function as an evaporative salt factory. The ponds appearance of open water surrounded by earthen levees is a character defining feature.

The ELER encompasses some of the earliest salt ponds developed for salt production from the naturally suitable tidal salt marsh lands. Remnant features of the salt works of the Oliver family, the Barton family's Union Pacific Salt Works, and J. Quigley's Alvarado Salt Works are represented by archaeological sites that are historic properties. Overprinting by the modern solar salt industry has altered the nineteenth century landscape, raising levees, combining small ponds into much larger evaporation ponds, and changing the flow of water. The levees, water control structures, intakes, and pump stations have all been altered over the years to accommodate the increased production capacity, yet the distinctive pond landscape and remnant features reflect the evolving solar salt production industry.

Assessment of Effects to the Alviso and Eden Landing Salt Works Historic Landscape

The assessment of effects is determined by applying the criteria of adverse effects as provided in 36 CFR 800.5(ii).

> *Alteration of a property, including restoration, rehabilitation, repair, maintenance, stabilization,. . . that is not consistent with the Secretary's standards for the treatment of historic properties and applicable guidelines.* The *Secretary's Standards* suggest that changes to historic properties should be minimal, follow the original plan, and should be compatible with existing materials or function.

The proposed modifications to remove salt works ponds from salt production will change their function and open water appearance, which are contributing characteristics of the historic landscape. The proposed restoration activities will alter these character defining features of the property which contributes to its eligibility and is an adverse effect as per 36 CFR 800.5(2)(iv). Additionally, altering the water flow from a controlled level to a tidally influenced dynamic flow may affect the six eligible sites within the Eden Landing Salt Works. Only the salt pond landscape will be affected by the restoration activities in the Alviso Salt Works.

Mitigation to resolve the adverse effects of the project activities is directed toward the salt pond landscape and six sites in the ELER.

Treatment Plan Actions
This Historic Properties Treatment Plan will affectively mitigate the effects of the SBSPRP. The USFWS and CDFG will ensure implementation of the treatment plan to include:

1) Documenting the salt works landscape based on consultation with the NPS Regional Coordinator for the Historic American Landscapes Survey (HALS);

2) Submitting the HALS documentation to NPS who will transmit it to the Library of Congress. Additionally, copies of the HALS documentation will be maintained at the DESFBNWR, USFWS Cultural Resources Team office, CDFG, and the Hayward Historical Society;

3) Protecting archaeological resources *in situ* within the ELER that are contributing elements of the historic landscape. Sites that are affected by fluctuating water levels will be documented with photography, GPS mapping, and limited subsurface testing of features and selective surface collection. The sites will then be monitored once a year at a low tide event or summer dry season for five consecutive years from the signing of this MOA. Monitoring will continue until the restoration work is completed. No additional affects are anticipated from the restoration work once the salt marsh habitat has been reestablished, at that point monitoring will cease. If any site appears to be accessible to vandals or the structure of the site changes due to vandalism, then a more substantial data collection procedure will be instituted.

4) Monitoring sites will include a site visit by a qualified archaeologist who will prepare a brief condition assessment report with photo-documentation of each site. Photographs will be taken from set photo points, each year, in order to trace any changes to the sites. Photographs will be maintained by the USFWS Cultural Resources Team (CRT). The CRT will evaluate the photographic record annually to provide site protection recommendations to the land managing agency. Reports will be archived with project materials at the CRT office.

5) Developing interpretive materials to be installed within the ELER that introduces the story of evaporative salt production in the San Francisco Bay region, including a boardwalk and interpretive panel at the Oliver Salt Works and Archimedes Screw Windmills.

Summary and Resolution of Adverse Effect
The mitigation measures presented in this Historic Properties Treatment Plan and stipulated in the Memorandum of Agreement will resolve the adverse effect of the South Bay Salt Pond Restoration Project.

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APPENDIX G

PUBLIC ACCESS AND RECREATION RESOURCES TECHNICAL APPENDIX

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This Appendix provides a summary of the recreation and public access features associated with the South Bay Salt Pond (SBSP) Restoration Project, Phase 2 Eden Landing Ecological Reserve (ELER) area actions, review of applicable plans and policies of regulatory agencies and project stakeholders, evaluation of trail use demand, and identification of key components and design guidelines for recreation and public access facilities that may be completed as part of this project, including strategies for design consistent with stakeholder and regulatory requirements. The project impacts associated with recreation and public access features are presented in Chapter 3.6, Recreation Resources, of the main text.

This Appendix contains information on the following components:

- Regulatory Framework;
- Existing Recreation and Public Access Facilities;
- Recreation Regulatory Permit Requirements;
- Phase 1 Recreation and Public Access Features;
- Phase 2 Recreation and Public Access Alternatives;
- Projected Trail Use; and
- Recreation and Public Access Design Guidelines.

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1. INTRODUCTION

A primary goal of the South Bay Salt Pond (SBSP) Restoration Project is to provide recreation and public access. The vision of the project is to help establish an interrelated trail system, provide wildlife viewing and interpretative opportunities, create small watercraft launch points, and allow for waterfowl hunting.

Phase 1 actions at Eden Landing included identification, design and implementation of trails and other public improvements at locations within each pond complex. This included several miles of new trails, interpretive features, and a kayak launch that were added to the northern half of the Eden Landing Ecological Reserve (ELER or Reserve).

Recreation and public access features to be evaluated as part of Phase 2 Action Alternatives, as well as information regarding uses in the surrounding vicinity were collected through several methods, including: stakeholder meetings and associated project information presentations; review of Geographic Information Systems (GIS) data compiled for this project; personal communications; site tours; research and review of existing plans, policies, regulations, codes, and reports; and baseline information contained in the SBSP Restoration Project Initial Stewardship Plan (ISP) and the SBSP Restoration Project Recreation and Public Access Phase I Existing Conditions Report, which is incorporated by reference.

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2. PHYSICAL SETTING

The Phase 2 project area includes the ponds in the southern half of the Reserve. All of the Eden Landing pond complex ponds are owned and managed by the California Department of Fish and Wildlife (CDFW) as part of the Reserve. In between some of the CDFW-owned lands, the Alameda County Flood Control and Water Conservation District (ACFCWCD) owns a stormwater channel, a stormwater detention basin, and a section of existing high marsh. There are also some private inholdings – including ponds, levees, and other lands –owned by Cargill. To the east, there are other parcels and facilities owned by ACFCWCD, Union Sanitary District, a private landfill operation company, the city of Union City and a mix of other private owners. Some of these lands may be considered for placement of public access facilities as part of Phase 2 actions.

Most of the recreation and public access facilities would be located on existing levees on or adjacent to the Phase 2 area, and would be located on lands owned by CDFW, Cargill, and/or Alameda County.

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3. REGULATORY SETTING

A detailed discussion of the regulatory framework for the SBSP Restoration Project area was provided in the project's Recreation and Public Access Existing Conditions Report. A summary of updated regulations related to recreation and public access is provided herein.

The portions of the SBSP Restoration Project Phase 2 at Eden Landing that are covered in the Draft Environmental Impact Statement/Environmental Impact Report (EIS/R) are primarily governed by the applicable codes, regulations, and policies of the State of California and California Department of Fish and Wildlife (CDFW), with additional regulation by the San Francisco Bay Conservation and Development Commission (BCDC). Together, these entities compose the primary legal and managerial framework with which to guide existing and proposed recreation and public access for the SBSP Restoration Project Phase 2. In some cases, public access facilities may be implemented on lands owned and/or managed by Alameda County Flood Control and Water Conservation District (ACFCWCD), East Bay Regional Park District (EBRPD), or private entities such as Cargill, for which an agreement to operate and manage public access would be needed. Such facilities would be subject to regulatory review by other local agencies, depending on precise alignment.

Additionally, the policies and guidelines of region-wide, recreation-related plans of agencies such as the Association of Bay Area Governments (ABAG) Bay Trail and, as well as county and city recreation and public access plans also influence the development of future recreation and public access facilities on SBSP Restoration Project, Phase 2 area lands; they are also summarized herein.

3.1 Recreation-Related Review and Permits

Proposed recreation components may be subject to various state and federal regulations that would require approvals and/or permits for proposed recreation and public access development.

CDFW will be the primary internal reviewer and approver of public access and regulatory facilities implemented on its lands. There are some options for a trail route that would be placed on lands not owned by CDFW. This includes the trail connection from northern Eden Landing to the Phase 2 area, as well as portions of several trail routes at the perimeter of the Phase 2 area. For those routes to be implemented, the owners of those parcels (e.g., Cargill, Alameda County) would have to sell, donate or enter into an agreement with the lead agency or implementing entity for public access, such as easement, memorandum of understanding or license agreement, for trail construction, use and/or management. The landowners would also review and approve the designs, plans, and other details.

Depending on the location of the proposed recreation and public access facilities located outside of the ELER (e.g., those on private and/or City or County –owned lands), local and regional jurisdictions may have regulatory review authority. In addition, the lead agency may partner with local or regional groups (*e.g.*, EBRPD) to execute specific recreation-related agreements for implementation of public access components . Depending on the location and type of facilities to be built, agencies that may have review and/or permit requirements over proposed recreational components include the cities of Hayward and/or Union City, EBRPD and Alameda County.

Table G-1 provides a summary of the types of permits or agreements that may be required to carry out specific construction or maintenance activities associated with recreation and public access development.

Table G-1. Recreation-Related Regulations and Permit Summary

ADMINISTERING AGENCIES	DESIGN REVIEW/AGREEMENT/PERMIT	REGULATION
USFWS	Issues “no effect” or “not likely to affect” letter.	Consultation with USACE under Section 7
	Protects against destruction of migratory bird nests and possession of migratory bird “parts.”	Migratory Bird Treaty Act
	Federal Lead Agency	National Environmental Policy Act
CDFW	State Lead Agency; Project Applicant	California Environmental Quality Act
BCDC	Conducts reviews and issues permits for filling, dredging, substantial change in use, or development activities within the shoreline band, at the salt ponds or managed wetland areas, including recreation-related projects.	McAteer-Petris Act
RWQCB	Issues water quality certification.	Section 401 of the Clean Water Act, Porter-Cologne Water Quality Act
USACE	Issues Nationwide or Individual Permit to perform dredge or fill activities in the Waters of the U.S., including wetlands.	Section 404 of Clean Water Act
	Issues permit to create obstructions or fill of navigable waters of the U.S. (bridges)	Section 10 of the Rivers and Harbors Act of 1899
	Alteration of federal flood control levees (Bridge at ACFCC)	Section 408, Operations and Maintenance
United States Coast Guard	Navigable waterways (bridges)	Section 9, Coast & Harbors Act
EBRPD	Review if project partner for implementation: consultation regarding temporary closure of EBRPD trails, if needed	Master Plan and Trails Plan consistency
Alameda County	Construction of facilities on County-owned land (Responsible Agency)	Grading, encroachment, use agreement
Union City and/ or Hayward	Construction of facilities on land within the City limits that is not within County or State owned lands (Responsible Agency)	Grading, encroachment, use agreement possible design or recreation review

ACFCC = Alameda Creek Flood Control Channel

BCDC = San Francisco Bay Conservation and Development Commission

CDFW = California Department of Fish and Wildlife

EBRPD = East Bay Regional parks District

RWQCB = San Francisco Bay Regional Water Quality Control Board

USACE = United States Army Corps of Engineers

USFWS = United States Fish and Wildlife Service

3.2 Regulatory and Managerial Framework

CDFW is the primary land-owning and managing agency in the SBSP Restoration Project, Phase 2 area.

The San Francisco Bay Conservation and Development Commission (BCDC) will issue a permit for the project.

Union City, Alameda County and EBRPD own adjacent recreation facilities that could be built on or connect directly to trails and recreation facilities that would be constructed as part of the project. Minor encroachment permits may be needed for construction at access or connection points. In addition, there are plans, studies and policy documents for the area in and around Phase 2 of the SBSP Restoration Project that contain guidelines and recommendations for recreation and public access facilities.

3.2.1 CDFW Eden Landing Ecological Reserve

CDFW is the owner of Eden Landing, and as an ecological reserve, the Eden Landing pond complex is governed by laws and directives that guide public use and recreation on State ecological reserves. The State's ecological reserve system was authorized by the California Legislature in 1968 and is designed to conserve areas for the protection of rare plants, animals, and habitats, and to provide areas for education and scientific research. The reserves also provide recreational opportunities for wildlife viewing, outdoor education, hunting, and fishing, subject to regulation. At ELER, bicycles and horseback riding are allowed only on designated trails.

The Phase 1 Eden Landing area (northern ponds) includes the following recreation and public access facilities:

- Approximately 13,000 feet of Bay Trail, installed and managed by EBRPD. This Bay Trail segment is closed ten days per year to accommodate hunting.
- Other trails including 5,000 feet of year round trail, and 8,000 feet of seasonally closed trail, and a spur trail to the Bay shoreline. Part of the loop trail in northern Eden Landing is closed seasonally from March through mid-September to avoid wildlife disturbance.
- Accessible watercraft/kayak launch.
- Interpretive exhibits and signage.
- Benches and site furnishings.
- A paved parking area at the Eden Landing Road trailhead provides 24 parking spaces, of which one is designated for disabled use. The parking area receives consistent use, although no counts or intercept surveys of visitor use have been conducted by CDFW. Trail count data is available for this area from information collected by EBRPD and is summarized in appendix trail counts. There is an overflow parking area of equivalent size that has not been used since completion[1].

Recreation use currently within the Eden Landing Phase 2 area includes the existing Alameda Creek Regional Trail segment at the western end of the Alameda Creek Flood Control Channel (ACFCC) and limited to seasonal waterfowl hunting (currently 10 days per year with written permission from CDFW).

[1] John Krause, Pers. Comm. September 2016.
[2] Trail Count data provided by Sean Dougan, EBRPD email corresp. 9/16

In the overall ELER, CDFW allows hunting in some of the ponds within the ELER. ELER conducts ten hunt days per year, with a capacity of 100 hunters. There has been consistent participation, with 44-130 hunters during each of the 2015-2016 hunt days.

There are several existing hunting blinds dispersed throughout the Phase 2 area. Most of these blinds are remnant facilities that were constructed prior to the property becoming part of the Reserve. CDFW has an informal policy to allow waterfowl hunters to maintain the facilities, as long as they do not interfere with wildlife (such as proximity to nesting areas) but does not actively maintain the facilities. One accessible hunting blind is provided within Pond 5EC. This blind is used consistently by one to four disabled users on hunt days.

Other uses and policies related to recreational use at ELER include:

- Horses could be allowed on “designated” trails within ELER, however, no trails are formally “designated”, and no equestrian use is currently allowed.
- Bicycles are allowed only on designated trails.
- Dogs are allowed associated with hunting, and may be allowed on leash.

Relationship to Phase 2 Actions

Hunting. Since the acquisition in 2003, CDFW has permitted limited waterfowl hunting on specified dates (currently 10 days annually between November and January, providing entry by written permission from CDFW at a hunter check station) within the ELER lands in the Phase 2 area, as well as areas north of OAC that were part of the Phase 1 actions. Restoration actions within the Phase 2 area will likely change the use and configuration of the current pond system, affecting the physical area available for such recreation activities, and/or the character of the recreation experience. For instance, managed ponds provide the best conditions for waterfowl hunting, so an increase in tidal ponds may reduce the physical area available for waterfowl hunting.

Only a portion of the southern Eden Landing ponds (those within the “Open Hunt Zone”) is currently open to hunting. With implementation of Phase 2 actions, there could be a considerable loss of hunting opportunities in those managed ponds that transition to tidal marsh habitat. Managed ponds at northern Eden Landing would remain, and hunting opportunities would continue to be available in those managed ponds and existing tidal areas. North Creek marsh in northern Eden Landing, which has been open to full tidal action for approximately 10 years, has been a popular waterfowl hunting area, as are fully tidal areas within OAC, and the outboard Whale’s Tail Marsh and mouth of Mount Eden Creek areas. More isolated marsh areas are accessed by hunters using small boats or kayaks, while some remaining berms and perimeter levees provide access by foot for hunting along and within such tidal areas.

Where existing blinds are removed to facilitate Phase 2 restoration activities, installation of new blinds (to facilitate hunting) by CDFW would be consistent with Reserve policies in areas where the use or management changes. Should access to the disabled access blind cease due to project design, it would be relocated to a similar location to provide an equivalent recreation experience, where feasible and available. Relocated blinds could reduce hunter access for others or contribute to overcrowding if quotas remain the same.

Public Access. For other recreation facilities added as part of Phase 2 implementation, use and operation would be prescribed by the managing authority and regulatory permit conditions. For instance, for portions of any trail designated as Bay Trail “spine” (the primary segment connecting Pond 20B in north Eden Landing with the Alameda Creek Regional Trail), it is expected that bicycles would be allowed, and the trail would be open year-round with the exception of waterfowl hunt days. As is the current practice, the Bay Trail spine would be closed to general use on waterfowl hunt days (currently 10 days per year) to ensure public safety. In addition, hunters are allowed to drive on portions of the Bay Trail spine to reach areas more remote from the sole entry allowed at the hunter check station. Any other trails (such as those that provide point access) might be similarly subject to seasonal closures or other restrictions. Equestrian use, which is allowed on the EBRPD’s Alameda Creek Regional Trail, may be regulated or restricted within the Phase 2 area. Management of dog use would likely be coordinated with policies on adjacent non-Refuge trails that connect to any new trail constructed for Phase 2.

3.2.2 San Francisco Bay Conservation and Development Commission

BCDC is a California state planning and regulatory agency with regional authority over the San Francisco Bay (or Bay) and the Bay’s shoreline. The McAteer-Petris Act (California Government Code 66600 – 66682) is the key legal provision under California state law that preserves San Francisco Bay from indiscriminate filling and to regulate shoreline public access. The McAteer-Petris Act requires that any person or governmental agency wishing to place fill in, or to extract materials exceeding 20 dollars in value from, or make any substantial change in use of any land, water, or structure within the area of BCDC’s jurisdiction must secure a permit from BCDC.

BCDC administers the *San Francisco Bay Plan* (Bay Plan) for the long-term use of the Bay, reviews applications for projects that fall within BCDC jurisdiction. With respect to the ELER, the Bay Plan states: “The California Department of Fish and Game manages and proposes to restore 5,500 acres of salt ponds and adjacent tidal habitats added to the Eden Landing Ecological Reserve to a mix of tidal and managed pond habitats. The proposed restoration use would be in accord with Bay Plan policies and provides excellent wildlife compatible recreation opportunities.”

Salt Pond Restoration

The BCDC amended the salt pond section of the San Francisco Bay Plan on August 18, 2005. The amendment focuses on the significance of salt ponds to Bay wildlife, on the opportunity for salt ponds to be restored to tidal action, and on the need to maximize recreation and public access opportunities while avoiding significant adverse effects on wildlife. Policy 5 of the amendment addresses the need for comprehensive planning of any development proposal in a salt pond that (1) integrates regional and local habitat restoration and management objectives and plans and (2) provides opportunities for collaboration among different stakeholders (e.g., agencies, landowners, other private interests, and the public). Relevant to recreation resources is the need to incorporate provisions for recreation and public access opportunities appropriate to the land’s use, size, and existing/and/or future habitat values in the planning process.

Public Access Design Guidelines

The San Francisco Bay Plan identifies the *Shoreline Spaces: Public Access Design Guidelines for San Francisco Bay* (handbook) as a guide to siting and designing public access. The handbook, published by BCDC, functions as a design resource for development projects along San Francisco Bay’s shoreline, and includes recommendations for site planning, designing, and developing attractive and usable public access areas. The handbook also covers in-lieu public access and management issues associated with maintenance of public access areas. The handbook discusses general planning principles, and specifies that "the design of public access areas should create a sense of place based on the site's unique shoreline characteristics, the aesthetic quality of the proposed development, and the intensity and nature of the proposed use" (BCDC 2005). The handbook identifies the following seven public access objectives and provides recommendations on how these objectives could be accomplished:

- Make public access public.
- Make public access usable.
- Provide, maintain, and enhance visual access to the Bay and shoreline.
- Maintain and enhance the visual quality of the Bay, shoreline and adjacent developments.
- Provide connections to and continuity along the shoreline.
- Take advantage of the Bay setting.
- Ensure that public access is compatible with wildlife through siting, design, and management strategies.

The handbook also identifies eighteen public access improvements that could be implemented with any given project. These improvements must be implemented in a manner consistent with the San Francisco Bay Plan's public access policies, and some are required as part of the BCDC's permit decisions. Included in these improvements are stormwater management systems, roads and highways along the shoreline, designated public access parking and staging areas, in-car Bay viewing, pedestrian and bicycle bridges, gathering and seating areas, site furnishings, signage/comprehensive sign programs, methods to avoid adverse effects on wildlife, shoreline erosion control, shoreline edge treatments that provide a closeness to the water, trail design, public access across launch ramps, shoreline planting, pedestrian and vehicular railings, fishing facilities, point access at ports and water-related industrial areas, and interpretative elements and public art. Although these are not legally enforceable standards, they are advisory and aimed at enhancing shoreline access and use.

Relationship to Phase 2 Actions

BCDC would have jurisdiction in the Eden Landing Phase 2 recreation and public access components and administer permit conditions related to their authority, as appropriate. As discussed above, a BCDC permit is required for filling, dredging, and substantial change in use of land, water, or structures within the area of BCDC's jurisdiction. Typical BCDC permit conditions include requirements for public access and other improvements, as related to the construction, installation, use, and maintenance of public access areas. Permit conditions might also include making a commitment to ongoing management and monitoring of public access improvements. Recreation and public access facilities would be evaluated for compliance with the State's climate change policies, including sea-level rise.

Recreation and public access facilities included in Phase 2 actions would be evaluated by BCDC for compliance with Bay Plan and ABAG Bay Trail Plan and policies. Where a proposed alignment does not fully comply with policies such as sea-level rise, alternate design strategies may be appropriate, and may include features such as:

- Constructing a trail footprint of sufficient width to allow raising the trail in the future (and have a trail with sufficient functional width).
- Reserving additional lands on the sides of unimproved trail for dedicated future trail improvements.
- Dedicating an alternate alignment where the trail would be located in the future. For instance, according to the Reserve Manager, the Mt. Eden Creek spur trail is intended to replace the ABAG Bay Trail planned spur trail along OAC out to the Bay at Whale's Tail Marsh (J. Krause, pers.comm. 2016).

3.2.3 San Francisco Bay Trail (Bay Trail)

The Bay Trail, administered by Association of Bay Area Governments (ABAG), is a planned recreational corridor that, when complete, will encircle San Francisco Bay and San Pablo Bay with a continuous network of bicycling and hiking trails. It will connect the shoreline of all nine Bay Area counties, link 47 cities, and cross the major toll bridges in the region. To date, approximately 310 miles of the alignment – over 60 percent of the Bay Trail's ultimate length – have been completed.

Relationship to Phase 2 Actions

Segments of the Bay Trail are located near the Eden Landing Phase 2 project area, including a segment of the Bay Trail that was added in northern Eden Landing as part of Phase 1 of the SBSP Restoration Project. Many of the public access facilities that would be constructed as part of the project could connect to these existing trail segments. Some new trail segments being considered as part of Phase 2 actions are not currently segments of the Bay Trail but could be considered to become part of the Bay Trail network in the future, if appropriate.

The Bay Trail Plan includes a shoreline spur to the Bay at Old Alameda Creek (OAC), as well as a bridge across ACFCC to access Coyote Hills Regional Park. The spur trail on Mt. Eden Creek, constructed under Phase 1 of the SBSP Restoration Project, was included along the managed ponds in northern Eden Landing to provide a similar experience for trail users and because it was anticipated that a spur trail along OAC would be problematic because of potential tidal breaches and adjacent species conservation concerns.

Although not a regulatory agency, ABAG has an interest in the project as a partner and potential funding source. The Bay Trail Plan has been prepared in consultation with local governments, and is periodically amended and updated in consultation with them. BCDC considers the Bay Trail Plan in making determinations as to whether a project is consistent with their policies on public access.

3.2.4 San Francisco Bay Area Water Trail (Water Trail)

The Water Trail was authorized by the San Francisco Bay Area Water Trail Act, which was signed into state law in September 2005. The Water Trail is a network of access sites (or "trailheads") that enables people using non-motorized small boats or other beachable sailcraft, such as kayaks, canoes, dragon boats, and stand-up paddle and windsurf boards, to safely enjoy single and multiple-day trips around San Francisco Bay.

Relationship to Phase 2 Actions

Non-motorized boat launch facilities constructed in the Phase 1 actions at northern Eden Landing are designated as existing Water Trail sites; they have launch facilities that are used for non-motorized small boat access and are open to the public. No additional Water Trail facilities are planned for Phase 2.

3.2.5 East Bay Regional Park District (EBRPD)

The East Bay Regional Park District (EBRPD) is a system of public parks and trails in Alameda and Contra Costa counties. The EBRPD owns and manages over 120,000 acres of open space, protected habitat, and other parklands. The 2013 District Master Plan provides the guidance for future expansion of parks trails and services. On the Master Plan, the Project Area is labeled Alvarado Wetlands, and potential trails 1B (San Francisco Bay Trail - Coyote Hills to Hayward Shoreline) and 11 (Old Alameda Creek Trail) are within the site. Policies related to trail development include:

- PRPT9: Regional Trails will connect regional parks or trails to each other, to parks and trails of other agencies, or to areas of unusual scenic beauty; vista points, San Francisco Bay, Delta or lake shoreline, natural or historic resources, or similar area of regional significance…
- PRPT10: The District encourages the creation of local trail networks that provide additional access points to the regional parklands and trails in order to provide loop trail experiences and to connect the regional system to the community. The District will support other agencies in completing local trail networks that complement the Regional Trail system and will coordinate with local agencies to incorporate local trail connections into District brochures.
- PRPT11: Regional trails may be part of a national, state, or Bay Area regional trail system. The District will cooperate with other agencies and organizations to implement these multi-jurisdictional efforts.
- PRPT18: The District will coordinate with other agencies and organizations involved in planning for jointly managed regional trails or trails that extend beyond the District's jurisdiction. When applicable, the District will use planning and environmental studies done by or in cooperation with other agencies for trail planning and development.

EBRPD is the owner and operator of Coyote Hills Regional Park, located south of Eden Landing, and Hayward Regional Shoreline, located north of Eden Landing. EBRPD also operates the Alameda Creek Regional Trail under an agreement with the ACFCWCD and manages the Bay Trail "spine" in the northern Eden Landing area, but not the "spur" trails and non-motorized launch.

Relationship to Phase 2 Actions

At the present time, no formal arrangements exist between CDFW and EBRPD for maintenance and shared responsibility of trails and other public access features in the Phase 1 or Phase 2 project area.

3.2.6 Alameda County Flood Control and Water Conservation District (ACFCWCD)

ACFCWCD is part of Alameda County Public Works Agency, responsible for maintaining the area's flood control facilities, including channels, levees, pumps and infrastructure related to flood control and stormwater management. The ACFCWCD provides planning, design and inspection of flood control projects, maintains flood control infrastructure, reviews new developments and supports watershed enhancement and education. ACFCWCD does not construct or manage trails, and would need to enter into an agreement with another entity for trail management, making them responsible for construction, maintenance, and operations of the trail, including patrol policing and emergency response. Flood control channels and creeks in the Phase 2 project area are in Zone 3A.

Relationship to Phase 2 Actions

Some of the proposed trail route options are located on County lands, including levees, access roads, ponds and the 20-tide gate structure crossing on OAC.

3.2.7 Cargill, Inc.

Cargill Inc. owns and operates lands in the Phase 2 project area including Pond Cargill Pond 3C (CP3C), Cal Hill and Turk Island. Proposed Trail Route 2 would be located on the existing Cargill owned levee only if an agreement with Cargill and all stakeholders were reached, or if they no longer owned the property.

Relationship to Phase 2 Actions

In order to proceed, an agreement with Cargill would be needed for construction, operation and management to open these lands to public access.

3.2.8 City of Hayward

ELER is within the city limits of Hayward, as are portions of County-owned lands west of Westport Way. Facilities that are located within the Reserve would not be subject to regulation by the City, since they are state lands.

Relationship to Phase 2 Actions

There are no existing or proposed recreation or public access facilities in the area that conflict with adopted City of Hayward plans.

3.2.9 City of Union City

The eastern and southern part of the Eden Landing Phase 2 project area, including County and Cargill-owned lands is within the Union City limits. In 2004, Union City (Alta Planning 2004) commissioned a study analyzing the feasibility of a Bay Trail segment from the EBRPD trail in northern Alameda County to the Alameda Creek Regional Trail (**Figure G-1**). Some of the trails proposed for the Phase 2 actions include portions of the trail segments analyzed as part of this study, including the northern Eden Landing segment along OAC, and portions of Trail Route Option 3.

In addition to access at Union City Blvd., the study identified five Community Connecters, “an important part of the Bay Trail system, ensuring that residents of neighborhoods located near the primary Bay Trail alignment have ready access to the regional trail network.” These community connecters were located at OAC south levee, Horner Street, Whipple/Benson Road, Mariner Park, and Westport Way. These routes have been incorporated into the City’s Bicycle and Pedestrian Plans, as well as those of Alameda County.

Figure G-1. Union City Bay Trail Feasibility Study Preferred Alignment (source: Alta Planning, 2004)

Figure 3-3
Preferred Alignment Map

Relationship to Phase 2 Actions

Depending on the alignment selected, recreation and public access improvements completed as part of the project (but outside the boundaries of the Reserve) may be subject to review and approval by the City of Union City.

3.2.10 Alameda Countywide Bicycle and Pedestrian Plans

The Alameda County Transportation Commission (ACTC) plans, funds and delivers transportation programs to expand and improve access and mobility in Alameda County. They administer funds from local state and federal funding sources, including Measures B and BB, vehicle registration, Clean Air funds, State Transportation Improvement Program and federal programs.

The Countywide Bicycle and Pedestrian Plans (2012), adopted by the ACTC identify specific investments and strategies to maintain, manage, and improve the non-motorized transportation network in Alameda County. The bicycle and pedestrian plans incorporate the ABAG Bay Trail components (ACTC central and south) within the Eden Landing Phase 2 area, including the Bay Trail spine (with notation that final alignment is to be determined), a spur trail on OAC, and a bridge across ACFCC. The plans also include a new connection to the city street network in the general vicinity of the 20-tide gate structure.

Relationship to Phase 2 Actions

Coordination with ACTC would be needed if the project partnered with them for funding of bicycle and pedestrian improvements. .

3.2.11 Other Planning Efforts

Other plans that guide or influence development of recreation and public access facilities for the SBSP Restoration Project area are summarized below.

The CDFW and USFWS published the South Bay Salt Pond Restoration Project Interim Stewardship Plan (ISP) in June 2003[2]. The ISP described the interim operation and maintenance of the former Cargill ponds prior to the development of the long-term plan. A Draft Environmental Impact Statement / Environmental Impact Report (EIS/R)[3], published in December 2003, was conducted to evaluate the environmental impacts that could occur with implementation of the ISP. The Final EIR/EIS for the ISP was published in March 2004.

The ISP summarized relevant regional plans that support open space, recreation, and public access uses. It did not provide policies or regulations associated with management of recreation or open space; rather, it references those documents that provide guidance on wetland restoration and address recreation and public access. The ISP indicates that many of the land use and open space elements for the county and cities are outdated, and land use planning documents and programs often supersede the documents and programs of local jurisdictions with respect to planning, protection, and restoration of lands within the Estuary. The ISP reviewed versions of the respective plans including BCDC's San Francisco Bay Plan[4], the San Francisco Estuary Project's (SFEP) Comprehensive Conservation Management Plan (CCMP)[5],

[2] Life Science!, June 2003, *South Bay Salt Pond Restoration Project Initial Stewardship Plan*.
[3] EDAW, Et. al., December 2007, *South Bay Salt Pond FEIS/R*.
[4] San Francisco Bay Conservation and Development Commission, 1968, amended October 2006, *San Francisco Bay Plan.*
[5] San Francisco Estuary Project, 2007, *Comprehensive Conservation Management Plan*.

the Baylands Ecosystem Habitat Goals Report[6], the San Francisco Bay Joint Venture (SFBJV) Implementation Strategy[7], and the Bay Trail Plan[8] for their wetland restoration goals and objectives, some of which include support for recreational opportunities. The ISP was eventually integrated into and superseded by the programmatic planning process for the SBSP Restoration Project as a whole, which included a separate join NEPA/CEQA process and environmental document. This Final EIS/R was published in 2007 and included the program-level environmental impacts and mitigation measures as well as those for the Phase 1 project actions.

These early plans, as well as others that provide guidance on development of recreation and public access components in or near the SBSP Restoration Project's Eden Landing Phase 2 area are summarized in **Table G-2** and should be considered during implementation of recreation and public access features to ensure consistency and coordination between projects.

Table G-2. SBSP Restoration Project Public Access Plans and Projects Considered in ISP

RELATED PLANS	AGENCY IN CHARGE	PLAN ESSENCE AND RELEVANCE TO RECREATION
Baylands Ecosystem Habitat Goals Report (1999)	San Francisco Bay Area Wetlands Ecosystem Goals Project	The Report is a guide for restoring the Baylands and adjacent habitats of the San Francisco Estuary. It recommends the types, extent, and distribution of habitats needed to sustain healthy wetlands ecosystems in the South Bay and the assessment of opportunities and constraints for public access during the design phase of all restoration activities.
SFBJV Implementation Strategy (2001)	SFBJV	The Strategy builds on the science-based recommendations of the Goals Project and establishes acreage goals for wetlands restoration, including bay habitats, seasonal wetlands, and creeks and lakes. The Implementation Strategy recognizes the contribution of recreation activities at wetlands.
Public Access and Wildlife Compatibility Staff Report, 2008	BCDC	A study to review the effects on wildlife from recreation and public access with strategies for minimizing adverse impacts through siting, design and management of public access.
The Bay Trail Plan	Association of Bay Area Governments (ABAG)	The Plan proposes to develop 500 miles of regional hiking and bicycling trails around San Francisco Bay and San Pablo Bay that connect more than 90 parks and publicly accessible open spaces and future water trails. (Portions of the proposed Bay Trail shown near the Phase 2 area are shown as conceptual alignments to be analyzed prior to final design.)
Wildlife and Public Access Study Preliminary Findings	Bay Trail Project	Scientific investigation of the potential effects of recreational trails on shorebirds and waterfowl that use mudflat foraging habitat adjacent to San Francisco Bay.

Note: Please refer to the South Bay Salt Pond Restoration Project Recreation and Public Access Existing Conditions Report.

3.2.12 Accessibility Regulations

Access to project facilities by people of all abilities is subject to regulations and standards set forth by the United States Access Board (https://www.access-board.gov/). The United States Access Board is an independent federal agency that promotes equality for people with disabilities, and develops and maintains design criteria for the built environment. The United States Access Board has developed standards for facilities as part of the Americans with Disabilities Act (ADA), which ensures access to the built environment for people with disabilities.

[6] Monroe, M. et al, SFEI, 1997, *Baylands Ecosystem Habitat Goals Report*.
[7] San Francisco Bay Joint Venture (SFBJV), 2001, *Implementation Strategy*.
[8] Association of Bay Area Governments, 1999, *Bay Trail Plan*.

Americans with Disabilities Act

The United States Congress enacted the Americans with Disabilities Act (ADA) in 1990 to address discrimination against individuals with physical and mental disabilities. The ADA Standards establish design requirements for the construction and alteration of facilities subject to this law. These enforceable standards apply to places of public accommodation, commercial facilities, and state and local government facilities.

Title 24, California Building Code

The State of California has adopted a set of design regulations for accessible facilities that incorporate state mandates and federal ADA guidelines. These provisions are contained in the California Code of Regulations, Title 24, Part 2, California Building Code (CBC)[9]. CBC contains general building design and construction requirements relating to fire and life safety, structural safety, and access compliance. The 2016 CBC will become effective on January 1, 2017 and is updated every three years.

Relationship to Phase 2 Actions

Recreation and public access facilities that are built as part of Phase 2 will need to comply with Title 24 and ADA accessibility regulations. This will be reviewed as part of permitting actions for project construction.

3.3 Existing Recreation and Public Access Facilities

The existing recreation and public access facilities in and near the Eden Landing Phase 2 ponds are shown on **Figure G-2**. Existing recreation and public access facilities in and near the project area (as well as facilities proposed by projects or general, master, or recreation plans other than the SBSP Restoration Project) are described in **Table G-3**. This list is not meant to be comprehensive or exhaustive of every public access opportunity or recreational resource, but it is intended to give a sense of the existing conditions regarding recreation and public access in the vicinity of Eden Landing.

[9] California Code of Regulations, Title 24 Part 2, July 2016.

Figure G-2. Recreation and Public Access in the Vicinity of the Phase 2 Area

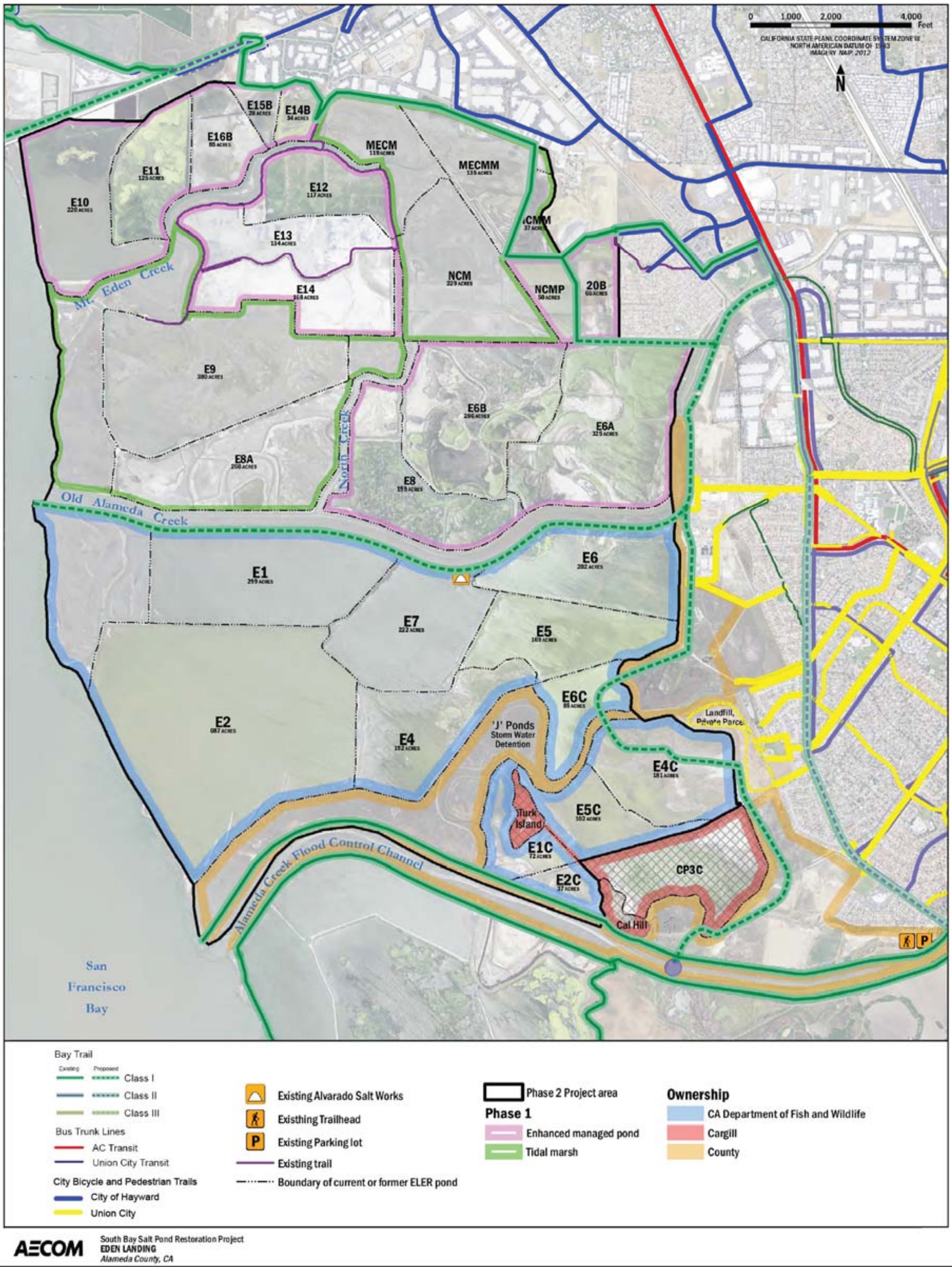


Table G-3. Existing Public Access and Recreation at or near Eden Landing

RECREATIONAL FEATURES	NEARBY LOCATIONS
Trails	▪ Phase 1 of the SBSP Restoration Project added year-round and seasonal trails inside of northern Eden Landing (a Bay Trail spur). ▪ The nearest segment of the Bay Trail on open space is in northern Eden Landing over a mile to the north of the Phase 2 project area. City streets used for Bay Trail access are approximately 0.5 mile to the east. ▪ The Alameda Creek Regional Trail is an EBRPD-managed pair of trails on both levees of the ACFCC, one of which is on the southern border of Eden Landing. ▪ The Coyote Hills Regional Park is to the south of the ACFCC and includes several trails.
Boating	Phase 1 of the SBSP Restoration Project added a launch for non-motorized boats (e.g., kayaks) along Mt. Eden Creek, which drains into San Francisco Bay from northern Eden Landing.
Access Points and Staging Areas	Northern Eden Landing ▪ The Phase 1 actions (trails and non-motorized boat launch in northern Eden Landing) are connected to the existing Bay Trail parking lot and staging area. Alameda Creek Regional Trail ▪ There is a parking area and a trail access point on the north side of the Alameda Creek Regional Trail east of the Phase 2 project area. This access includes equestrian staging. Eden Shores Access ▪ Bay Trail connector via Eden Shores neighborhood, Hayward
Historic Features	▪ Oliver Salt Works at the northwest end of Pond E13 ▪ Union City Salt Works at the northwest end of Pond E6
Waterfowl Hunting	CDFW allows limited waterfowl hunting, currently 10 annually specified days within the season, by issuing written permission at a hunter check station for certain portions of Eden Landing.
Dog Use	Dogs are allowed for retrieval use in hunting areas during waterfowl hunting season. Dogs are allowed on leash on the Alameda Creek Regional Trail. Dogs are precluded from certain sections of the Bay Trail, including areas within Eden Landing, per EBRPD regulations.
Equestrian Use	Horses are allowed on Alameda Creek Regional Trail.
Fishing	Fishing by boat is allowed in the Bay and sloughs and from shore in areas designated by CDFW.
Active Recreation	▪ Gordon E. Oliver Eden Shores Park, Hayward, located 1,000 feet east of a project proposed trail, has basketball, tennis, playfields, parking area and picnic facilities ▪ Sea Breeze Park, Union City, located 700 feet east of the project proposed Route 3 and 3,000 feet east of Routes1 and 2, has ball fields, play area, picnic facilities and parking area.

4. RECREATION AND PUBLIC ACCESS ALTERNATIVES

4.1 Overview

The 2007 Final EIS/R valuated potential recreation impacts of three long-term program-level alternatives. Programmatic Alternative A would be the No Action Alternative. Programmatic Alternative B would be a 50/50-percent mix of tidal marsh and enhanced managed ponds, which was named the Managed Pond Emphasis, and Programmatic Alternative C would be a 90 percent tidal marsh/10 percent managed pond mix called the Tidal Habitat Emphasis.

Some of the recreation and public access features identified in previous planning efforts are within or adjacent to the Phase 2 project areas, and certain features were identified as being interchangeable, depending upon managed pond or tidal emphasis, and adaptively managed during implementation. Descriptions of recreation and public access alternatives are contained in the Final 2007 EIS/R, Chapter 2, Description of Alternatives; Chapter 3.7, Recreation Resources; and the following 2007 EIS/R figures (**Figure G-3**):

Figure A-7. Programmatic EIS/R Alternative B: Managed Pond Emphasis, and

Figure A-8. Programmatic EIS/R Alternative C: Tidal Habitat Emphasis

Figure G-3. Phase 1 Programmatic Recreation and Public Access Alternatives

Figure A-7. Programmatic EIS/R Alternative B: Managed Pond Emphasis

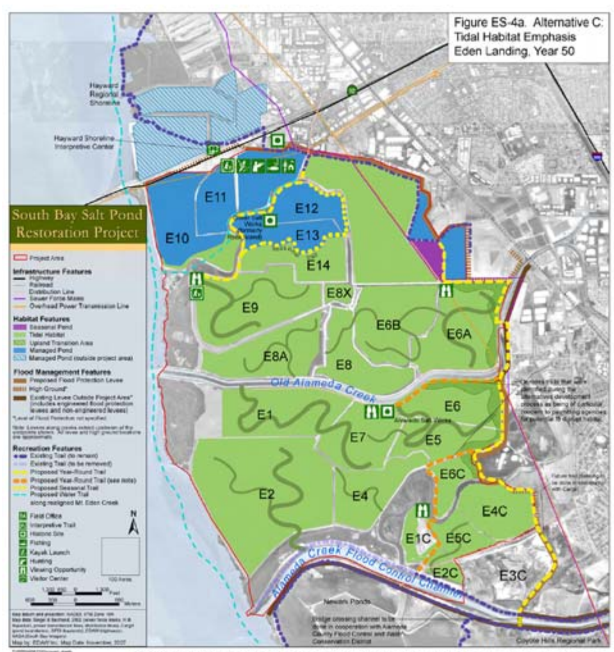


Figure A-8. Programmatic EIS/R Alternative C: Tidal Habitat Emphasis

The programmatic portion of the 2007 EIR/S contained descriptions of potential recreation and public access features within the Phase 2 project area at Eden Landing. Some of the trail segments identified in prior planning were of concern to regulatory agencies or stakeholders, and a notation was made on the figures for these segments: “Denotes trails that were identified during the alternatives development process as being of particular concern to permitting agencies for potential to disrupt habitat.” This means that certain trails shown on the maps in the 2007 EIS/R might not be feasible to implement in consideration of the project's wildlife habitat-related goals.

4.2 Managed Pond Emphasis

Recreation and public access components. This alternative included continuation of the Bay Trail spine generally along the eastern edge of ELER, including a bridge over ACFCC. This alternative included two loop trail segments, at OAC (including a bridge) and south of Pond E4C. A neighborhood connector was included at Westport Way. Recreation facilities included three viewing platforms: at the northeastern edge of Pond E6A, at OAC and Pond E2C.

4.3 Tidal Habitat Emphasis

Recreation and public access components. This alternative included completion of the Bay Trail spine, generally along the eastern edge of ELER, including a bridge over ACFCC. One loop trail segment through the southern ponds, and a spur trail to the Alvarado Salt Works was proposed. Recreation facilities included three viewing platforms: at the northeastern edge of Pond E6A, at the Alvarado Salt Works, and overlooking the J-Ponds.

4.4 Programmatic Public Access Features Not in Phase 2

The programmatic portions of the 2007 EIS/R included the following recreation and public access features that were not included in Phase 1 and are not included in the current plans for the Phase 2 actions, although some of these features could be included, depending on final design:

- Wildlife viewing platform at the northwest corner of Pond E6A (in northern Eden Landing).
- Wildlife viewing platform within the Southern Ponds.
- Bay trail access connection to Union City in the vicinity of Westport Way (this is included as part of Route 3).
- Potential trail alignments along the north and west side of Pond E6C, rather than only on the south side.
- Bay Trail alignment along the east side of Pond E4C and Cargill CP3C (instead, one proposed alignment has shifted further west and wraps around the Southern Ponds; another stays east and terminates at Westport Way).

Note that the Action Alternatives under consideration for Phase 2 at Eden Landing include substitutes for many of these features that were not included in these alternatives. For example, there is a proposed wildlife viewing platform along the Alameda Creek Regional Trail adjacent to the Southern Ponds and not far from the location on the map of Programmatic Alternative C. Similar adjustment to the various portions of the Bay Trail spine through southern Eden Landing have been made to resemble the trail options shown in the 2007 EIS/R. Adjustments to portions of the Bay Trail spine through southern Eden Landing have been made to reflect restoration options and are equivalent to those shown in the 2007 EIS/R.

5. PHASE 2 EDEN LANDING RECREATION AND PUBLIC ACCESS ALTERNATIVES

5.1 Overview

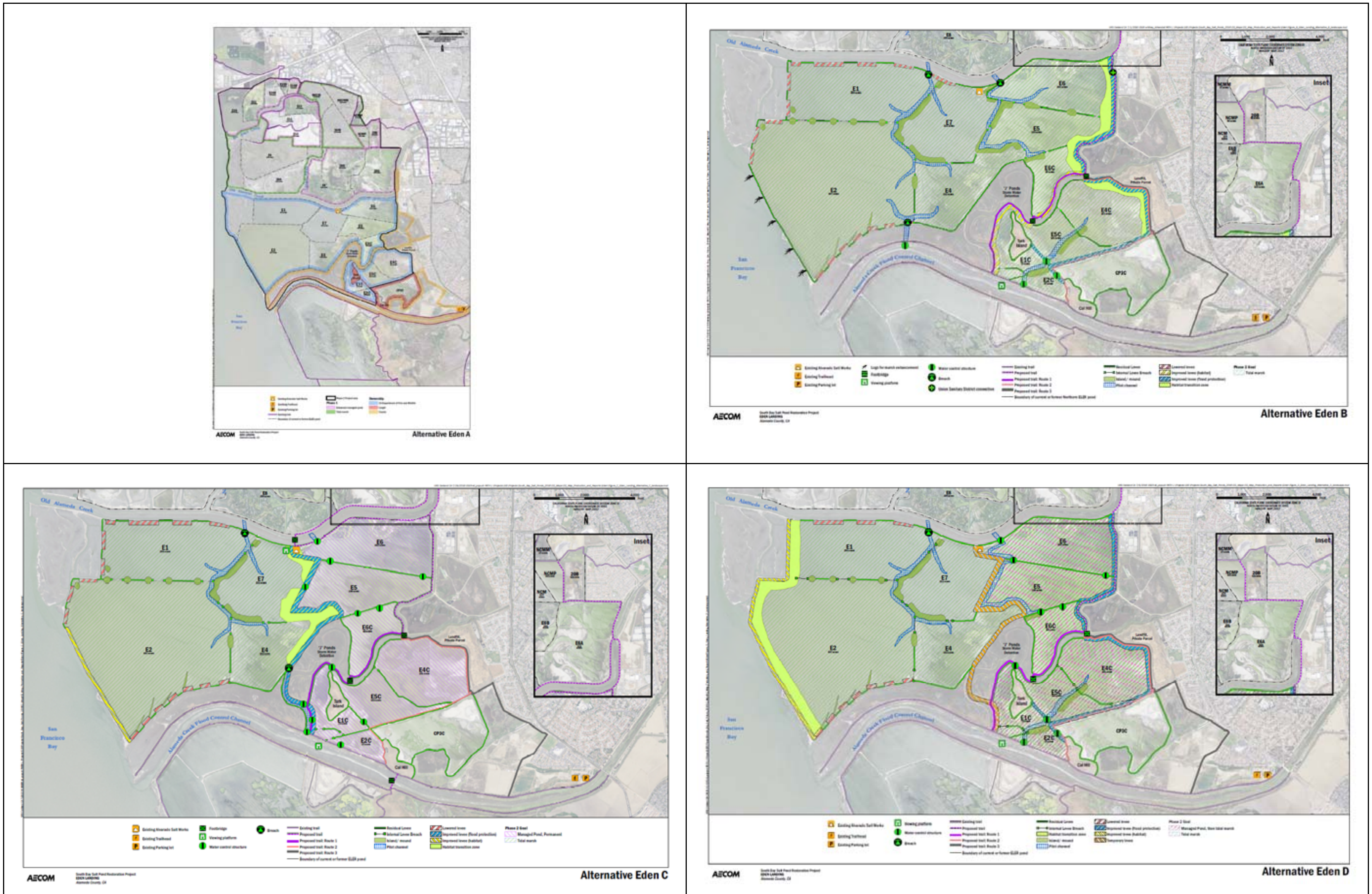
The Phase 2 project area at Eden Landing includes all eleven CDFW-owned ponds in the southern half of Eden Landing; the levees surrounding each pond; the fringing marsh outside of these levees; the ACFCWCD-owned storm water detention ponds and high marsh, portions of the OAC channel, the northern levee of the ACFCC, and some Cargill-owned levees bordering CDFW's ponds. Also, a Union Sanitary District outflow pipe and East Bay Discharge Authority (EBDA) treated wastewater force main immediately adjacent to the border of Eden Landing is also included in the project area, as well as connections to Alameda County Water District's (ACWD) Aquifer Reclamation Program (ARP) wells. Existing Pacific Gas and Electric (PG&E) power transmission and distribution lines are also included in the project area. Recreation and public access facilities are also evaluated that would be located on lands owned by ACFCWCD and Cargill, as well as construction access that would occur across land owned by Union Sanitary District, City of Union City, and Alameda County.

The Eden Landing Phase 2 Action Alternatives propose restoration, flood management, and recreation/ public access activities in the southern half of Eden Landing. Existing trails, trailheads, access points and viewing platforms in the surrounding areas that are not within the project area would remain unchanged; however, some existing trail facilities may be subject to temporary closure or relocation during project construction. The Action Alternatives focus on different restoration and flood risk management options: (1) restoring the entire area to predominantly tidal marsh; (2) restoring a mix of tidal marsh and managed ponds; and (3) a two-stage restoration that would restore the area to tidal marsh through an adaptive management process. Three recreation and public access route options are also evaluated within the context of the Action Alternatives. The proposed recreation and public access features would construct a segment of the Bay Trail spine through southern Eden Landing to close an existing gap in the Bay Trail. The recreation and public access features would provide access to existing parks and trails by adding two local connector trails, and would also provide interpretive amenities. The new recreation and public access facilities would provide access to CDFW lands that would not occur without the project. At a minimum, the Action Alternatives include construction of a Bay Trail spine segment to provide partial-to-complete closure of a gap in the Bay Trail. This trail is proposed along one of three routes being evaluated in the Action Alternatives. Additional spur trails could also be implemented, as shown in Alternative Eden C; these trails would not be considered the primary Bay Trail spine.

Two construction access points have been identified to accommodate site construction, via the Horner/Veasy Street access, and via Westport Way in the vicinity of Sea Breeze Park. The SBSP Restoration Project intends to coordinate with EBRPD, the City of Union City, and other adjacent landowners (including Union Sanitary District and ACFCWCD) regarding these access points as "community connections" that would provide ongoing public access connections through agreement with the underlying property owners. Although physical improvement of the access roads or trails for construction purposes (such as leveling, widening and/or surfacing) may be necessary, it is anticipated that physical improvements needed to convert this access for trail use would be minimal, such as surfacing, signage and entry gates.

The proposed recreation and public access features are shown in Chapter 2 – Alternatives of the Draft EIR/S and reproduced in **Figure G-4.**

Figure G-4. Eden Landing Phase 2 Alternatives



5.2 Alternative Eden A (No Action)

Under Alternative Eden A, no new public access or recreation features would be completed. Existing trails, the non-motorized boat launch, and other features in northern Eden Landing would be retained and managed by CDFW, as would the EBRPD's Alameda Creek Regional Trail along the north and south ACFCC levees. The latter of these would continue to be separately maintained by EBRPD. Seasonal hunting in portions of Eden Landing would continue. The existing Bay Trail spine would continue to have a gap between the current trail near the Eden Shores development (along the eastern edge of northern Eden Landing) and the Alameda Creek Regional Trail adjacent to ACFCC and Coyote Hills Regional Park.

5.3 Recreation and Public Access Components Included in all Action Alternatives

Each of the Action Alternatives includes extending the Bay Trail from the existing trail in northern Eden Landing near the Eden Shores development to the southeast corner of Pond E6C. The Bay Trail would extend approximately 16,000 feet from the junction of Pond NCMP and Pond 20B, south and east along the border of ELER, across the 20-tide gate structure in the OAC channel and on the ACFCWCD levee near Veasy Street and USD into southern ELER. It would then continue on CDFW levees to the southeast corner of Pond E6C. There would be no restoration, levee improvements or flood risk management measures implemented in the northern ponds associated with completion of this trail segment. Fencing, infrastructure or other improvements may be needed to protect ACFCWCD facilities, as discussed in Appendix G**.**

The existing levees in this portion of northern Eden Landing are at elevations 7 to 9 feet (North American Vertical Datum of 1988 or NAVD88) for interior levees, and 10 feet along OAC, with a crest width of 9 to 12 feet. The USD/ACFCWCD levee is at elevation 14 to 16 feet (NAVD88) with a surfaced width of 12 feet or more. Levees on the east side of Ponds E5 and E6 are at elevations 12 feet (NAVD88) and above, with a minimum crest width of at least 12 feet, and the east side of Pond E4C is at elevation 11 feet (NAVD88) with a surfaced width of 6 feet or less.

Trail Route Options. From this location, the trail would continue on one of three routes:

- Route 1: CDFW Property only; 7,400 linear feet; to be placed on existing or improved levees.
- Route 2: CDFW & Cargill Property (subject to sale, easement, or use agreement with CDFW or another cooperating partner); 10,500 linear feet; to be placed on the eastern and southern levees of the Southern Ponds, where they wrap around the CP3C and Cal Hill or provide access to Turk Island.
- Route 3: CDFW & Alameda County Property; approximately 5,200 linear feet; to be placed on the CDFW-owned levee on the eastern side of Pond E4C and then route onto County lands to the east onto existing sidewalks in Union City at Westport Way. The eastern portion of this trail would be located on 1,000 feet of existing 10 to 12 foot-wide access road to be improved for trail use, terminating at Westport Way, at approximate elevation 7 to 8 feet.
- Each of the Action Alternatives would include one new viewing platform on the Alameda Creek Regional Trail.

- Each of the Action Alternatives would include improvements to the project construction access roads at two locations to allow neighborhood access to the trail.

This section describes each of these route options within the context of the restoration and flood management alternatives being evaluated.

Route 3 Modifications. During the scoping process for the Phase 2 project at southern Eden Landing, an additional trail segment for Route 3 was under consideration. As discussed above, Route 3 includes a segment that connect from the bridge over the ACFCWCD channel, around Pond E4C, and then along the 1,000 feet of improved access road to Westport Way. From there, however, an additional trail segment would have turned south through County-owned lands located behind houses on Monterey Drive, and wrap around to Union City Boulevard. The trail would have used Union City Boulevard sidewalks for about 700 feet, and then ACFCWCD access roads (at elevation 9 feet [NAVD88], with a width of at least 8 to 10 feet) for about 3,000 feet until it connected with the Alameda Creek Regional Trail.

This route was identified as the preferred alignment in the Union City Bay Trail Feasibility Study, with the caveat that this segment could be one of the most challenging, with potential wetland/biological impacts, berm/fill geotechnical and structural issues, right of way ownership, and cost, including either extensive fill and retaining wall, or construction of a boardwalk behind Monterey Drive (estimated at 1.4 to 2.9 million in 2005 dollars). Due to the range of potential environmental issues and costs associated with this segment, Route 3 was subsequently shortened to terminate at Westport Way. The additional trail segment (south of Westport Way) would not be precluded if implemented as a future, separate project by local agencies, but would not be implemented as part of Phase 2 actions.

5.4 Alternative Eden B

Alternative Eden B focuses on restoring much of the Phase 2 area to tidal marsh. In this alternative, the existing levee along the eastern edge of the project area would be raised and improved, as would the levees along the northern and western edges of CP3C. Levees would also be improved for habitat separation purposes along the western edge of Pond E1C and the southern edge of Pond E6C. Trails south of OAC would be located on levees improved for habitat or flood risk management purposes, and would be constructed of sufficient width to comply with Bay Trail guidelines, with a minimum top width of 18 feet.

Recreation/Public Access Alternative Eden B, Route 1

Minimum trail width: 18 feet (south of OAC) **Trail elevation:** minimum 12 feet (south of OAC)

Route B1 includes continuation of the Bay Trail from its current trail within the Phase 1 area on existing CDFW and Alameda County facilities 16,000 feet to the southeast corner of Pond E6C.

From there, it would continue an additional 7,400 feet southwesterly on the improved habitat levees, terminating at the Alameda Creek Regional Trail east of the J-ponds. One 300-foot long pedestrian bridge would be constructed crossing the J-ponds at the southwestern tip of Pond E6C. One viewing platform with interpretive exhibits would be constructed along the Alameda Creek Regional Trail.

Anticipated shoreline views would be predominantly of tidal marsh, with water views expected at OAC and at the Alameda Creek Regional Trail terminus.

Recreation/Public Access Alternative Eden B, Route 2

Minimum trail width: 18 feet (south of OAC)   **Trail elevation:** minimum 12 feet (south of OAC)

Route B2 includes continuation of the Bay Trail from its current trail within the Phase 1 area on existing CDFW and Alameda County facilities 16,000 feet to the southeast corner of Pond E6C.

From there, it would continue an additional 10,500 feet south and west along Pond E4C improved levee, west/south along CP3C levee and connect with the Alameda Creek Regional Trail on the west side of Cal Hill (owned by Cargill). One 250-foot long pedestrian bridge would be constructed crossing the J-ponds at the southeastern tip of Pond E6C. One viewing platform with interpretive exhibits would be constructed along Alameda Creek Regional Trail.

Anticipated shoreline views would be predominantly of tidal marsh, with water views expected at OAC and at the Alameda Creek Regional Trail terminus.

Recreation/Public Access Alternative Eden B, Route 3

Minimum trail width: 8 to 10 feet (south of OAC)   **Trail elevation:** 7 to 8 feet

Route B3 includes continuation of the Bay Trail from its current trail within the Phase 1 area on existing CDFW and Alameda County facilities 16,000 feet to the southeast corner of Pond E6C.

From there, it would continue south along Pond E4C improved levee, then east along an existing access road that terminates at Westport Way. No new Bay Trail facilities would be built south of Westport Way. One viewing platform with interpretive exhibits would be constructed along Alameda Creek Regional Trail.

Anticipated shoreline views would include tidal marsh, managed lands, and landscaped urban areas, with water views expected at OAC and along the Alameda Creek Regional Trail.

5.5 Alternative Eden C

Alternative Eden C focuses on a combination of tidal marsh and permanently managed ponds. This would be accomplished by constructing a mid-complex levee bisecting the project area, with a habitat separation levee along a portion of the existing Bay shoreline. Trails would be located on existing and unimproved levees at current widths and elevations, except for a 1,000-foot long section west of Pond E1C. Where the trail is located adjacent to managed ponds or other habitat areas, operations and maintenance (O&M) agreements would be used to permit routine maintenance (J. Krause, pers. comm. 2016), however, the ability to provide maintenance and reconstruction may be constrained in the future due to potential wildlife or habitat disruption.

Alternative Eden C includes several features for improved recreation and public access; these would be completed in addition to any of the Alternative Eden C trail route options:

- A 600-foot long bridge over ACFCC near Pond E2C to connect with the existing Bay Trail that continues to the south. This bridge would be high enough in the center to allow periodic channel dredging as well as high enough over its entire length to allow 100-year floods to pass beneath the bridge. The bridge would be intended to be accessible to pedestrians and bicycles and not necessarily by maintenance vehicles.

- A new Bay Trail spur trail to the former site of the Alvarado Salt Works. This spur trail would run along the northern edge of Pond E6 to a viewing platform and interpretive feature that would be included there to explain the history and the remnant structures there. The mid-complex levee would be built to the west of the former salt works site so that its degradation would not be accelerated. From this point, a 500-foot long bridge would cross over the OAC channel, and a parallel trail would run eastward, back to the Bay Trail spine, along the southern levees of Pond A8 and E6A to form a loop. The total length of this trail loop is approximately 13,500 feet.

Recreation/Public Access Alternative Eden C, Route 1

Minimum trail width: 8 feet (south of OAC) **Trail elevation:** minimum 8 to 9 feet

In addition to the recreation features described above, Route C1 includes continuation of the Bay Trail from its current trail within the Phase 1 area on CDFW and Alameda County facilities 16,000 feet to the southeast corner of Pond E6C.

From there, it would continue an additional 7,400 feet southwesterly on an existing levee, terminating at the Alameda Creek Regional Trail east of the J-ponds. One 300-foot long pedestrian bridge would be constructed crossing the J-ponds at the southwestern tip of Pond E6C. One viewing platform with interpretive exhibits would be constructed along Alameda Creek Regional Trail.

Trail improvements would include clearing, grading, and/or surfacing the existing levee surface as needed to be appropriate for trail use, but no levee reconstruction, widening or raising for the trail elevation would be completed, except for a 1,000-foot long section to be located on the improved levee west of Pond E1C. This route would be protected from flooding and sea-level rise impacts by the improved levee further west.

In some areas, the trail would be located on unimproved levees that may deteriorate over time, necessitating maintenance such as topping or reconstruction to provide usable trail width and elevation.

Anticipated shoreline views would be predominantly of managed ponds and the improved levee, with water views expected on the 1,000-foot long segment of improved levee, at OAC and at the Alameda Creek Regional Trail terminus.

Recreation/Public Access Alternative Eden C, Route 2

Minimum trail width: 8 to 10 feet (south of OAC) **Trail elevation:** minimum 8 to 9 feet

In addition to the recreation features described above, Route C2 includes continuation of the Bay Trail from its current trail within the Phase 1 area on CDFW and Alameda County facilities 16,000 feet to the southeast corner of Pond E6C.

From there, it would continue an additional 10,500 feet south and west along Pond E4C existing levee, west/south along the existing CP3C levee and connect with the Alameda Creek Regional Trail on the west side of Cal Hill (owned by Cargill). One 250-foot long pedestrian bridge would be constructed crossing the J-ponds at the southeastern tip of Pond E6C. One viewing platform with interpretive exhibits would be constructed along Alameda Creek Regional Trail.

Trail improvements would include clearing, grading, and/or surfacing the existing levee surface as needed to be appropriate for trail use, but no levee reconstruction, widening or raising for the trail elevation would be completed. This route would be protected from flooding and sea-level rise impacts by the improved levee further west.

In some areas, the trail would be located on unimproved levees that may deteriorate over time, necessitating maintenance such as topping or reconstruction to provide usable trail width and elevation.

Anticipated shoreline views would be predominantly of managed ponds, with water views expected at OAC and at the Alameda Creek Regional Trail terminus.

Recreation/Public Access Alternative Eden C, Route 3

Minimum trail width: 8 to 10 feet (south of OAC) **Trail elevation:** 7 to 8 feet

In addition to the recreation features described above, Route C3 includes continuation of the Bay Trail from its current trail within the Phase 1 area on CDFW and Alameda County facilities 16,000 feet to the southeast corner of Pond E6C.

From there, it would continue south along Pond E4C improved levee, then east along an existing access road that terminates at Westport Way. One viewing platform with interpretive exhibits would be constructed along Alameda Creek Regional Trail. This option would also include the bridge across ACFCC.

Trail improvements would include clearing, grading, and/or surfacing the existing land surface as needed to be appropriate for trail use, but no levee widening or raising for the trail would be completed. This route would be protected from flooding and sea-level rise impacts by the improved levee further west.

Anticipated shoreline views would include managed ponds, lands and landscaped urban areas, with water views expected at OAC and at the Alameda Creek Regional Trail terminus.

5.6 Alternative Eden D

Alternative Eden D provides a two-stage approach to tidal restoration, to be accomplished by constructing an improved habitat levee at the existing Bay shoreline, as well as a temporary levee bisecting the project area. In this alternative, the Inland and Southern Ponds are intended to eventually become salt marsh subject to tidal action but may be retained as managed ponds, if ongoing Adaptive Management Plan (AMP) monitoring of pond-associated wildlife shows that it is necessary. A new habitat levee and habitat transition zone would be built at the existing Bay shoreline, but the existing levees that currently provide access to the western side of Eden Landing would be breached, and no public access or recreation facilities would be provided in that area.

Recreation/Public Access Alternative Eden D, Route 1

Minimum trail width: 8 feet (south of OAC) **Trail elevation:** minimum 8 to 9 feet

Route D1 includes continuation of the Bay Trail from its current trail within the Phase 1 area on existing CDFW and Alameda County facilities 16,000 feet to the southeast corner of Pond E6C.

From there, it would continue an additional 7,400 feet southwesterly on an existing levee, terminating at the Alameda Creek Regional Trail east of the J-ponds. One 300-foot long pedestrian bridge would be constructed crossing the J-ponds at the southwestern tip of Pond E6C. One viewing platform with interpretive exhibits would be constructed along Alameda Creek Regional Trail.

Trail improvements would include clearing, grading, and/or surfacing the existing land surface as needed to be appropriate for trail use, but no levee reconstruction, widening or raising for the trail elevation would be completed.

In some areas, the trail would be located on unimproved levees that may deteriorate over time, necessitating maintenance such as topping or reconstruction to provide usable trail width and elevation.

Anticipated shoreline views would include managed ponds transitioning to tidal marsh, with water views expected at OAC and at the Alameda Creek Regional Trail terminus.

If Alternative Eden D1 is selected for implementation, it is likely that portions of the route along the existing J-ponds and E6C levees will eventually be lost due to settlement, deterioration and sea-level rise. The portion of the trail that is located on the temporary levee could be retained as a spur trail (this portion of the levee would need to be retained), and/or improvements considered to create a loop trail through Turk Island and along the improved levee along E1C.

Recreation/Public Access Alternative Eden D, Route 2

Minimum trail width: 18 feet (south of OAC) **Trail elevation:** minimum 12 feet

Route D2 includes continuation of the Bay Trail from its current trail within the Phase 1 area on existing CDFW and Alameda County facilities 16,000 feet to the southeast corner of Pond E6C.

From there, it would continue an additional 10,500 feet south and west along Pond E4C improved levee, west/south along CP3C levee (owned by Cargill) and connect with the Alameda Creek Regional Trail on the west side of Cal Hill (Cargill). These levees would be improved for flood risk management. One 250 foot long pedestrian bridge would be constructed crossing the J-ponds at the southeastern tip of Pond E6C. One viewing platform with interpretive exhibits would be constructed along Alameda Creek Regional Trail.

Anticipated shoreline views would be predominantly of managed ponds, transitioning to tidal marsh, with water views expected at OAC and at the Alameda Creek Regional Trail terminus.

Recreation/Public Access Alternative Eden D, Route 3

Minimum trail width: 8 to 10 feet (south of OAC) **Trail elevation:** 7 to 8 feet

Route D3 includes continuation of the Bay Trail from its current trail within the Phase 1 area on existing CDFW and Alameda County facilities 16,000 feet to the southeast corner of Pond E6C.

From there, it would continue south along Pond E4C improved levee, then east along an existing access road that terminates at Westport Way. One viewing platform with interpretive exhibits would be constructed along Alameda Creek Regional Trail.

Anticipated shoreline views would include managed lands transitioning to tidal marsh, and landscaped urban areas, with water views expected at OAC and at the Alameda Creek Regional Trail terminus.

5.7 Other Recreation Features Considered in Phase 2

Other recreation and public access features were included in the Phase 1 and programmatic analyses, and are also considered some of the Phase 2 alternatives:

- Alternative C, described above, includes a 600-foot bridge over the ACFCC at the Alameda Creek Regional Trail to connect with the Bay Trail within Coyote Hills Regional Park. This bridge is not now included in all of the route options, but potentially could be included in any of the implementation scenarios, as it would be located on an existing improved levee with no restoration or flood risk management actions that would preclude implementation.

- The loop/Bay Trail spur to Alvarado Salt Works would not be feasible under Alternative B due to the proposed levee breaches and reconfiguration, but could be implemented as a trail spur. This loop could be completed as part of Alternatives Eden C or Eden D, but no levee improvements on either side of OAC are proposed in those alternatives.

- Community Connector to allow neighborhood access from Union City to the Bay Trail would be completed as part of the project and all of the Route options.

5.8 Consistency with Public Access Policies

Table G-4 outlines the Action Alternatives for consistency with recreation and public access policies of the three primary reviewing agencies with public access policies applicable to the project: BCDC, ABAG's Bay Trail, and EBRPD. In this table, the different route options are evaluated against those policies and evaluated as being consistent (Y), not being consistent (N), or whether the policy or standard does not apply (N/A). The asterisks with the "N" conclusions refer to further explanations in the notes below the table.

Table G-4. Phase 2 Consistency with BCDC, Bay Trail and EBRPD Recreation and Public Access Policies

POLICY		TRAIL ROUTE OPTIONS								
	EDEN A	EDEN B			EDEN C			EDEN D		
	--	1	2	3	1	2	3	1	2	3
BCDC										
1. Maximum feasible public access	N	Y*	Y*	N*	Y	Y	N	Y*	Y*	N*
2. Maximum feasible access to waterfront, except where inconsistent with public safety or significant use conflicts	N	Y*	Y*	N*	Y	Y	N	Y*	Y*	N*
3. Provide public access to natural areas and consult with agencies for appropriate location and type of access	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
4. Site, design and manage access to prevent significant adverse effects on wildlife	N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y
5. Site, design and manage access to avoid significant adverse impacts from sea-level rise ***	N/A	Y	Y	Y	Y	Y	Y	N	Y	Y
6. Permanently guarantee public access and make viable in event of sea-level rise or provide equivalent access	N	Y	Y	N**	Y	Y	N**	N	Y	N**
7. Public access should be consistent with environment, encourage diverse Bay-related activities, be barrier-free, and maintained	N	Y	Y	N**	Y	Y	N**	Y	Y	N**
8. Fill may be allowed if necessary for	N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y

POLICY		TRAIL ROUTE OPTIONS								
	EDEN A	EDEN B			EDEN C			EDEN D		
	--	1	2	3	1	2	3	1	2	3
public access in some areas										
9. Access to and along the waterfront should be provided and connect to the nearest public thoroughfare. Provide diverse and interesting public access experiences	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
10. Roads near water edge should be scenic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11. Cooperate to provide appropriate regional trail system, such as Bay Trail	N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y
12. Use Public Access Design Guidelines in project review	N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y
13. Integrate public access early in restoration projects	N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y
14. Support scientific study on public access effects on wildlife	N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y
ABAG Bay Trail										
1. Locate the Bay Trail as close to the Bay shoreline as feasible	N/A	Y	N	N	N	N	N	N	N	N
2. Create a Bay Trail that provides views of the Bay and/or a "Bay" experience	N	Y	N	N	N	N	N	N	N	N
3. Design a Bay Trail that is physically separated from streets and roadways in order to provide a safe trail experience for users.	N	Y	Y	N	Y	Y	N	Y	Y	N
4. Align the Bay Trail to provide usable and logical connections with shoreline parks	N/A	N*	N*	N*	Y	Y	Y	N*	N*	N*
EBRPD										
PRPT9. Connect regional trails to parks, shorelines and other areas of regional significance	N	N*	N*	N*	Y	Y	Y	N*	N*	N*
PRPT 10. Create local trail networks that provide additional access points to regional parks and trails	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
PRPT11. Cooperate with other agencies to implement multi-jurisdictional efforts.	N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y

Y = Yes; N = No; N/A = Not Applicable

* This option does not include shoreline access via an ACFCC bridge, but does not preclude future implementation by another entity. Shoreline access would be precluded along OAC in Alternatives B and D due to levee breaching.

** This option includes public access on lands that are not owned by the Project Lead Agency. While no agreement between such a project proponent and respective landowners currently exists for permanent trail implementation, this project does not preclude the possibility of such a project from being developed and implemented.

*** This consistency analysis focuses on Phase 2 action alternatives. Levee improvements to existing levees in northern Eden Landing may also be needed to address sea-level rise as part of the common trail improvements proposed for all trail route options.

Consistency with recreation and public access goals and policies, especially as they relate to the provision of shoreline or waterfront access, may vary depending on the habitat or flood risk management alternative ultimately selected. Many of these policies include considerations for implementation feasibility, avoiding adverse impacts on wildlife, the selection of appropriate locations for public access features, or other constraints. Selection of recreation and public access features must be balanced with other project goals, and an alternative could be consistent with these policies even while not providing every public access feature shown in previous project documents and would not prevent implementation in future phases. In addition, trail route options on lands that are not part of the Reserve may be precluded if permanent access agreements or easements are not obtained, in which case, an alternate alignment would need to be provided in order to fully meet Project and regulatory goals and policies for recreation and public access, including completion of the Bay Trail spine.

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6. PROJECTED TRAIL USE

The purpose of this section is to provide an estimate of the expected usage of the proposed project trail system and recreational facilities within and immediately adjacent to the Phase 2 ELER. The trail segment options proposed for Phase 2 include implementation of a segment of the Bay Trail spine with one alternative also containing a recreational spur trail and providing a bridge over ACFCC, to link the trail network in Eden Landing to the Bay Trail spine south of the ACFCC. The Bay Trail and associated recreational amenities would serve several purposes, as they would provide a non-motorized transportation connection from one neighborhood location to another in the Hayward-Union City area, and would also provide additional access to facilities for hiking and exercise, wildlife viewing, and other activities within ELER.

Based on a trail user satisfaction survey completed for the Don Edwards San Francisco Bay National Wildlife Refuge (Refuge) to the south of ELER (Sokale and Trulio 2013), recreational trail users who would be expected to use the ELER trails are likely to be primarily local (live within 5 to 10 miles of the trail), and may drive or bicycle to the trailhead parking from where they live. In addition, a small but significant percentage of the potential recreational facility users would work in the immediate area and would likely use the trail system during work hours, such as lunch time or after work walks.

The Sokale and Trulio 2013 trail user satisfaction survey found slightly higher trail use during weekends than during week days, and slightly higher trail use during the late spring, summer, and early fall months when weather is good, rather than during the late fall and winter months when weather is more likely to be cool or wet. The trail user survey also found that trail user priorities included keeping the trail clean and well maintained with good signage and facilities such as parking, restrooms, and benches. The 568 visitors who completed surveys were less interested in historical and natural history interpretive signs and panels, and overlooks than in facilities for active hiking.

Some Refuge trail use information applicable to the Phase 2 actions at Eden Landing is also reported in the Sokale and Trulio trail user satisfaction survey, which allows for extrapolation and a rough approximation of the number of new trail users expected as a result of the ELER project public use improvements. Between 750,000 and 900,000 people were estimated to have visited the Refuge annually between 2009 and 2011, and a majority of these visitors used the 30 miles of trails within the 30,000-acre Refuge, especially the trail system near the Visitor Center and Environmental Education Center (EEC) parking areas (Sokale and Trulio 2013). This equates to approximately 25 to 30 visitors annually per acre of Refuge, or about 25,000 to 30,000 visitors annually per mile of trail. This information does not consider that a disproportionate amount of trail use likely occurs in the 1 or 2 miles of trail immediately surrounding the main visitor center in Fremont and the EEC in Alviso, but, along with other sources of information, provides a rough guide that can be used to gauge Phase 2 ELER trail use.

Important points to make in comparing the Refuge with the ELER is that the Refuge is considerably larger, has more miles of trails, and has a Visitors Center with exhibits and interpretive information, while no visitor center is proposed at Eden Landing. However, ELER does provide facilities such as a kayak launch platform, while a comparable facility is not provided at the Refuge. There is a small boat launch at the Alviso Marina, very near the Refuge’s EEC, however.

In addition, as noted earlier, the Phase 2 trails within ELER will be part of the Bay Trail and available for both recreational uses and commuter bicycle use, although without the ACFCC bicycle/pedestrian bridge, the link between adjacent areas is not as direct and is more circuitous than on-street bicycle/pedestrian travel routes between Hayward and Union City.

For general discussion purposes, if trail users at Don Edwards are computed on a per mile of use intensity and spread out equally each day throughout the year, there would be a daily use of about 68 to 82 people per day per mile of trail. Each of the three Bay Trail spine routes being considered has different amounts of trail that would be completed. Consistent with the ELER project construction cost estimate, this analysis used 10,000 linear feet or about 2 miles of trail. Based simply on extrapolating trail mileage, this equates to about 136 to 164 recreational trail users per day. Considering that recreational trail use would be more concentrated during the better-weather months of the year, with slightly more trail use on weekends, daily recreational trail use is likely to be in the range of 150 to 250 people per day during periods of highest use, with average daily use throughout the year in the range of 100 to 125. Annual recreational trail use would be in the range of 36,500 to 40,000 users.

Another way of extrapolating the Refuge trail use estimates and applying them to Eden Landing is based on facility size. The total area of the Refuge is about 12 times larger than ELER. At a use rate of 25 to 30 persons per acre per year, the annual usage at Eden Landing would be in the range of 62,500 to 75,000.

Actual trail count data are available from EBRPD for the Phase 1 project at northern Eden Landing (S. Dougan, EBRPD, email with trail database attachment, Sept. 2013). This traffic count data was obtained using a TRAFx automated trail traffic counter system, with the sensor/counter embedded under the trail surface (www.trafx.net). Trail count data for a portion of the Bay Trail located near the Gordon E. Oliver Eden Shores Park in Hayward, in the southeast corner of the Phase 1 area, indicated average daily use of about 19 trail users (2012 data). Recorded monthly trail use at this location ranges from 252 to 2195, with average daily use of 19 trail users (2012 data). Trail use is much higher near the Phase 1 parking lot, located near the intersection of Eden Landing Road and Arden Road, with monthly totals ranging from 1460 to over 2,000 and averaging 126 users per day (2012 data). Trail use was slightly higher on weekdays than on weekends, and with the highest use periods in the spring and early fall months. The majority of use was between 10 AM and 2 PM, but some use extended until after 7 PM during the spring and summer months.

Importantly, these counts were done before the completion of the Phase 1 actions at Eden Landing, and use of those Phase 1 amenities (the spur trail to the viewing platform, the seasonal loop trail, the interpretive features, and the kayak launch). Anecdotally, usage of and visitation to northern Eden Landing has increased since these features were opened to the public, but no new quantitative data is available.

Trail count data available from EBRPD for recreational trails at Hayward Marsh show average daily uses in the range of 150 to 200 (2012 & 2013 count data) , at Hayward Landing in the range of 120 to 150 (2012 & 2013 data) and at the San Lorenzo Trail Bridge of 145 to 160 users per day (2012 & 2013 data).

Based on a review of all of the above information, it is reasonable to expect between 100 and 150 recreational trail users per day.

In addition to a recreational trail use component, the Bay Trail through ELER will also provide a transportation component, as an alternative and more pleasant mode of transportation between two neighborhoods, or a travel destination. This use also needs to be accounted for in the overall Trail Use Estimate.

ACTC has been conducting bicycle and pedestrian counts along major streets for all of the cities and major unincorporated areas in the County since 2002. Although not trail systems, counts conducted along Thornton Avenue and Willow Street in Newark indicate daily travel by bicycle and pedestrians of about 25 people per day. More heavily used bikeways such as Paseo Padre and Mowry Ave in Fremont have counts of about 219 per day and for Decoto Road near Alvarado Niles Road, 107 bicycler users in 2010.

Expected use of this segment of the Bay Trail by bicyclists can also be estimated using US Census and demographic information on bicyclists and residential population estimates with 0.5 to 1.5 miles of a proposed bicycle route, based on a method developed by the National Highway Research Program. This method, (which provides low-range, mid-range and high-range estimates) was 31,057 per year, or 85 per day for the mid-range estimate.

Based on reviewing all of the above, an estimated 50 to 100 bicyclists may use the Bay Trail as a transportation route between Hayward and Union City on a daily basis, with slightly more on weekends. Added to the recreational trail use estimate of 100 to 150 users per day, this would put total daily usage of the new facilities at Eden Landing in the range of 150 to 250 daily users.

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7. RECREATION AND PUBLIC ACCESS DESIGN GUIDELINES

This section provides guidance regarding the physical design of recreation and public access features, such as trails, viewing platforms, signage, and site furnishings. This section also identifies construction protocols that will be implemented as part of the project to minimize disturbance to adjacent areas and avoid disruption of sensitive species during construction. Trail design issues include:

- Design strategies to comply with BCDC public access policies
- Accessibility
- San Francisco Bay Trail Design Guidelines and Toolkit
- Community Connectors
- ACFCWCD Facilities
- Recreation and Public Access Facilities

Where feasible, all recreation and public access facilities must be designed to be accessible. In addition, BCDC policy requires that public access facilities be designed to be viable in the event of future sea level rise or flooding, or equivalent access consistent with the project should be provided nearby.

7.1 Design Strategies to Comply With BCDC Public Access Policies

BCDC review of public access facilities will likely focus on three areas: design to maximize shoreline access, resilient design of public access facilities, and design to minimize wildlife conflicts.

Design to Maximize Shoreline Access

Phase 2 actions would essentially move the Bay shoreline to the east, eventually replace some or all managed ponds with tidal marsh. Point access to the shoreline will continue to be provided in all alternatives via the Alameda Creek Regional Trail, as well as the trail spur that was added as part of Phase 1.

Design Strategies to Address Sea Level Rise for Public Access Facilities

For this project, which is likely to be affected by future sea level rise and storm activity during the life of the project, BCDC requires that public access facilities:

- Be set back far enough from the shoreline to avoid flooding;
- Be elevated above expected flood levels;
- Be designed to tolerate flooding; or
- Employ other means of addressing flood risks.

Trails on Improved Flood Risk Management or Habitat Levees. As described in the Alternatives Figure 4.2 of the Phase 2 Design Memorandum, proposed levees to provide flood risk management or habitat enhancement are to be a minimum elevation of 12 feet NAVD88 with a 12-foot crest width, with 4:1 side slopes. If these improved levees also have trail improvements, the crest width at this elevation should be at least 24 feet to accommodate a twelve-foot trail at year 2100, this would allow sufficient width for topping to raise the trail elevation in the future with sufficient width. This may require steeper side slopes, use of retaining walls, rails or other features in the future to ensure trail user safety (**Figure G-5**).

Figure G-5. Typical Improved Trail Section

Design:

- Top elevation: Raised levees will have a minimum crest elevation of 12 feet NAVD88.
- Top width: Raised levees will have a minimum crest width of 12 feet.
- Side slope: The improved levees will have side slopes of 4:1 (H:V).

A typical cross-section of the proposed levee raising is shown in Figure 4.2.

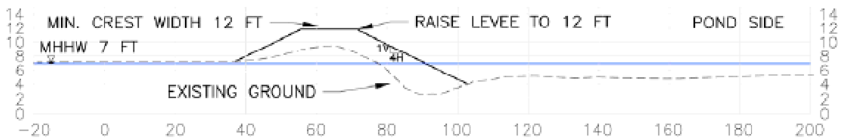


Figure 4.2. Proposed Levee Raising – Typical Section

Trails on Existing Pond Levees. The existing pond levees are generally underlain by former tidal marsh and were created beginning in the early 1900's by dredging and placing Bay Mud soils on the drained and diked lands to create the berms to prevent tidal waters from entering the salt production areas, and are generally at an elevation of 8 to 10 feet[10], though many of the levees around the external border of the pond complex are higher (in the range of 11 to 12 feet elevation). Portions of the proposed trail extension in northern Eden Landing, Trail Route Option D1, and the OAC levee loop trail would be located on such pond levees. (Trail Route Option C1 would also be located on an unimproved levee, but would be protected by a habitat levee further west). If design resilience is a project design goal, trail segments that are subject to flood influence and sea level rise would need to be built at a minimum elevation of 12 feet and/or designed to accommodate future overtopping. The trail would need to have the following width at construction to allow a 12-foot wide trail during the facility's design life (2050), assuming 2:1 side slopes that are geotechnically stable, as shown in **Table G-5**.

Table G-5. Adaptive Management Trail Construction Width

EXISTING LEVEE ELEVATION (FEET NAVD88)	LEVEE ELEVATION YEAR 2050 (FEET NAVD88)	TRAIL CONSTRUCTION WIDTH (FEET)	YEAR 2050 TRAIL WIDTH (FEET)
8	12	28	12
9	12	24	12
10	12	20	12
11	12	16	12
12	12	12	12

If the trail is intended to meet the 18-foot wide Bay Trail guidelines (Option D2), or if 3:1 or 4:1 side slopes are implemented, then additional width should initially be reserved for future remedial actions. For example, in Option D1, some berms are currently a maximum of 10-12 ft. wide at elevation 7- 8, so a future trail could not be accommodated within the current berm footprint, and adjacent habitat would preclude future adaptive actions.

[10] SBSP Levee Assessment, Geomatrix 2005.

Consideration should be given to locating the Bay Trail spine and other public access features on improved levees (such as in Alternative Eden B, or on the flood risk management levee in Alternative Eden C) to avoid the temporal width and elevation challenges described herein.

Geotechnical issues related to the placement of public access facilities on these unimproved levee berms is discussed in Section 3.2 – Hydrology and Section 3.4 – Geology and Soils.

Design to Minimize Wildlife Conflicts

An important component of providing public access near sensitive wildlife areas is to limit the potential impact of human intrusion and trespass into sensitive areas. The selection of public access alternatives to be considered as part of project evaluation has included extensive input from regulatory agencies as well as site-specific studies. All proposed trails are located on existing levees, and several project alternatives include the creation of habitat transition zones to increase habitat diversity, but these features would also provide a buffer between trails and areas that may become habitat to sensitive species in the future.

A study conducted in 2014 to determine the effects of human disturbance on waterbird nesting at SBSP Pond SF2 concluded there was no pattern of disturbance associated with public access facilities, including trails, viewing platforms, restrooms, and interpretive elements, which are all located at least 300 feet from nesting habitat features.

In 2013, the SBSP Restoration Project sponsored an experimental study of shorebird response near trails. Recommendations from that study that could be applied to project design include:

- Locate trails 150 feet from foraging habitat where feasible.
- Incorporate wide borrow ditches in the restored areas to provide a buffer between levees.
- Place trails in areas of high human demand, rather than areas with infrequent use.
- Provide consolidated areas without trails.
- Increase the quantity and quality of forage in restoration areas that are not near trails.

A similar study conducted in 2012 focused on human disturbance in proximity to nesting western snowy plover habitat, and concluded that flushing was seven times higher than background flushing; however, the consequences of this flushing were unknown. Other conclusions were that locating trails 500 feet from nesting habitat reduced flushing to background levels, and that bird response could vary depending on whether the trails were new or existing trails.

The Phase 2 Action Alternatives were developed with a focus on flood risk management and habitat enhancement. Of the more than 2,000 acres at southern Eden Landing site, recreation and public access features range from 7 to 10.8 acres (if all options shown in Alternative C are implemented)[11]. This represents less than one-half of one percent of the Phase 2 area, and less if recreation and public access improvements are built on the off-site route options. Additionally, several public access features shown in the 2007 EIS/R were eliminated, which would further reduce potential wildlife impacts due to human use.

[11] Eden Landing Phase 2 Preliminary Design Memorandum, August 2016.

7.2 Accessibility

To meet the Federal Accessibility criteria, trails must provide a firm and stable surface, with sufficient width, gradient and vertical clearance for unobstructed passage. Trails that connect facilities such as parking areas, restrooms, and viewing platforms are considered "Outdoor Recreation Access Routes", with a minimum 48-inch clearance width with additional passage (60-inch minimum width at 200 foot intervals) in California. A minimum of 60 inches unobstructed tread width is typical for public access facilities to meet accessibility. The trail section must have a firm and stable surface with no gaps or obstructions of more than one-half inch. Typical trail surfaces may include concrete, asphalt, or compacted aggregate to meet accessibility requirements.

The trail must have maximum cross slope of 2 percent and 5 percent longitudinal grade. Short ramps are allowed for up to 30-inch rise to accommodate grade transitions. Since the site is relatively flat, all trails should be built in compliance with accessibility guidelines without design exceptions.

Site furnishings such as benches, viewing scopes, and interpretive panels must be designed and oriented to avoid creating an obstacle and to facilitate the intended use.

Recommendations

New trail segments that are to be considered part of the Bay Trail should be designed (where feasible) in compliance with Bay Trail Guidelines. These guidelines were substantially updated with the new version released in June 2016. (www.baytrail.org/pdfs/BayTrailDTK_082616_web.pdf)

The trail should be surfaced with a durable material that complies with universal access needs. Paving designs should be selected that provide permeability, where appropriate, and that fit with the shoreline setting. In some locations, it will be appropriate to remain as "natural" as feasible, using permeable materials and construction methods. Trails in segments that will be routinely utilized by motorized vehicles for access and maintenance should be paved.

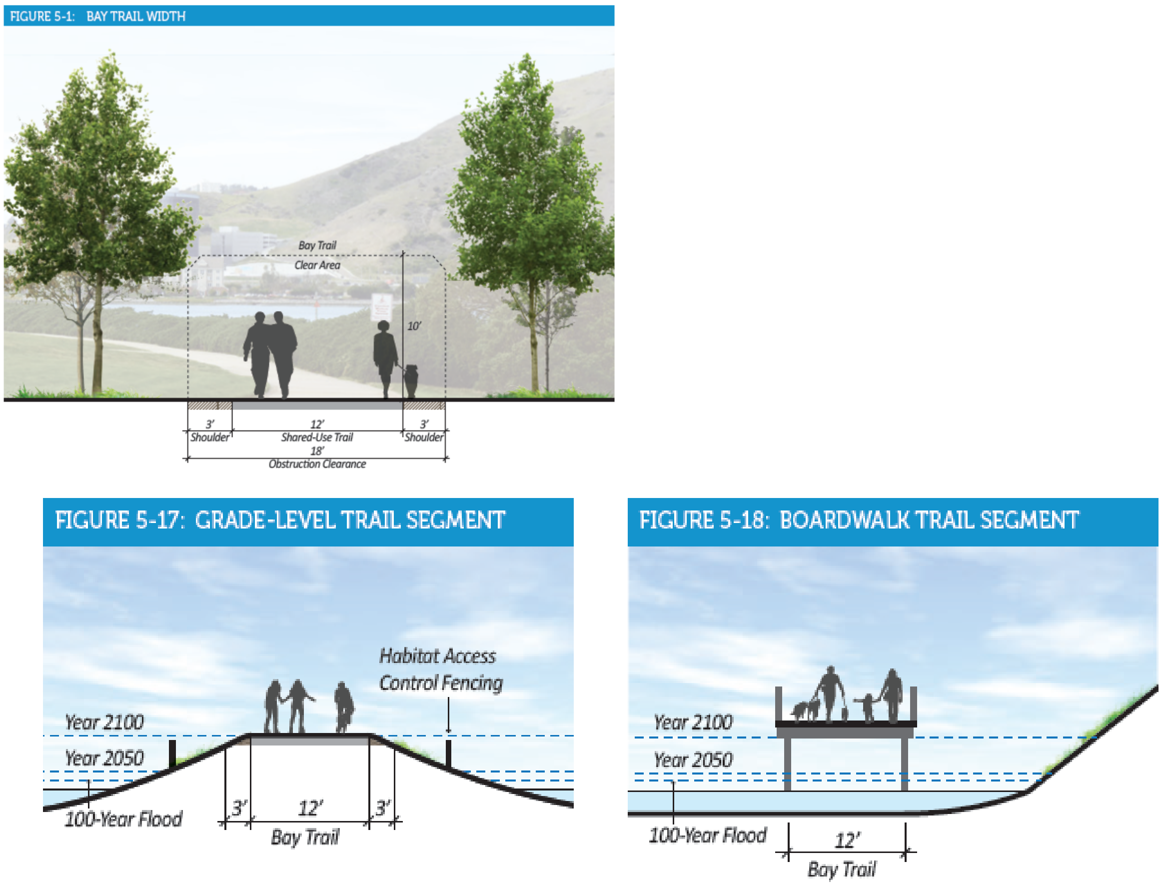
The trail should generally be elevated slightly above the adjacent grade to allow construction of a uniform trail surface without obstacles. During the design of each trail segment, the design of facilities should consider levee slope stability, erosion potential, and pathway drainage. In general, trails on levee segments should be crowned to minimize erosion risk.

7.3 Bay Trail Design Guidelines

Consistency with the Bay Trail Plan design guidelines will be needed for segments that are incorporated into this regional trail system. Guidelines adopted in June 2016 for the Bay Trail emphasize that *"Bay Trail users should be able to enjoy a Bay experience."* and recommend a minimum 18-foot wide trail commitment consisting of a 12-foot wide trail surface with three-foot shoulders (wider in high use areas). Due to the length and lack of community trail connections, this width should be sufficient. The guidelines further recommend that the elevation of the Bay Trail should be elevated to accommodate future sea level rise.[12] See **Figure 5-6** for examples.

[12] Bay Trail Design Guidelines and Toolkit, 2016

Figure G-6. Bay Trail Guidelines (source: Bay Trail Design Guidelines and Toolkit, 2016)



The Bay Trail Design Guidelines and Toolkit contains strategies for design of recreation and public access facilities to minimize public access and wildlife compatibility conflicts. This includes:

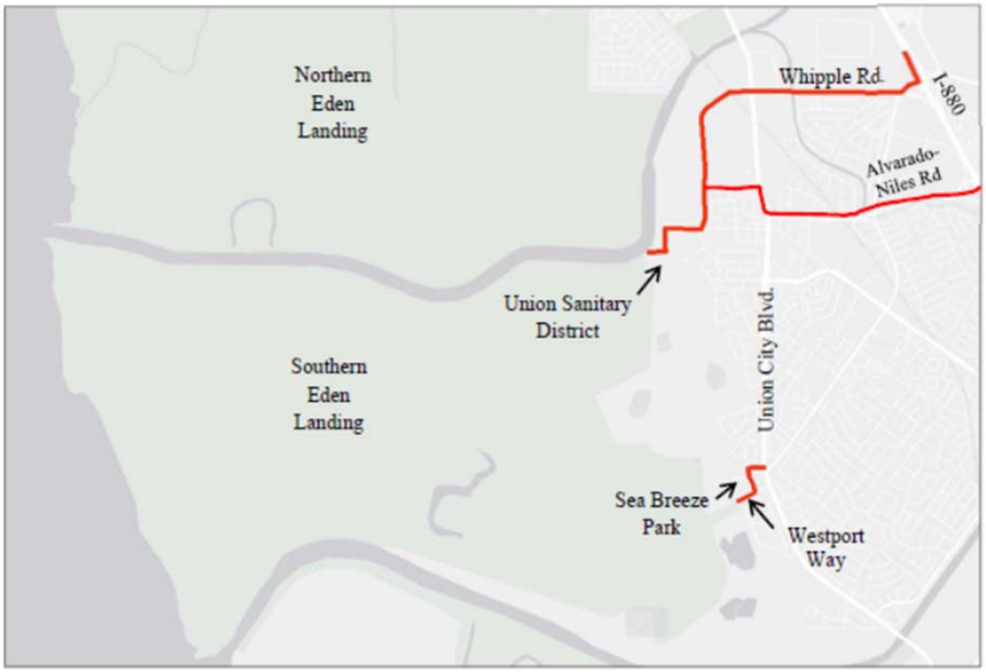
- Alignment, to provide a fulfilling, varied and interesting access experience
- Parking and staging area siting
- Education, such as interpretive signs
- Observation Points at strategic locations
- Reducing opportunities for raptor perching
- No/minimal lighting
- Physical and visual separation, such as:
    - Wildlife friendly fencing
    - Upland buffers
    - Moats and wetlands
    - Strategic vegetation buffers

Many of these strategies have been incorporated into the preliminary Phase 2 designs, and additional features may be incorporated into the precise design to sensitively incorporate public access into the restoration.

7.4 Community Connectors

Several of the adopted community and regional plans highlight the need for neighborhood connections to the trail (**Figure G-7**). The two existing trailheads that serve this area are over six miles apart, with one existing connector that serves the Eden Shores neighborhood.

Figure G-7. Project Construction Access Roads, Community Connectors



Two construction access points have been identified to accommodate site construction, via the Horner/Veasy Street access, and via Westport Way in the vicinity of Sea Breeze Park. The SBSP Restoration Project intends to coordinate and enter into agreements with the underlying property owners such as EBRPD, the City of Union City, and other adjacent landowners (including Union Sanitary District and ACFCWCD) to formalize these access points as Community Connectors that would provide connections to the Bay Trail. . Since physical improvement of the access roads or trails for construction purposes (such as leveling, widening and/or surfacing) may be necessary, it is anticipated that physical improvements needed to convert this access for trail use will be minimal, such as surfacing, signage and entry gates.

7.5 ACFCWCD Facilities

Some segments of the proposed trail would occur on Alameda County lands. This section excerpts portions of the Union City Bay Trail Study that identified specific design strategies (**Figure G-8**) to address ACFCWCD concerns regarding access and public safety around their facilities. Although some of this information may be dated, it is included for reference so that these issues can be addressed during the later stages of project design.

20-Tide Gate Structure

Issues identified in the Union City Bay Trail Feasibility Study related to the 20-Tide Gate structure include:

- Edge treatment to warn trail users away from the structure edge
- Address risk and liability concerns
- Facilitate maintenance
- Provide safety features without structural elements
- Allow for ease of maintenance, operations, and heavy vehicle use of structure by ACFCWCD.

The preliminary design strategy developed in 2004 included striping, pavement detectors, curbing and collapsible bollards. These issues and design options should be revisited as part of final project design to meet current construction, accessibility and safety standards.

Figure G-8. Trail Design on ACFCWCD Structures

Source: Alta Planning 2004

Trails on ACFCWCD Levees

In addition to the 20-Tide Gate structure preliminary design, the 2004 feasibility study also discussed the use and design of trails on ACFCWCD levees, which are used by heavy equipment to transport dredge materials. This discussion identified the following design issues that should be addressed as part of final project design (applies only to ACFCWCD levees):

- Gravel surfacing of levees for drainage and public access
- Installation of security fencing and controlled access at the Alvarado Pump Station

- Construction of bridges for maintenance vehicle access[13]
- Modification of existing vehicle gates at trail entry points to facilitate bicycle and pedestrian access, including modification of access gates at other connecting levees

7.6 Recreation and Public Access Facilities

Bridges and Boardwalks

Several of the trail route options would necessitate bridges to provide a complete trail connection. Depending on the location, these might be used by ACFCWCD, EBRPD, and/or Alameda County Mosquito Abatement District. These agencies have requested that any bridges be designed to accommodate light duty vehicles. The project presently proposes pedestrian and bicycle access only on the bridges over the ACFCC and the OAC, but the bridges over the ACFCWCD-owned channel to the J-ponds would be designed to accommodate access by maintenance and emergency vehicles. Any bridges should be designed for the marine environment. Detailed foundation and structural recommendations as part of a comprehensive geotechnical investigation and structural analysis would be completed as part of the final construction plans.

EBRPD also noted that ACFCWCD requires bridges across channels that they maintain to be designed to accommodate dredging equipment, such as a removable center section. Such bridges have been constructed across Sulphur Creek and San Lorenzo Creek within Hayward Regional Shoreline.. A bridge over ACFCC would need to conform to regulations for federal flood levees.

If a boardwalk is constructed for any of the trail routes under consideration, it should be built using strong and durable materials requiring a minimum of maintenance and capable of supporting lightweight vehicle loads. Non-corrosive piers or pilings and connector would likely be needed for the boardwalk foundation system, and coated or sealed to avoid leaching of material into adjacent aquatic environment.

Bridge location and connectivity. The Action Alternatives presented in the Phase 2 analysis represent preliminary design concepts that will be refined and finalized as part of the project design and implementation process. The precise location of bridges and other structures to provide trail connections should be determined based on optimal resource use (placement of levees for flood risk management or habitat enhancement), minimizing wildlife conflicts, and placement of structures at the narrowest crossing location that will otherwise meet project goals. For the Pond E6C bridges, shifting the bridge crossing to the narrowest channel crossing, and providing short levee improvements on the opposite side could reduce bridge length (and cost) significantly, especially since geotechnical improvements will be necessary on both sides of the channel for abutments and access.

For a bridge across ACFCC, consideration could be given to locating the bridge crossing further east, where the channel is more trapezoidal with a narrow channel transition zone. In this area, the overall bridge length could be reduced to approximately 400 feet, with significant cost and habitat savings. This alignment would necessitate utilizing some of the Alameda Creek Regional Trail to make a direct connection, but could be considered as a viable choice for effectively meeting Project goals.

[13] EBRPD identified the need for vehicle access on any project bridges, although the project currently proposes access for pedestrian/bicycle loads only.

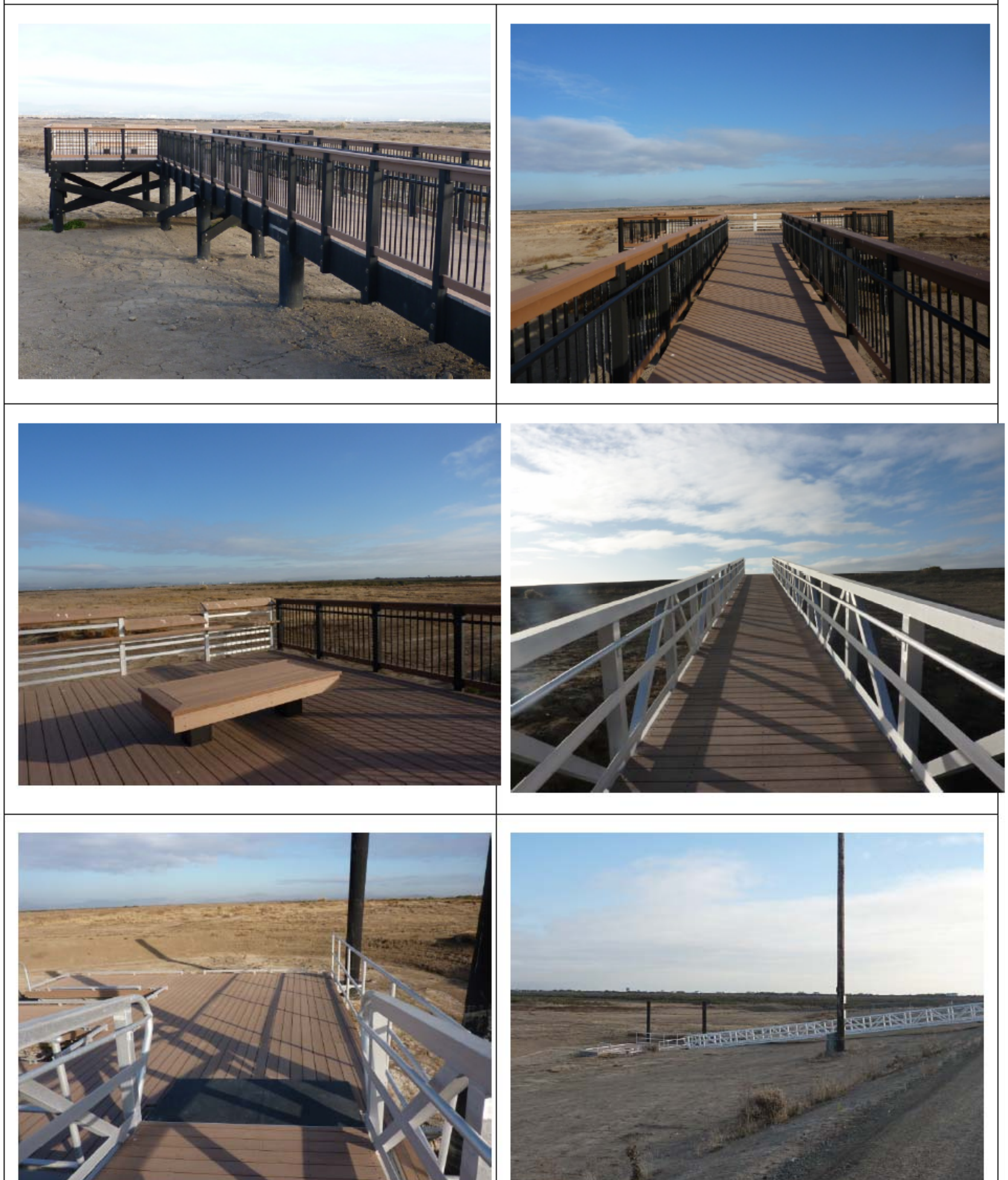
Viewing Platforms

At least one viewing platform is proposed at southern Eden Landing. The viewing platform would generally be constructed within or adjacent to the existing levee/upland footprint. Since the viewing platform would be constructed along the existing Alameda Creek Regional Trail, it would need to be designed to meet current guidelines for Outdoor Recreation Access Routes regarding accessibility. A second viewing platform is under consideration at the site of the Alvarado Salt Works in Pond E6 along the OAC; this feature could be constructed if the spur trail and/or the loop trail from the Bay Trail spine is/are selected. Additional viewing platforms, if included, would also need to meet accessibility guidelines. The final design may include consideration of providing additional viewing platforms, including raised facilities, especially where views of the Bay or tidal areas are obscured by adjacent levees.

Facilities that were installed in fall 2013 at Cullinan Ranch, which is part of San Pablo Bay National Wildlife Refuge, are shown on **Figure G-9**. These facilities include prefabricated aluminum ramps, dock platforms, a viewing platform, a permeable trail, and other facilities that incorporate composite materials and may be appropriate.

Figure G-9. Facilities at Cullinan Ranch, San Pablo Bay National Wildlife Refuge

Typical Boardwalk and Platform Elements[7]



[7] Cullinan Ranch, San Pablo Bay National Wildlife Refuge, January 2014

Signage, Wayfinding and Site Furnishings

Signs, interpretive elements, benches, viewing scopes and other built features must be located to provide adequate usable space as well as vertical clearance. These elements should not be placed within the area designated as a trail or access route.

Caltrans' *California Manual on Uniform Traffic Control Devices* (Caltrans 2014) includes advisory, warning, directional, and informational signs for bicyclists, pedestrians, and other users. Signage for the project should be consistent with all regulatory agencies.

Sign design should be consistent throughout the project, and sign elements should be grouped and designed to minimize visual intrusion. Sign elements may include more than one agency's signs as well as directional and informational elements. In accordance with accessibility regulations, it may be appropriate to provide information about a trail's length, running slope, width, cross-slope, and other characteristics to enable people to make informed decisions about using trails based on the characteristics of the trails. Signs along the levee tops should be minimized to avoid creation of raptor perches.

In general, all signs should be located 2 to 4 feet from the edge of the trail surface, have a minimum vertical clearance of 8.5 feet when located above the trail surface, and be a minimum of 4 feet above the trail surface when located on the side of the trail. All signs should be oriented so that trail users can see them clearly.

Phase 2 site design themes and prototypical site furnishings were developed as part of Phase 1 actions and should be continued, where appropriate, to provide a common design scheme. Typical facilities (developed for and implemented in Phase 1) are shown on **Figure G-10**.

Figure G-10. Typical Recreation and Public Access Facilities

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APPENDIX H

TRAFFIC IMPACT ANALYSIS
EDEN LANDING PHASE 2 EIS/R

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DRAFT

Traffic Impact Analysis

Eden Landing Phase 2 EIS/R

Prepared by:

AECOM

100 West San Fernando Street, Suite 200
San Jose, CA 95113

October 6, 2016

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APPENDIX

I PROJECT DESCRIPTION

The purpose of this traffic analysis is to evaluate the potential traffic impacts resulting from the truck trips required for bringing fill to the project areas shown in Figure 1.

There are three project alternatives, each with a different fill quantity, as well as the no-build scenario. For the purposes of this study, a conservative approach was adopted by assigning outbound trips from the project site equal to the inbound trips to the project site during AM and PM peak hours. As this project is a restoration project, the only project traffic would be generated during the construction period.

II TRAFFIC IMPACT STUDY AREA

The project site is bounded by Union City Boulevard to the west, SR 92 to the north and Alameda Creek to the south. There are two access points to the site, to be used by trucks carrying fill material. The fill material will be transported to the site from I-880 via Whipple Road to Union City Boulevard before accessing the site from Horner Street (North Entrance) and Westport Way (South Entrance). Figure 2 presents the truck route for transporting material.

The study will analyze six study intersections that are also presented in Figure 2:

1. I-880 NB Ramps / Whipple Road / Industrial Parkway (Caltrans, in Hayward)
2. I-880 SB Ramps / Whipple Road / Dyer Street (Caltrans, in Union City)
3. Union City Boulevard / Whipple Road (Union City)
4. Union City Boulevard / Horner Street (Union City)
5. Union City Boulevard / Alvarado Boulevard (Union City)
6. Union City Boulevard / Dyer Street (Union City)

Intersection turning movement volumes were collected in June 2016 during the following time periods:

- 7:00 a.m. to 9:00 a.m. for the AM peak hour
- 4:00 p.m. to 6:00 p.m. for the PM peak hour

Traffic volumes were projected and impacts were assessed for the following conditions during the AM and PM peak hours:

1. Existing Conditions – Traffic conditions were evaluated based on existing lane geometries, traffic controls and traffic volumes; and
2. Existing plus Project Conditions – Traffic conditions were evaluated with proposed project trips added to existing traffic volumes.

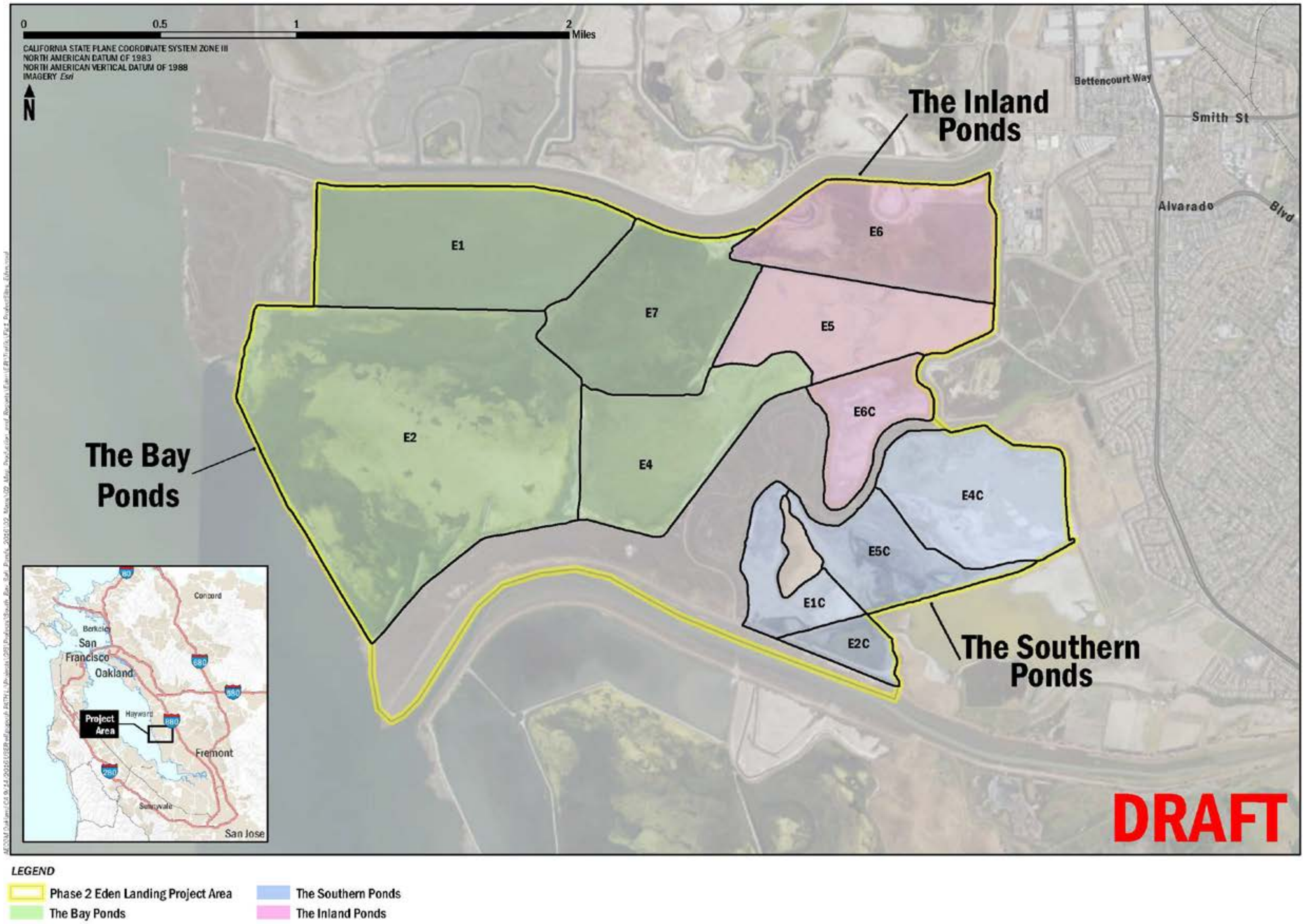


Figure 1 – Project Area Boundary

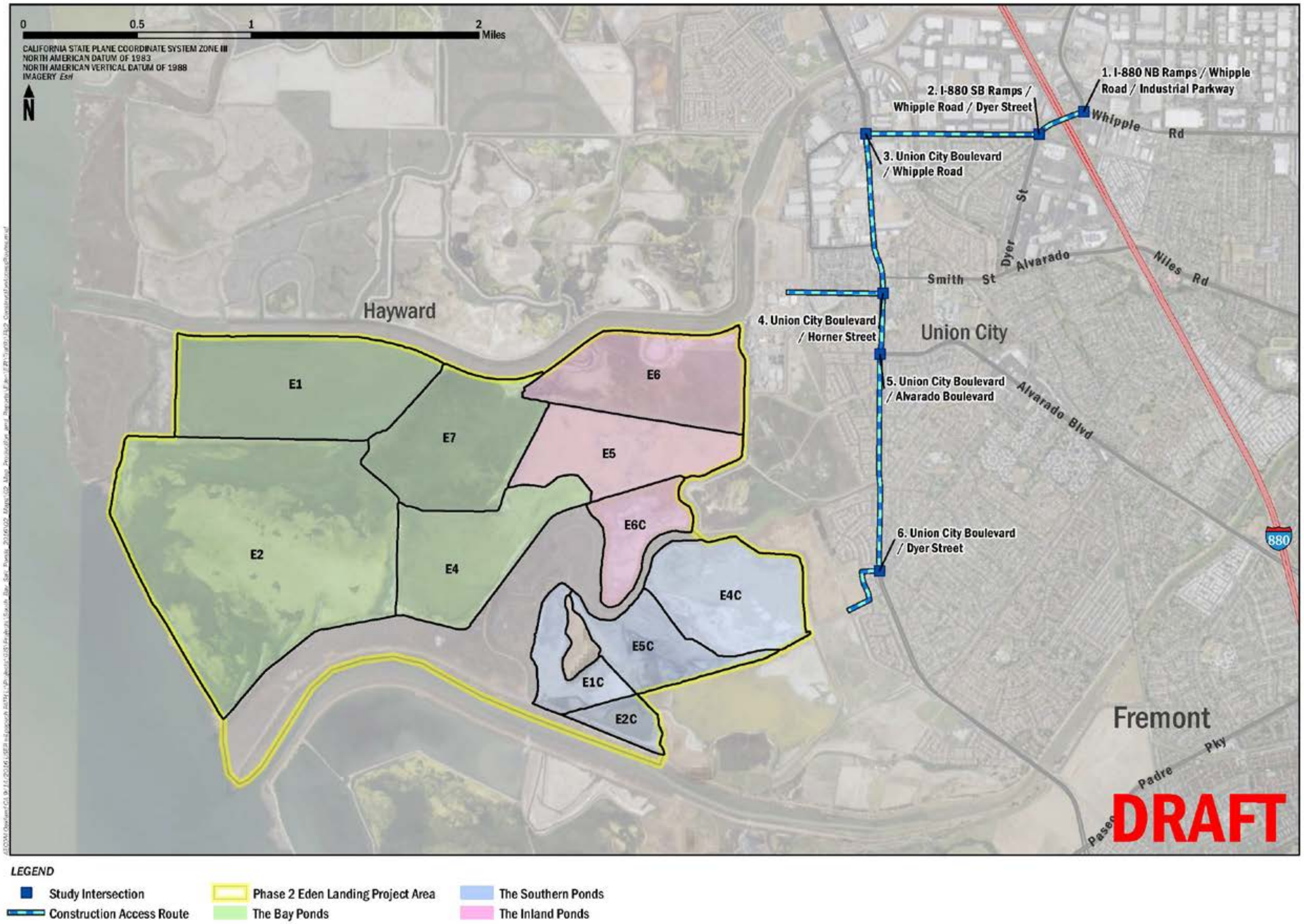


Figure 2– Construction Access Route and Study Intersections

III EVALUATION ANALYSIS

Evaluation Criteria

This section summarizes the methodologies used to perform the peak hour intersection capacity analysis at signalized intersections. Level of service analysis was performed using Synchro 9.0 software package based on the traffic data collected by AECOM according to the methodologies outlined in the Highway Capacity Manual (HCM 2000).

The resulting level of service (LOS) and delays were compared between the no-build and each project alternative. LOS measures traffic operating conditions, which varies from LOS A to LOS F. Table 1 presents a description of LOS and provides associated delays with each LOS letter grade for signalized intersections.

Table 1 – Signalized Intersection LOS Thresholds

Level of Service	Description	Delay (sec/veh)
A	Free-flow speeds prevail. Vehicles are almost completely unimpeded in their ability to maneuver within the traffic stream.	≤ 10
B	Free-flow speeds are maintained. The ability to maneuver with the traffic stream is only slightly restricted.	>10-20
C	Flow with speeds at or near free-flow speeds. Freedom to maneuver with the traffic stream is noticeably restricted, and lane changes require more care and vigilance on the part of the driver.	>20-35
D	Speeds decline slightly with increasing flows. Freedom to maneuver with the traffic stream is more noticeably limited, and the driver experiences reduced physical and psychological comfort.	>35-55
E	Operation at capacity. There are virtually no usable gaps within the traffic stream, leaving little room to maneuver. Any disruption can be expected to produce a breakdown with queuing.	>55-80
F	Represents a breakdown in flow.	>80

Source: Highway Capacity Manual (Transportation Research Board, 2000)

IV EXISTING CONDITIONS

Existing lane geometries and traffic controls for the 6 study intersections are illustrated in Figure 3.

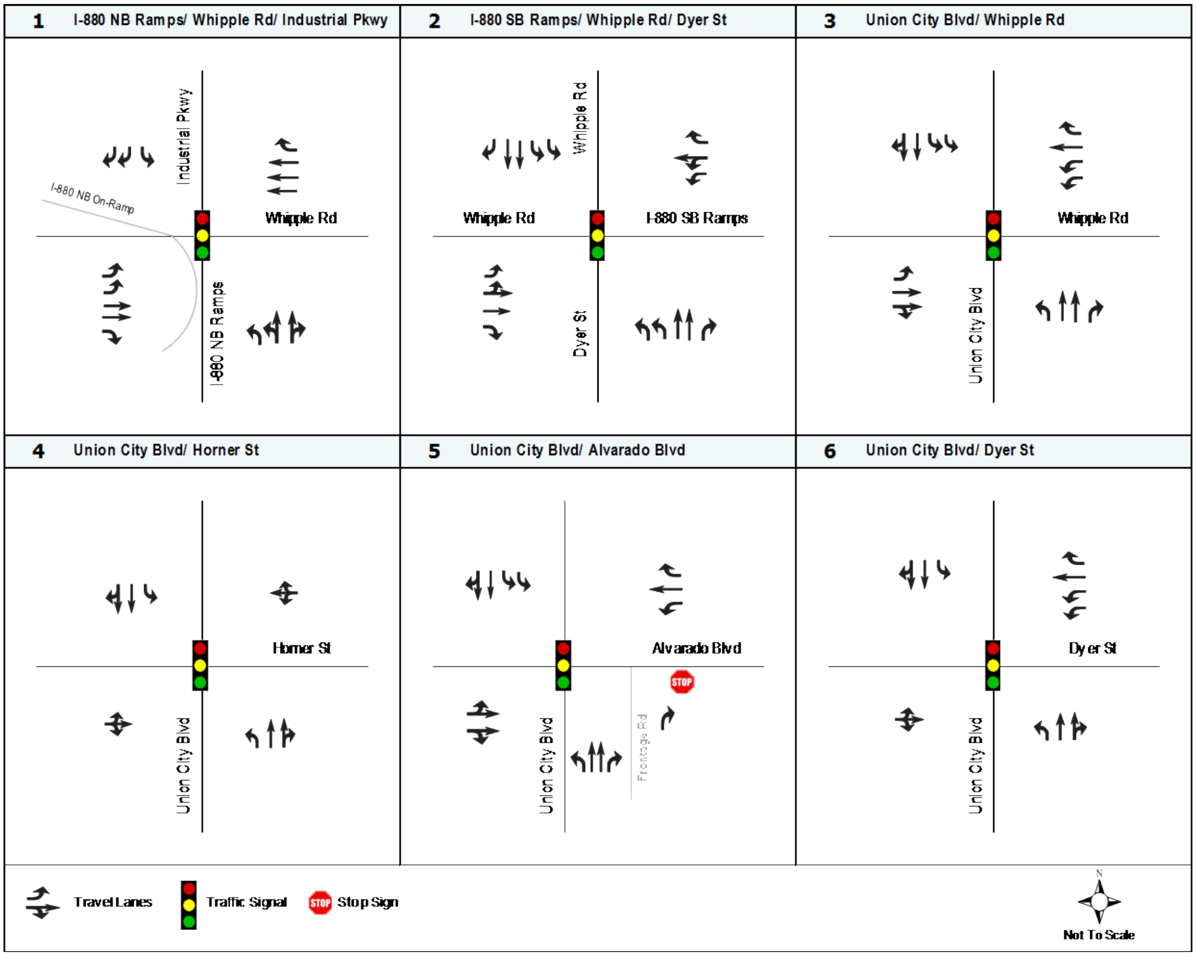


Figure 3 – Existing Lane Geometry

Existing intersection turning movement volumes at the study intersections are illustrated in Figure 4. The detailed counts for the AM and PM peak periods collected are provided in Appendix A.

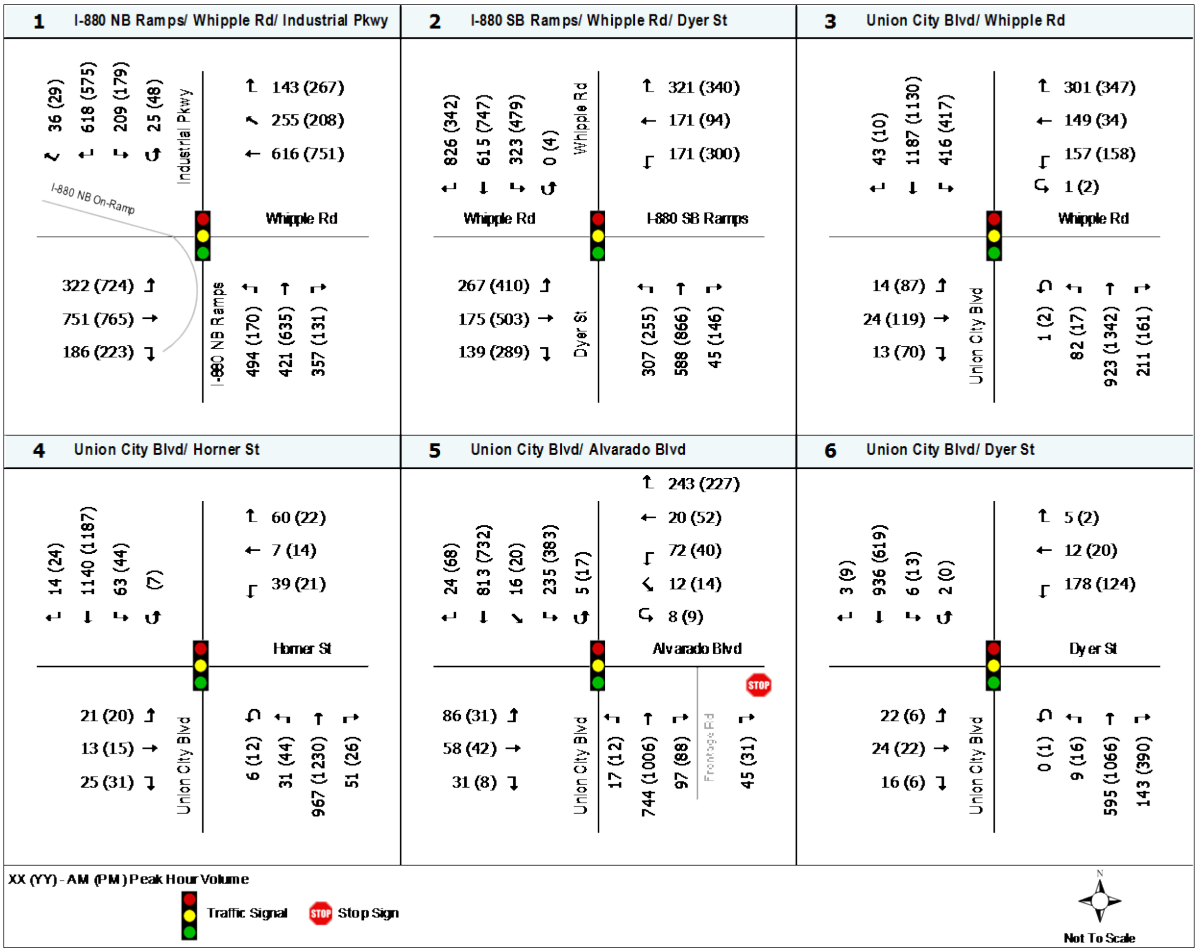


Figure 4 – Existing Peak Hour Turning Movement Volumes

V PROJECT CONDITION IMPACT ANALYSIS

There are two 'with project' scenarios being analyzed. The first scenario is the 'base case' and the second being the 'worst case'. Project trips generated under the 'base case' are dependent on the expected work duration of each project alternative, whereas the 'worst case' project trips are based on the daily maximum number of expected trips that the fill material can be brought to the project site. Details of each scenario are described below.

Trip generation

<u>Base Case:</u>
The estimated project trips using each of the two site accesses are shown in Table 2. It is assumed that each truck would carry 11 cubic yards of fill and the number of outbound trips is equal to the number of inbound trips in the same hour. The expected number of work days for each alternative as well as the number of work hours per day is also included in the table. It is projected that each alternative will generate a total of 10 trips (5 inbound, 5 outbound) in the AM and PM Peak Hours, with Alternatives B and C being expected to generate the same distribution pattern. Alternative D is expected to generate one inbound

trip a day at the South Access. This trip is assumed to be made during the peak hour for a conservative calculation. In addition, it is assumed that fill material will be brought to the project site via I-880; 50% from the north and 50% from the south. Figures 5a-b illustrate the proposed project trips at the study intersections for each alternative.

Table 2 – Base Case Trip Generation for Project Alternatives

	Project Alternative	Site Access	Net Import (CY)	Total Inbound Truck Trips	# of Work Days	Inbound Trips / Day	Work Hours / Day	Inbound Trips / Hour
A	No Build	-	-	-	-	-	-	-
B	Restore Entire South Eden Landing to Tidal	North	44,000	4,000	209	20	10	2
	Marsh	South	48,000	4,364		21		3
C	Retain Inland and Southern Ponds as	North	18,000	1,634	134	13	10	2
	Managed Ponds	South	41,000	3,728		28		3
D	Staged Implementation of Tidal Marsh	North	152,000	13,819	350	40	10	4
	Restoration	South	2,000	182		1		1*

Source: AECOM 2016

*Assumes trip is made during peak hour for conservative calculation

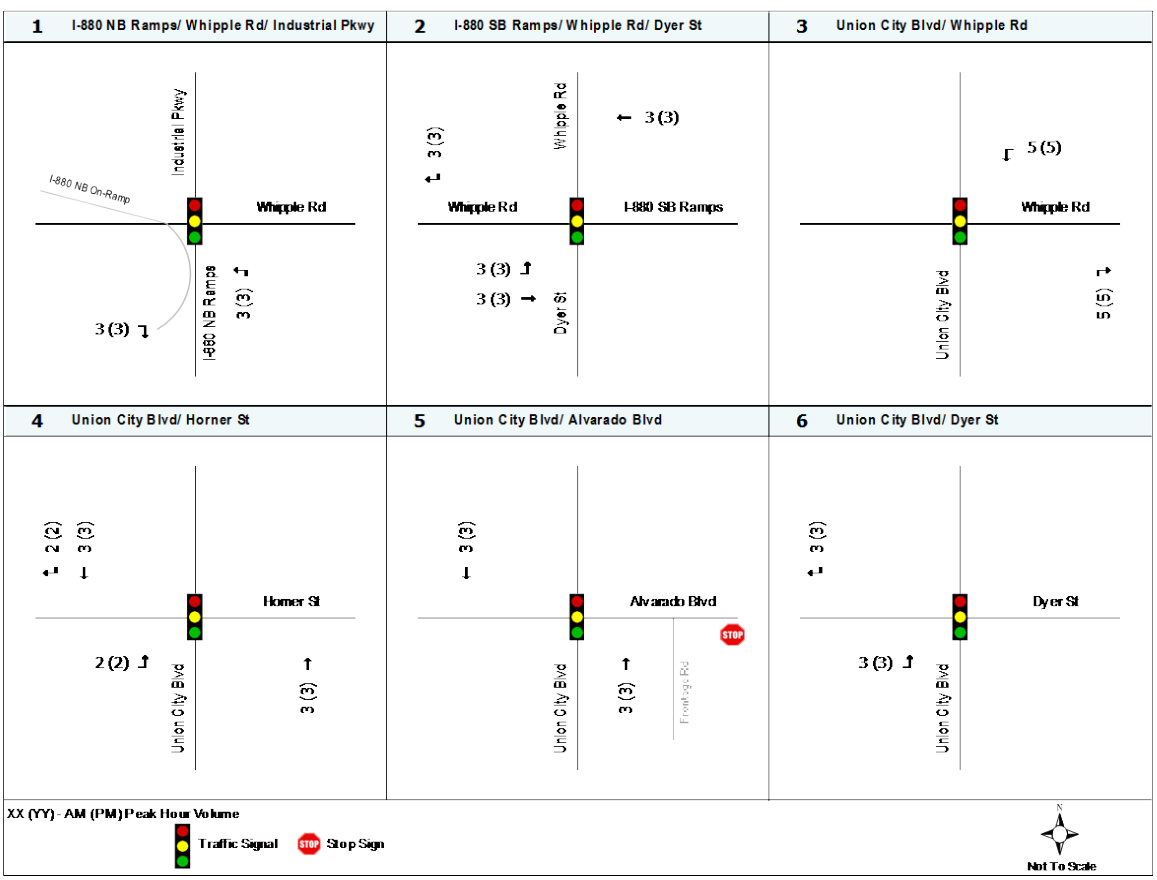


Figure 5a – Base Case Project Alternatives B & C Turning Movement Volumes

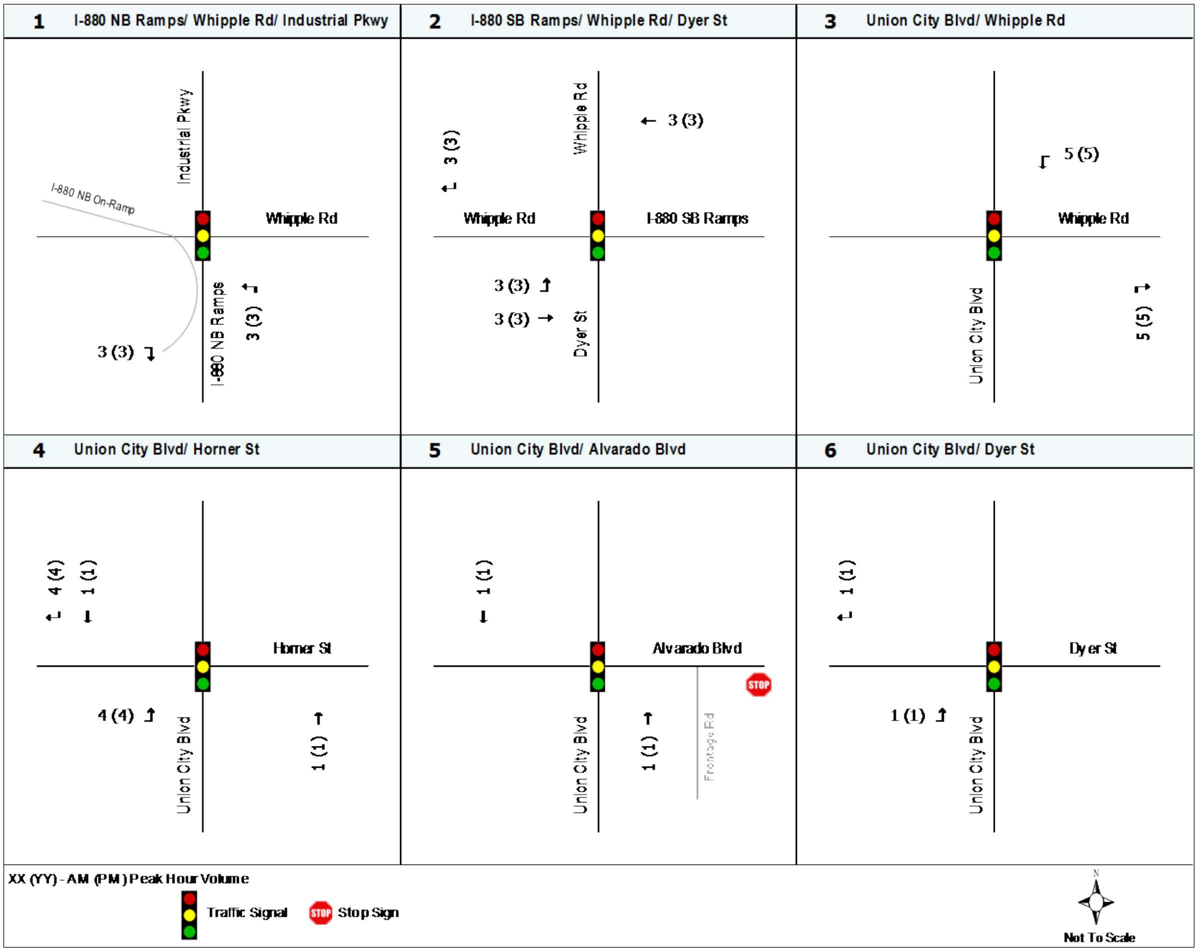


Figure 5b – Base Case Project Alternative D Turning Movement Volumes

<u>Worst Case:</u>
The estimated project trips using each of the two site accesses are shown in Table 3. It is assumed that a daily maximum of 200 trucks would bring fill material to the project site via the two accesses. It is therefore projected that each alternative will generate a total of 40 trips (20 inbound, 20 outbound) in the AM and PM Peak Hours. For a conservative calculation, Alternative B & D are expected to generate one additional inbound trip during the peak hours at the South Access. In addition, it is assumed that fill material will be brought to the project site via I-880; 50% from the north and 50% from the south. Figures 6a-c illustrate the proposed project trips at the study intersections for each alternative.

Table 3 – Worst Case Trip Generation for Project Alternatives

	Project Alternative	Site Access	Access usage	Inbound Trips / day	Work Hours / Day	Inbound Trips / Hour
A	No Build	-	-	-	-	-
B	Restore Entire South Eden Landing to Tidal Marsh	North	48%	96	10	10
		South	52%	104		11*
C	Retain Inland and Southern Ponds as Managed Ponds	North	30%	60	10	6
		South	70%	140		14
D	Staged Implementation of Tidal Marsh Restoration	North	99%	198	10	20
		South	1%	2		1*

Source: AECOM 2016
*Assumes an additional trip for conservative calculation

Figure 6a – Worst Case Project Alternative B Turning Movement Volumes

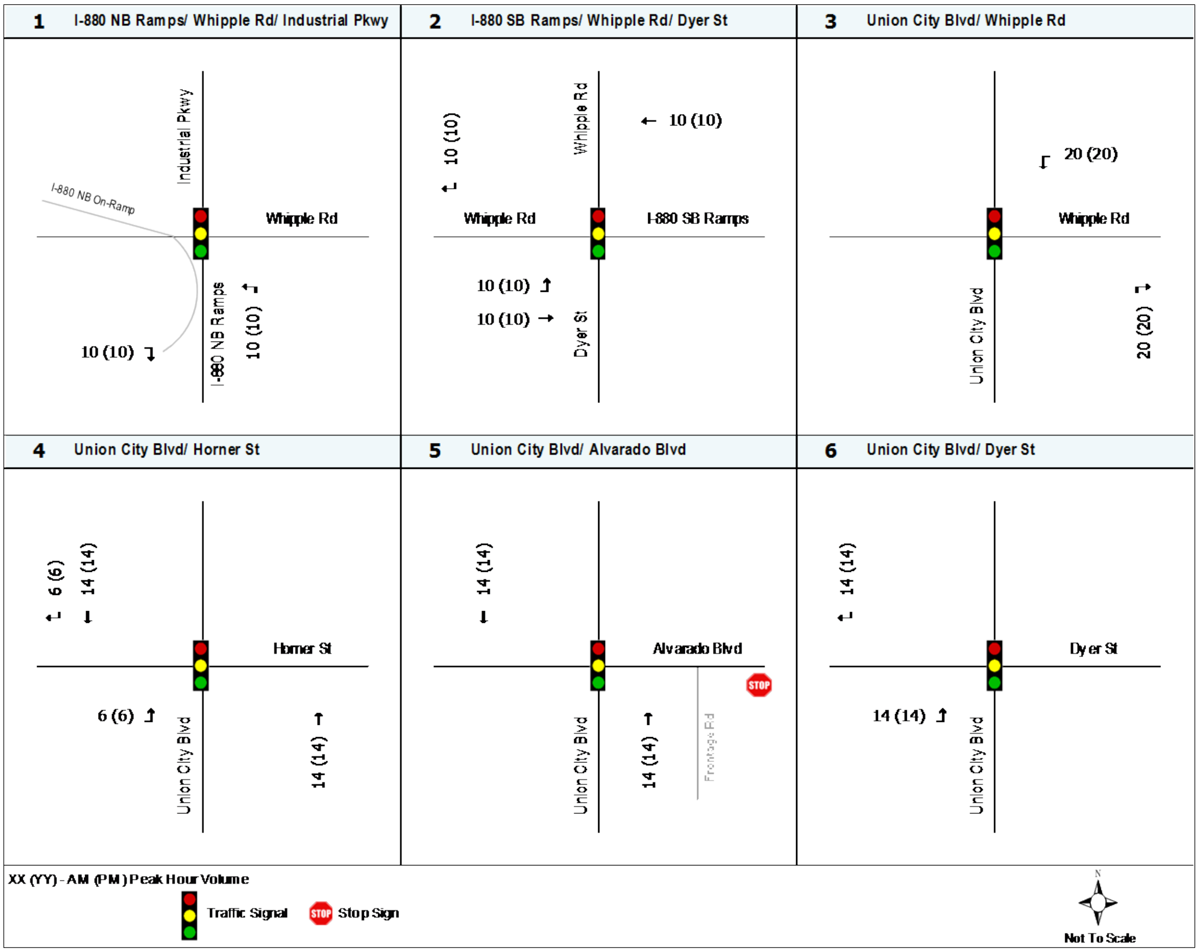


Figure 6b – Worst Case Project Alternative C Turning Movement Volumes

Significant Impact Thresholds

Two of the six study intersections are operated and maintained by Caltrans while the remaining four are operated and maintained by the City of Union City. Caltrans recommend using the corresponding City's significant impact threshold criteria for the two intersections under their charge. One of the Caltrans intersection falls within the city limits of Hayward and the other is in Union City.

For intersection #1 (I-880 NB Ramps / Whipple Road / Industrial Parkway), the City of Hayward thresholds have been considered.

For the rest of the study intersections, the City of Union City thresholds have been considered.

According to the City of Hayward guidelines for signalized intersections,

- LOS E is treated as an acceptable LOS. If the project causes an intersection operating at LOS E or better to fall below LOS E, then the project is projected to be causing a significant impact.

Figure 6c – Worst Case Project Alternative D Turning Movement Volumes

- For an intersection already operating at unacceptable LOS F, if the project increases the average control delay by five (5) seconds or more, the project is projected to be causing a significant impact.

According to the City of Union City guidelines for signalized intersections,

- LOS D is treated as an acceptable LOS. If the project causes an intersection operating at LOS D or better to fall below LOS D, then the project is projected to be causing a significant impact.

Impact Analysis

Analysis was conducted by comparing the 'with' and 'without' project intersection LOS and delay to determine if the project causes a significant impact. Tables 4a-b present the analysis results for the Base Case and Tables 5a-c present the results for the Worst Case.

Base Case:

It can be seen from Tables 4a and 4b that all study intersections, except intersection #2, will continue to operate within acceptable levels of service under all three project alternatives. The LOS for intersection #2, located in Union City, is currently at an unacceptable LOS E during the AM peak hour. It is expected to remain at the same LOS E under all the project alternatives. The average delay at this intersection is expected to increase by 2.2 seconds in the AM peak hour due to the additional project trips. Detailed level of service calculation sheets are provided in Appendix B.

Table 4a – Base Case LOS and Delay for Alternative B & C

	Intersection	Peak Hour	No Project LOS	No Project Avg Delay[1] (sec)	With Project LOS	With Project Avg Delay[1] (sec)	With Project Increase in Avg delay[2] (sec)
1	I-880 NB Ramps / Whipple Road / Industrial Parkway [3]	AM	E	55.4	E	55.9	n/a
		PM	E	73.1	E	73.0	
2	I-880 SB Ramps / Whipple Road / Dyer Street	AM	**E**	**66.9**	**E**	**69.1**	**2.2**
		PM	D	50.7	D	51.1	n/a
3	Union City Boulevard / Whipple Road	AM	C	30.8	C	31.0	n/a
		PM	D	48.1	D	48.1	
4	Union City Boulevard / Horner Street	AM	B	15.3	B	15.4	n/a
		PM	C	22.3	C	22.4	
5	Union City Boulevard / Alvarado Boulevard	AM	C	25.2	C	25.3	n/a
		PM	C	25.2	C	25.2	
6	Union City Boulevard / Dyer Street	AM	B	11.5	B	11.6	n/a
		PM	A	7.6	A	7.6	

Source: AECOM 2016

Bold indicates LOS at unacceptable levels

1. Intersection Control Delay per HCM 2000 methodology
2. Increase in average delay only calculated for intersection at unacceptable level under 'with project' conditions to determine project impact.
3. Intersection #1 in City of Hayward; acceptable LOS is E or better.

Table 4b – Base Case LOS and Delay for Alternative D

	Intersection	Peak Hour	No Project LOS	No Project Avg Delay[1] (sec)	With Project LOS	With Project Avg Delay[1] (sec)	With Project Increase in Avg delay[2] (sec)
1	I-880 NB Ramps / Whipple Road / Industrial Parkway [3]	AM	E	55.4	E	55.9	n/a
		PM	E	73.1	E	73.0	
2	I-880 SB Ramps / Whipple Road / Dyer Street	AM	**E**	**66.9**	**E**	**69.1**	**2.2**
		PM	D	50.7	D	51.1	n/a
3	Union City Boulevard /	AM	C	30.8	C	31.0	n/a

	Intersection	Peak Hour	No Project LOS	No Project Avg Delay[1] (sec)	With Project LOS	With Project Avg Delay[1] (sec)	Increase in Avg delay[2] (sec)
	Whipple Road	PM	D	48.1	D	48.1	
4	Union City Boulevard / Horner Street	AM	B	15.3	B	15.4	n/a
		PM	C	22.3	C	21.8	
5	Union City Boulevard / Alvarado Boulevard	AM	C	25.2	C	25.2	n/a
		PM	C	25.2	C	25.2	
6	Union City Boulevard / Dyer Street	AM	B	11.5	B	11.5	n/a
		PM	A	7.6	A	7.6	

Source: AECOM 2016
Bold indicates LOS at unacceptable levels
1. Intersection Control Delay per HCM 2000 methodology
2. Increase in average delay only calculated for intersection at unacceptable level under 'with project' conditions to determine project impact.
3. Intersection #1 in City of Hayward; acceptable LOS is E or better.

Worst Case:

It can be seen from Tables 5a-c that all study intersections, except intersection #2, will continue to operate within acceptable levels of service under all three project alternatives.

Table 5a- Worst Case LOS and Delay for Alternative B

	Intersection	Peak Hour	No Project LOS	No Project Avg Delay[1] (sec)	With Project LOS	With Project Avg Delay[1] (sec)	Increase in Avg delay[2] (sec)
1	I-880 NB Ramps / Whipple Road / Industrial Parkway [3]	AM	E	55.4	E	56.7	n/a
		PM	E	73.1	E	72.7	
2	I-880 SB Ramps / Whipple Road / Dyer Street	AM	**E**	**66.9**	**E**	**74.9**	**8.0**
		PM	D	50.7	D	52.1	n/a
3	Union City Boulevard / Whipple Road	AM	C	30.8	C	31.3	n/a
		PM	D	48.1	D	49.0	
4	Union City Boulevard / Horner Street	AM	B	15.3	B	15.8	n/a
		PM	C	22.3	C	22.2	
5	Union City Boulevard / Alvarado Boulevard	AM	C	25.2	C	25.4	n/a
		PM	C	25.2	C	25.5	
6	Union City Boulevard / Dyer Street	AM	B	11.5	B	11.8	n/a
		PM	A	7.6	A	7.8	

Source: AECOM 2016
Bold indicates LOS at unacceptable levels
1. Intersection Control Delay per HCM 2000 methodology
2. Increase in average delay only calculated for intersection at unacceptable level under 'with project' conditions to determine project impact.
3. Intersection #1 in City of Hayward; acceptable LOS is E or better.

The LOS for intersection #2, located in Union City, is currently at an unacceptable LOS E during the AM peak hour. It is expected to remain at the same LOS E under all the project alternatives. The average delay at this intersection, under the worst case scenario, is expected to increase by 8.0 seconds in the AM peak hour due to the additional project trips. Detailed level of service calculation sheets are provided in Appendix C.

Table 5b- Worst Case LOS and Delay for Alternative C

	Intersection	Peak Hour	No Project LOS	No Project Avg Delay[1] (sec)	With Project LOS	With Project Avg Delay[1] (sec)	With Project Increase in Avg delay[2] (sec)
1	I-880 NB Ramps / Whipple Road / Industrial Parkway [3]	AM	E	55.4	E	56.7	n/a
		PM	E	73.1	E	72.7	
2	I-880 SB Ramps / Whipple Road / Dyer Street	AM	**E**	**66.9**	**E**	**74.9**	**8.0**
		PM	D	50.7	D	52.1	n/a
3	Union City Boulevard / Whipple Road	AM	C	30.8	C	31.3	n/a
		PM	D	48.1	D	49.0	
4	Union City Boulevard / Horner Street	AM	B	15.3	B	15.6	n/a
		PM	C	22.3	C	21.9	
5	Union City Boulevard / Alvarado Boulevard	AM	C	25.2	C	25.5	n/a
		PM	C	25.2	C	25.5	
6	Union City Boulevard / Dyer Street	AM	B	11.5	B	11.8	n/a
		PM	A	7.6	A	7.8	

Source: AECOM 2016

Bold indicates LOS at unacceptable levels

1. Intersection Control Delay per HCM 2000 methodology
2. Increase in average delay only calculated for intersection at unacceptable level under 'with project' conditions to determine project impact.
3. Intersection #1 in City of Hayward; acceptable LOS is E or better.

Table 5c- Worst Case LOS and Delay for Alternative D

	Intersection	Peak Hour	No Project LOS	No Project Avg Delay[1] (sec)	With Project LOS	With Project Avg Delay[1] (sec)	With Project Increase in Avg delay[2] (sec)
1	I-880 NB Ramps / Whipple Road / Industrial Parkway [3]	AM	E	55.4	E	56.7	n/a
		PM	E	73.1	E	72.7	
2	I-880 SB Ramps / Whipple Road / Dyer Street	AM	**E**	**66.9**	**E**	**74.9**	**8.0**
		PM	D	50.7	D	52.1	n/a
3	Union City Boulevard / Whipple Road	AM	C	30.8	C	31.3	n/a
		PM	D	48.1	D	49.0	
4	Union City Boulevard / Horner Street	AM	B	15.3	B	17.1	n/a
		PM	C	22.3	C	23.1	
5	Union City Boulevard / Alvarado Boulevard	AM	C	25.2	C	25.2	n/a
		PM	C	25.2	C	25.2	

	Intersection	Peak Hour	No Project LOS	No Project Avg Delay[1] (sec)	With Project LOS	With Project Avg Delay[1] (sec)	With Project Increase in Avg delay[2] (sec)
6	Union City Boulevard / Dyer Street	AM	B	11.5	B	11.5	n/a
		PM	A	7.6	A	7.6	

Source: AECOM 2016
Bold indicates LOS at unacceptable levels

1. Intersection Control Delay per HCM 2000 methodology
2. Increase in average delay only calculated for intersection at unacceptable level under 'with project' conditions to determine project impact.
3. Intersection #1 in City of Hayward; acceptable LOS is E or better.

VII MITIGATION MEASURES

No mitigation measures are necessary for study intersections #1, #3, #4, #5 and #6 under both the Base Case and Worse Case scenarios. For intersection #2, it is already operating at an unacceptable LOS under existing (without project) conditions and the City of Union City does not have an impact criterion for such a condition.

Under the Base Case scenario, an additional delay of 2.2 seconds in the AM peak hour is generally considered less than significant (based on impact criteria of other surrounding cities in the Bay Area). It is therefore reasonable to conclude that the project would not cause any significant impact to intersection #2 as well and no mitigation measure would be necessary.

Under the Worst Case scenario, an additional delay of 8.0 seconds in the AM peak hour can be considered significant. Optimizing the timing at intersection #2 would mitigate the impact to less than significant. However, this mitigation is not feasible as intersection #2 is part of a synchronized series of intersections.

VIII CONCLUSION

It is determined from the analysis that the project will cause no significant impact to study intersections #1, #3, #4, #5 and #6. For intersection #2 the 'with project' LOS is expected to remain at unacceptable levels during the AM peak hour under both the Base Case and Worst Case scenarios, similar to its existing 'without project' conditions. However, under the Base Case scenario, an additional delay of 2.2 seconds in the AM peak hour can be considered insignificant. As such, intersection #2 will not be significantly impacted under the Base Case scenario. Under the Worst Case scenario, an additional 8.0 seconds of delay in the AM peak hour can be considered significant but there are no feasible mitigation measures available. As such, the project impact at intersection #2 is considered significant and unavoidable under the Worst Case scenario.

APPENDIX A
DETAILED INTERSECTION TURNING MOVEMENT VOLUMES

B.A.Y.M.E.T.R.I.C.S.

INTERSECTION TURNING MOVEMENT SUMMARY

PROJECT:	**TRAFFIC COUNTS IN UNION CITY**		**SURVEY DATE:**	**6/7/2016**	**DAY:**	**TUESDAY**
N-S APPROACH:	**I-880 NB RAMPS**	**- INDUSTRIAL PKWY**	**SURVEY TIME:**	**7:00 AM**	**TO**	**9:00 AM**
E-W APPROACH:	**WHIPPLE ROAD**		**JURISDICTION:**	**UNION CITY**	**FILE:**	**3606057-1AM**

PEAK HOUR
7:30 AM to 8:30 AM

INDUSTRIAL PKWY NORTH
36 | 618 | 209 | 25
*

* I-880 NB ON-RAMP

0 | 143
322 | 255 *
4433
751 | 616
* 186 | 0

WHIPPLE ROAD

0 | 494 | 421 | 357
I-880 NB RAMPS

ARRIVAL / DEPARTURE VOLUMES

PHF = 0.87
888 | 911
PHF = 0.91
1728 | 1014
1259 | 1317
PHF = 0.89
477 | 1272
* ON-RAMP
PHF = 0.92

TIME		PERIOD	NORTHBOUND				SOUTHBOUND				EASTBOUND				WESTBOUND				TOTAL
From		To	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	RIGHT	ONRAMP	U-TURN	LEFT	THRU	ONRAMP	U-TURN	THRU	ONRAMP	RIGHT	
SURVEY DATA																			
7:00 AM	to	7:15 AM		56	65	82	2	46	176	11		48	102	63	0	112	67	12	**842**
7:15 AM	to	7:30 AM		132	154	169	5	79	352	30		99	191	137	0	225	128	52	**1753**
7:30 AM	to	7:45 AM		233	255	248	10	126	525	40		172	331	201	0	359	196	78	**2774**
7:45 AM	to	8:00 AM		353	351	352	15	191	702	48		250	583	225	0	516	262	119	**3967**
8:00 AM	to	8:15 AM		490	471	440	23	227	836	63		330	786	290	0	652	331	158	**5097**
8:15 AM	to	8:30 AM		626	575	526	30	288	970	66		421	942	323	0	841	383	195	**6186**
8:30 AM	to	8:45 AM		749	696	608	41	318	1136	89		482	1038	380	0	984	423	227	**7171**
8:45 AM	to	9:00 AM		853	801	693	47	354	1256	103		561	1179	423	0	1134	475	268	**8147**
TOTAL BY PERIOD																			
7:00 AM	to	7:15 AM	0	56	65	82	2	46	176	11	0	48	102	63	0	112	67	12	**842**
7:15 AM	to	7:30 AM	0	76	89	87	3	33	176	19	0	51	89	74	0	113	61	40	**911**
7:30 AM	to	7:45 AM	0	101	101	79	5	47	173	10	0	73	140	64	0	134	68	26	**1021**
7:45 AM	to	8:00 AM	0	120	96	104	5	65	177	8	0	78	252	24	0	157	66	41	**1193**
8:00 AM	to	8:15 AM	0	137	120	88	8	36	134	15	0	80	203	65	0	136	69	39	**1130**
8:15 AM	to	8:30 AM	0	136	104	86	7	61	134	3	0	91	156	33	0	189	52	37	**1089**
8:30 AM	to	8:45 AM	0	123	121	82	11	30	166	23	0	61	96	57	0	143	40	32	**985**
8:45 AM	to	9:00 AM	0	104	105	85	6	36	120	14	0	79	141	43	0	150	52	41	**976**
HOURLY TOTALS																			
7:00 AM	to	8:00 AM	0	353	351	352	15	191	702	48	0	250	583	225	0	516	262	119	**3967**
7:15 AM	to	8:15 AM	0	434	406	358	21	181	660	52	0	282	684	227	0	540	264	146	**4255**
7:30 AM	to	8:30 AM	0	494	421	357	25	209	618	36	0	322	751	186	0	616	255	143	**4433**
7:45 AM	to	8:45 AM	0	516	441	360	31	192	611	49	0	310	707	179	0	625	227	149	**4397**
8:00 AM	to	9:00 AM	0	500	450	341	32	163	554	55	0	311	596	198	0	618	213	149	**4180**

PEAK HOUR SUMMARY

7:30 AM to 8:30 AM	NORTHBOUND				SOUTHBOUND				EASTBOUND				WESTBOUND				TOTAL
	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	RIGHT	ONRAMP	U-TURN	LEFT	THRU	ONRAMP	U-TURN	THRU	ONRAMP	RIGHT	
VOLUME	0	494	421	357	25	209	618	36	0	322	751	186	0	616	255	143	**4433**
PHF BY MOVEMENT	0.00	0.90	0.88	0.86	0.78	0.80	0.87	0.60	0.00	0.88	0.75	0.72	0.00	0.81	0.92	0.87	OVERALI
PHF BY APPROACH	0.92				0.87				0.89				0.91				0.93
BICYCLE	0				0				0				0				**0**
PEDESTRIAN	2				0				4				2				**8**
	N-LEG				**S-LEG**				**E-LEG**				**W-LEG**				
PEDESTRIAN BY LEG:	6				0				2				0				**8**

TEL: (510) 232 - 1271 FAX: (510) 232 - 1272

B.A.Y.M.E.T.R.I.C.S.

INTERSECTION TURNING MOVEMENT SUMMARY

PROJECT:	**TRAFFIC COUNTS IN UNION CITY**		**SURVEY DATE:**	**6/7/2016**	**DAY:**	**TUESDAY**
N-S APPROACH:	**I-880 NB RAMPS**	**- INDUSTRIAL PKWY**	**SURVEY TIME:**	**4:00 PM**	**TO**	**6:00 PM**
E-W APPROACH:	**WHIPPLE ROAD**		**JURISDICTION:**	**UNION CITY**	**FILE:**	**3606057-1PM**

PEAK HOUR
4:30 PM to 5:30 PM

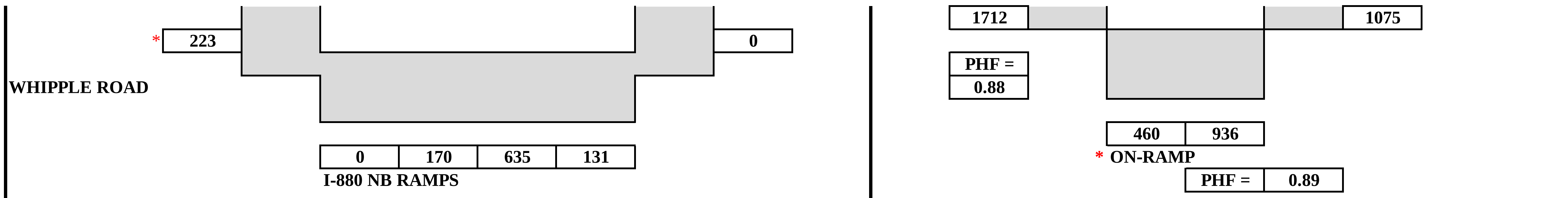
INDUSTRIAL PKWY NORTH
29 | 575 | 179 | 48
*

* I-880 NB ON-RAMP

1 | 267
723 | 208 *
4705
765 | 751

ARRIVAL / DEPARTURE VOLUMES

PHF = 0.94
831 | 1673
PHF = 0.95
1497 | 1226



TIME		PERIOD	NORTHBOUND				SOUTHBOUND				EASTBOUND				WESTBOUND				TOTAL
From		To	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	RIGHT	ONRAMP	U-TURN	LEFT	THRU	ONRAMP	U-TURN	THRU	ONRAMP	RIGHT	
SURVEY DATA																			
4:00 PM	to	4:15 PM		40	164	54	6	50	118	7	0	179	167	58		164	45	65	**1117**
4:15 PM	to	4:30 PM		102	312	99	15	97	242	15	1	348	354	127		336	87	117	**2252**
4:30 PM	to	4:45 PM		154	484	139	28	139	365	23	1	532	528	206		530	132	182	**3443**
4:45 PM	to	5:00 PM		192	627	176	41	185	517	31	1	744	752	257		721	177	249	**4670**
5:00 PM	to	5:15 PM		234	774	201	54	230	657	37	1	898	925	303		918	237	313	**5782**
5:15 PM	to	5:30 PM		272	947	230	63	276	817	44	2	1071	1119	350		1087	295	384	**6957**
5:30 PM	to	5:45 PM		330	1114	261	75	318	969	46	3	1238	1278	405		1302	327	454	**8120**
5:45 PM	to	6:00 PM		352	1293	299	84	375	1121	51	4	1413	1456	458		1477	374	525	**9282**
TOTAL BY PERIOD																			
4:00 PM	to	4:15 PM	0	40	164	54	6	50	118	7	0	179	167	58	0	164	45	65	**1117**
4:15 PM	to	4:30 PM	0	62	148	45	9	47	124	8	1	169	187	69	0	172	42	52	**1135**
4:30 PM	to	4:45 PM	0	52	172	40	13	42	123	8	0	184	174	79	0	194	45	65	**1191**
4:45 PM	to	5:00 PM	0	38	143	37	13	46	152	8	0	212	224	51	0	191	45	67	**1227**
5:00 PM	to	5:15 PM	0	42	147	25	13	45	140	6	0	154	173	46	0	197	60	64	**1112**
5:15 PM	to	5:30 PM	0	38	173	29	9	46	160	7	1	173	194	47	0	169	58	71	**1175**
5:30 PM	to	5:45 PM	0	58	167	31	12	42	152	2	1	167	159	55	0	215	32	70	**1163**
5:45 PM	to	6:00 PM	0	22	179	38	9	57	152	5	1	175	178	53	0	175	47	71	**1162**
HOURLY TOTALS																			
4:00 PM	to	5:00 PM	0	192	627	176	41	185	517	31	1	744	752	257	0	721	177	249	**4670**
4:15 PM	to	5:15 PM	0	194	610	147	48	180	539	30	1	719	758	245	0	754	192	248	**4665**
4:30 PM	to	5:30 PM	0	170	635	131	48	179	575	29	1	723	765	223	0	751	208	267	**4705**
4:45 PM	to	5:45 PM	0	176	630	122	47	179	604	23	2	706	750	199	0	772	195	272	**4677**
5:00 PM	to	6:00 PM	0	160	666	123	43	190	604	20	3	669	704	201	0	756	197	276	**4612**

PEAK HOUR SUMMARY

4:30 PM to 5:30 PM	NORTHBOUND				SOUTHBOUND				EASTBOUND				WESTBOUND				TOTAL
	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	RIGHT	ONRAMP	U-TURN	LEFT	THRU	ONRAMP	U-TURN	THRU	ONRAMP	RIGHT	
VOLUME	0	170	635	131	48	179	575	29	1	723	765	223	0	751	208	267	**4705**
PHF BY MOVEMENT	0.00	0.82	0.92	0.82	0.92	0.97	0.90	0.91	0.25	0.85	0.85	0.71	0.00	0.95	0.87	0.94	OVERALL
PHF BY APPROACH	0.89				0.94				0.88				0.95				0.96
BICYCLE	0				0				0				0				**0**
PEDESTRIAN	1				3				5				4				**13**
	N-LEG				**S-LEG**				**E-LEG**				**W-LEG**				
PEDESTRIAN BY LEG:	9				0				4				0				**13**

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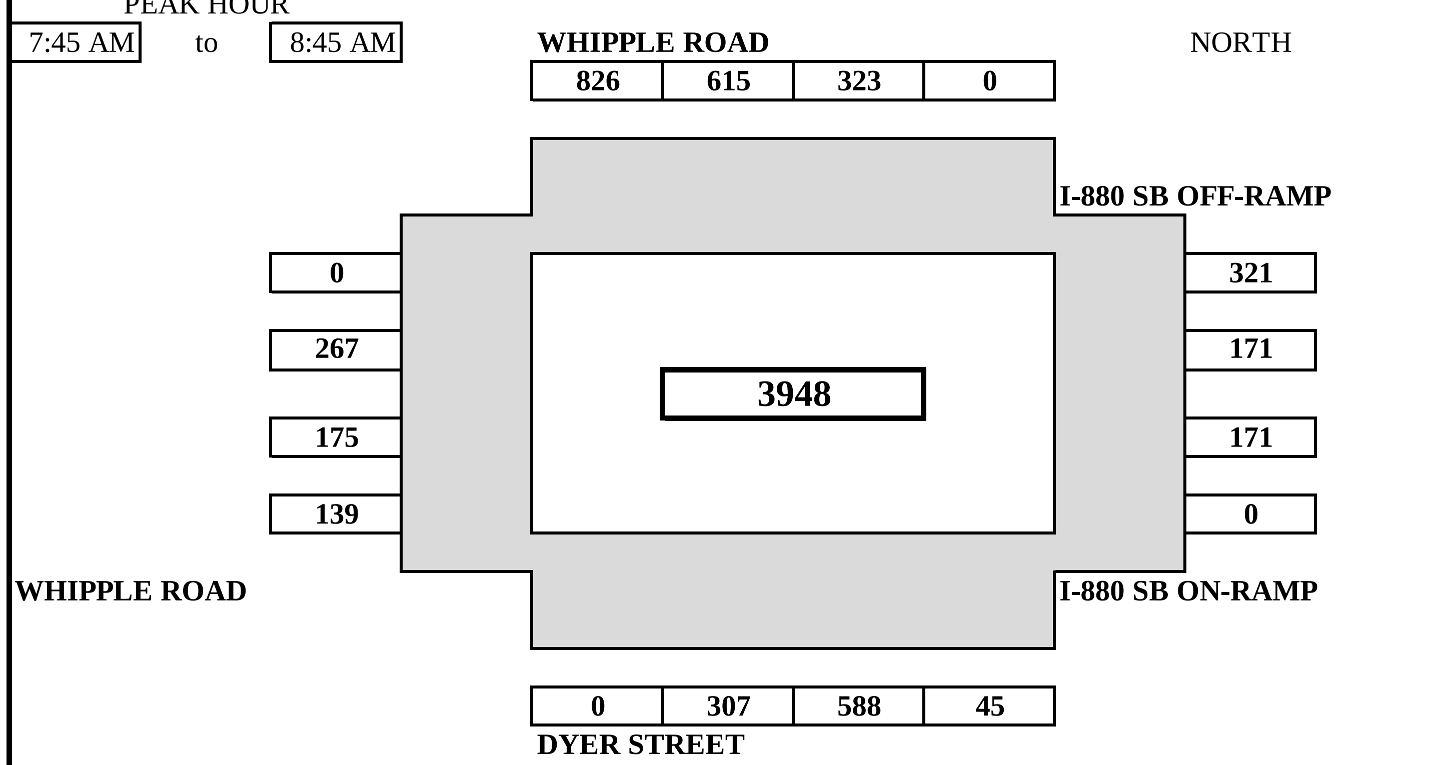
B.A.Y.M.E.T.R.I.C.S.

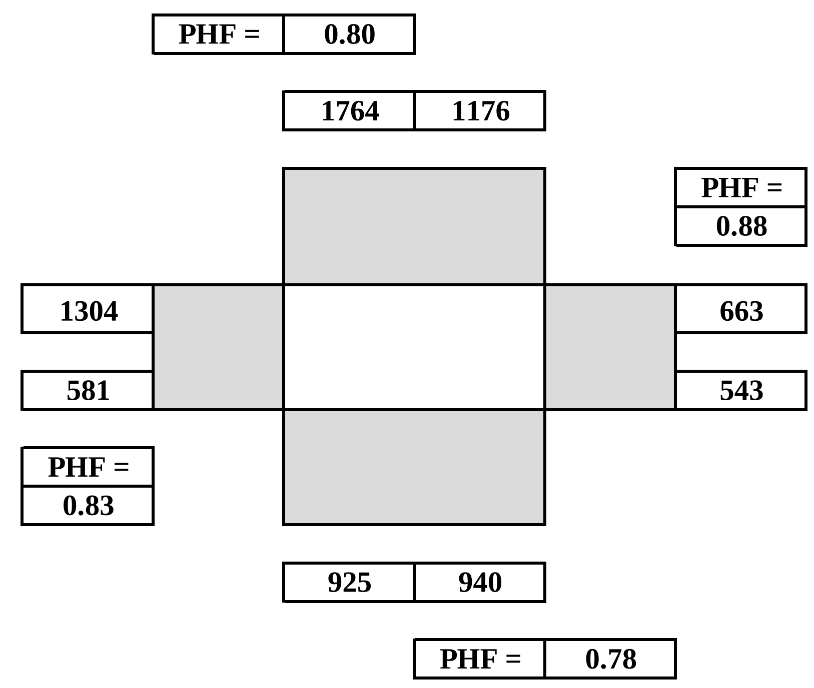
INTERSECTION TURNING MOVEMENT SUMMARY

PROJECT:	TRAFFIC COUNTS IN UNION CITY			SURVEY DATE:	6/7/2016	DAY:	TUESDAY
N-S APPROACH:	WHIPPLE ROAD	-	DYER STREET	SURVEY TIME:	7:00 AM	TO	9:00 AM
E-W APPROACH:	WHIPPLE ROAD	-	I-88O SB RAMPS	JURISDICTION:	UNION CITY	FILE:	3606057-2AM

PEAK HOUR
7:45 AM to 8:45 AM



ARRIVAL / DEPARTURE VOLUMES



TIME		PERIOD	NORTHBOUND				SOUTHBOUND				EASTBOUND				WESTBOUND				TOTAL
From		To	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	THRU	RIGHT	
SURVEY DATA																			
7:00 AM	to	7:15 AM		30	103	11		88	107	112		52	40	16		30	18	58	**665**
7:15 AM	to	7:30 AM		58	192	32		212	242	257		117	96	40		80	45	122	**1493**
7:30 AM	to	7:45 AM		122	327	40		299	264	415		184	157	75		103	62	218	**2266**
7:45 AM	to	8:00 AM		193	466	49		408	503	620		267	214	110		143	103	326	**3402**
8:00 AM	to	8:15 AM		295	651	62		488	611	822		345	256	146		182	136	413	**4407**
8:15 AM	to	8:30 AM		369	803	72		548	766	1055		407	303	174		229	187	479	**5392**
8:30 AM	to	8:45 AM		429	915	85		622	879	1241		451	332	214		274	233	539	**6214**
8:45 AM	to	9:00 AM		485	1021	94		695	1004	1455		507	380	258		326	284	638	**7147**
TOTAL BY PERIOD																			
7:00 AM	to	7:15 AM	0	30	103	11	0	88	107	112	0	52	40	16	0	30	18	58	**665**
7:15 AM	to	7:30 AM	0	28	89	21	0	124	135	145	0	65	56	24	0	50	27	64	**828**
7:30 AM	to	7:45 AM	0	64	135	8	0	87	22	158	0	67	61	35	0	23	17	96	**773**
7:45 AM	to	8:00 AM	0	71	139	9	0	109	239	205	0	83	57	35	0	40	41	108	**1136**
8:00 AM	to	8:15 AM	0	102	185	13	0	80	108	202	0	78	42	36	0	39	33	87	**1005**
8:15 AM	to	8:30 AM	0	74	152	10	0	60	155	233	0	62	47	28	0	47	51	66	**985**
8:30 AM	to	8:45 AM	0	60	112	13	0	74	113	186	0	44	29	40	0	45	46	60	**822**
8:45 AM	to	9:00 AM	0	56	106	9	0	73	125	214	0	56	48	44	0	52	51	99	**933**
HOURLY TOTALS																			
7:00 AM	to	8:00 AM	0	193	466	49	0	408	503	620	0	267	214	110	0	143	103	326	**3402**
7:15 AM	to	8:15 AM	0	265	548	51	0	400	504	710	0	293	216	130	0	152	118	355	**3742**
7:30 AM	to	8:30 AM	0	311	611	40	0	336	524	798	0	290	207	134	0	149	142	357	**3899**
7:45 AM	to	8:45 AM	0	307	588	45	0	323	615	826	0	267	175	139	0	171	171	321	**3948**
8:00 AM	to	9:00 AM	0	292	555	45	0	287	501	835	0	240	166	148	0	183	181	312	**3745**

PEAK HOUR SUMMARY

7:45 AM to 8:45 AM	NORTHBOUND				SOUTHBOUND				EASTBOUND				WESTBOUND				TOTAL
	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	
VOLUME	0	307	588	45	0	323	615	826	0	267	175	139	0	171	171	321	**3948**
PHF BY MOVEMENT	0.00	0.75	0.79	0.87	0.00	0.74	0.64	0.89	0.00	0.80	0.77	0.87	0.00	0.91	0.84	0.74	OVERALL
PHF BY APPROACH	0.78				0.80				0.83				0.88				0.87
BICYCLE	1				4				1				0				**6**
PEDESTRIAN	4				1				0				0				**5**
	N-LEG				S-LEG				E-LEG				W-LEG				
PEDESTRIAN BY LEG:	0				0				0				5				**5**

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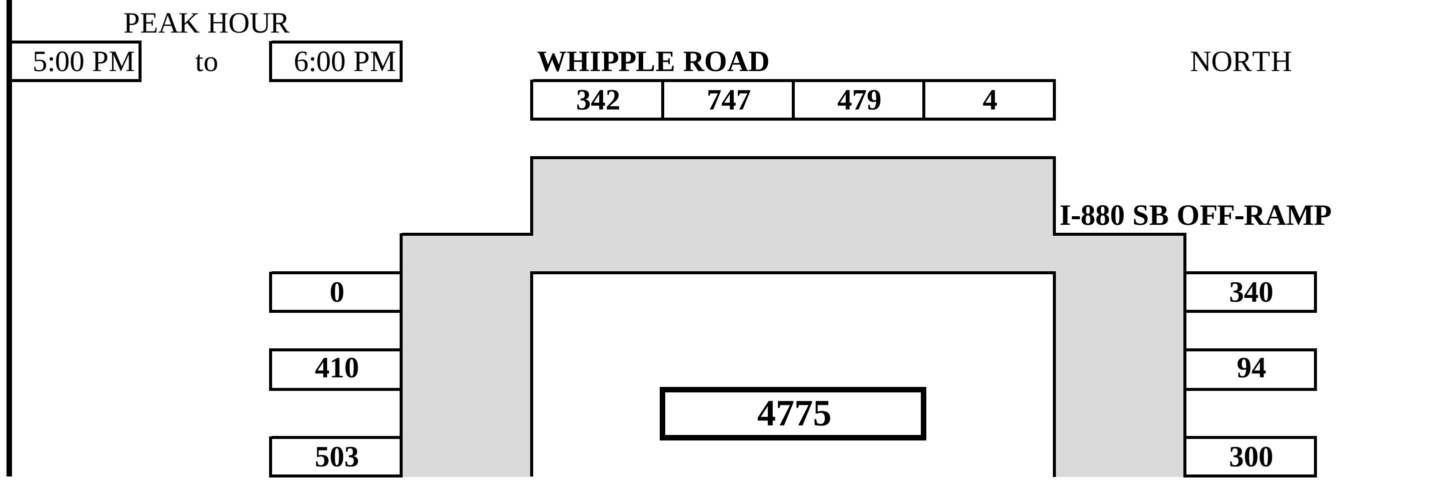
B.A.Y.M.E.T.R.I.C.S.

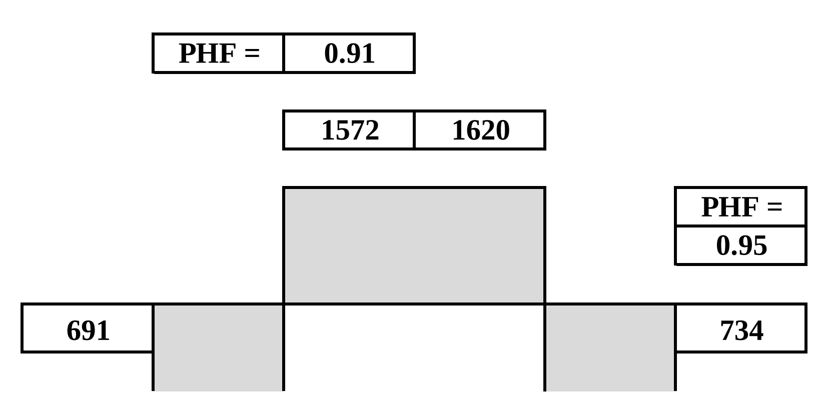
INTERSECTION TURNING MOVEMENT SUMMARY

PROJECT:	TRAFFIC COUNTS IN UNION CITY			SURVEY DATE:	6/7/2016	DAY:	TUESDAY
N-S APPROACH:	WHIPPLE ROAD	-	DYER STREET	SURVEY TIME:	4:00 PM	TO	6:00 PM
E-W APPROACH:	WHIPPLE ROAD	-	I-88O SB RAMPS	JURISDICTION:	UNION CITY	FILE:	3606057-2PM

PEAK HOUR
5:00 PM to 6:00 PM



ARRIVAL / DEPARTURE VOLUMES



	289			0	
WHIPPLE ROAD				I-880 SB ON-RAMP	
	0	255	866	146	
	DYER STREET				

1202			1128
PHF = 0.96			
	1336	1267	
	PHF =	0.92	

TIME		PERIOD	NORTHBOUND				SOUTHBOUND				EASTBOUND				WESTBOUND				TOTAL
From		To	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	THRU	RIGHT	
S U R V E Y D A T A																			
4:00 PM	to	4:15 PM	0	74	245	26	0	102	143	79		80	94	62		69	26	79	**1079**
4:15 PM	to	4:30 PM	1	135	481	57	0	205	298	200		176	185	127		133	62	176	**2236**
4:30 PM	to	4:45 PM	1	195	717	92	0	324	442	293		299	264	185		206	97	259	**3374**
4:45 PM	to	5:00 PM	3	265	951	118	2	432	640	376		438	373	273		279	120	335	**4605**
5:00 PM	to	5:15 PM	3	330	1174	150	2	557	810	456		537	509	347		349	142	436	**5802**
5:15 PM	to	5:30 PM	3	377	1381	192	3	681	970	539		646	641	419		421	166	526	**6965**
5:30 PM	to	5:45 PM	3	436	1593	228	4	801	1156	628		753	773	489		503	185	590	**8142**
5:45 PM	to	6:00 PM	3	520	1817	264	6	911	1387	718		848	876	562		579	214	675	**9380**
T O T A L B Y P E R I O D																			
4:00 PM	to	4:15 PM	0	74	245	26	0	102	143	79	0	80	94	62	0	69	26	79	**1079**
4:15 PM	to	4:30 PM	1	61	236	31	0	103	155	121	0	96	91	65	0	64	36	97	**1157**
4:30 PM	to	4:45 PM	0	60	236	35	0	119	144	93	0	123	79	58	0	73	35	83	**1138**
4:45 PM	to	5:00 PM	2	70	234	26	2	108	198	83	0	139	109	88	0	73	23	76	**1231**
5:00 PM	to	5:15 PM	0	65	223	32	0	125	170	80	0	99	136	74	0	70	22	101	**1197**
5:15 PM	to	5:30 PM	0	47	207	42	1	124	160	83	0	109	132	72	0	72	24	90	**1163**
5:30 PM	to	5:45 PM	0	59	212	36	1	120	186	89	0	107	132	70	0	82	19	64	**1177**
5:45 PM	to	6:00 PM	0	84	224	36	2	110	231	90	0	95	103	73	0	76	29	85	**1238**
H O U R L Y T O T A L S																			
4:00 PM	to	5:00 PM	3	265	951	118	2	432	640	376	0	438	373	273	0	279	120	335	**4605**
4:15 PM	to	5:15 PM	3	256	929	124	2	455	667	377	0	457	415	285	0	280	116	357	**4723**
4:30 PM	to	5:30 PM	2	242	900	135	3	476	672	339	0	470	456	292	0	288	104	350	**4729**
4:45 PM	to	5:45 PM	2	241	876	136	4	477	714	335	0	454	509	304	0	297	88	331	**4768**
5:00 PM	to	6:00 PM	0	255	866	146	4	479	747	342	0	410	503	289	0	300	94	340	**4775**

P E A K H O U R S U M M A R Y

5:00 PM to 6:00 PM	NORTHBOUND				SOUTHBOUND				EASTBOUND				WESTBOUND				TOTAL
	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	
VOLUME	0	255	866	146	4	479	747	342	0	410	503	289	0	300	94	340	**4775**
PHF BY MOVEMENT	0.00	0.76	0.97	0.87	0.50	0.96	0.81	0.95	0.00	0.94	0.92	0.98	0.00	0.91	0.81	0.84	OVERALL
PHF BY APPROACH	0.92				0.91				0.96				0.95				0.96
BICYCLE	0				8				4				2				**14**
PEDESTRIAN	3				7				0				0				**10**
	N-LEG				**S-LEG**				**E-LEG**				**W-LEG**				
PEDESTRIAN BY LEG:	0				0				0				10				**10**

TEL: (510) 232 - 1271 FAX: (510) 232 - 1272

B.A.Y.M.E.T.R.I.C.S.

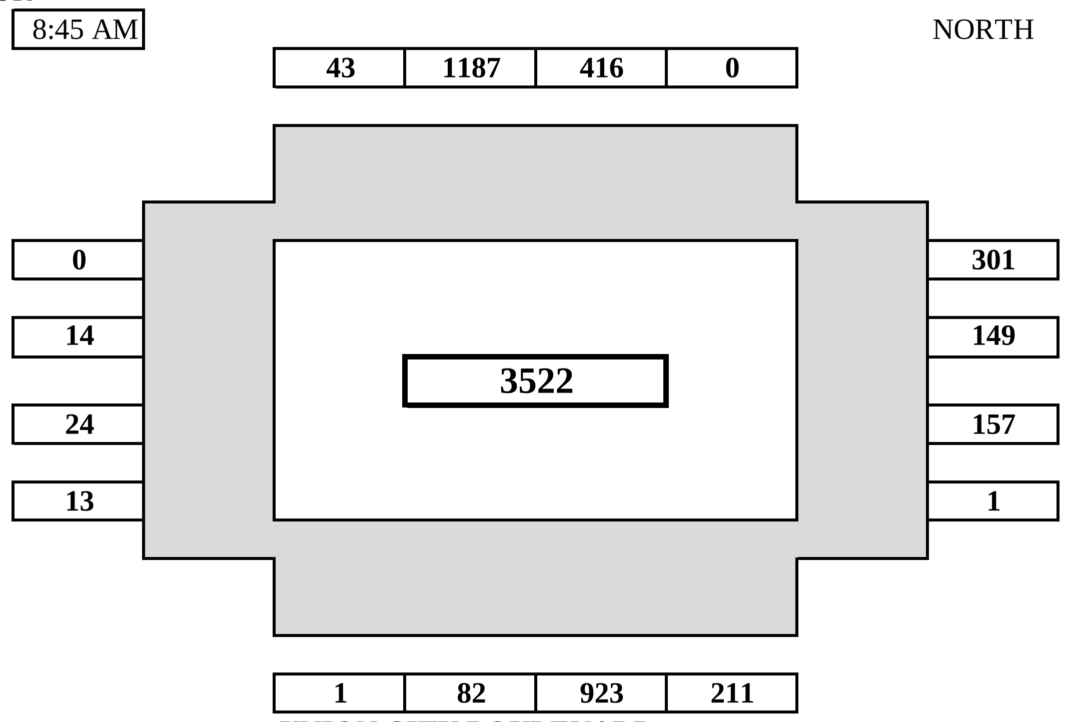
INTERSECTION TURNING MOVEMENT SUMMARY

PROJECT:	TRAFFIC COUNTS IN UNION CITY	SURVEY DATE:	6/7/2016	DAY:	TUESDAY
N-S APPROACH:	UNION CITY BOULEVARD	SURVEY TIME:	7:00 AM	TO	9:00 AM
E-W APPROACH:	WHIPPLE ROAD	JURISDICTION:	UNION CITY	FILE:	3606057-3AM

PEAK HOUR

7:45 AM to 8:45 AM

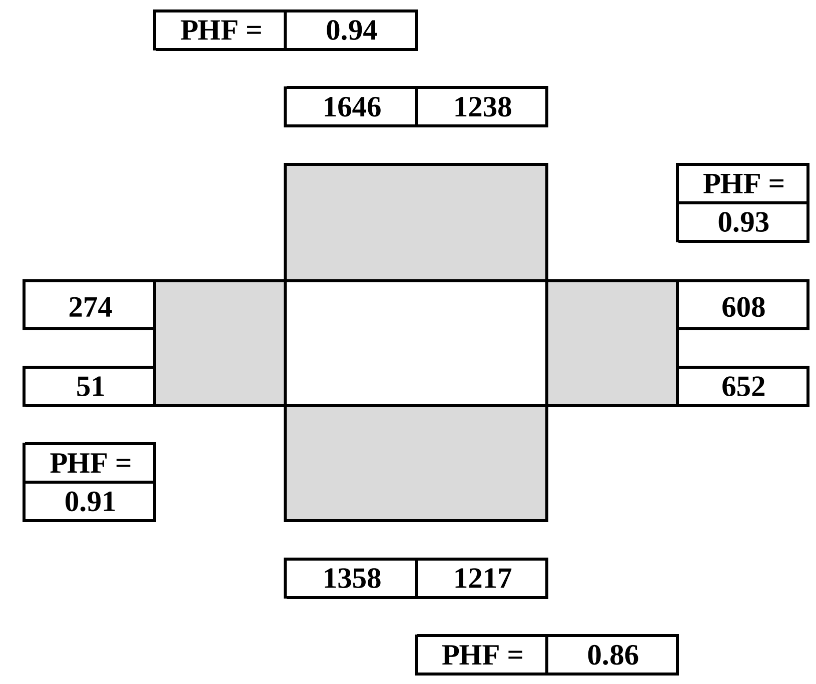
NORTH



WHIPPLE ROAD

UNION CITY BOULEVARD

ARRIVAL / DEPARTURE VOLUMES



TIME From		PERIOD To	NORTHBOUND U-TURN	NORTHBOUND LEFT	NORTHBOUND THRU	NORTHBOUND RIGHT	SOUTHBOUND U-TURN	SOUTHBOUND LEFT	SOUTHBOUND THRU	SOUTHBOUND RIGHT	EASTBOUND U-TURN	EASTBOUND LEFT	EASTBOUND THRU	EASTBOUND RIGHT	WESTBOUND U-TURN	WESTBOUND LEFT	WESTBOUND THRU	WESTBOUND RIGHT	TOTAL
SURVEY DATA																			
7:00 AM	to	7:15 AM	0	8	143	30	0	68	276	6		1	1	1	0	22	13	57	**626**
7:15 AM	to	7:30 AM	1	10	306	63	0	173	595	9		2	6	4	0	54	20	120	**1363**
7:30 AM	to	7:45 AM	1	15	480	104	0	282	869	15		5	12	6	1	82	38	199	**2109**
7:45 AM	to	8:00 AM	1	31	729	165	0	423	1157	25		9	16	11	2	130	54	276	**3029**
8:00 AM	to	8:15 AM	1	51	991	238	0	512	1425	39		12	22	12	2	160	97	366	**3928**
8:15 AM	to	8:30 AM	1	80	1178	288	0	605	1728	49		16	27	17	2	207	144	427	**4769**
8:30 AM	to	8:45 AM	2	97	1403	315	0	698	2056	58		19	36	19	2	239	187	500	**5631**
8:45 AM	to	9:00 AM	2	116	1571	353	1	791	2337	74		27	51	22	2	265	274	554	**6440**
TOTAL BY PERIOD																			
7:00 AM	to	7:15 AM	0	8	143	30	0	68	276	6	0	1	1	1	0	22	13	57	**626**
7:15 AM	to	7:30 AM	1	2	163	33	0	105	319	3	0	1	5	3	0	32	7	63	**737**
7:30 AM	to	7:45 AM	0	5	174	41	0	109	274	6	0	3	6	2	1	28	18	79	**746**
7:45 AM	to	8:00 AM	0	16	249	61	0	141	288	10	0	4	4	5	1	48	16	77	**920**
8:00 AM	to	8:15 AM	0	20	262	73	0	89	268	14	0	3	6	1	0	30	43	90	**899**
8:15 AM	to	8:30 AM	0	29	187	50	0	93	303	10	0	4	5	5	0	47	47	61	**841**
8:30 AM	to	8:45 AM	1	17	225	27	0	93	328	9	0	3	9	2	0	32	43	73	**862**
8:45 AM	to	9:00 AM	0	19	168	38	1	93	281	16	0	8	15	3	0	26	87	54	**809**
HOURLY TOTALS																			
7:00 AM	to	8:00 AM	1	31	729	165	0	423	1157	25	0	9	16	11	2	130	54	276	**3029**
7:15 AM	to	8:15 AM	1	43	848	208	0	444	1149	33	0	11	21	11	2	138	84	309	**3302**
7:30 AM	to	8:30 AM	0	70	872	225	0	432	1133	40	0	14	21	13	2	153	124	307	**3406**
7:45 AM	to	8:45 AM	1	82	923	211	0	416	1187	43	0	14	24	13	1	157	149	301	**3522**
8:00 AM	to	9:00 AM	1	85	842	188	1	368	1180	49	0	18	35	11	0	135	220	278	**3411**

PEAK HOUR SUMMARY

7:45 AM to 8:45 AM	NORTHBOUND				SOUTHBOUND				EASTBOUND				WESTBOUND				TOTAL
	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	
VOLUME	1	82	923	211	0	416	1187	43	0	14	24	13	1	157	149	301	**3522**
PHF BY MOVEMENT	0.25	0.71	0.88	0.72	0.00	0.74	0.90	0.77	0.00	0.88	0.67	0.65	0.25	0.82	0.79	0.84	OVERALL
PHF BY APPROACH	0.86				0.94				0.91				0.93				0.96
BICYCLE	2				1				0				0				**3**
PEDESTRIAN	0				2				1				1				**4**
	N-LEG				S-LEG				E-LEG				W-LEG				
PEDESTRIAN BY LEG:	1				1				2				0				**4**

TEL: (510) 232 - 1271 FAX: (510) 232 - 1272

B.A.Y.M.E.T.R.I.C.S.

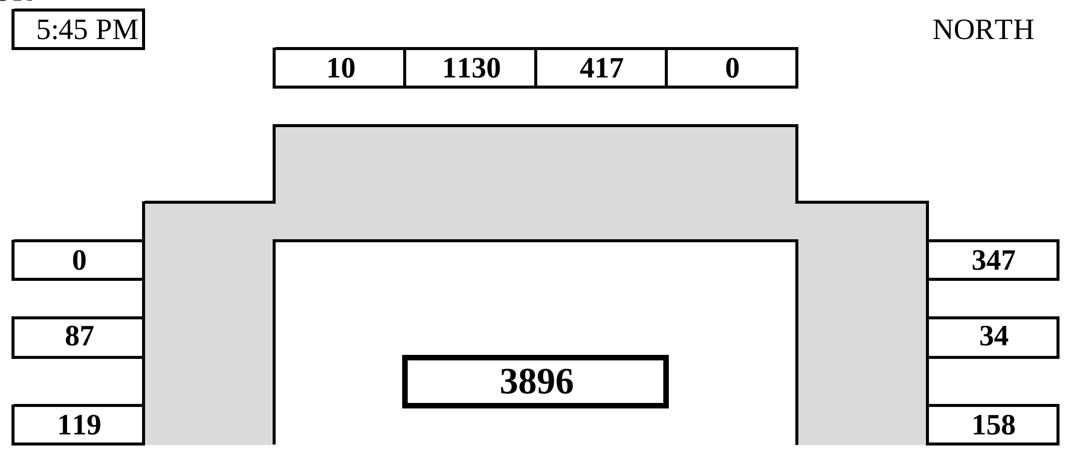
INTERSECTION TURNING MOVEMENT SUMMARY

PROJECT:	TRAFFIC COUNTS IN UNION CITY	SURVEY DATE:	6/7/2016	DAY:	TUESDAY
N-S APPROACH:	UNION CITY BOULEVARD	SURVEY TIME:	4:00 PM	TO	6:00 PM
E-W APPROACH:	WHIPPLE ROAD	JURISDICTION:	UNION CITY	FILE:	3606057-3PM

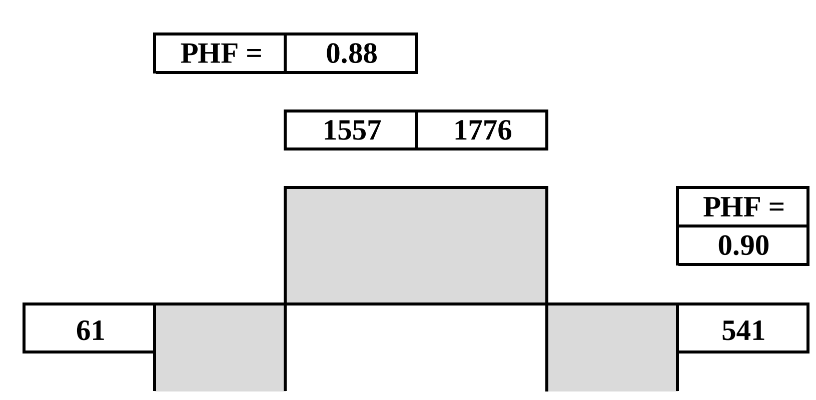
PEAK HOUR

4:45 PM to 5:45 PM

NORTH



ARRIVAL / DEPARTURE VOLUMES



70

2

WHIPPLE ROAD

276

699

PHF = 0.71

1360 | 1522

PHF = 0.89

2 | 17 | 1342 | 161

UNION CITY BOULEVARD

TIME		PERIOD	NORTHBOUND				SOUTHBOUND				EASTBOUND				WESTBOUND				TOTAL
From		To	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	THRU	RIGHT	
SURVEY DATA																			
4:00 PM	to	4:15 PM	0	9	367	56	0	121	241	4		12	20	7	1	28	17	70	**953**
4:15 PM	to	4:30 PM	0	15	688	101	0	225	462	7		37	48	19	2	64	42	142	**1852**
4:30 PM	to	4:45 PM	0	19	1045	159	0	308	686	8		58	78	34	2	91	57	211	**2756**
4:45 PM	to	5:00 PM	1	25	1423	202	0	415	938	11		75	100	41	2	135	68	306	**3742**
5:00 PM	to	5:15 PM	2	29	1722	248	0	508	1179	14		107	142	64	2	181	79	396	**4673**
5:15 PM	to	5:30 PM	2	31	2072	288	0	613	1489	16		123	169	86	3	212	86	486	**5676**
5:30 PM	to	5:45 PM	2	36	2387	320	0	725	1816	18		145	197	104	4	249	91	558	**6652**
5:45 PM	to	6:00 PM	3	41	2699	355	2	825	2111	23		153	214	106	4	277	101	664	**7578**
TOTAL BY PERIOD																			
4:00 PM	to	4:15 PM	0	9	367	56	0	121	241	4	0	12	20	7	1	28	17	70	**953**
4:15 PM	to	4:30 PM	0	6	321	45	0	104	221	3	0	25	28	12	1	36	25	72	**899**
4:30 PM	to	4:45 PM	0	4	357	58	0	83	224	1	0	21	30	15	0	27	15	69	**904**
4:45 PM	to	5:00 PM	1	6	378	43	0	107	252	3	0	17	22	7	0	44	11	95	**986**
5:00 PM	to	5:15 PM	1	4	299	46	0	93	241	3	0	32	42	23	0	46	11	90	**931**
5:15 PM	to	5:30 PM	0	2	350	40	0	105	310	2	0	16	27	22	1	31	7	90	**1003**
5:30 PM	to	5:45 PM	0	5	315	32	0	112	327	2	0	22	28	18	1	37	5	72	**976**
5:45 PM	to	6:00 PM	1	5	312	35	2	100	295	5	0	8	17	2	0	28	10	106	**926**
HOURLY TOTALS																			
4:00 PM	to	5:00 PM	1	25	1423	202	0	415	938	11	0	75	100	41	2	135	68	306	**3742**
4:15 PM	to	5:15 PM	2	20	1355	192	0	387	938	10	0	95	122	57	1	153	62	326	**3720**
4:30 PM	to	5:30 PM	2	16	1384	187	0	388	1027	9	0	86	121	67	1	148	44	344	**3824**
4:45 PM	to	5:45 PM	2	17	1342	161	0	417	1130	10	0	87	119	70	2	158	34	347	**3896**
5:00 PM	to	6:00 PM	2	16	1276	153	2	410	1173	12	0	78	114	65	2	142	33	358	**3836**

PEAK HOUR SUMMARY

4:45 PM to 5:45 PM	NORTHBOUND				SOUTHBOUND				EASTBOUND				WESTBOUND				TOTAL
	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	
VOLUME	2	17	1342	161	0	417	1130	10	0	87	119	70	2	158	34	347	**3896**
PHF BY MOVEMENT	0.50	0.71	0.89	0.88	0.00	0.93	0.86	0.83	0.00	0.68	0.71	0.76	0.50	0.86	0.77	0.91	OVERALL
PHF BY APPROACH	0.89				0.88				0.71				0.90				0.97
BICYCLE	0				5				0				1				**6**
PEDESTRIAN	1				3				5				3				**12**
	N-LEG				**S-LEG**				**E-LEG**				**W-LEG**				
PEDESTRIAN BY LEG:	4				4				1				3				**12**

TEL: (510) 232 - 1271 FAX: (510) 232 - 1272

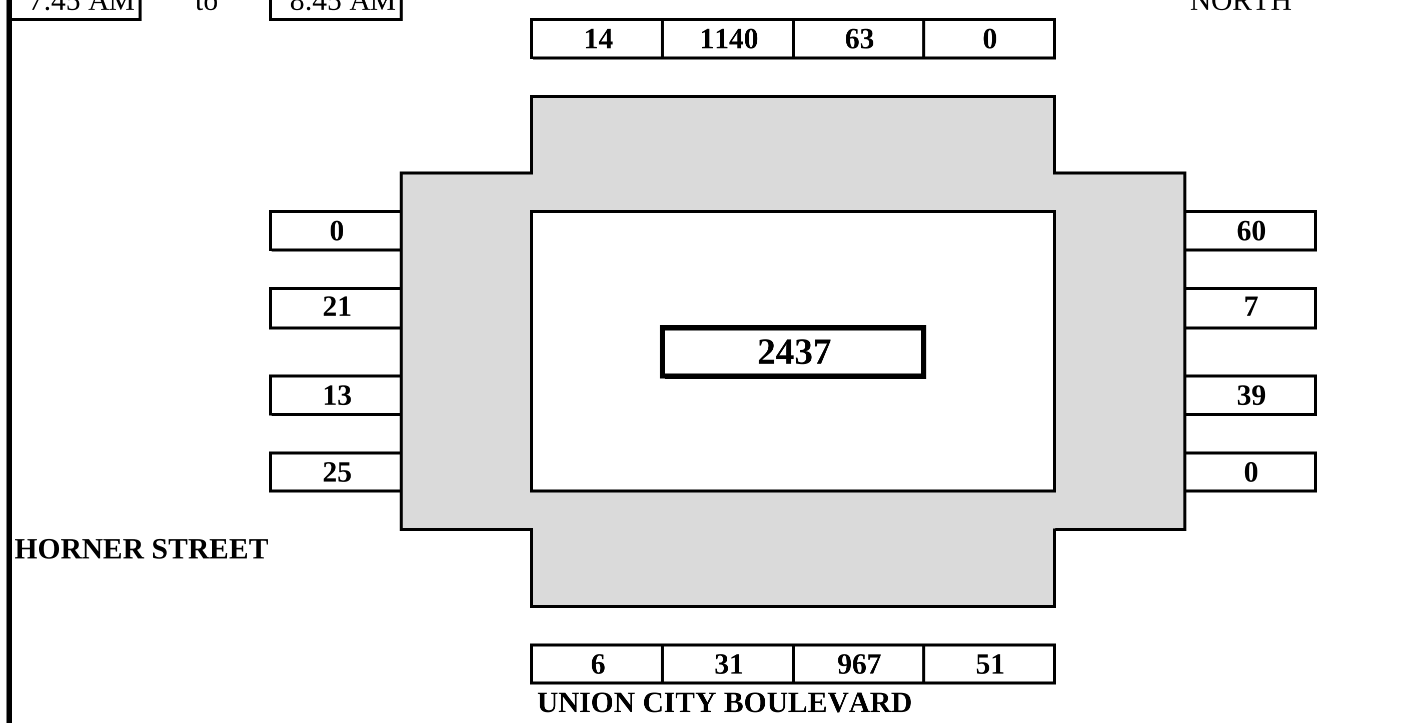
B.A.Y.M.E.T.R.I.C.S.

INTERSECTION TURNING MOVEMENT SUMMARY

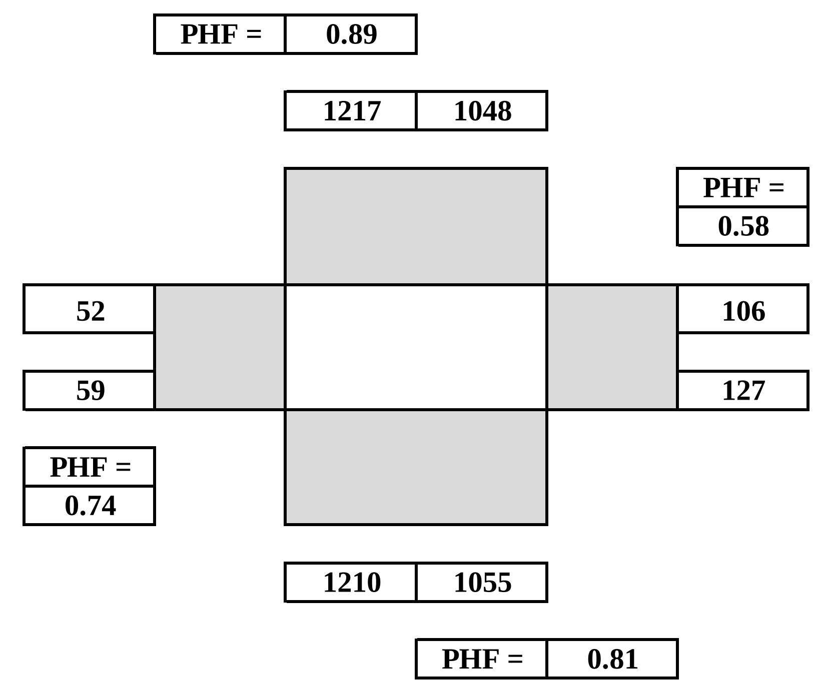
PROJECT:	**TRAFFIC COUNTS IN UNION CITY**	**SURVEY DATE:**	**6/7/2016**	**DAY:**	**TUESDAY**
N-S APPROACH:	**UNION CITY BOULEVARD**	**SURVEY TIME:**	**7:00 AM**	**TO**	**9:00 AM**
E-W APPROACH:	**HORNER STREET**	**JURISDICTION:**	**UNION CITY**	**FILE:**	**3606057-4AM**

PEAK HOUR

7:45 AM to 8:45 AM



ARRIVAL / DEPARTURE VOLUMES



TIME PERIOD			NORTHBOUND				SOUTHBOUND				EASTBOUND				WESTBOUND				TOTAL
From		To	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	THRU	RIGHT	
S U R V E Y D A T A																			
7:00 AM	to	7:15 AM	2	8	159	6		5	297	25		7	4	5		3	3	4	**528**
7:15 AM	to	7:30 AM	2	12	340	9		15	562	26		10	6	11		4	4	11	**1012**
7:30 AM	to	7:45 AM	4	16	534	37		31	835	31		15	9	28		13	4	23	**1580**
7:45 AM	to	8:00 AM	5	24	801	57		62	1088	36		22	14	36		20	5	39	**2209**
8:00 AM	to	8:15 AM	5	31	1098	77		77	1338	36		25	19	43		40	6	64	**2859**
8:15 AM	to	8:30 AM	6	37	1296	87		94	1656	43		30	21	48		46	6	78	**3448**
8:30 AM	to	8:45 AM	10	47	1501	88		94	1975	45		36	22	53		52	11	83	**4017**
8:45 AM	to	9:00 AM	12	53	1679	92		102	2265	50		41	24	53		53	14	89	**4527**
T O T A L B Y P E R I O D																			
7:00 AM	to	7:15 AM	2	8	159	6	0	5	297	25	0	7	4	5	0	3	3	4	**528**
7:15 AM	to	7:30 AM	0	4	181	3	0	10	265	1	0	3	2	6	0	1	1	7	**484**
7:30 AM	to	7:45 AM	2	4	194	28	0	16	273	5	0	5	3	17	0	9	0	12	**568**
7:45 AM	to	8:00 AM	1	8	267	20	0	31	253	5	0	7	5	8	0	7	1	16	**629**
8:00 AM	to	8:15 AM	0	7	297	20	0	15	250	0	0	3	5	7	0	20	1	25	**650**
8:15 AM	to	8:30 AM	1	6	198	10	0	17	318	7	0	5	2	5	0	6	0	14	**589**
8:30 AM	to	8:45 AM	4	10	205	1	0	0	319	2	0	6	1	5	0	6	5	5	**569**
8:45 AM	to	9:00 AM	2	6	178	4	0	8	290	5	0	5	2	0	0	1	3	6	**510**
H O U R L Y T O T A L S																			
7:00 AM	to	8:00 AM	5	24	801	57	0	62	1088	36	0	22	14	36	0	20	5	39	**2209**
7:15 AM	to	8:15 AM	3	23	939	71	0	72	1041	11	0	18	15	38	0	37	3	60	**2331**
7:30 AM	to	8:30 AM	4	25	956	78	0	79	1094	17	0	20	15	37	0	42	2	67	**2436**
7:45 AM	to	8:45 AM	6	31	967	51	0	63	1140	14	0	21	13	25	0	39	7	60	**2437**
8:00 AM	to	9:00 AM	7	29	878	35	0	40	1177	14	0	19	10	17	0	33	9	50	**2318**

P E A K H O U R S U M M A R Y

7:45 AM to 8:45 AM	NORTHBOUND				SOUTHBOUND				EASTBOUND				WESTBOUND				TOTAL
	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	
VOLUME	6	31	967	51	0	63	1140	14	0	21	13	25	0	39	7	60	**2437**
PHF BY MOVEMENT	0.38	0.78	0.81	0.64	0.00	0.51	0.89	0.50	0.00	0.75	0.65	0.78	0.00	0.49	0.35	0.60	OVERALL
PHF BY APPROACH	0.81				0.89				0.74				0.58				0.94
BICYCLE	3				1				2				1				**7**
PEDESTRIAN	7				6				26				14				**53**
	N-LEG				**S-LEG**				**E-LEG**				**W-LEG**				
PEDESTRIAN BY LEG:	29				11				11				2				**53**

TEL: (510) 232 - 1271   FAX: (510) 232 - 1272

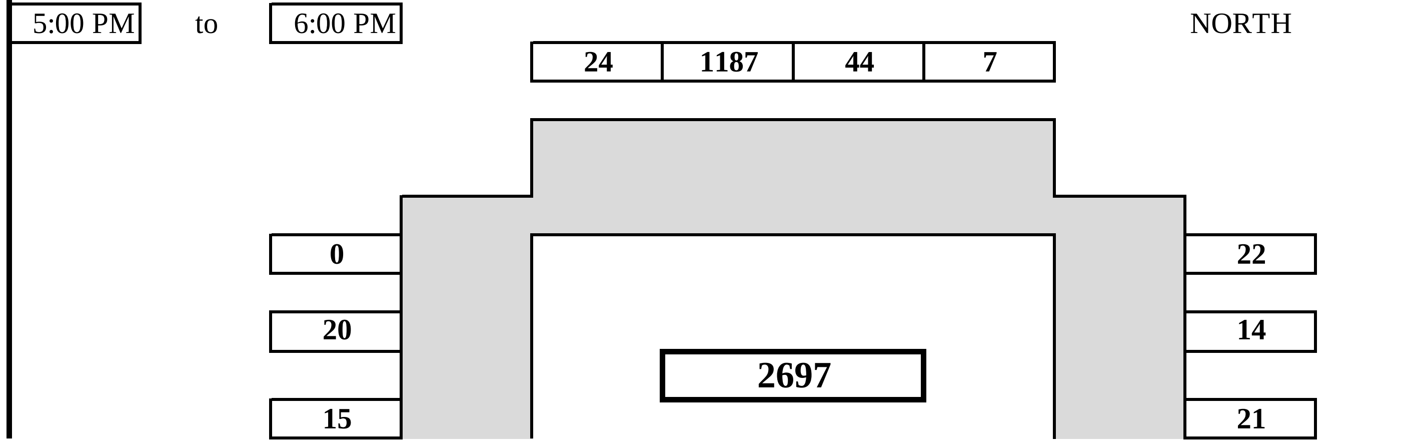
B.A.Y.M.E.T.R.I.C.S.

INTERSECTION TURNING MOVEMENT SUMMARY

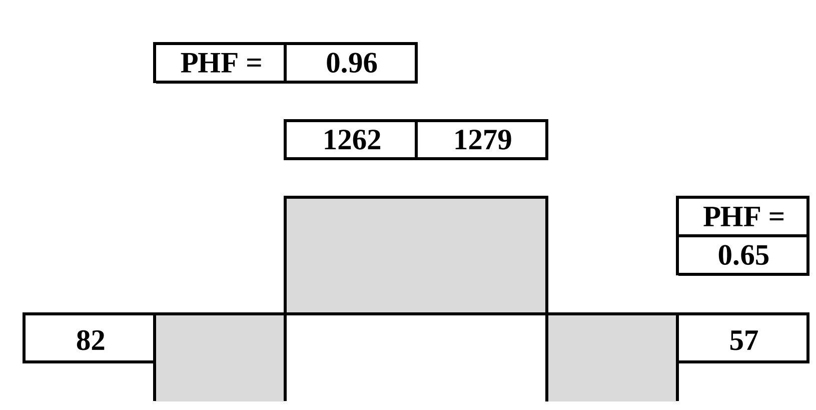
PROJECT:	**TRAFFIC COUNTS IN UNION CITY**	**SURVEY DATE:**	**6/7/2016**	**DAY:**	**TUESDAY**
N-S APPROACH:	**UNION CITY BOULEVARD**	**SURVEY TIME:**	**4:00 PM**	**TO**	**6:00 PM**
E-W APPROACH:	**HORNER STREET**	**JURISDICTION:**	**UNION CITY**	**FILE:**	**3606057-4PM**

PEAK HOUR

5:00 PM to 6:00 PM



ARRIVAL / DEPARTURE VOLUMES



	31	0
HORNER STREET		
12	44	1230	26
UNION CITY BOULEVARD		

66			85
PHF = 0.75			
	1251	1312	
	PHF =	0.93	

TIME		PERIOD	NORTHBOUND				SOUTHBOUND				EASTBOUND				WESTBOUND				TOTAL
From		To	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	THRU	RIGHT	U-TURN	LEFT	THRU	RIGHT	
SURVEY DATA																			
4:00 PM	to	4:15 PM	1	8	328	9	1	15	228	12		2	3	0		9	3	8	**627**
4:15 PM	to	4:30 PM	3	17	693	16	2	24	449	22		3	4	4		11	4	15	**1267**
4:30 PM	to	4:45 PM	4	25	984	27	3	39	686	30		6	7	6		18	9	21	**1865**
4:45 PM	to	5:00 PM	9	33	1316	32	3	47	907	35		9	10	11		18	12	25	**2467**
5:00 PM	to	5:15 PM	10	44	1639	40	7	68	1184	39		9	11	16		20	12	27	**3126**
5:15 PM	to	5:30 PM	13	61	1960	47	7	70	1489	48		15	15	26		28	18	31	**3828**
5:30 PM	to	5:45 PM	17	72	2209	53	8	81	1795	57		21	17	36		33	20	37	**4456**
5:45 PM	to	6:00 PM	21	77	2546	58	10	91	2094	59		29	25	42		39	26	47	**5164**
TOTAL BY PERIOD																			
4:00 PM	to	4:15 PM	1	8	328	9	1	15	228	12	0	2	3	0	0	9	3	8	**627**
4:15 PM	to	4:30 PM	2	9	365	7	1	9	221	10	0	1	1	4	0	2	1	7	**640**
4:30 PM	to	4:45 PM	1	8	291	11	1	15	237	8	0	3	3	2	0	7	5	6	**598**
4:45 PM	to	5:00 PM	5	8	332	5	0	8	221	5	0	3	3	5	0	0	3	4	**602**
5:00 PM	to	5:15 PM	1	11	323	8	4	21	277	4	0	0	1	5	0	2	0	2	**659**
5:15 PM	to	5:30 PM	3	17	321	7	0	2	305	9	0	6	4	10	0	8	6	4	**702**
5:30 PM	to	5:45 PM	4	11	249	6	1	11	306	9	0	6	2	10	0	5	2	6	**628**
5:45 PM	to	6:00 PM	4	5	337	5	2	10	299	2	0	8	8	6	0	6	6	10	**708**
HOURLY TOTALS																			
4:00 PM	to	5:00 PM	9	33	1316	32	3	47	907	35	0	9	10	11	0	18	12	25	**2467**
4:15 PM	to	5:15 PM	9	36	1311	31	6	53	956	27	0	7	8	16	0	11	9	19	**2499**
4:30 PM	to	5:30 PM	10	44	1267	31	5	46	1040	26	0	12	11	22	0	17	14	16	**2561**
4:45 PM	to	5:45 PM	13	47	1225	26	5	42	1109	27	0	15	10	30	0	15	11	16	**2591**
5:00 PM	to	6:00 PM	12	44	1230	26	7	44	1187	24	0	20	15	31	0	21	14	22	**2697**

PEAK HOUR SUMMARY

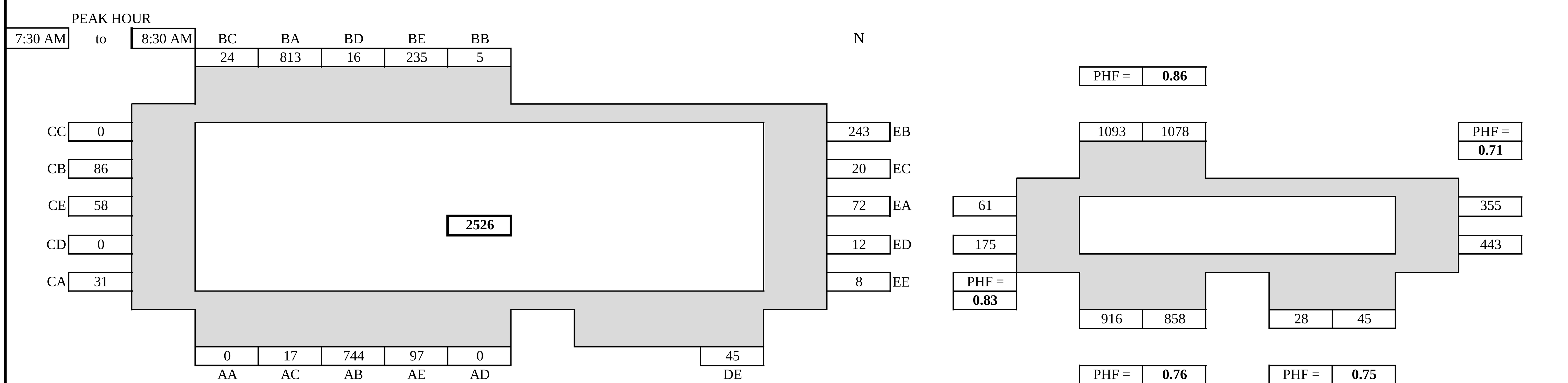
5:00 PM to 6:00 PM	NORTHBOUND				SOUTHBOUND				EASTBOUND				WESTBOUND				TOTAL
	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	
VOLUME	12	44	1230	26	7	44	1187	24	0	20	15	31	0	21	14	22	**2697**
PHF BY MOVEMENT	0.75	0.65	0.91	0.81	0.44	0.52	0.97	0.67	0.00	0.63	0.47	0.78	0.00	0.66	0.58	0.55	OVERALI
PHF BY APPROACH	0.93				0.96				0.75				0.65				0.95
BICYCLE	1				5				0				2				**8**
PEDESTRIAN	20				8				8				6				**42**
	N-LEG				**S-LEG**				**E-LEG**				**W-LEG**				
PEDESTRIAN BY LEG:	7				7				22				6				**42**

TEL: (510) 232 - 1271 FAX: (510) 232 - 1272

B.A.Y.M.E.T.R.I.C.S.

INTERSECTION TURNING MOVEMENT SUMMARY

PROJECT:	TRAFFIC COUNTS IN OAKLAND	SURVEY DATE:	6/7/2016	DAY:	TUESDAY
N-S APPROACH:	UNION CITY BOULEVARD	SURVEY TIME:	7:00 AM TO		9:00 AM
E-W APPROACH:	ALVERADO BOULEVARD	JURISDICTION:	OAKLAND	FILE:	3606057-5AM



TIME PERIOD FROM		TO	A (UNION CITY BL) NB AA	AC	AB	AE	AD	B (UNION CITY BL) SB BB	BE	BD	BA	BC	D DE	C (ALVARADO BL) EB CC	CB	CE	CD	CA	E (ALVERADO BL) WB EE	ED	EA	EC	EB	TOTAL
SURVEY DATA																								
7:00 AM	to	7:15 AM	0	0	121	2	0	2	37	2	205	3	8		18	19	1	3	0	0	8	1	20	*450*
7:15 AM	to	7:30 AM	0	1	224	10	0	4	89	5	439	10	23		41	34	1	12	1	1	11	7	68	*981*
7:30 AM	to	7:45 AM	0	1	396	17	0	5	148	5	690	16	35		70	47	1	23	3	3	20	8	116	*1604*
7:45 AM	to	8:00 AM	0	7	592	53	0	7	201	10	827	18	50		90	63	1	34	5	6	34	16	180	*2194*
8:00 AM	to	8:15 AM	0	14	822	97	0	8	270	16	1009	28	61		108	74	1	36	7	11	65	22	261	*2910*
8:15 AM	to	8:30 AM	0	18	968	107	0	9	324	21	1252	34	68		127	92	1	43	9	13	83	27	311	*3507*
8:30 AM	to	8:45 AM	0	19	1110	115	0	12	381	22	1522	37	75		138	99	1	48	9	13	92	30	369	*4092*
8:45 AM	to	9:00 AM	1	20	1244	122	0	13	440	24	1751	42	83		153	115	1	53	12	14	95	33	422	*4638*
TOTAL BY PERIOD																								
7:00 AM	to	7:15 AM	0	0	121	2	0	2	37	2	205	3	8	0	18	19	1	3	0	0	8	1	20	*450*
7:15 AM	to	7:30 AM	0	1	103	8	0	2	52	3	234	7	15	0	23	15	0	9	1	1	3	6	48	*531*
7:30 AM	to	7:45 AM	0	0	172	7	0	1	59	0	251	6	12	0	29	13	0	11	2	2	9	1	48	*623*
7:45 AM	to	8:00 AM	0	6	196	36	0	2	53	5	137	2	15	0	20	16	0	11	2	3	14	8	64	*590*
8:00 AM	to	8:15 AM	0	7	230	44	0	1	69	6	182	10	11	0	18	11	0	2	2	5	31	6	81	*716*
8:15 AM	to	8:30 AM	0	4	146	10	0	1	54	5	243	6	7	0	19	18	0	7	2	2	18	5	50	*597*
8:30 AM	to	8:45 AM	0	1	142	8	0	3	57	1	270	3	7	0	11	7	0	5	0	0	9	3	58	*585*
8:45 AM	to	9:00 AM	1	1	134	7	0	1	59	2	229	5	8	0	15	16	0	5	3	1	3	3	53	*546*
HOURLY TOTALS																								
7:00 AM	to	8:00 AM	0	7	592	53	0	7	201	10	827	18	50	0	90	63	1	34	5	6	34	16	180	*2194*
7:15 AM	to	8:15 AM	0	14	701	95	0	6	233	14	804	25	53	0	90	55	0	33	7	11	57	21	241	*2460*
7:30 AM	to	8:30 AM	0	17	744	97	0	5	235	16	813	24	45	0	86	58	0	31	8	12	72	20	243	*2526*
7:45 AM	to	8:45 AM	0	18	714	98	0	7	233	17	832	21	40	0	68	52	0	25	6	10	72	22	253	*2488*
8:00 AM	to	9:00 AM	1	13	652	69	0	6	239	14	924	24	33	0	63	52	0	19	7	8	61	17	242	*2444*

PEAK HOUR SUMMARY

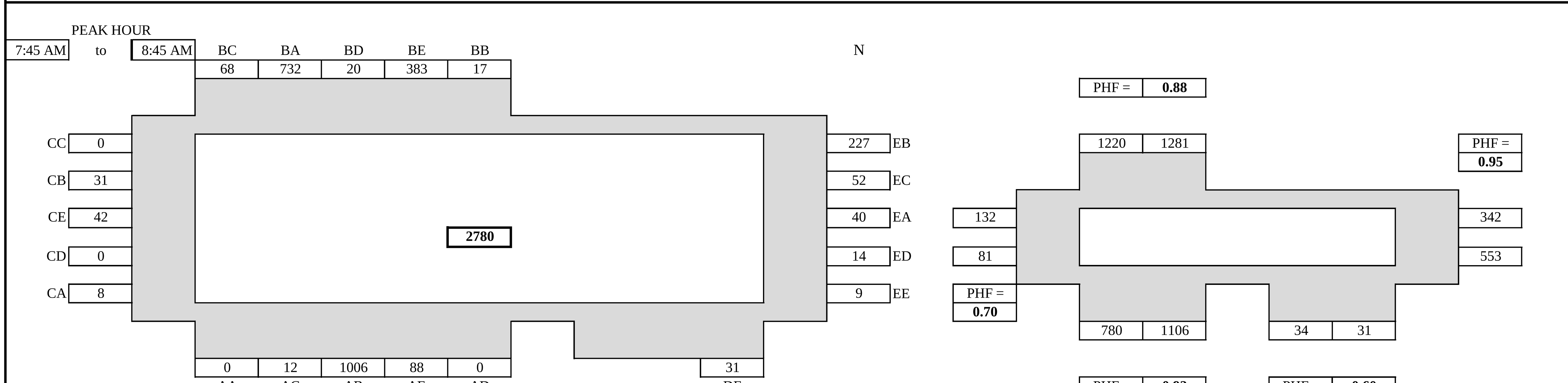
7:30 AM to 8:30 AM	A (UNION CITY BL) NB AA	AC	AB	AE	AD	B (UNION CITY BL) SB BC	BA	BD	BE	BB	D DE	C (ALVARADO BL) EB CC	CB	CE	CD	CA	E (ALVERADO BL) WB EB	EC	EA	ED	EE	TOTAL
VOLUME	0	17	744	97	0	5	235	16	813	24	45	0	86	58	0	31	8	12	72	20	243	2526
PHF BY MOVEMENT	0.00	0.61	0.81	0.55	0.00	0.63	0.85	0.67	0.81	0.60	0.75	0.00	0.74	0.81	0.00	0.70	1.00	0.60	0.58	0.63	0.75	OVERALL
PHF BY APPROACH	0.76					0.86					0.75	0.83					0.71					0.88
PEDESTRIANS	4					1						16					3					24
BICYCLE	2					0					1	0					0					3

TEL: (510) 232 - 1271 **FAX: (510) 232 - 1272**

B.A.Y.M.E.T.R.I.C.S.

INTERSECTION TURNING MOVEMENT SUMMARY

PROJECT:	TRAFFIC COUNTS IN OAKLAND	SURVEY DATE:	6/7/2016	DAY:	TUESDAY
N-S APPROACH:	UNION CITY BOULEVARD	SURVEY TIME:	7:00 AM TO		9:00 AM
E-W APPROACH:	ALVERADO BOULEVARD	JURISDICTION:	OAKLAND	FILE:	3606057-5AM



TIME PERIOD FROM		TO	A (UNION CITY BL) NB AA	AC	AB	AE	AD	B (UNION CITY BL) SB BB	BE	BD	BA	BC	D DE	C (ALVARADO BL) EB CC	CB	CE	CD	CA	E (ALVERADO BL) WB EE	ED	EA	EC	EB	TOTAL
SURVEY DATA																								
7:00 AM	to	7:15 AM		1	289	13	1	6	81	4	128	8	4		8	3	0	1	2	2	7	7	33	*598*
7:15 AM	to	7:30 AM		3	562	33	2	7	166	5	262	18	16		16	11	0	2	5	4	8	19	87	*1226*
7:30 AM	to	7:45 AM		6	820	47	2	8	219	6	404	27	24		24	21	0	5	5	6	23	33	153	*1833*
7:45 AM	to	8:00 AM		10	1087	78	2	15	321	10	564	46	32		30	33	0	10	7	9	36	45	209	*2544*
8:00 AM	to	8:15 AM		14	1334	101	2	18	411	14	731	62	38		38	43	0	11	9	12	45	53	277	*3213*
8:15 AM	to	8:30 AM		15	1576	114	2	19	511	21	917	71	42		42	49	0	11	11	16	58	66	335	*3876*
8:30 AM	to	8:45 AM		18	1826	135	2	25	602	26	1136	95	55		55	63	0	13	14	20	63	85	380	*4613*
8:45 AM	to	9:00 AM		21	2062	146	4	31	706	29	1301	113	64		65	65	0	13	16	24	67	96	435	*5258*
TOTAL BY PERIOD																								
7:00 AM	to	7:15 AM	0	1	289	13	1	6	81	4	128	8	4	0	8	3	0	1	2	2	7	7	33	*598*
7:15 AM	to	7:30 AM	0	2	273	20	1	1	85	1	134	10	12	0	8	8	0	1	3	2	1	12	54	*628*
7:30 AM	to	7:45 AM	0	3	258	14	0	1	53	1	142	9	8	0	8	10	0	3	0	2	15	14	66	*607*
7:45 AM	to	8:00 AM	0	4	267	31	0	7	102	4	160	19	8	0	6	12	0	5	2	3	13	12	56	*711*

8:00 AM	to	8:15 AM	0	4	247	23	0	3	90	4	167	16	6	0	8	10	0	1	2	3	9	8	68	***669***
8:15 AM	to	8:30 AM	0	1	242	13	0	1	100	7	186	9	4	0	4	6	0	0	2	4	13	13	58	***663***
8:30 AM	to	8:45 AM	0	3	250	21	0	6	91	5	219	24	13	0	13	14	0	2	3	4	5	19	45	***737***
8:45 AM	to	9:00 AM	0	3	236	11	2	6	104	3	165	18	9	0	10	2	0	0	2	4	4	11	55	***645***
H O U R L Y T O T A L S																								
7:00 AM	to	8:00 AM	0	10	1087	78	2	15	321	10	564	46	32	0	30	33	0	10	7	9	36	45	209	***2544***
7:15 AM	to	8:15 AM	0	13	1045	88	1	12	330	10	603	54	34	0	30	40	0	10	7	10	38	46	244	***2615***
7:30 AM	to	8:30 AM	0	12	1014	81	0	12	345	16	655	53	26	0	26	38	0	9	6	12	50	47	248	***2650***
7:45 AM	to	8:45 AM	0	12	1006	88	0	17	383	20	732	68	31	0	31	42	0	8	9	14	40	52	227	***2780***
8:00 AM	to	9:00 AM	0	11	975	68	2	16	385	19	737	67	32	0	35	32	0	3	9	15	31	51	226	***2714***
P E A K H O U R S U M M A R Y																								
7:45 AM	to	8:45 AM	A (UNION CITY BL) NB					B (UNION CITY BL) SB					D	C (ALVARADO BL) EB					E (ALVERADO BL) WB					TOTAL
			AA	AC	AB	AE	AD	BC	BA	BD	BE	BB	DE	CC	CB	CE	CD	CA	EB	EC	EA	ED	EE	
VOLUME			0	12	1006	88	0	17	383	20	732	68	31	0	31	42	0	8	9	14	40	52	227	2780
PHF BY MOVEMENT			0.00	0.75	0.94	0.71	0.00	0.61	0.94	0.71	0.84	0.71	0.60	0.00	0.60	0.75	0.00	0.40	0.75	0.88	0.77	0.68	0.83	OVERALL
PHF BY APPROACH			0.92					0.88					0.60	0.70					0.95					0.94
PEDESTRIANS			2					0						7					1					10
BICYCLE			1					7					0	2					1					11

TEL: (510) 232 - 1271 **FAX: (510) 232 - 1272**

B.A.Y.M.E.T.R.I.C.S.

INTERSECTION TURNING MOVEMENT SUMMARY

PROJECT:	**TRAFFIC COUNTS IN UNION CITY**	**SURVEY DATE:**	**6/7/2016**	**DAY:**	**TUESDAY**
N-S APPROACH:	**UNION CITY BOULEVARD**	**SURVEY TIME:**	**7:00 AM**	**TO**	**9:00 AM**
E-W APPROACH:	**DYER STREET**	**JURISDICTION:**	**UNION CITY**	**FILE:**	**3606057-6AM**

PEAK HOUR

7:30 AM to 8:30 AM

NORTH

3 **936** **6** **2**

0
22
24
16

1951

5
12
178
0

DYER STREET

0 **9** **595** **143**

UNION CITY BOULEVARD

ARRIVAL / DEPARTURE VOLUMES

PHF = 0.79

947 **624**

PHF = 0.68

24 **195**

62 **173**

PHF = 0.78

1130 **747**

PHF = 0.74

TIME From		PERIOD To	NORTHBOUND U-TURN	LEFT	THRU	RIGHT	SOUTHBOUND U-TURN	LEFT	THRU	RIGHT	EASTBOUND U-TURN	LEFT	THRU	RIGHT	WESTBOUND U-TURN	LEFT	THRU	RIGHT	TOTAL
SURVEY DATA																			
7:00 AM	to	7:15 AM		0	57	14	0	1	265	1		2	4	8		74	2	1	**429**
7:15 AM	to	7:30 AM		1	127	34	0	1	489	4		6	9	17		135	5	1	**829**
7:30 AM	to	7:45 AM		1	246	70	1	5	782	4		10	19	23		186	8	3	**1358**
7:45 AM	to	8:00 AM		5	414	118	1	6	935	4		15	25	30		205	10	3	**1771**
8:00 AM	to	8:15 AM		9	620	159	2	6	1148	6		22	29	33		247	14	3	**2298**
8:15 AM	to	8:30 AM		10	722	177	2	7	1425	7		28	33	33		313	17	6	**2780**
8:30 AM	to	8:45 AM		13	829	199	2	10	1711	9		30	36	40		372	17	7	**3275**
8:45 AM	to	9:00 AM		13	908	212	3	10	1949	11		32	38	43		406	19	7	**3651**
TOTAL BY PERIOD																			
7:00 AM	to	7:15 AM	0	0	57	14	0	1	265	1	0	2	4	8	0	74	2	1	**429**
7:15 AM	to	7:30 AM	0	1	70	20	0	0	224	3	0	4	5	9	0	61	3	0	**400**
7:30 AM	to	7:45 AM	0	0	119	36	1	4	293	0	0	4	10	6	0	51	3	2	**529**
7:45 AM	to	8:00 AM	0	4	168	48	0	1	153	0	0	5	6	7	0	19	2	0	**413**
8:00 AM	to	8:15 AM	0	4	206	41	1	0	213	2	0	7	4	3	0	42	4	0	**527**
8:15 AM	to	8:30 AM	0	1	102	18	0	1	277	1	0	6	4	0	0	66	3	3	**482**
8:30 AM	to	8:45 AM	0	3	107	22	0	3	286	2	0	2	3	7	0	59	0	1	**495**
8:45 AM	to	9:00 AM	0	0	79	13	1	0	238	2	0	2	2	3	0	34	2	0	**376**
HOURLY TOTALS																			
7:00 AM	to	8:00 AM	0	5	414	118	1	6	935	4	0	15	25	30	0	205	10	3	**1771**
7:15 AM	to	8:15 AM	0	9	563	145	2	5	883	5	0	20	25	25	0	173	12	2	**1869**
7:30 AM	to	8:30 AM	0	9	595	143	2	6	936	3	0	22	24	16	0	178	12	5	**1951**
7:45 AM	to	8:45 AM	0	12	583	129	1	5	929	5	0	20	17	17	0	186	9	4	**1917**
8:00 AM	to	9:00 AM	0	8	494	94	2	4	1014	7	0	17	13	13	0	201	9	4	**1880**

PEAK HOUR SUMMARY

7:30 AM to 8:30 AM	NORTHBOUND NBU	NBL	NBT	NBR	SOUTHBOUND SBU	SBL	SBT	SBR	EASTBOUND EBU	EBL	EBT	EBR	WESTBOUND WBU	WBL	WBT	WBR	TOTAL
VOLUME	0	9	595	143	2	6	936	3	0	22	24	16	0	178	12	5	**1951**
PHF BY MOVEMENT	0.00	0.56	0.72	0.74	0.50	0.38	0.80	0.38	0.00	0.79	0.60	0.57	0.00	0.67	0.75	0.42	OVERALL
PHF BY APPROACH	0.74				0.79				0.78				0.68				0.92
BICYCLE	2				0				0				1				**3**
PEDESTRIAN	3				4				2				2				**11**
	N-LEG				**S-LEG**				**E-LEG**				**W-LEG**				
PEDESTRIAN BY LEG:	4				0				0				7				**11**

TEL: (510) 232 - 1271 FAX: (510) 232 - 1272

B.A.Y.M.E.T.R.I.C.S.

INTERSECTION TURNING MOVEMENT SUMMARY

PROJECT:	**TRAFFIC COUNTS IN UNION CITY**	**SURVEY DATE:**	**6/7/2016**	**DAY:**	**TUESDAY**
N-S APPROACH:	**UNION CITY BOULEVARD**	**SURVEY TIME:**	**4:00 PM**	**TO**	**6:00 PM**
E-W APPROACH:	**DYER STREET**	**JURISDICTION:**	**UNION CITY**	**FILE:**	**3606057-6PM**

PEAK HOUR

5:00 PM to 6:00 PM

NORTH

9 **619** **13** **0**

0
6
22

2294

2
20
124

ARRIVAL / DEPARTURE VOLUMES

PHF = 0.93

641 **1074**

PHF = 0.91

45 **146**

	6		0		34	425
DYER STREET					PHF = 0.57	
	1	16	1066	390	750	1473
	UNION CITY BOULEVARD				PHF =	0.93

TIME From	PERIOD	To	NORTHBOUND U-TURN	LEFT	THRU	RIGHT	SOUTHBOUND U-TURN	LEFT	THRU	RIGHT	EASTBOUND U-TURN	LEFT	THRU	RIGHT	WESTBOUND U-TURN	LEFT	THRU	RIGHT	TOTAL
SURVEY DATA																			
4:00 PM	to	4:15 PM	0	6	332	104		2	103	3		0	3	2		25	2	0	**582**
4:15 PM	to	4:30 PM	0	9	640	215		4	210	6		4	5	5		50	8	3	**1159**
4:30 PM	to	4:45 PM	1	10	918	333		6	338	8		5	8	8		84	8	4	**1731**
4:45 PM	to	5:00 PM	1	11	1179	447		7	446	12		7	14	8		110	13	5	**2260**
5:00 PM	to	5:15 PM	2	15	1434	537		8	592	16		11	22	11		141	20	5	**2814**
5:15 PM	to	5:30 PM	2	22	1698	652		13	744	19		11	28	12		166	25	5	**3397**
5:30 PM	to	5:45 PM	2	24	1994	749		18	909	21		12	30	12		198	31	5	**4005**
5:45 PM	to	6:00 PM	2	27	2245	837		20	1065	21		13	36	14		234	33	7	**4554**
TOTAL BY PERIOD																			
4:00 PM	to	4:15 PM	0	6	332	104	0	2	103	3	0	0	3	2	0	25	2	0	**582**
4:15 PM	to	4:30 PM	0	3	308	111	0	2	107	3	0	4	2	3	0	25	6	3	**577**
4:30 PM	to	4:45 PM	1	1	278	118	0	2	128	2	0	1	3	3	0	34	0	1	**572**
4:45 PM	to	5:00 PM	0	1	261	114	0	1	108	4	0	2	6	0	0	26	5	1	**529**
5:00 PM	to	5:15 PM	1	4	255	90	0	1	146	4	0	4	8	3	0	31	7	0	**554**
5:15 PM	to	5:30 PM	0	7	264	115	0	5	152	3	0	0	6	1	0	25	5	0	**583**
5:30 PM	to	5:45 PM	0	2	296	97	0	5	165	2	0	1	2	0	0	32	6	0	**608**
5:45 PM	to	6:00 PM	0	3	251	88	0	2	156	0	0	1	6	2	0	36	2	2	**549**
HOURLY TOTALS																			
4:00 PM	to	5:00 PM	1	11	1179	447	0	7	446	12	0	7	14	8	0	110	13	5	**2260**
4:15 PM	to	5:15 PM	2	9	1102	433	0	6	489	13	0	11	19	9	0	116	18	5	**2232**
4:30 PM	to	5:30 PM	2	13	1058	437	0	9	534	13	0	7	23	7	0	116	17	2	**2238**
4:45 PM	to	5:45 PM	1	14	1076	416	0	12	571	13	0	7	22	4	0	114	23	1	**2274**
5:00 PM	to	6:00 PM	1	16	1066	390	0	13	619	9	0	6	22	6	0	124	20	2	**2294**

PEAK HOUR SUMMARY

5:00 PM to 6:00 PM	NORTHBOUND NBU	NBL	NBT	NBR	SOUTHBOUND SBU	SBL	SBT	SBR	EASTBOUND EBU	EBL	EBT	EBR	WESTBOUND WBU	WBL	WBT	WBR	TOTAL
VOLUME	1	16	1066	390	0	13	619	9	0	6	22	6	0	124	20	2	**2294**
PHF BY MOVEMENT	0.25	0.57	0.90	0.85	0.00	0.65	0.94	0.56	0.00	0.38	0.69	0.50	0.00	0.86	0.71	0.25	OVERALL
PHF BY APPROACH	0.93				0.93				0.57				0.91				0.94
BICYCLE	1				0				3				0				**4**
PEDESTRIAN	2				4				2				3				**11**
	N-LEG				**S-LEG**				**E-LEG**				**W-LEG**				
PEDESTRIAN BY LEG:	5				0				2				4				**11**

TEL: (510) 232 - 1271 FAX: (510) 232 - 1272

APPENDIX B
LEVEL OF SERVICE CALCULATION SHEETS
for
BASE CASE SCENARIO

Movement	EBL	EBT	EBR	WBT	WBR	WBR2	NBL2	NBT	NBR	SBU	SBL	SBR
Lane Configurations												
Traffic Volume (vph)	322	751	186	616	255	143	494	421	357	25	209	618
Future Volume (vph)	322	751	186	616	255	143	494	421	357	25	209	618
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.7	5.4	4.0	5.4	5.4	5.4	5.1	5.1			4.4	4.4
Lane Util. Factor	0.97	0.95	1.00	0.95	1.00	1.00	1.00	0.95			1.00	0.88
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.98	1.00	0.99			1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.85	0.85	1.00	0.93			1.00	0.85
Flt Protected	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (prot)	3127	3223	1442	3223	1442	1414	1612	2982			1630	2538
Flt Permitted	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (perm)	3127	3223	1442	3223	1442	1414	1612	2982			1630	2538
Peak-hour factor, PHF	0.89	0.89	0.89	0.91	0.91	0.91	0.92	0.92	0.92	0.87	0.87	0.87
Adj. Flow (vph)	362	844	209	677	280	157	537	458	388	29	240	710
RTOR Reduction (vph)	0	0	0	0	0	117	0	64	0	0	0	47
Lane Group Flow (vph)	362	844	209	677	280	40	537	782	0	0	269	704
Confl. Peds. (#/hr)	6					6			2		2	
Heavy Vehicles (%)	12%	12%	12%	12%	12%	12%	12%	12%	12%	0%	12%	12%
Turn Type	Prot	NA	Free	NA	Prot	Perm	Split	NA		Prot	Prot	pt+ov
Protected Phases	5	2		6	6		8	8		7	7	7 5
Permitted Phases			Free			6						
Actuated Green, G (s)	15.0	49.5	120.0	30.8	30.8	30.8	37.6	37.6			18.0	37.4
Effective Green, g (s)	15.0	49.5	120.0	30.8	30.8	30.8	37.6	37.6			18.0	37.4
Actuated g/C Ratio	0.12	0.41	1.00	0.26	0.26	0.26	0.31	0.31			0.15	0.31
Clearance Time (s)	3.7	5.4		5.4	5.4	5.4	5.1	5.1			4.4	
Vehicle Extension (s)	2.0	4.0		4.0	4.0	4.0	2.0	2.0			2.0	
Lane Grp Cap (vph)	390	1329	1442	827	370	362	505	934			244	791
v/s Ratio Prot	0.12	0.26		c0.21	0.19		c0.33	0.26			c0.16	c0.28
v/s Ratio Perm			0.14			0.03						
v/c Ratio	0.93	0.64	0.14	0.82	0.76	0.11	1.06	0.84			1.10	0.89
Uniform Delay, d1	52.0	28.1	0.0	42.0	41.1	34.1	41.2	38.4			51.0	39.3
Progression Factor	0.74	1.15	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Incremental Delay, d2	23.3	1.8	0.2	8.9	13.5	0.6	57.9	6.3			87.8	11.9
Delay (s)	61.9	34.1	0.2	50.8	54.6	34.7	99.1	44.7			138.8	51.3
Level of Service	E	C	A	D	D	C	F	D			F	D
Approach Delay (s)		36.2		49.5				65.8				
Approach LOS		D		D				E				

Intersection Summary			
HCM 2000 Control Delay	55.4	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	0.99		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	18.6
Intersection Capacity Utilization	86.8%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	SBR2
Lane Configurations	
Traffic Volume (vph)	36
Future Volume (vph)	36
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.87
Adj. Flow (vph)	41
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	
Heavy Vehicles (%)	12%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	267	175	139	171	171	321	307	588	45	323	615	826
Future Volume (vph)	267	175	139	171	171	321	307	588	45	323	615	826
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.3	5.3	5.3	4.9	4.9	4.9	4.7	5.4	5.4	4.7	5.4	5.4
Lane Util. Factor	0.91	0.91	1.00	0.95	0.95	1.00	0.97	0.95	1.00	0.97	0.95	1.00
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.98	1.00	1.00	1.00	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	0.98	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1579	3258	1583	1681	1731	1410	3433	3539	1583	3127	3539	1533
Flt Permitted	0.95	0.98	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1579	3258	1583	1681	1731	1410	3433	3539	1583	3127	3539	1533
Peak-hour factor, PHF	0.83	0.83	0.83	0.88	0.88	0.88	0.78	0.78	0.78	0.80	0.80	0.80
Adj. Flow (vph)	322	211	167	194	194	365	394	754	58	404	769	1032
RTOR Reduction (vph)	0	0	143	0	0	257	0	0	36	0	0	284
Lane Group Flow (vph)	174	359	24	175	213	108	394	754	22	404	769	749
Confl. Peds. (#/hr)	5					5						
Confl. Bikes (#/hr)												1
Heavy Vehicles (%)	4%	4%	2%	2%	4%	12%	2%	2%	2%	12%	2%	4%
Turn Type	Split	NA	Perm	Split	NA	Perm	Prot	NA	Perm	Prot	NA	Perm
Protected Phases	7	7		8	8		5	2		1	6	
Permitted Phases			7			8			2			6
Actuated Green, G (s)	17.4	17.4	17.4	17.8	17.8	17.8	16.8	46.0	46.0	18.5	47.7	47.7
Effective Green, g (s)	17.4	17.4	17.4	17.8	17.8	17.8	16.8	46.0	46.0	18.5	47.7	47.7
Actuated g/C Ratio	0.14	0.14	0.14	0.15	0.15	0.15	0.14	0.38	0.38	0.15	0.40	0.40
Clearance Time (s)	5.3	5.3	5.3	4.9	4.9	4.9	4.7	5.4	5.4	4.7	5.4	5.4
Vehicle Extension (s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0	2.0	3.0	3.0
Lane Grp Cap (vph)	228	472	229	249	256	209	480	1356	606	482	1406	609
v/s Ratio Prot	c0.11	0.11		0.10	c0.12		0.11	0.21		c0.13	0.22	
v/s Ratio Perm			0.02			0.08			0.01			c0.49
v/c Ratio	0.76	0.76	0.11	0.70	0.83	0.52	0.82	0.56	0.04	0.84	0.55	1.23
Uniform Delay, d1	49.3	49.3	44.5	48.6	49.6	47.1	50.1	29.0	23.1	49.3	27.8	36.1
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	0.97	0.99
Incremental Delay, d2	12.7	6.4	0.1	7.1	19.3	0.9	10.3	1.6	0.1	7.1	0.9	111.7
Delay (s)	62.0	55.7	44.6	55.7	68.9	48.0	60.4	30.6	23.3	57.0	28.0	147.6
Level of Service	E	E	D	E	E	D	E	C	C	E	C	F
Approach Delay (s)		54.6			55.7			40.0			89.3	
Approach LOS		D			E			D			F	

Intersection Summary			
HCM 2000 Control Delay	66.9	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.02		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	20.3
Intersection Capacity Utilization	82.0%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL
Lane Configurations												
Traffic Volume (vph)	14	24	13	1	157	149	301	1	82	923	211	416
Future Volume (vph)	14	24	13	1	157	149	301	1	82	923	211	416
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.6	5.3			4.6	5.3	5.3		4.6	5.3	5.3	4.6
Lane Util. Factor	1.00	0.95			0.97	1.00	1.00		1.00	0.95	1.00	0.97
Frpb, ped/bikes	1.00	1.00			1.00	1.00	0.99		1.00	1.00	0.99	1.00
Flpb, ped/bikes	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Frt	1.00	0.95			1.00	1.00	0.85		1.00	1.00	0.85	1.00
Flt Protected	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (prot)	1770	3353			3368	1863	1533		1770	3471	1530	3367
Flt Permitted	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (perm)	1770	3353			3368	1863	1533		1770	3471	1530	3367
Peak-hour factor, PHF	0.91	0.91	0.91	0.93	0.93	0.93	0.93	0.86	0.86	0.86	0.86	0.94
Adj. Flow (vph)	15	26	14	1	169	160	324	1	95	1073	245	443
RTOR Reduction (vph)	0	13	0	0	0	0	270	0	0	0	78	0
Lane Group Flow (vph)	15	27	0	0	170	160	54	0	96	1073	167	443
Confl. Peds. (#/hr)	1						1		1		2	2
Confl. Bikes (#/hr)											1	
Heavy Vehicles (%)	2%	2%	2%	0%	4%	2%	4%	0%	2%	4%	4%	4%
Turn Type	Prot	NA		Prot	Prot	NA	Perm	Prot	Prot	NA	Perm	Prot
Protected Phases	7	4		3	3	8		5	5	2		1
Permitted Phases							8				2	
Actuated Green, G (s)	2.7	10.5			11.6	19.4	19.4		12.4	53.9	53.9	20.7
Effective Green, g (s)	2.7	10.5			11.6	19.4	19.4		12.4	53.9	53.9	20.7
Actuated g/C Ratio	0.02	0.09			0.10	0.17	0.17		0.11	0.46	0.46	0.18
Clearance Time (s)	4.6	5.3			4.6	5.3	5.3		4.6	5.3	5.3	4.6
Vehicle Extension (s)	2.0	2.0			2.0	2.0	2.0		2.0	4.0	4.0	2.0
Lane Grp Cap (vph)	41	302			335	310	255		188	1605	707	598
v/s Ratio Prot	0.01	0.01			c0.05	c0.09			0.05	0.31		c0.13
v/s Ratio Perm							0.04				0.11	
v/c Ratio	0.37	0.09			0.51	0.52	0.21		0.51	0.67	0.24	0.74
Uniform Delay, d1	56.1	48.6			49.7	44.3	41.9		49.2	24.4	18.9	45.4
Progression Factor	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2	2.0	0.0			0.4	0.6	0.2		1.0	1.2	0.2	4.3
Delay (s)	58.1	48.7			50.2	44.9	42.1		50.2	25.5	19.1	49.7
Level of Service	E	D			D	D	D		D	C	B	D
Approach Delay (s)		51.2				44.9				26.1		
Approach LOS		D				D				C		

Intersection Summary			
HCM 2000 Control Delay	30.8	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	116.5	Sum of lost time (s)	19.8
Intersection Capacity Utilization	66.9%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR
Lane Configurations		
Traffic Volume (vph)	1187	43
Future Volume (vph)	1187	43
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	5.3	
Lane Util. Factor	0.95	
Frpb, ped/bikes	1.00	
Flpb, ped/bikes	1.00	
Frt	0.99	
Flt Protected	1.00	
Satd. Flow (prot)	3452	
Flt Permitted	1.00	
Satd. Flow (perm)	3452	
Peak-hour factor, PHF	0.94	0.94
Adj. Flow (vph)	1263	46
RTOR Reduction (vph)	1	0
Lane Group Flow (vph)	1308	0
Confl. Peds. (#/hr)		1
Confl. Bikes (#/hr)		1
Heavy Vehicles (%)	4%	2%
Turn Type	NA	
Protected Phases	6	
Permitted Phases		
Actuated Green, G (s)	62.2	
Effective Green, g (s)	62.2	
Actuated g/C Ratio	0.53	
Clearance Time (s)	5.3	
Vehicle Extension (s)	4.0	
Lane Grp Cap (vph)	1843	
v/s Ratio Prot	c0.38	
v/s Ratio Perm		
v/c Ratio	0.71	
Uniform Delay, d1	20.4	
Progression Factor	1.00	
Incremental Delay, d2	1.4	
Delay (s)	21.7	
Level of Service	C	
Approach Delay (s)	28.8	
Approach LOS	C	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	21	13	25	39	7	60	6	31	967	51	63	1140
Future Volume (vph)	21	13	25	39	7	60	6	31	967	51	63	1140
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.9			4.9			4.9	5.3		4.9	5.3
Lane Util. Factor		1.00			1.00			1.00	0.95		1.00	0.95
Frpb, ped/bikes		0.99			0.97			1.00	1.00		1.00	1.00
Flpb, ped/bikes		0.99			1.00			1.00	1.00		1.00	1.00
Frt		0.94			0.92			1.00	0.99		1.00	1.00
Flt Protected		0.98			0.98			0.95	1.00		0.95	1.00
Satd. Flow (prot)		1694			1641			1775	3439		1770	3465
Flt Permitted		0.74			0.85			0.95	1.00		0.95	1.00
Satd. Flow (perm)		1271			1418			1775	3439		1770	3465
Peak-hour factor, PHF	0.74	0.74	0.74	0.58	0.58	0.58	0.81	0.81	0.81	0.81	0.89	0.89
Adj. Flow (vph)	28	18	34	67	12	103	7	38	1194	63	71	1281
RTOR Reduction (vph)	0	29	0	0	52	0	0	0	2	0	0	1
Lane Group Flow (vph)	0	51	0	0	130	0	0	45	1255	0	71	1296
Confl. Peds. (#/hr)	29		11	11		29		2		11	11	
Confl. Bikes (#/hr)			2			1				3		
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	0%	2%	4%	2%	2%	4%
Turn Type	Perm	NA		Perm	NA		Prot	Prot	NA		Prot	NA
Protected Phases		4			8		5	5	2		1	6
Permitted Phases	4			8								
Actuated Green, G (s)		13.3			13.3			4.5	69.8		6.8	72.1
Effective Green, g (s)		13.3			13.3			4.5	69.8		6.8	72.1
Actuated g/C Ratio		0.13			0.13			0.04	0.66		0.06	0.69
Clearance Time (s)		4.9			4.9			4.9	5.3		4.9	5.3
Vehicle Extension (s)		1.5			1.5			1.0	4.0		1.0	4.5
Lane Grp Cap (vph)		160			179			76	2286		114	2379
v/s Ratio Prot								0.03	0.36		c0.04	c0.37
v/s Ratio Perm		0.04			c0.09							
v/c Ratio		0.32			0.73			0.59	0.55		0.62	0.54
Uniform Delay, d1		41.7			44.1			49.3	9.3		47.9	8.2
Progression Factor		1.00			1.00			1.00	1.00		1.00	1.00
Incremental Delay, d2		0.4			11.8			8.0	1.0		7.4	0.9
Delay (s)		42.2			55.9			57.3	10.2		55.2	9.1
Level of Service		D			E			E	B		E	A
Approach Delay (s)		42.2			55.9				11.9			11.5
Approach LOS		D			E				B			B

Intersection Summary			
HCM 2000 Control Delay	15.3	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	105.0	Sum of lost time (s)	15.1
Intersection Capacity Utilization	66.5%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	14
Future Volume (vph)	14
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.89
Adj. Flow (vph)	16
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	2
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	2%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR2	WBU	WBL2	WBL	WBT	WBR	NBL	NBT	NBR	SBU
Lane Configurations												
Traffic Volume (vph)	86	58	31	8	12	72	20	243	17	744	97	5
Future Volume (vph)	86	58	31	8	12	72	20	243	17	744	97	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.9				4.9	4.9	4.9	4.9	5.3	5.3	
Lane Util. Factor		0.95				1.00	1.00	1.00	1.00	0.95	1.00	
Frpb, ped/bikes		1.00				1.00	1.00	0.98	1.00	1.00	0.98	
Flpb, ped/bikes		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Frt		0.97				1.00	1.00	0.85	1.00	1.00	0.85	
Flt Protected		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (prot)		3363				1746	1863	1518	1770	3471	1529	
Flt Permitted		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (perm)		3363				1746	1863	1518	1770	3471	1529	
Peak-hour factor, PHF	0.83	0.83	0.83	0.71	0.71	0.71	0.71	0.71	0.76	0.76	0.76	0.86
Adj. Flow (vph)	104	70	37	11	17	101	28	342	22	979	128	6
RTOR Reduction (vph)	0	130	0	0	0	0	0	297	0	0	0	0
Lane Group Flow (vph)	0	81	0	0	0	129	28	45	22	979	128	0
Confl. Peds. (#/hr)	13					3		13	3		2	
Confl. Bikes (#/hr)											2	
Heavy Vehicles (%)	2%	2%	2%	0%	2%	4%	2%	4%	2%	4%	4%	0%
Turn Type	Split	NA		Split	Split	Split	NA	Perm	Prot	NA	Perm	Prot
Protected Phases	4	4		8	8	8	8		5	2		1
Permitted Phases								8			2	
Actuated Green, G (s)		8.0				11.9	11.9	11.9	2.4	38.2	38.2	
Effective Green, g (s)		8.0				11.9	11.9	11.9	2.4	38.2	38.2	
Actuated g/C Ratio		0.09				0.13	0.13	0.13	0.03	0.42	0.42	
Clearance Time (s)		4.9				4.9	4.9	4.9	4.9	5.3	5.3	
Vehicle Extension (s)		3.0				2.0	2.0	2.0	2.0	4.0	4.0	
Lane Grp Cap (vph)		296				229	244	199	46	1463	644	
v/s Ratio Prot		c0.02				c0.07	0.02		0.01	c0.28		
v/s Ratio Perm								0.03			0.08	
v/c Ratio		0.27				0.56	0.11	0.23	0.48	0.67	0.20	
Uniform Delay, d1		38.6				36.9	34.7	35.2	43.5	21.1	16.5	
Progression Factor		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2		0.5				1.9	0.1	0.2	2.8	1.3	0.2	
Delay (s)		39.1				38.8	34.8	35.4	46.3	22.4	16.7	
Level of Service		D				D	C	D	D	C	B	
Approach Delay (s)		39.1					36.3			22.2		
Approach LOS		D					D			C		

Intersection Summary			
HCM 2000 Control Delay	25.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	90.6	Sum of lost time (s)	20.0
Intersection Capacity Utilization	71.8%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBL2	SBL	SBT	SBR	NWR2
Lane Configurations					
Traffic Volume (vph)	235	16	813	24	45
Future Volume (vph)	235	16	813	24	45
Ideal Flow (vphpl)	1900	1900	1900	1900	1900
Total Lost time (s)	4.9	4.9	5.3		4.9
Lane Util. Factor	0.91	0.95	0.95		1.00
Frpb, ped/bikes	1.00	1.00	1.00		0.99
Flpb, ped/bikes	1.00	1.00	1.00		1.00
Frt	1.00	1.00	1.00		0.86
Flt Protected	0.95	0.95	1.00		1.00
Satd. Flow (prot)	1582	1653	3456		1589
Flt Permitted	0.95	0.95	1.00		1.00
Satd. Flow (perm)	1582	1653	3456		1589
Peak-hour factor, PHF	0.86	0.86	0.86	0.86	0.75
Adj. Flow (vph)	273	19	945	28	60
RTOR Reduction (vph)	0	0	1	0	52
Lane Group Flow (vph)	148	150	972	0	8
Confl. Peds. (#/hr)	2	2		3	
Confl. Bikes (#/hr)					1
Heavy Vehicles (%)	4%	2%	4%	2%	2%
Turn Type	Prot	Prot	NA		Perm
Protected Phases	1	1	6		
Permitted Phases					8
Actuated Green, G (s)	12.5	12.5	48.3		11.9
Effective Green, g (s)	12.5	12.5	48.3		11.9
Actuated g/C Ratio	0.14	0.14	0.53		0.13
Clearance Time (s)	4.9	4.9	5.3		4.9
Vehicle Extension (s)	1.0	1.0	4.0		2.0
Lane Grp Cap (vph)	218	228	1842		208
v/s Ratio Prot	c0.09	0.09	0.28		
v/s Ratio Perm					0.00
v/c Ratio	0.68	0.66	0.53		0.04
Uniform Delay, d1	37.1	37.0	13.7		34.4
Progression Factor	1.00	1.00	1.00		1.00
Incremental Delay, d2	6.5	5.1	0.4		0.0
Delay (s)	43.6	42.2	14.1		34.4
Level of Service	D	D	B		C
Approach Delay (s)			20.8		
Approach LOS			C		

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBU	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	22	24	16	178	12	5	9	595	143	2	6	936
Future Volume (vph)	22	24	16	178	12	5	9	595	143	2	6	936
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.9		4.9	4.9	4.9	4.9	5.7	5.7		4.9	5.7
Lane Util. Factor		1.00		0.95	0.95	1.00	1.00	0.95	1.00		1.00	0.95
Frpb, ped/bikes		1.00		1.00	1.00	0.98	1.00	1.00	0.98		1.00	1.00
Flpb, ped/bikes		1.00		1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
Frt		0.96		1.00	1.00	0.85	1.00	1.00	0.85		1.00	1.00
Flt Protected		0.98		0.95	0.96	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (prot)		1764		1681	1696	1555	1766	3471	1550		1770	3469
Flt Permitted		0.85		0.83	0.77	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (perm)		1527		1469	1367	1555	1766	3471	1550		1770	3469
Peak-hour factor, PHF	0.78	0.78	0.78	0.68	0.68	0.68	0.74	0.74	0.74	0.79	0.79	0.79
Adj. Flow (vph)	28	31	21	262	18	7	12	804	193	3	8	1185
RTOR Reduction (vph)	0	12	0	0	0	6	0	0	62	0	0	0
Lane Group Flow (vph)	0	68	0	139	141	1	12	804	131	0	11	1189
Confl. Peds. (#/hr)	4					4	7					
Confl. Bikes (#/hr)						1			2			
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	4%	2%	2%	2%	4%
Turn Type	Perm	NA		Perm	NA	Perm	Prot	NA	Perm	Prot	Prot	NA
Protected Phases		4			8		5	2		1	1	6
Permitted Phases	4			8		8			2			
Actuated Green, G (s)		11.6		11.6	11.6	11.6	0.8	36.1	36.1		0.8	36.1
Effective Green, g (s)		11.6		11.6	11.6	11.6	0.8	36.1	36.1		0.8	36.1
Actuated g/C Ratio		0.18		0.18	0.18	0.18	0.01	0.56	0.56		0.01	0.56
Clearance Time (s)		4.9		4.9	4.9	4.9	4.9	5.7	5.7		4.9	5.7
Vehicle Extension (s)		2.0		2.0	2.0	2.0	1.0	4.0	4.0		1.0	4.0
Lane Grp Cap (vph)		276		266	247	281	22	1957	874		22	1956
v/s Ratio Prot							c0.01	0.23			0.01	c0.34
v/s Ratio Perm		0.04		0.09	c0.10	0.00			0.08			
v/c Ratio		0.25		0.52	0.57	0.00	0.55	0.41	0.15		0.50	0.61
Uniform Delay, d1		22.4		23.7	23.9	21.5	31.4	7.9	6.6		31.4	9.3
Progression Factor		1.00		1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
Incremental Delay, d2		0.2		0.9	2.0	0.0	14.0	0.2	0.1		6.4	0.6
Delay (s)		22.6		24.6	25.9	21.5	45.4	8.1	6.7		37.8	9.9
Level of Service		C		C	C	C	D	A	A		D	A
Approach Delay (s)		22.6			25.1			8.3				10.1
Approach LOS		C			C			A				B

Intersection Summary			
HCM 2000 Control Delay	11.5	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	64.0	Sum of lost time (s)	15.5
Intersection Capacity Utilization	47.0%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	3
Future Volume (vph)	3
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.79
Adj. Flow (vph)	4
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	7
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	2%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBT	WBR	WBR2	NBL2	NBT	NBR	SBU	SBL	SBR
Lane Configurations												
Traffic Volume (vph)	724	765	223	751	208	267	170	635	131	48	179	575
Future Volume (vph)	724	765	223	751	208	267	170	635	131	48	179	575
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	2.6	4.0	4.0	4.0	4.0	4.0			4.0	4.0
Lane Util. Factor	0.97	0.95	1.00	0.95	1.00	1.00	1.00	0.95			1.00	0.88
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.98	1.00	1.00			1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.85	0.85	1.00	0.97			1.00	0.85
Flt Protected	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (prot)	3127	3223	1442	3223	1442	1408	1612	3132			1649	2538
Flt Permitted	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (perm)	3127	3223	1442	3223	1442	1408	1612	3132			1649	2538
Peak-hour factor, PHF	0.88	0.88	0.88	0.95	0.95	0.95	0.89	0.89	0.89	0.94	0.94	0.94
Adj. Flow (vph)	823	869	253	791	219	281	191	713	147	51	190	612
RTOR Reduction (vph)	0	0	0	0	0	112	0	14	0	0	0	40
Lane Group Flow (vph)	823	869	253	791	219	169	191	846	0	0	241	603
Confl. Peds. (#/hr)	9					9			4		4	
Heavy Vehicles (%)	12%	12%	12%	12%	12%	12%	12%	12%	12%	0%	12%	12%
Turn Type	Prot	NA	Free	NA	Prot	Perm	Split	NA		Prot	Prot	pt+ov
Protected Phases	5	2		6	6		8	8		7	7	7 5
Permitted Phases			Free			6						
Actuated Green, G (s)	26.0	62.1	130.0	32.4	32.4	32.4	35.6	35.6			17.4	47.8
Effective Green, g (s)	25.7	63.5	130.0	33.8	33.8	33.8	36.7	36.7			17.8	48.2
Actuated g/C Ratio	0.20	0.49	1.00	0.26	0.26	0.26	0.28	0.28			0.14	0.37
Clearance Time (s)	3.7	5.4		5.4	5.4	5.4	5.1	5.1			4.4	
Vehicle Extension (s)	2.0	4.0		4.0	4.0	4.0	2.0	2.0			2.0	
Lane Grp Cap (vph)	618	1574	1442	837	374	366	455	884			225	941
v/s Ratio Prot	c0.26	0.27		c0.25	0.15		0.12	c0.27			c0.15	0.24
v/s Ratio Perm			0.18			0.12						
v/c Ratio	1.33	0.55	0.18	0.95	0.59	0.46	0.42	0.96			1.07	0.64
Uniform Delay, d1	52.1	23.3	0.0	47.2	42.0	40.5	38.0	45.9			56.1	33.8
Progression Factor	0.72	1.05	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Incremental Delay, d2	156.5	0.9	0.2	20.3	6.6	4.2	0.2	20.3			80.1	1.1
Delay (s)	194.2	25.4	0.2	67.5	48.6	44.6	38.2	66.1			136.2	34.9
Level of Service	F	C	A	E	D	D	D	E			F	C
Approach Delay (s)		93.5		59.3				61.1				
Approach LOS		F		E				E				

Intersection Summary			
HCM 2000 Control Delay	73.1	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.05		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	93.6%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

Movement	SBR2
Lane Configurations	
Traffic Volume (vph)	29
Future Volume (vph)	29
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.94
Adj. Flow (vph)	31
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	
Heavy Vehicles (%)	12%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBU	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	410	503	289	300	94	340	255	866	146	4	479	747
Future Volume (vph)	410	503	289	300	94	340	255	866	146	4	479	747
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		4.0	4.0
Lane Util. Factor	0.91	0.91	1.00	0.95	0.95	1.00	0.97	0.95	1.00		0.97	0.95
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00		1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85		1.00	1.00
Flt Protected	0.95	0.99	1.00	0.95	0.97	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (prot)	1579	3294	1583	1681	1708	1423	3433	3539	1583		3129	3539
Flt Permitted	0.95	0.99	1.00	0.95	0.97	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (perm)	1579	3294	1583	1681	1708	1423	3433	3539	1583		3129	3539
Peak-hour factor, PHF	0.96	0.96	0.96	0.95	0.95	0.95	0.92	0.92	0.92	0.91	0.91	0.91
Adj. Flow (vph)	427	524	301	316	99	358	277	941	159	4	526	821
RTOR Reduction (vph)	0	0	194	0	0	226	0	0	95	0	0	0
Lane Group Flow (vph)	307	644	107	205	210	132	277	941	64	0	530	821
Confl. Peds. (#/hr)							10					
Confl. Bikes (#/hr)						1						
Heavy Vehicles (%)	4%	4%	2%	2%	4%	12%	2%	2%	2%	0%	12%	2%
Turn Type	Split	NA	Perm	Split	NA	Perm	Prot	NA	Perm	Prot	Prot	NA
Protected Phases	7	7		8	8		5	2		1	1	6
Permitted Phases			7			8			2			
Actuated Green, G (s)	29.1	29.1	29.1	19.3	19.3	19.3	14.5	36.7	36.7		24.6	46.8
Effective Green, g (s)	30.4	30.4	30.4	20.2	20.2	20.2	15.2	38.1	38.1		25.3	48.2
Actuated g/C Ratio	0.23	0.23	0.23	0.16	0.16	0.16	0.12	0.29	0.29		0.19	0.37
Clearance Time (s)	5.3	5.3	5.3	4.9	4.9	4.9	4.7	5.4	5.4		4.7	5.4
Vehicle Extension (s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0		2.0	3.0
Lane Grp Cap (vph)	369	770	370	261	265	221	401	1037	463		608	1312
v/s Ratio Prot	0.19	c0.20		0.12	c0.12		0.08	c0.27			c0.17	0.23
v/s Ratio Perm			0.07			0.09			0.04			
v/c Ratio	0.83	0.84	0.29	0.79	0.79	0.60	0.69	0.91	0.14		0.87	0.63
Uniform Delay, d1	47.4	47.4	40.9	52.8	52.9	51.1	55.1	44.3	33.9		50.8	33.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		0.96	0.83
Incremental Delay, d2	14.1	7.5	0.2	13.3	14.0	2.9	4.1	13.0	0.6		9.1	1.6
Delay (s)	61.5	55.0	41.1	66.1	66.9	54.0	59.3	57.2	34.5		57.8	29.3
Level of Service	E	D	D	E	E	D	E	E	C		E	C
Approach Delay (s)		53.2			60.7			55.0				40.8
Approach LOS		D			E			E				D

Intersection Summary			
HCM 2000 Control Delay	50.7	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.86		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	16.7
Intersection Capacity Utilization	89.3%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	342
Future Volume (vph)	342
Ideal Flow (vphpl)	1900
Total Lost time (s)	4.0
Lane Util. Factor	1.00
Frpb, ped/bikes	0.97
Flpb, ped/bikes	1.00
Frt	0.85
Flt Protected	1.00
Satd. Flow (prot)	1511
Flt Permitted	1.00
Satd. Flow (perm)	1511
Peak-hour factor, PHF	0.91
Adj. Flow (vph)	376
RTOR Reduction (vph)	237
Lane Group Flow (vph)	139
Confl. Peds. (#/hr)	10
Confl. Bikes (#/hr)	7
Heavy Vehicles (%)	4%
Turn Type	Perm
Protected Phases	
Permitted Phases	6
Actuated Green, G (s)	46.8
Effective Green, g (s)	48.2
Actuated g/C Ratio	0.37
Clearance Time (s)	5.4
Vehicle Extension (s)	3.0
Lane Grp Cap (vph)	560
v/s Ratio Prot	
v/s Ratio Perm	0.09
v/c Ratio	0.25
Uniform Delay, d1	28.4
Progression Factor	1.46
Incremental Delay, d2	0.7
Delay (s)	42.1
Level of Service	D
Approach Delay (s)	
Approach LOS	

Intersection Summary

HCM Signalized Intersection Capacity Analysis
3: Union City Blvd & Whipple Rd

Existing PM

Movement	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL
Lane Configurations												
Traffic Volume (vph)	87	119	70	2	158	34	347	2	17	1342	161	417
Future Volume (vph)	87	119	70	2	158	34	347	2	17	1342	161	417
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			3.3	4.0	4.0		4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	0.95			0.97	1.00	1.00		1.00	0.95	1.00	0.97
Frpb, ped/bikes	1.00	0.99			1.00	1.00	0.98		1.00	1.00	0.99	1.00
Flpb, ped/bikes	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Frt	1.00	0.94			1.00	1.00	0.85		1.00	1.00	0.85	1.00
Flt Protected	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (prot)	1770	3322			3368	1863	1527		1773	3471	1532	3367
Flt Permitted	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (perm)	1770	3322			3368	1863	1527		1773	3471	1532	3367
Peak-hour factor, PHF	0.71	0.71	0.71	0.90	0.90	0.90	0.90	0.89	0.89	0.89	0.89	0.88
Adj. Flow (vph)	123	168	99	2	176	38	386	2	19	1508	181	474
RTOR Reduction (vph)	0	75	0	0	0	0	254	0	0	0	55	0
Lane Group Flow (vph)	123	192	0	0	178	38	132	0	21	1508	126	474
Confl. Peds. (#/hr)	4		4		4		4		3		1	1
Confl. Bikes (#/hr)												
Heavy Vehicles (%)	2%	2%	2%	0%	4%	2%	4%	0%	2%	4%	4%	4%
Turn Type	Prot	NA		Prot	Prot	NA	Perm	Prot	Prot	NA	Perm	Prot
Protected Phases	7	4		3	3	8		5	5	2		1
Permitted Phases							8				2	
Actuated Green, G (s)	14.0	18.0			12.4	16.4	16.4		6.0	55.6	55.6	28.2
Effective Green, g (s)	14.6	19.3			13.7	17.7	17.7		6.6	56.9	56.9	28.8
Actuated g/C Ratio	0.11	0.14			0.10	0.13	0.13		0.05	0.42	0.42	0.21
Clearance Time (s)	4.6	5.3			4.6	5.3	5.3		4.6	5.3	5.3	4.6
Vehicle Extension (s)	3.0	2.0			3.0	2.0	2.0		2.0	4.0	4.0	2.0
Lane Grp Cap (vph)	192	478			344	246	201		87	1473	650	723
v/s Ratio Prot	c0.07	0.06			0.05	0.02			0.01	c0.43		c0.14
v/s Ratio Perm							c0.09				0.08	
v/c Ratio	0.64	0.40			0.52	0.15	0.66		0.24	1.02	0.19	0.66
Uniform Delay, d1	57.2	52.1			57.0	51.5	55.3		61.3	38.5	24.2	48.1
Progression Factor	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2	7.1	0.2			1.3	0.1	5.7		0.5	29.7	0.7	1.6
Delay (s)	64.3	52.3			58.3	51.6	61.0		61.8	68.2	24.8	49.7
Level of Service	E	D			E	D	E		E	E	C	D
Approach Delay (s)		56.1				59.6				63.5		
Approach LOS		E				E				E		

Intersection Summary			
HCM 2000 Control Delay	48.1	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.83		
Actuated Cycle Length (s)	134.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	80.1%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR
Lane Configurations		
Traffic Volume (vph)	1130	10
Future Volume (vph)	1130	10
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	4.0	
Lane Util. Factor	0.95	
Frpb, ped/bikes	1.00	
Flpb, ped/bikes	1.00	
Frt	1.00	
Flt Protected	1.00	
Satd. Flow (prot)	3466	
Flt Permitted	1.00	
Satd. Flow (perm)	3466	
Peak-hour factor, PHF	0.88	0.88
Adj. Flow (vph)	1284	11
RTOR Reduction (vph)	0	0
Lane Group Flow (vph)	1295	0
Confl. Peds. (#/hr)		3
Confl. Bikes (#/hr)		4
Heavy Vehicles (%)	4%	2%
Turn Type	NA	
Protected Phases	6	
Permitted Phases		
Actuated Green, G (s)	77.8	
Effective Green, g (s)	79.1	
Actuated g/C Ratio	0.59	
Clearance Time (s)	5.3	
Vehicle Extension (s)	4.0	
Lane Grp Cap (vph)	2045	
v/s Ratio Prot	0.37	
v/s Ratio Perm		
v/c Ratio	0.63	
Uniform Delay, d1	18.0	
Progression Factor	1.00	
Incremental Delay, d2	1.5	
Delay (s)	19.5	
Level of Service	B	
Approach Delay (s)	27.6	
Approach LOS	C	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL
Lane Configurations												
Traffic Volume (vph)	20	15	31	21	14	22	12	44	1230	26	7	44
Future Volume (vph)	20	15	31	21	14	22	12	44	1230	26	7	44
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0			4.0	4.0			4.0
Lane Util. Factor		1.00			1.00			1.00	0.95			1.00
Frpb, ped/bikes		0.99			0.99			1.00	1.00			1.00
Flpb, ped/bikes		1.00			1.00			1.00	1.00			1.00
Frt		0.94			0.95			1.00	1.00			1.00
Flt Protected		0.98			0.98			0.95	1.00			0.95
Satd. Flow (prot)		1700			1713			1777	3456			1774
Flt Permitted		0.79			0.75			0.95	1.00			0.11
Satd. Flow (perm)		1369			1305			1777	3456			197
Peak-hour factor, PHF	0.75	0.75	0.75	0.65	0.65	0.65	0.93	0.93	0.93	0.93	0.96	0.96
Adj. Flow (vph)	27	20	41	32	22	34	13	47	1323	28	7	46
RTOR Reduction (vph)	0	32	0	0	23	0	0	0	2	0	0	0
Lane Group Flow (vph)	0	56	0	0	65	0	0	60	1349	0	0	53
Confl. Peds. (#/hr)	7		7	7		7		6		22		22
Confl. Bikes (#/hr)						2				1		
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	0%	2%	4%	2%	0%	2%
Turn Type	Perm	NA		Perm	NA		Prot	Prot	NA			Prot
Protected Phases		4			8		5	5	2			1
Permitted Phases	4			8								
Actuated Green, G (s)		8.0			8.0			6.6	54.8			37.1
Effective Green, g (s)		8.9			8.9			7.5	56.1			38.0
Actuated g/C Ratio		0.08			0.08			0.07	0.49			0.33
Clearance Time (s)		4.9			4.9			4.9	5.3			4.9
Vehicle Extension (s)		1.5			1.5			1.0	4.0			1.0
Lane Grp Cap (vph)		105			100			115	1685			65
v/s Ratio Prot								0.03	c0.39			
v/s Ratio Perm		0.04			c0.05							c0.27
v/c Ratio		0.53			0.65			0.52	0.80			0.82
Uniform Delay, d1		51.0			51.5			52.0	24.8			35.3
Progression Factor		1.00			1.00			1.00	1.00			1.00
Incremental Delay, d2		2.6			10.4			2.0	4.1			50.2
Delay (s)		53.6			61.9			54.0	28.9			85.5
Level of Service		D			E			D	C			F
Approach Delay (s)		53.6			61.9				29.9			
Approach LOS		D			E				C			

Intersection Summary			
HCM 2000 Control Delay	22.3	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	115.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	57.2%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR
Lane Configurations	↑↱	
Traffic Volume (vph)	1187	24
Future Volume (vph)	1187	24
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	4.0	
Lane Util. Factor	0.95	
Frpb, ped/bikes	1.00	
Flpb, ped/bikes	1.00	
Frt	1.00	
Flt Protected	1.00	
Satd. Flow (prot)	3460	
Flt Permitted	1.00	
Satd. Flow (perm)	3460	
Peak-hour factor, PHF	0.96	0.96
Adj. Flow (vph)	1236	25
RTOR Reduction (vph)	1	0
Lane Group Flow (vph)	1260	0
Confl. Peds. (#/hr)		6
Confl. Bikes (#/hr)		5
Heavy Vehicles (%)	4%	2%
Turn Type	NA	
Protected Phases	6	
Permitted Phases		
Actuated Green, G (s)	85.3	
Effective Green, g (s)	86.6	
Actuated g/C Ratio	0.75	
Clearance Time (s)	5.3	
Vehicle Extension (s)	4.5	
Lane Grp Cap (vph)	2605	
v/s Ratio Prot	0.36	
v/s Ratio Perm		
v/c Ratio	0.48	
Uniform Delay, d1	5.5	
Progression Factor	1.00	
Incremental Delay, d2	0.6	
Delay (s)	6.2	
Level of Service	A	
Approach Delay (s)	9.4	
Approach LOS	A	

Intersection Summary

Movement	EBL	EBT	EBR2	WBU	WBL2	WBL	WBT	WBR	NBL	NBT	NBR	SBU
Lane Configurations												
Traffic Volume (vph)	31	42	8	9	14	40	52	227	12	1006	88	17
Future Volume (vph)	31	42	8	9	14	40	52	227	12	1006	88	17
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0				4.0	4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor		0.95				1.00	1.00	1.00	1.00	0.95	1.00	
Frpb, ped/bikes		1.00				1.00	1.00	0.98	1.00	1.00	0.99	
Flpb, ped/bikes		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Frt		0.99				1.00	1.00	0.85	1.00	1.00	0.85	
Flt Protected		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (prot)		3418				1752	1863	1526	1770	3471	1532	
Flt Permitted		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (perm)		3418				1752	1863	1526	1770	3471	1532	
Peak-hour factor, PHF	0.70	0.70	0.70	0.95	0.95	0.95	0.95	0.95	0.92	0.92	0.92	0.88
Adj. Flow (vph)	44	60	11	9	15	42	55	239	13	1093	96	19
RTOR Reduction (vph)	0	106	0	0	0	0	0	214	0	0	0	0
Lane Group Flow (vph)	0	9	0	0	0	66	55	25	13	1093	96	0
Confl. Peds. (#/hr)	4		2			2		4			1	
Confl. Bikes (#/hr)								1			1	
Heavy Vehicles (%)	2%	2%	2%	0%	2%	4%	2%	4%	2%	4%	4%	0%
Turn Type	Split	NA		Split	Split	Split	NA	Perm	Prot	NA	Perm	Prot
Protected Phases	4	4		8	8	8	8		5	2		1
Permitted Phases								8			2	
Actuated Green, G (s)		6.2				8.4	8.4	8.4	1.1	40.6	40.6	
Effective Green, g (s)		7.1				9.3	9.3	9.3	2.0	41.9	41.9	
Actuated g/C Ratio		0.08				0.10	0.10	0.10	0.02	0.46	0.46	
Clearance Time (s)		4.9				4.9	4.9	4.9	4.9	5.3	5.3	
Vehicle Extension (s)		3.0				2.0	2.0	2.0	2.0	4.0	4.0	
Lane Grp Cap (vph)		268				180	191	156	39	1607	709	
v/s Ratio Prot		c0.00				c0.04	0.03		0.01	c0.31		
v/s Ratio Perm								0.02			0.06	
v/c Ratio		0.03				0.37	0.29	0.16	0.33	0.68	0.14	
Uniform Delay, d1		38.5				37.9	37.5	37.0	43.6	19.0	13.9	
Progression Factor		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2		0.1				0.5	0.3	0.2	1.8	1.3	0.1	
Delay (s)		38.6				38.3	37.8	37.2	45.4	20.4	14.0	
Level of Service		D				D	D	D	D	C	B	
Approach Delay (s)		38.6					37.5			20.1		
Approach LOS		D					D			C		

Intersection Summary			
HCM 2000 Control Delay	25.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	90.5	Sum of lost time (s)	16.0
Intersection Capacity Utilization	75.3%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBL2	SBL	SBT	SBR	NWR2
Lane Configurations					
Traffic Volume (vph)	383	20	732	68	31
Future Volume (vph)	383	20	732	68	31
Ideal Flow (vphpl)	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0
Lane Util. Factor	0.91	0.95	0.95		1.00
Frpb, ped/bikes	1.00	1.00	1.00		1.00
Flpb, ped/bikes	1.00	1.00	1.00		1.00
Frt	1.00	1.00	0.99		0.86
Flt Protected	0.95	0.95	1.00		1.00
Satd. Flow (prot)	1584	1652	3426		1611
Flt Permitted	0.95	0.95	1.00		1.00
Satd. Flow (perm)	1584	1652	3426		1611
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.60
Adj. Flow (vph)	435	23	832	77	52
RTOR Reduction (vph)	0	0	3	0	47
Lane Group Flow (vph)	254	223	906	0	5
Confl. Peds. (#/hr)	1	1			
Confl. Bikes (#/hr)				5	
Heavy Vehicles (%)	4%	2%	4%	2%	2%
Turn Type	Prot	Prot	NA		Perm
Protected Phases	1	1	6		
Permitted Phases					8
Actuated Green, G (s)	15.3	15.3	54.8		8.4
Effective Green, g (s)	16.2	16.2	56.1		9.3
Actuated g/C Ratio	0.18	0.18	0.62		0.10
Clearance Time (s)	4.9	4.9	5.3		4.9
Vehicle Extension (s)	1.0	1.0	4.0		2.0
Lane Grp Cap (vph)	283	295	2123		165
v/s Ratio Prot	c0.16	0.13	0.26		
v/s Ratio Perm					0.00
v/c Ratio	0.90	0.76	0.43		0.03
Uniform Delay, d1	36.3	35.3	8.9		36.5
Progression Factor	1.00	1.00	1.00		1.00
Incremental Delay, d2	27.9	9.4	0.2		0.0
Delay (s)	64.2	44.7	9.1		36.6
Level of Service	E	D	A		D
Approach Delay (s)			24.9		
Approach LOS			C		

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	6	22	6	124	20	2	1	16	1066	390	13	619
Future Volume (vph)	6	22	6	124	20	2	1	16	1066	390	13	619
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0	4.0		4.0	4.0	4.0	3.2	4.0
Lane Util. Factor		1.00		0.95	0.95	1.00		1.00	0.95	1.00	1.00	0.95
Frpb, ped/bikes		1.00		1.00	1.00	0.98		1.00	1.00	0.98	1.00	1.00
Flpb, ped/bikes		1.00		1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00
Frt		0.98		1.00	1.00	0.85		1.00	1.00	0.85	1.00	1.00
Flt Protected		0.99		0.95	0.96	1.00		0.95	1.00	1.00	0.95	1.00
Satd. Flow (prot)		1794		1681	1706	1557		1772	3471	1548	1770	3463
Flt Permitted		0.93		0.94	0.78	1.00		0.95	1.00	1.00	0.95	1.00
Satd. Flow (perm)		1680		1665	1378	1557		1772	3471	1548	1770	3463
Peak-hour factor, PHF	0.57	0.57	0.57	0.91	0.91	0.91	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	11	39	11	136	22	2	1	17	1146	419	14	666
RTOR Reduction (vph)	0	8	0	0	0	2	0	0	0	83	0	0
Lane Group Flow (vph)	0	53	0	72	86	0	0	18	1146	336	14	676
Confl. Peds. (#/hr)	5					5		4		2	2	
Confl. Bikes (#/hr)			3									
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	0%	2%	4%	2%	2%	4%
Turn Type	Perm	NA		Perm	NA	Perm	Prot	Prot	NA	Perm	Prot	NA
Protected Phases		4			8		5	5	2		1	6
Permitted Phases	4			8		8				2		
Actuated Green, G (s)		6.9		6.9	6.9	6.9		0.8	33.8	33.8	0.7	33.7
Effective Green, g (s)		7.8		7.8	7.8	7.8		1.7	35.5	35.5	2.4	35.4
Actuated g/C Ratio		0.14		0.14	0.14	0.14		0.03	0.62	0.62	0.04	0.62
Clearance Time (s)		4.9		4.9	4.9	4.9		4.9	5.7	5.7	4.9	5.7
Vehicle Extension (s)		2.0		2.0	2.0	2.0		1.0	4.0	4.0	1.0	4.0
Lane Grp Cap (vph)		230		228	188	213		52	2165	965	74	2154
v/s Ratio Prot								c0.01	c0.33		0.01	0.20
v/s Ratio Perm		0.03		0.04	c0.06	0.00				0.22		
v/c Ratio		0.23		0.32	0.46	0.00		0.35	0.53	0.35	0.19	0.31
Uniform Delay, d1		21.9		22.1	22.6	21.2		27.1	6.0	5.1	26.3	5.0
Progression Factor		1.00		1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2		0.2		0.3	0.6	0.0		1.5	0.3	0.3	0.5	0.1
Delay (s)		22.1		22.4	23.2	21.2		28.5	6.3	5.4	26.8	5.2
Level of Service		C		C	C	C		C	A	A	C	A
Approach Delay (s)		22.1			22.9				6.3			5.6
Approach LOS		C			C				A			A

Intersection Summary			
HCM 2000 Control Delay	7.6	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.52		
Actuated Cycle Length (s)	56.9	Sum of lost time (s)	12.9
Intersection Capacity Utilization	47.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	9
Future Volume (vph)	9
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.93
Adj. Flow (vph)	10
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	4
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	2%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	
Intersection Summary	

HCM Signalized Intersection Capacity Analysis
1: I-880 NB Off-Ramp/Industrial Pkwy & Whipple Rd

Project Alternative B&C AM

Movement	EBL	EBT	EBR	WBT	WBR	WBR2	NBL2	NBT	NBR	SBU	SBL	SBR
Lane Configurations												
Traffic Volume (vph)	322	751	189	616	255	143	497	421	357	25	209	618
Future Volume (vph)	322	751	189	616	255	143	497	421	357	25	209	618
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.7	5.4	4.0	5.4	5.4	5.4	5.1	5.1			4.4	4.4
Lane Util. Factor	0.97	0.95	1.00	0.95	1.00	1.00	1.00	0.95			1.00	0.88
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.98	1.00	0.99			1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.85	0.85	1.00	0.93			1.00	0.85
Flt Protected	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (prot)	3127	3223	1417	3223	1442	1414	1597	2982			1630	2538
Flt Permitted	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (perm)	3127	3223	1417	3223	1442	1414	1597	2982			1630	2538
Peak-hour factor, PHF	0.89	0.89	0.89	0.91	0.91	0.91	0.92	0.92	0.92	0.87	0.87	0.87
Adj. Flow (vph)	362	844	212	677	280	157	540	458	388	29	240	710
RTOR Reduction (vph)	0	0	0	0	0	117	0	64	0	0	0	47
Lane Group Flow (vph)	362	844	212	677	280	40	540	782	0	0	269	704
Confl. Peds. (#/hr)	6					6			2		2	
Heavy Vehicles (%)	12%	12%	14%	12%	12%	12%	13%	12%	12%	0%	12%	12%
Turn Type	Prot	NA	Free	NA	Prot	Perm	Split	NA		Prot	Prot	pt+ov
Protected Phases	5	2		6	6		8	8		7	7	7 5
Permitted Phases			Free			6						
Actuated Green, G (s)	15.0	49.5	120.0	30.8	30.8	30.8	37.6	37.6			18.0	37.4
Effective Green, g (s)	15.0	49.5	120.0	30.8	30.8	30.8	37.6	37.6			18.0	37.4
Actuated g/C Ratio	0.12	0.41	1.00	0.26	0.26	0.26	0.31	0.31			0.15	0.31
Clearance Time (s)	3.7	5.4		5.4	5.4	5.4	5.1	5.1			4.4	
Vehicle Extension (s)	2.0	4.0		4.0	4.0	4.0	2.0	2.0			2.0	
Lane Grp Cap (vph)	390	1329	1417	827	370	362	500	934			244	791
v/s Ratio Prot	0.12	0.26		c0.21	0.19		c0.34	0.26			c0.16	c0.28
v/s Ratio Perm			0.15			0.03						
v/c Ratio	0.93	0.64	0.15	0.82	0.76	0.11	1.08	0.84			1.10	0.89
Uniform Delay, d1	52.0	28.1	0.0	42.0	41.1	34.1	41.2	38.4			51.0	39.3
Progression Factor	0.74	1.14	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Incremental Delay, d2	23.1	1.8	0.2	8.9	13.5	0.6	63.5	6.3			87.8	11.9
Delay (s)	61.7	33.8	0.2	50.8	54.6	34.7	104.7	44.7			138.8	51.3
Level of Service	E	C	A	D	D	C	F	D			F	D
Approach Delay (s)		35.9		49.5				68.1				
Approach LOS		D		D				E				

Intersection Summary			
HCM 2000 Control Delay	55.9	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.00		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	18.6
Intersection Capacity Utilization	87.0%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	SBR2
Lane Configurations	
Traffic Volume (vph)	36
Future Volume (vph)	36
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.87
Adj. Flow (vph)	41
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	
Heavy Vehicles (%)	12%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	270	178	139	171	174	321	307	588	45	323	615	829
Future Volume (vph)	270	178	139	171	174	321	307	588	45	323	615	829
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.3	5.3	5.3	4.9	4.9	4.9	4.7	5.4	5.4	4.7	5.4	5.4
Lane Util. Factor	0.91	0.91	1.00	0.95	0.95	1.00	0.97	0.95	1.00	0.97	0.95	1.00
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.98	1.00	1.00	1.00	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	0.98	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1564	3209	1583	1681	1701	1411	3433	3539	1583	3127	3539	1533
Flt Permitted	0.95	0.98	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1564	3209	1583	1681	1701	1411	3433	3539	1583	3127	3539	1533
Peak-hour factor, PHF	0.83	0.83	0.83	0.88	0.88	0.88	0.78	0.78	0.78	0.80	0.80	0.80
Adj. Flow (vph)	325	214	167	194	198	365	394	754	58	404	769	1036
RTOR Reduction (vph)	0	0	142	0	0	255	0	0	36	0	0	286
Lane Group Flow (vph)	175	364	25	175	217	110	394	754	22	404	769	750
Confl. Peds. (#/hr)	5					5						
Confl. Bikes (#/hr)												1
Heavy Vehicles (%)	5%	6%	2%	2%	6%	12%	2%	2%	2%	12%	2%	4%
Turn Type	Split	NA	Perm	Split	NA	Perm	Prot	NA	Perm	Prot	NA	Perm
Protected Phases	7	7		8	8		5	2		1	6	
Permitted Phases			7			8			2			6
Actuated Green, G (s)	17.7	17.7	17.7	18.2	18.2	18.2	16.8	45.3	45.3	18.5	47.0	47.0
Effective Green, g (s)	17.7	17.7	17.7	18.2	18.2	18.2	16.8	45.3	45.3	18.5	47.0	47.0
Actuated g/C Ratio	0.15	0.15	0.15	0.15	0.15	0.15	0.14	0.38	0.38	0.15	0.39	0.39
Clearance Time (s)	5.3	5.3	5.3	4.9	4.9	4.9	4.7	5.4	5.4	4.7	5.4	5.4
Vehicle Extension (s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0	2.0	3.0	3.0
Lane Grp Cap (vph)	230	473	233	254	257	214	480	1335	597	482	1386	600
v/s Ratio Prot	0.11	c0.11		0.10	c0.13		0.11	0.21		c0.13	0.22	
v/s Ratio Perm			0.02			0.08			0.01			c0.49
v/c Ratio	0.76	0.77	0.11	0.69	0.84	0.51	0.82	0.56	0.04	0.84	0.55	1.25
Uniform Delay, d1	49.1	49.2	44.3	48.2	49.5	46.8	50.1	29.6	23.6	49.3	28.4	36.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	0.98	0.99
Incremental Delay, d2	12.5	6.7	0.1	6.1	20.8	0.9	10.3	1.7	0.1	7.1	0.9	120.7
Delay (s)	61.6	55.9	44.4	54.3	70.4	47.7	60.4	31.3	23.7	56.7	28.6	157.0
Level of Service	E	E	D	D	E	D	E	C	C	E	C	F
Approach Delay (s)		54.6			55.7			40.4			94.0	
Approach LOS		D			E			D			F	

Intersection Summary			
HCM 2000 Control Delay	69.1	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.03		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	20.3
Intersection Capacity Utilization	82.3%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
3: Union City Blvd & Whipple Rd

Project Alternative B&C AM

Movement	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL
Lane Configurations												
Traffic Volume (vph)	14	24	13	1	162	149	301	1	82	923	216	416
Future Volume (vph)	14	24	13	1	162	149	301	1	82	923	216	416
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.6	5.3			4.6	5.3	5.3		4.6	5.3	5.3	4.6
Lane Util. Factor	1.00	0.95			0.97	1.00	1.00		1.00	0.95	1.00	0.97
Frpb, ped/bikes	1.00	1.00			1.00	1.00	0.99		1.00	1.00	0.99	1.00
Flpb, ped/bikes	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Frt	1.00	0.95			1.00	1.00	0.85		1.00	1.00	0.85	1.00
Flt Protected	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (prot)	1770	3353			3274	1863	1533		1770	3471	1501	3367
Flt Permitted	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (perm)	1770	3353			3274	1863	1533		1770	3471	1501	3367
Peak-hour factor, PHF	0.91	0.91	0.91	0.93	0.93	0.93	0.93	0.86	0.86	0.86	0.86	0.94
Adj. Flow (vph)	15	26	14	1	174	160	324	1	95	1073	251	443
RTOR Reduction (vph)	0	13	0	0	0	0	270	0	0	0	80	0
Lane Group Flow (vph)	15	27	0	0	175	160	54	0	96	1073	171	443
Confl. Peds. (#/hr)	1						1		1		2	2
Confl. Bikes (#/hr)											1	
Heavy Vehicles (%)	2%	2%	2%	0%	7%	2%	4%	0%	2%	4%	6%	4%
Turn Type	Prot	NA		Prot	Prot	NA	Perm	Prot	Prot	NA	Perm	Prot
Protected Phases	7	4		3	3	8		5	5	2		1
Permitted Phases							8				2	
Actuated Green, G (s)	2.7	10.4			11.9	19.6	19.6		12.4	54.0	54.0	20.7
Effective Green, g (s)	2.7	10.4			11.9	19.6	19.6		12.4	54.0	54.0	20.7
Actuated g/C Ratio	0.02	0.09			0.10	0.17	0.17		0.11	0.46	0.46	0.18
Clearance Time (s)	4.6	5.3			4.6	5.3	5.3		4.6	5.3	5.3	4.6
Vehicle Extension (s)	2.0	2.0			2.0	2.0	2.0		2.0	4.0	4.0	2.0
Lane Grp Cap (vph)	40	298			333	312	257		187	1604	693	596
v/s Ratio Prot	0.01	0.01			c0.05	c0.09			0.05	0.31		c0.13
v/s Ratio Perm							0.04				0.11	
v/c Ratio	0.38	0.09			0.53	0.51	0.21		0.51	0.67	0.25	0.74
Uniform Delay, d1	56.2	48.9			49.8	44.3	41.9		49.3	24.4	19.1	45.5
Progression Factor	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2	2.1	0.0			0.7	0.6	0.2		1.0	1.2	0.3	4.4
Delay (s)	58.4	48.9			50.5	44.8	42.1		50.3	25.6	19.3	49.9
Level of Service	E	D			D	D	D		D	C	B	D
Approach Delay (s)		51.5				45.0				26.2		
Approach LOS		D				D				C		

Intersection Summary			
HCM 2000 Control Delay	31.0	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	116.8	Sum of lost time (s)	19.8
Intersection Capacity Utilization	67.1%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR
Lane Configurations		
Traffic Volume (vph)	1187	43
Future Volume (vph)	1187	43
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	5.3	
Lane Util. Factor	0.95	
Frpb, ped/bikes	1.00	
Flpb, ped/bikes	1.00	
Frt	0.99	
Flt Protected	1.00	
Satd. Flow (prot)	3452	
Flt Permitted	1.00	
Satd. Flow (perm)	3452	
Peak-hour factor, PHF	0.94	0.94
Adj. Flow (vph)	1263	46
RTOR Reduction (vph)	1	0
Lane Group Flow (vph)	1308	0
Confl. Peds. (#/hr)		1
Confl. Bikes (#/hr)		1
Heavy Vehicles (%)	4%	2%
Turn Type	NA	
Protected Phases	6	
Permitted Phases		
Actuated Green, G (s)	62.3	
Effective Green, g (s)	62.3	
Actuated g/C Ratio	0.53	
Clearance Time (s)	5.3	
Vehicle Extension (s)	4.0	
Lane Grp Cap (vph)	1841	
v/s Ratio Prot	c0.38	
v/s Ratio Perm		
v/c Ratio	0.71	
Uniform Delay, d1	20.5	
Progression Factor	1.00	
Incremental Delay, d2	1.4	
Delay (s)	21.9	
Level of Service	C	
Approach Delay (s)	29.0	
Approach LOS	C	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	23	13	25	39	7	60	6	31	970	51	63	1143
Future Volume (vph)	23	13	25	39	7	60	6	31	970	51	63	1143
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.9			4.9			4.9	5.3		4.9	5.3
Lane Util. Factor		1.00			1.00			1.00	0.95		1.00	0.95
Frpb, ped/bikes		0.99			0.97			1.00	1.00		1.00	1.00
Flpb, ped/bikes		0.99			1.00			1.00	1.00		1.00	1.00
Frt		0.94			0.92			1.00	0.99		1.00	1.00
Flt Protected		0.98			0.98			0.95	1.00		0.95	1.00
Satd. Flow (prot)		1630			1641			1775	3440		1770	3456
Flt Permitted		0.71			0.84			0.95	1.00		0.95	1.00
Satd. Flow (perm)		1183			1411			1775	3440		1770	3456
Peak-hour factor, PHF	0.74	0.74	0.74	0.58	0.58	0.58	0.81	0.81	0.81	0.81	0.89	0.89
Adj. Flow (vph)	31	18	34	67	12	103	7	38	1198	63	71	1284
RTOR Reduction (vph)	0	27	0	0	52	0	0	0	2	0	0	1
Lane Group Flow (vph)	0	56	0	0	130	0	0	45	1259	0	71	1301
Confl. Peds. (#/hr)	29		11	11		29		2		11	11	
Confl. Bikes (#/hr)			2			1				3		
Heavy Vehicles (%)	13%	2%	2%	2%	2%	2%	0%	2%	4%	2%	2%	4%
Turn Type	Perm	NA		Perm	NA		Prot	Prot	NA		Prot	NA
Protected Phases		4			8		5	5	2		1	6
Permitted Phases	4			8								
Actuated Green, G (s)		13.2			13.2			4.5	69.9		6.8	72.2
Effective Green, g (s)		13.2			13.2			4.5	69.9		6.8	72.2
Actuated g/C Ratio		0.13			0.13			0.04	0.67		0.06	0.69
Clearance Time (s)		4.9			4.9			4.9	5.3		4.9	5.3
Vehicle Extension (s)		1.5			1.5			1.0	4.0		1.0	4.5
Lane Grp Cap (vph)		148			177			76	2290		114	2376
v/s Ratio Prot								0.03	0.37		c0.04	c0.38
v/s Ratio Perm		0.05			c0.09							
v/c Ratio		0.38			0.74			0.59	0.55		0.62	0.55
Uniform Delay, d1		42.1			44.2			49.3	9.3		47.9	8.2
Progression Factor		1.00			1.00			1.00	1.00		1.00	1.00
Incremental Delay, d2		0.6			12.8			8.0	1.0		7.4	0.9
Delay (s)		42.7			57.1			57.3	10.2		55.2	9.1
Level of Service		D			E			E	B		E	A
Approach Delay (s)		42.7			57.1				11.8			11.5
Approach LOS		D			E				B			B

Intersection Summary			
HCM 2000 Control Delay	15.4	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	105.0	Sum of lost time (s)	15.1
Intersection Capacity Utilization	66.6%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	16
Future Volume (vph)	16
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.89
Adj. Flow (vph)	18
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	2
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	19%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR2	WBU	WBL2	WBL	WBT	WBR	NBL	NBT	NBR	SBU
Lane Configurations												
Traffic Volume (vph)	86	58	31	8	12	72	20	243	17	747	97	5
Future Volume (vph)	86	58	31	8	12	72	20	243	17	747	97	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.9				4.9	4.9	4.9	4.9	5.3	5.3	
Lane Util. Factor		0.95				1.00	1.00	1.00	1.00	0.95	1.00	
Frpb, ped/bikes		1.00				1.00	1.00	0.98	1.00	1.00	0.98	
Flpb, ped/bikes		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Frt		0.97				1.00	1.00	0.85	1.00	1.00	0.85	
Flt Protected		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (prot)		3363				1746	1863	1518	1770	3471	1529	
Flt Permitted		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (perm)		3363				1746	1863	1518	1770	3471	1529	
Peak-hour factor, PHF	0.83	0.83	0.83	0.71	0.71	0.71	0.71	0.71	0.76	0.76	0.76	0.86
Adj. Flow (vph)	104	70	37	11	17	101	28	342	22	983	128	6
RTOR Reduction (vph)	0	130	0	0	0	0	0	297	0	0	0	0
Lane Group Flow (vph)	0	81	0	0	0	129	28	45	22	983	128	0
Confl. Peds. (#/hr)	13					3		13	3		2	
Confl. Bikes (#/hr)											2	
Heavy Vehicles (%)	2%	2%	2%	0%	2%	4%	2%	4%	2%	4%	4%	0%
Turn Type	Split	NA		Split	Split	Split	NA	Perm	Prot	NA	Perm	Prot
Protected Phases	4	4		8	8	8	8		5	2		1
Permitted Phases								8			2	
Actuated Green, G (s)		8.0				11.9	11.9	11.9	2.4	38.3	38.3	
Effective Green, g (s)		8.0				11.9	11.9	11.9	2.4	38.3	38.3	
Actuated g/C Ratio		0.09				0.13	0.13	0.13	0.03	0.42	0.42	
Clearance Time (s)		4.9				4.9	4.9	4.9	4.9	5.3	5.3	
Vehicle Extension (s)		3.0				2.0	2.0	2.0	2.0	4.0	4.0	
Lane Grp Cap (vph)		296				229	244	199	46	1465	645	
v/s Ratio Prot		c0.02				c0.07	0.02		0.01	c0.28		
v/s Ratio Perm								0.03			0.08	
v/c Ratio		0.27				0.56	0.11	0.23	0.48	0.67	0.20	
Uniform Delay, d1		38.6				37.0	34.8	35.3	43.5	21.1	16.5	
Progression Factor		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2		0.5				1.9	0.1	0.2	2.8	1.3	0.2	
Delay (s)		39.1				38.9	34.8	35.5	46.4	22.5	16.7	
Level of Service		D				D	C	D	D	C	B	
Approach Delay (s)		39.1					36.3			22.3		
Approach LOS		D					D			C		

Intersection Summary			
HCM 2000 Control Delay	25.3	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	90.7	Sum of lost time (s)	20.0
Intersection Capacity Utilization	71.9%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBL2	SBL	SBT	SBR	NWR2
Lane Configurations					
Traffic Volume (vph)	235	16	816	24	45
Future Volume (vph)	235	16	816	24	45
Ideal Flow (vphpl)	1900	1900	1900	1900	1900
Total Lost time (s)	4.9	4.9	5.3		4.9
Lane Util. Factor	0.91	0.95	0.95		1.00
Frpb, ped/bikes	1.00	1.00	1.00		0.99
Flpb, ped/bikes	1.00	1.00	1.00		1.00
Frt	1.00	1.00	1.00		0.86
Flt Protected	0.95	0.95	1.00		1.00
Satd. Flow (prot)	1582	1653	3456		1589
Flt Permitted	0.95	0.95	1.00		1.00
Satd. Flow (perm)	1582	1653	3456		1589
Peak-hour factor, PHF	0.86	0.86	0.86	0.86	0.75
Adj. Flow (vph)	273	19	949	28	60
RTOR Reduction (vph)	0	0	1	0	52
Lane Group Flow (vph)	148	150	976	0	8
Confl. Peds. (#/hr)	2	2		3	
Confl. Bikes (#/hr)					1
Heavy Vehicles (%)	4%	2%	4%	2%	2%
Turn Type	Prot	Prot	NA		Perm
Protected Phases	1	1	6		
Permitted Phases					8
Actuated Green, G (s)	12.5	12.5	48.4		11.9
Effective Green, g (s)	12.5	12.5	48.4		11.9
Actuated g/C Ratio	0.14	0.14	0.53		0.13
Clearance Time (s)	4.9	4.9	5.3		4.9
Vehicle Extension (s)	1.0	1.0	4.0		2.0
Lane Grp Cap (vph)	218	227	1844		208
v/s Ratio Prot	c0.09	0.09	0.28		
v/s Ratio Perm					0.00
v/c Ratio	0.68	0.66	0.53		0.04
Uniform Delay, d1	37.2	37.1	13.7		34.4
Progression Factor	1.00	1.00	1.00		1.00
Incremental Delay, d2	6.5	5.5	0.4		0.0
Delay (s)	43.6	42.6	14.1		34.4
Level of Service	D	D	B		C
Approach Delay (s)			20.9		
Approach LOS			C		

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBU	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	25	24	16	178	12	5	9	595	143	2	6	936
Future Volume (vph)	25	24	16	178	12	5	9	595	143	2	6	936
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.9		4.9	4.9	4.9	4.9	5.7	5.7		4.9	5.7
Lane Util. Factor		1.00		0.95	0.95	1.00	1.00	0.95	1.00		1.00	0.95
Frpb, ped/bikes		1.00		1.00	1.00	0.98	1.00	1.00	0.98		1.00	1.00
Flpb, ped/bikes		1.00		1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
Frt		0.97		1.00	1.00	0.85	1.00	1.00	0.85		1.00	1.00
Flt Protected		0.98		0.95	0.96	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (prot)		1676		1681	1696	1555	1766	3471	1550		1770	3453
Flt Permitted		0.83		0.81	0.78	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (perm)		1425		1439	1376	1555	1766	3471	1550		1770	3453
Peak-hour factor, PHF	0.78	0.78	0.78	0.68	0.68	0.68	0.74	0.74	0.74	0.79	0.79	0.79
Adj. Flow (vph)	32	31	21	262	18	7	12	804	193	3	8	1185
RTOR Reduction (vph)	0	11	0	0	0	6	0	0	62	0	0	0
Lane Group Flow (vph)	0	73	0	139	141	1	12	804	131	0	11	1193
Confl. Peds. (#/hr)	4					4	7					
Confl. Bikes (#/hr)						1			2			
Heavy Vehicles (%)	16%	2%	2%	2%	2%	2%	2%	4%	2%	2%	2%	4%
Turn Type	Perm	NA		Perm	NA	Perm	Prot	NA	Perm	Prot	Prot	NA
Protected Phases		4			8		5	2		1	1	6
Permitted Phases	4			8		8			2			
Actuated Green, G (s)		11.6		11.6	11.6	11.6	0.8	36.9	36.9		0.8	36.9
Effective Green, g (s)		11.6		11.6	11.6	11.6	0.8	36.9	36.9		0.8	36.9
Actuated g/C Ratio		0.18		0.18	0.18	0.18	0.01	0.57	0.57		0.01	0.57
Clearance Time (s)		4.9		4.9	4.9	4.9	4.9	5.7	5.7		4.9	5.7
Vehicle Extension (s)		2.0		2.0	2.0	2.0	1.0	4.0	4.0		1.0	4.0
Lane Grp Cap (vph)		255		257	246	278	21	1976	882		21	1966
v/s Ratio Prot							c0.01	0.23			0.01	c0.35
v/s Ratio Perm		0.05		0.10	c0.10	0.00			0.08			
v/c Ratio		0.28		0.54	0.57	0.00	0.57	0.41	0.15		0.52	0.61
Uniform Delay, d1		23.0		24.2	24.3	21.9	31.8	7.8	6.6		31.8	9.2
Progression Factor		1.00		1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
Incremental Delay, d2		0.2		1.2	2.0	0.0	21.2	0.2	0.1		10.4	0.6
Delay (s)		23.2		25.4	26.3	21.9	53.0	8.0	6.7		42.2	9.8
Level of Service		C		C	C	C	D	A	A		D	A
Approach Delay (s)		23.2			25.8			8.3				10.1
Approach LOS		C			C			A				B

Intersection Summary			
HCM 2000 Control Delay	11.6	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	64.8	Sum of lost time (s)	15.5
Intersection Capacity Utilization	46.4%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	6
Future Volume (vph)	6
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.79
Adj. Flow (vph)	8
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	7
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	67%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBT	WBR	WBR2	NBL2	NBT	NBR	SBU	SBL	SBR
Lane Configurations												
Traffic Volume (vph)	724	765	226	751	208	267	173	635	131	48	179	575
Future Volume (vph)	724	765	226	751	208	267	173	635	131	48	179	575
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	2.6	4.0	4.0	4.0	4.0	4.0			4.0	4.0
Lane Util. Factor	0.97	0.95	1.00	0.95	1.00	1.00	1.00	0.95			1.00	0.88
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.98	1.00	1.00			1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.85	0.85	1.00	0.97			1.00	0.85
Flt Protected	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (prot)	3127	3223	1429	3223	1442	1408	1583	3132			1649	2538
Flt Permitted	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (perm)	3127	3223	1429	3223	1442	1408	1583	3132			1649	2538
Peak-hour factor, PHF	0.88	0.88	0.88	0.95	0.95	0.95	0.89	0.89	0.89	0.94	0.94	0.94
Adj. Flow (vph)	823	869	257	791	219	281	194	713	147	51	190	612
RTOR Reduction (vph)	0	0	0	0	0	112	0	14	0	0	0	40
Lane Group Flow (vph)	823	869	257	791	219	169	194	846	0	0	241	603
Confl. Peds. (#/hr)	9					9			4		4	
Heavy Vehicles (%)	12%	12%	13%	12%	12%	12%	14%	12%	12%	0%	12%	12%
Turn Type	Prot	NA	Free	NA	Prot	Perm	Split	NA		Prot	Prot	pt+ov
Protected Phases	5	2		6	6		8	8		7	7	7 5
Permitted Phases			Free			6						
Actuated Green, G (s)	26.0	62.1	130.0	32.4	32.4	32.4	35.6	35.6			17.4	47.8
Effective Green, g (s)	25.7	63.5	130.0	33.8	33.8	33.8	36.7	36.7			17.8	48.2
Actuated g/C Ratio	0.20	0.49	1.00	0.26	0.26	0.26	0.28	0.28			0.14	0.37
Clearance Time (s)	3.7	5.4		5.4	5.4	5.4	5.1	5.1			4.4	
Vehicle Extension (s)	2.0	4.0		4.0	4.0	4.0	2.0	2.0			2.0	
Lane Grp Cap (vph)	618	1574	1429	837	374	366	446	884			225	941
v/s Ratio Prot	c0.26	0.27		c0.25	0.15		0.12	c0.27			c0.15	0.24
v/s Ratio Perm			0.18			0.12						
v/c Ratio	1.33	0.55	0.18	0.95	0.59	0.46	0.43	0.96			1.07	0.64
Uniform Delay, d1	52.1	23.3	0.0	47.2	42.0	40.5	38.2	45.9			56.1	33.8
Progression Factor	0.72	1.04	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Incremental Delay, d2	156.4	0.9	0.2	20.3	6.6	4.2	0.2	20.3			80.1	1.1
Delay (s)	194.2	25.2	0.2	67.5	48.6	44.6	38.4	66.1			136.2	34.9
Level of Service	F	C	A	E	D	D	D	E			F	C
Approach Delay (s)		93.3		59.3				61.0				
Approach LOS		F		E				E				

Intersection Summary			
HCM 2000 Control Delay	73.0	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.05		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	93.6%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

Movement	SBR2
Lane Configurations	
Traffic Volume (vph)	29
Future Volume (vph)	29
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.94
Adj. Flow (vph)	31
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	
Heavy Vehicles (%)	12%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBU	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	413	506	289	300	97	340	255	866	146	4	479	747
Future Volume (vph)	413	506	289	300	97	340	255	866	146	4	479	747
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		4.0	4.0
Lane Util. Factor	0.91	0.91	1.00	0.95	0.95	1.00	0.97	0.95	1.00		0.97	0.95
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00		1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85		1.00	1.00
Flt Protected	0.95	0.99	1.00	0.95	0.97	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (prot)	1564	3263	1583	1681	1685	1423	3433	3539	1583		3129	3539
Flt Permitted	0.95	0.99	1.00	0.95	0.97	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (perm)	1564	3263	1583	1681	1685	1423	3433	3539	1583		3129	3539
Peak-hour factor, PHF	0.96	0.96	0.96	0.95	0.95	0.95	0.92	0.92	0.92	0.91	0.91	0.91
Adj. Flow (vph)	430	527	301	316	102	358	277	941	159	4	526	821
RTOR Reduction (vph)	0	0	193	0	0	225	0	0	95	0	0	0
Lane Group Flow (vph)	310	647	108	205	213	133	277	941	64	0	530	821
Confl. Peds. (#/hr)							10					
Confl. Bikes (#/hr)						1						
Heavy Vehicles (%)	5%	5%	2%	2%	7%	12%	2%	2%	2%	0%	12%	2%
Turn Type	Split	NA	Perm	Split	NA	Perm	Prot	NA	Perm	Prot	Prot	NA
Protected Phases	7	7		8	8		5	2		1	1	6
Permitted Phases			7			8			2			
Actuated Green, G (s)	29.3	29.3	29.3	19.5	19.5	19.5	14.5	36.6	36.6		24.3	46.4
Effective Green, g (s)	30.6	30.6	30.6	20.4	20.4	20.4	15.2	38.0	38.0		25.0	47.8
Actuated g/C Ratio	0.24	0.24	0.24	0.16	0.16	0.16	0.12	0.29	0.29		0.19	0.37
Clearance Time (s)	5.3	5.3	5.3	4.9	4.9	4.9	4.7	5.4	5.4		4.7	5.4
Vehicle Extension (s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0		2.0	3.0
Lane Grp Cap (vph)	368	768	372	263	264	223	401	1034	462		601	1301
v/s Ratio Prot	0.20	c0.20		0.12	c0.13		0.08	c0.27			c0.17	0.23
v/s Ratio Perm			0.07			0.09			0.04			
v/c Ratio	0.84	0.84	0.29	0.78	0.81	0.60	0.69	0.91	0.14		0.88	0.63
Uniform Delay, d1	47.4	47.4	40.8	52.6	52.9	51.0	55.1	44.4	33.9		51.1	33.8
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		0.95	0.83
Incremental Delay, d2	15.3	8.0	0.2	12.5	15.5	2.8	4.1	13.3	0.6		10.1	1.6
Delay (s)	62.7	55.4	40.9	65.1	68.4	53.8	59.3	57.6	34.6		58.8	29.6
Level of Service	E	E	D	E	E	D	E	E	C		E	C
Approach Delay (s)		53.7			60.8			55.3				41.5
Approach LOS		D			E			E				D

Intersection Summary			
HCM 2000 Control Delay	51.1	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.87		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	16.7
Intersection Capacity Utilization	89.4%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	345
Future Volume (vph)	345
Ideal Flow (vphpl)	1900
Total Lost time (s)	4.0
Lane Util. Factor	1.00
Frpb, ped/bikes	0.97
Flpb, ped/bikes	1.00
Frt	0.85
Flt Protected	1.00
Satd. Flow (prot)	1497
Flt Permitted	1.00
Satd. Flow (perm)	1497
Peak-hour factor, PHF	0.91
Adj. Flow (vph)	379
RTOR Reduction (vph)	240
Lane Group Flow (vph)	139
Confl. Peds. (#/hr)	10
Confl. Bikes (#/hr)	7
Heavy Vehicles (%)	5%
Turn Type	Perm
Protected Phases	
Permitted Phases	6
Actuated Green, G (s)	46.4
Effective Green, g (s)	47.8
Actuated g/C Ratio	0.37
Clearance Time (s)	5.4
Vehicle Extension (s)	3.0
Lane Grp Cap (vph)	550
v/s Ratio Prot	
v/s Ratio Perm	0.09
v/c Ratio	0.25
Uniform Delay, d1	28.7
Progression Factor	1.47
Incremental Delay, d2	0.8
Delay (s)	42.9
Level of Service	D
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL
Lane Configurations												
Traffic Volume (vph)	87	119	70	2	163	34	347	2	17	1342	166	417
Future Volume (vph)	87	119	70	2	163	34	347	2	17	1342	166	417
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			3.3	4.0	4.0		4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	0.95			0.97	1.00	1.00		1.00	0.95	1.00	0.97
Frpb, ped/bikes	1.00	0.99			1.00	1.00	0.98		1.00	1.00	0.99	1.00
Flpb, ped/bikes	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Frt	1.00	0.94			1.00	1.00	0.85		1.00	1.00	0.85	1.00
Flt Protected	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (prot)	1770	3322			3275	1863	1527		1773	3471	1489	3367
Flt Permitted	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (perm)	1770	3322			3275	1863	1527		1773	3471	1489	3367
Peak-hour factor, PHF	0.71	0.71	0.71	0.90	0.90	0.90	0.90	0.89	0.89	0.89	0.89	0.88
Adj. Flow (vph)	123	168	99	2	181	38	386	2	19	1508	187	474
RTOR Reduction (vph)	0	76	0	0	0	0	254	0	0	0	56	0
Lane Group Flow (vph)	123	191	0	0	183	38	132	0	21	1508	131	474
Confl. Peds. (#/hr)	4		4		4		4		3		1	1
Confl. Bikes (#/hr)												
Heavy Vehicles (%)	2%	2%	2%	0%	7%	2%	4%	0%	2%	4%	7%	4%
Turn Type	Prot	NA		Prot	Prot	NA	Perm	Prot	Prot	NA	Perm	Prot
Protected Phases	7	4		3	3	8		5	5	2		1
Permitted Phases							8				2	
Actuated Green, G (s)	14.0	17.6			12.8	16.4	16.4		6.0	55.6	55.6	28.2
Effective Green, g (s)	14.6	18.9			14.1	17.7	17.7		6.6	56.9	56.9	28.8
Actuated g/C Ratio	0.11	0.14			0.11	0.13	0.13		0.05	0.42	0.42	0.21
Clearance Time (s)	4.6	5.3			4.6	5.3	5.3		4.6	5.3	5.3	4.6
Vehicle Extension (s)	3.0	2.0			3.0	2.0	2.0		2.0	4.0	4.0	2.0
Lane Grp Cap (vph)	192	468			344	246	201		87	1473	632	723
v/s Ratio Prot	c0.07	0.06			0.06	0.02			0.01	c0.43		c0.14
v/s Ratio Perm							c0.09				0.09	
v/c Ratio	0.64	0.41			0.53	0.15	0.66		0.24	1.02	0.21	0.66
Uniform Delay, d1	57.2	52.5			56.8	51.5	55.3		61.3	38.5	24.3	48.1
Progression Factor	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2	7.1	0.2			1.6	0.1	5.7		0.5	29.7	0.7	1.6
Delay (s)	64.3	52.7			58.4	51.6	61.0		61.8	68.2	25.1	49.7
Level of Service	E	D			E	D	E		E	E	C	D
Approach Delay (s)		56.3				59.6				63.4		
Approach LOS		E				E				E		

Intersection Summary			
HCM 2000 Control Delay	48.1	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.83		
Actuated Cycle Length (s)	134.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	80.1%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR
Lane Configurations		
Traffic Volume (vph)	1130	10
Future Volume (vph)	1130	10
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	4.0	
Lane Util. Factor	0.95	
Frpb, ped/bikes	1.00	
Flpb, ped/bikes	1.00	
Frt	1.00	
Flt Protected	1.00	
Satd. Flow (prot)	3466	
Flt Permitted	1.00	
Satd. Flow (perm)	3466	
Peak-hour factor, PHF	0.88	0.88
Adj. Flow (vph)	1284	11
RTOR Reduction (vph)	0	0
Lane Group Flow (vph)	1295	0
Confl. Peds. (#/hr)		3
Confl. Bikes (#/hr)		4
Heavy Vehicles (%)	4%	2%
Turn Type	NA	
Protected Phases	6	
Permitted Phases		
Actuated Green, G (s)	77.8	
Effective Green, g (s)	79.1	
Actuated g/C Ratio	0.59	
Clearance Time (s)	5.3	
Vehicle Extension (s)	4.0	
Lane Grp Cap (vph)	2045	
v/s Ratio Prot	0.37	
v/s Ratio Perm		
v/c Ratio	0.63	
Uniform Delay, d1	18.0	
Progression Factor	1.00	
Incremental Delay, d2	1.5	
Delay (s)	19.5	
Level of Service	B	
Approach Delay (s)	27.6	
Approach LOS	C	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL
Lane Configurations												
Traffic Volume (vph)	22	15	31	21	14	22	12	44	1233	26	7	44
Future Volume (vph)	22	15	31	21	14	22	12	44	1233	26	7	44
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0			4.0	4.0			4.0
Lane Util. Factor		1.00			1.00			1.00	0.95			1.00
Frpb, ped/bikes		0.99			0.99			1.00	1.00			1.00
Flpb, ped/bikes		1.00			1.00			1.00	1.00			1.00
Frt		0.94			0.95			1.00	1.00			1.00
Flt Protected		0.98			0.98			0.95	1.00			0.95
Satd. Flow (prot)		1639			1713			1777	3456			1774
Flt Permitted		0.79			0.75			0.95	1.00			0.11
Satd. Flow (perm)		1308			1301			1777	3456			197
Peak-hour factor, PHF	0.75	0.75	0.75	0.65	0.65	0.65	0.93	0.93	0.93	0.93	0.96	0.96
Adj. Flow (vph)	29	20	41	32	22	34	13	47	1326	28	7	46
RTOR Reduction (vph)	0	31	0	0	23	0	0	0	2	0	0	0
Lane Group Flow (vph)	0	59	0	0	65	0	0	60	1352	0	0	53
Confl. Peds. (#/hr)	7		7	7		7		6		22		22
Confl. Bikes (#/hr)						2				1		
Heavy Vehicles (%)	14%	2%	2%	2%	2%	2%	0%	2%	4%	2%	0%	2%
Turn Type	Perm	NA		Perm	NA		Prot	Prot	NA			Prot
Protected Phases		4			8		5	5	2			1
Permitted Phases	4			8								
Actuated Green, G (s)		8.0			8.0			6.6	54.8			37.1
Effective Green, g (s)		8.9			8.9			7.5	56.1			38.0
Actuated g/C Ratio		0.08			0.08			0.07	0.49			0.33
Clearance Time (s)		4.9			4.9			4.9	5.3			4.9
Vehicle Extension (s)		1.5			1.5			1.0	4.0			1.0
Lane Grp Cap (vph)		101			100			115	1685			65
v/s Ratio Prot								0.03	c0.39			
v/s Ratio Perm		0.04			c0.05							c0.27
v/c Ratio		0.58			0.65			0.52	0.80			0.82
Uniform Delay, d1		51.2			51.5			52.0	24.8			35.3
Progression Factor		1.00			1.00			1.00	1.00			1.00
Incremental Delay, d2		5.4			10.4			2.0	4.2			50.2
Delay (s)		56.6			61.9			54.0	28.9			85.5
Level of Service		E			E			D	C			F
Approach Delay (s)		56.6			61.9				30.0			
Approach LOS		E			E				C			

Intersection Summary			
HCM 2000 Control Delay	22.4	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	115.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	57.4%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR
Lane Configurations		
Traffic Volume (vph)	1190	26
Future Volume (vph)	1190	26
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	4.0	
Lane Util. Factor	0.95	
Frpb, ped/bikes	1.00	
Flpb, ped/bikes	1.00	
Frt	1.00	
Flt Protected	1.00	
Satd. Flow (prot)	3452	
Flt Permitted	1.00	
Satd. Flow (perm)	3452	
Peak-hour factor, PHF	0.96	0.96
Adj. Flow (vph)	1240	27
RTOR Reduction (vph)	1	0
Lane Group Flow (vph)	1266	0
Confl. Peds. (#/hr)		6
Confl. Bikes (#/hr)		5
Heavy Vehicles (%)	4%	12%
Turn Type	NA	
Protected Phases	6	
Permitted Phases		
Actuated Green, G (s)	85.3	
Effective Green, g (s)	86.6	
Actuated g/C Ratio	0.75	
Clearance Time (s)	5.3	
Vehicle Extension (s)	4.5	
Lane Grp Cap (vph)	2599	
v/s Ratio Prot	0.37	
v/s Ratio Perm		
v/c Ratio	0.49	
Uniform Delay, d1	5.5	
Progression Factor	1.00	
Incremental Delay, d2	0.7	
Delay (s)	6.2	
Level of Service	A	
Approach Delay (s)	9.4	
Approach LOS	A	

Intersection Summary

Movement	EBL	EBT	EBR2	WBU	WBL2	WBL	WBT	WBR	NBL	NBT	NBR	SBU
Lane Configurations												
Traffic Volume (vph)	31	42	8	9	14	40	52	227	12	1009	88	17
Future Volume (vph)	31	42	8	9	14	40	52	227	12	1009	88	17
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0				4.0	4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor		0.95				1.00	1.00	1.00	1.00	0.95	1.00	
Frpb, ped/bikes		1.00				1.00	1.00	0.98	1.00	1.00	0.99	
Flpb, ped/bikes		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Frt		0.99				1.00	1.00	0.85	1.00	1.00	0.85	
Flt Protected		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (prot)		3418				1752	1863	1526	1770	3471	1532	
Flt Permitted		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (perm)		3418				1752	1863	1526	1770	3471	1532	
Peak-hour factor, PHF	0.70	0.70	0.70	0.95	0.95	0.95	0.95	0.95	0.92	0.92	0.92	0.88
Adj. Flow (vph)	44	60	11	9	15	42	55	239	13	1097	96	19
RTOR Reduction (vph)	0	106	0	0	0	0	0	214	0	0	0	0
Lane Group Flow (vph)	0	9	0	0	0	66	55	25	13	1097	96	0
Confl. Peds. (#/hr)	4		2			2		4			1	
Confl. Bikes (#/hr)								1			1	
Heavy Vehicles (%)	2%	2%	2%	0%	2%	4%	2%	4%	2%	4%	4%	0%
Turn Type	Split	NA		Split	Split	Split	NA	Perm	Prot	NA	Perm	Prot
Protected Phases	4	4		8	8	8	8		5	2		1
Permitted Phases								8			2	
Actuated Green, G (s)		6.2				8.4	8.4	8.4	1.1	40.7	40.7	
Effective Green, g (s)		7.1				9.3	9.3	9.3	2.0	42.0	42.0	
Actuated g/C Ratio		0.08				0.10	0.10	0.10	0.02	0.46	0.46	
Clearance Time (s)		4.9				4.9	4.9	4.9	4.9	5.3	5.3	
Vehicle Extension (s)		3.0				2.0	2.0	2.0	2.0	4.0	4.0	
Lane Grp Cap (vph)		267				179	191	156	39	1609	710	
v/s Ratio Prot		c0.00				c0.04	0.03		0.01	c0.32		
v/s Ratio Perm								0.02			0.06	
v/c Ratio		0.03				0.37	0.29	0.16	0.33	0.68	0.14	
Uniform Delay, d1		38.6				37.9	37.6	37.1	43.6	19.1	13.9	
Progression Factor		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2		0.1				0.5	0.3	0.2	1.8	1.3	0.1	
Delay (s)		38.6				38.4	37.9	37.2	45.5	20.4	14.0	
Level of Service		D				D	D	D	D	C	B	
Approach Delay (s)		38.6					37.6			20.1		
Approach LOS		D					D			C		

Intersection Summary			
HCM 2000 Control Delay	25.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	90.6	Sum of lost time (s)	16.0
Intersection Capacity Utilization	75.4%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBL2	SBL	SBT	SBR	NWR2
Lane Configurations					
Traffic Volume (vph)	383	20	735	68	31
Future Volume (vph)	383	20	735	68	31
Ideal Flow (vphpl)	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0
Lane Util. Factor	0.91	0.95	0.95		1.00
Frpb, ped/bikes	1.00	1.00	1.00		1.00
Flpb, ped/bikes	1.00	1.00	1.00		1.00
Frt	1.00	1.00	0.99		0.86
Flt Protected	0.95	0.95	1.00		1.00
Satd. Flow (prot)	1584	1652	3426		1611
Flt Permitted	0.95	0.95	1.00		1.00
Satd. Flow (perm)	1584	1652	3426		1611
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.60
Adj. Flow (vph)	435	23	835	77	52
RTOR Reduction (vph)	0	0	3	0	47
Lane Group Flow (vph)	254	223	909	0	5
Confl. Peds. (#/hr)	1	1			
Confl. Bikes (#/hr)				5	
Heavy Vehicles (%)	4%	2%	4%	2%	2%
Turn Type	Prot	Prot	NA		Perm
Protected Phases	1	1	6		
Permitted Phases					8
Actuated Green, G (s)	15.3	15.3	54.9		8.4
Effective Green, g (s)	16.2	16.2	56.2		9.3
Actuated g/C Ratio	0.18	0.18	0.62		0.10
Clearance Time (s)	4.9	4.9	5.3		4.9
Vehicle Extension (s)	1.0	1.0	4.0		2.0
Lane Grp Cap (vph)	283	295	2125		165
v/s Ratio Prot	c0.16	0.13	0.27		
v/s Ratio Perm					0.00
v/c Ratio	0.90	0.76	0.43		0.03
Uniform Delay, d1	36.4	35.3	8.9		36.6
Progression Factor	1.00	1.00	1.00		1.00
Incremental Delay, d2	27.9	9.4	0.2		0.0
Delay (s)	64.2	44.7	9.1		36.6
Level of Service	E	D	A		D
Approach Delay (s)			24.9		
Approach LOS			C		

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	9	22	6	124	20	2	1	16	1066	390	13	619
Future Volume (vph)	9	22	6	124	20	2	1	16	1066	390	13	619
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0	4.0		4.0	4.0	4.0	3.2	4.0
Lane Util. Factor		1.00		0.95	0.95	1.00		1.00	0.95	1.00	1.00	0.95
Frpb, ped/bikes		1.00		1.00	1.00	0.98		1.00	1.00	0.98	1.00	1.00
Flpb, ped/bikes		1.00		1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00
Frt		0.98		1.00	1.00	0.85		1.00	1.00	0.85	1.00	1.00
Flt Protected		0.99		0.95	0.96	1.00		0.95	1.00	1.00	0.95	1.00
Satd. Flow (prot)		1629		1681	1706	1557		1772	3471	1548	1770	3441
Flt Permitted		0.90		0.91	0.82	1.00		0.95	1.00	1.00	0.95	1.00
Satd. Flow (perm)		1485		1611	1449	1557		1772	3471	1548	1770	3441
Peak-hour factor, PHF	0.57	0.57	0.57	0.91	0.91	0.91	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	16	39	11	136	22	2	1	17	1146	419	14	666
RTOR Reduction (vph)	0	8	0	0	0	2	0	0	0	83	0	1
Lane Group Flow (vph)	0	58	0	72	86	0	0	18	1146	336	14	678
Confl. Peds. (#/hr)	5					5		4		2	2	
Confl. Bikes (#/hr)			3									
Heavy Vehicles (%)	44%	2%	2%	2%	2%	2%	0%	2%	4%	2%	2%	4%
Turn Type	Perm	NA		Perm	NA	Perm	Prot	Prot	NA	Perm	Prot	NA
Protected Phases		4			8		5	5	2		1	6
Permitted Phases	4			8		8				2		
Actuated Green, G (s)		6.9		6.9	6.9	6.9		0.8	33.8	33.8	0.7	33.7
Effective Green, g (s)		7.8		7.8	7.8	7.8		1.7	35.5	35.5	2.4	35.4
Actuated g/C Ratio		0.14		0.14	0.14	0.14		0.03	0.62	0.62	0.04	0.62
Clearance Time (s)		4.9		4.9	4.9	4.9		4.9	5.7	5.7	4.9	5.7
Vehicle Extension (s)		2.0		2.0	2.0	2.0		1.0	4.0	4.0	1.0	4.0
Lane Grp Cap (vph)		203		220	198	213		52	2165	965	74	2140
v/s Ratio Prot								c0.01	c0.33		0.01	0.20
v/s Ratio Perm		0.04		0.04	c0.06	0.00				0.22		
v/c Ratio		0.29		0.33	0.43	0.00		0.35	0.53	0.35	0.19	0.32
Uniform Delay, d1		22.1		22.2	22.5	21.2		27.1	6.0	5.1	26.3	5.1
Progression Factor		1.00		1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2		0.3		0.3	0.6	0.0		1.5	0.3	0.3	0.5	0.1
Delay (s)		22.3		22.5	23.1	21.2		28.5	6.3	5.4	26.8	5.2
Level of Service		C		C	C	C		C	A	A	C	A
Approach Delay (s)		22.3			22.8				6.3			5.6
Approach LOS		C			C				A			A

Intersection Summary			
HCM 2000 Control Delay	7.6	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.52		
Actuated Cycle Length (s)	56.9	Sum of lost time (s)	12.9
Intersection Capacity Utilization	47.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	12
Future Volume (vph)	12
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.93
Adj. Flow (vph)	13
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	4
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	33%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBT	WBR	WBR2	NBL2	NBT	NBR	SBU	SBL	SBR
Lane Configurations												
Traffic Volume (vph)	322	751	189	616	255	143	497	421	357	25	209	618
Future Volume (vph)	322	751	189	616	255	143	497	421	357	25	209	618
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.7	5.4	4.0	5.4	5.4	5.4	5.1	5.1			4.4	4.4
Lane Util. Factor	0.97	0.95	1.00	0.95	1.00	1.00	1.00	0.95			1.00	0.88
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.98	1.00	0.99			1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.85	0.85	1.00	0.93			1.00	0.85
Flt Protected	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (prot)	3127	3223	1417	3223	1442	1414	1597	2982			1630	2538
Flt Permitted	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (perm)	3127	3223	1417	3223	1442	1414	1597	2982			1630	2538
Peak-hour factor, PHF	0.89	0.89	0.89	0.91	0.91	0.91	0.92	0.92	0.92	0.87	0.87	0.87
Adj. Flow (vph)	362	844	212	677	280	157	540	458	388	29	240	710
RTOR Reduction (vph)	0	0	0	0	0	117	0	64	0	0	0	47
Lane Group Flow (vph)	362	844	212	677	280	40	540	782	0	0	269	704
Confl. Peds. (#/hr)	6					6			2		2	
Heavy Vehicles (%)	12%	12%	14%	12%	12%	12%	13%	12%	12%	0%	12%	12%
Turn Type	Prot	NA	Free	NA	Prot	Perm	Split	NA		Prot	Prot	pt+ov
Protected Phases	5	2		6	6		8	8		7	7	7 5
Permitted Phases			Free			6						
Actuated Green, G (s)	15.0	49.5	120.0	30.8	30.8	30.8	37.6	37.6			18.0	37.4
Effective Green, g (s)	15.0	49.5	120.0	30.8	30.8	30.8	37.6	37.6			18.0	37.4
Actuated g/C Ratio	0.12	0.41	1.00	0.26	0.26	0.26	0.31	0.31			0.15	0.31
Clearance Time (s)	3.7	5.4		5.4	5.4	5.4	5.1	5.1			4.4	
Vehicle Extension (s)	2.0	4.0		4.0	4.0	4.0	2.0	2.0			2.0	
Lane Grp Cap (vph)	390	1329	1417	827	370	362	500	934			244	791
v/s Ratio Prot	0.12	0.26		c0.21	0.19		c0.34	0.26			c0.16	c0.28
v/s Ratio Perm			0.15			0.03						
v/c Ratio	0.93	0.64	0.15	0.82	0.76	0.11	1.08	0.84			1.10	0.89
Uniform Delay, d1	52.0	28.1	0.0	42.0	41.1	34.1	41.2	38.4			51.0	39.3
Progression Factor	0.74	1.14	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Incremental Delay, d2	23.1	1.8	0.2	8.9	13.5	0.6	63.5	6.3			87.8	11.9
Delay (s)	61.7	33.8	0.2	50.8	54.6	34.7	104.7	44.7			138.8	51.3
Level of Service	E	C	A	D	D	C	F	D			F	D
Approach Delay (s)		35.9		49.5				68.1				
Approach LOS		D		D				E				

Intersection Summary			
HCM 2000 Control Delay	55.9	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.00		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	18.6
Intersection Capacity Utilization	87.0%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	SBR2
Lane Configurations	
Traffic Volume (vph)	36
Future Volume (vph)	36
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.87
Adj. Flow (vph)	41
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	
Heavy Vehicles (%)	12%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	270	178	139	171	174	321	307	588	45	323	615	829
Future Volume (vph)	270	178	139	171	174	321	307	588	45	323	615	829
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.3	5.3	5.3	4.9	4.9	4.9	4.7	5.4	5.4	4.7	5.4	5.4
Lane Util. Factor	0.91	0.91	1.00	0.95	0.95	1.00	0.97	0.95	1.00	0.97	0.95	1.00
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.98	1.00	1.00	1.00	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	0.98	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1564	3209	1583	1681	1701	1411	3433	3539	1583	3127	3539	1533
Flt Permitted	0.95	0.98	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1564	3209	1583	1681	1701	1411	3433	3539	1583	3127	3539	1533
Peak-hour factor, PHF	0.83	0.83	0.83	0.88	0.88	0.88	0.78	0.78	0.78	0.80	0.80	0.80
Adj. Flow (vph)	325	214	167	194	198	365	394	754	58	404	769	1036
RTOR Reduction (vph)	0	0	142	0	0	255	0	0	36	0	0	286
Lane Group Flow (vph)	175	364	25	175	217	110	394	754	22	404	769	750
Confl. Peds. (#/hr)	5					5						
Confl. Bikes (#/hr)												1
Heavy Vehicles (%)	5%	6%	2%	2%	6%	12%	2%	2%	2%	12%	2%	4%
Turn Type	Split	NA	Perm	Split	NA	Perm	Prot	NA	Perm	Prot	NA	Perm
Protected Phases	7	7		8	8		5	2		1	6	
Permitted Phases			7			8			2			6
Actuated Green, G (s)	17.7	17.7	17.7	18.2	18.2	18.2	16.8	45.3	45.3	18.5	47.0	47.0
Effective Green, g (s)	17.7	17.7	17.7	18.2	18.2	18.2	16.8	45.3	45.3	18.5	47.0	47.0
Actuated g/C Ratio	0.15	0.15	0.15	0.15	0.15	0.15	0.14	0.38	0.38	0.15	0.39	0.39
Clearance Time (s)	5.3	5.3	5.3	4.9	4.9	4.9	4.7	5.4	5.4	4.7	5.4	5.4
Vehicle Extension (s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0	2.0	3.0	3.0
Lane Grp Cap (vph)	230	473	233	254	257	214	480	1335	597	482	1386	600
v/s Ratio Prot	0.11	c0.11		0.10	c0.13		0.11	0.21		c0.13	0.22	
v/s Ratio Perm			0.02			0.08			0.01			c0.49
v/c Ratio	0.76	0.77	0.11	0.69	0.84	0.51	0.82	0.56	0.04	0.84	0.55	1.25
Uniform Delay, d1	49.1	49.2	44.3	48.2	49.5	46.8	50.1	29.6	23.6	49.3	28.4	36.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	0.98	0.99
Incremental Delay, d2	12.5	6.7	0.1	6.1	20.8	0.9	10.3	1.7	0.1	7.1	0.9	120.7
Delay (s)	61.6	55.9	44.4	54.3	70.4	47.7	60.4	31.3	23.7	56.7	28.6	157.0
Level of Service	E	E	D	D	E	D	E	C	C	E	C	F
Approach Delay (s)		54.6			55.7			40.4			94.0	
Approach LOS		D			E			D			F	

Intersection Summary			
HCM 2000 Control Delay	69.1	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.03		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	20.3
Intersection Capacity Utilization	82.3%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL
Lane Configurations												
Traffic Volume (vph)	14	24	13	1	162	149	301	1	82	923	216	416
Future Volume (vph)	14	24	13	1	162	149	301	1	82	923	216	416
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.6	5.3			4.6	5.3	5.3		4.6	5.3	5.3	4.6
Lane Util. Factor	1.00	0.95			0.97	1.00	1.00		1.00	0.95	1.00	0.97
Frpb, ped/bikes	1.00	1.00			1.00	1.00	0.99		1.00	1.00	0.99	1.00
Flpb, ped/bikes	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Frt	1.00	0.95			1.00	1.00	0.85		1.00	1.00	0.85	1.00
Flt Protected	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (prot)	1770	3353			3274	1863	1533		1770	3471	1501	3367
Flt Permitted	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (perm)	1770	3353			3274	1863	1533		1770	3471	1501	3367
Peak-hour factor, PHF	0.91	0.91	0.91	0.93	0.93	0.93	0.93	0.86	0.86	0.86	0.86	0.94
Adj. Flow (vph)	15	26	14	1	174	160	324	1	95	1073	251	443
RTOR Reduction (vph)	0	13	0	0	0	0	270	0	0	0	80	0
Lane Group Flow (vph)	15	27	0	0	175	160	54	0	96	1073	171	443
Confl. Peds. (#/hr)	1						1		1		2	2
Confl. Bikes (#/hr)											1	
Heavy Vehicles (%)	2%	2%	2%	0%	7%	2%	4%	0%	2%	4%	6%	4%
Turn Type	Prot	NA		Prot	Prot	NA	Perm	Prot	Prot	NA	Perm	Prot
Protected Phases	7	4		3	3	8		5	5	2		1
Permitted Phases							8				2	
Actuated Green, G (s)	2.7	10.4			11.9	19.6	19.6		12.4	54.0	54.0	20.7
Effective Green, g (s)	2.7	10.4			11.9	19.6	19.6		12.4	54.0	54.0	20.7
Actuated g/C Ratio	0.02	0.09			0.10	0.17	0.17		0.11	0.46	0.46	0.18
Clearance Time (s)	4.6	5.3			4.6	5.3	5.3		4.6	5.3	5.3	4.6
Vehicle Extension (s)	2.0	2.0			2.0	2.0	2.0		2.0	4.0	4.0	2.0
Lane Grp Cap (vph)	40	298			333	312	257		187	1604	693	596
v/s Ratio Prot	0.01	0.01			c0.05	c0.09			0.05	0.31		c0.13
v/s Ratio Perm							0.04				0.11	
v/c Ratio	0.38	0.09			0.53	0.51	0.21		0.51	0.67	0.25	0.74
Uniform Delay, d1	56.2	48.9			49.8	44.3	41.9		49.3	24.4	19.1	45.5
Progression Factor	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2	2.1	0.0			0.7	0.6	0.2		1.0	1.2	0.3	4.4
Delay (s)	58.4	48.9			50.5	44.8	42.1		50.3	25.6	19.3	49.9
Level of Service	E	D			D	D	D		D	C	B	D
Approach Delay (s)		51.5				45.0				26.2		
Approach LOS		D				D				C		

Intersection Summary			
HCM 2000 Control Delay	31.0	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	116.8	Sum of lost time (s)	19.8
Intersection Capacity Utilization	67.1%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR
Lane Configurations		
Traffic Volume (vph)	1187	43
Future Volume (vph)	1187	43
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	5.3	
Lane Util. Factor	0.95	
Frpb, ped/bikes	1.00	
Flpb, ped/bikes	1.00	
Frt	0.99	
Flt Protected	1.00	
Satd. Flow (prot)	3452	
Flt Permitted	1.00	
Satd. Flow (perm)	3452	
Peak-hour factor, PHF	0.94	0.94
Adj. Flow (vph)	1263	46
RTOR Reduction (vph)	1	0
Lane Group Flow (vph)	1308	0
Confl. Peds. (#/hr)		1
Confl. Bikes (#/hr)		1
Heavy Vehicles (%)	4%	2%
Turn Type	NA	
Protected Phases	6	
Permitted Phases		
Actuated Green, G (s)	62.3	
Effective Green, g (s)	62.3	
Actuated g/C Ratio	0.53	
Clearance Time (s)	5.3	
Vehicle Extension (s)	4.0	
Lane Grp Cap (vph)	1841	
v/s Ratio Prot	c0.38	
v/s Ratio Perm		
v/c Ratio	0.71	
Uniform Delay, d1	20.5	
Progression Factor	1.00	
Incremental Delay, d2	1.4	
Delay (s)	21.9	
Level of Service	C	
Approach Delay (s)	29.0	
Approach LOS	C	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	25	13	25	39	7	60	6	31	968	51	63	1141
Future Volume (vph)	25	13	25	39	7	60	6	31	968	51	63	1141
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.9			4.9			4.9	5.3		4.9	5.3
Lane Util. Factor		1.00			1.00			1.00	0.95		1.00	0.95
Frpb, ped/bikes		0.99			0.97			1.00	1.00		1.00	1.00
Flpb, ped/bikes		0.99			1.00			1.00	1.00		1.00	1.00
Frt		0.95			0.92			1.00	0.99		1.00	1.00
Flt Protected		0.98			0.98			0.95	1.00		0.95	1.00
Satd. Flow (prot)		1586			1641			1775	3440		1770	3450
Flt Permitted		0.69			0.84			0.95	1.00		0.95	1.00
Satd. Flow (perm)		1119			1404			1775	3440		1770	3450
Peak-hour factor, PHF	0.74	0.74	0.74	0.58	0.58	0.58	0.81	0.81	0.81	0.81	0.89	0.89
Adj. Flow (vph)	34	18	34	67	12	103	7	38	1195	63	71	1282
RTOR Reduction (vph)	0	25	0	0	52	0	0	0	2	0	0	1
Lane Group Flow (vph)	0	61	0	0	130	0	0	45	1256	0	71	1301
Confl. Peds. (#/hr)	29		11	11		29		2		11	11	
Confl. Bikes (#/hr)			2			1				3		
Heavy Vehicles (%)	20%	2%	2%	2%	2%	2%	0%	2%	4%	2%	2%	4%
Turn Type	Perm	NA		Perm	NA		Prot	Prot	NA		Prot	NA
Protected Phases		4			8		5	5	2		1	6
Permitted Phases	4			8								
Actuated Green, G (s)		13.2			13.2			4.5	69.9		6.8	72.2
Effective Green, g (s)		13.2			13.2			4.5	69.9		6.8	72.2
Actuated g/C Ratio		0.13			0.13			0.04	0.67		0.06	0.69
Clearance Time (s)		4.9			4.9			4.9	5.3		4.9	5.3
Vehicle Extension (s)		1.5			1.5			1.0	4.0		1.0	4.5
Lane Grp Cap (vph)		140			176			76	2290		114	2372
v/s Ratio Prot								0.03	0.37		c0.04	c0.38
v/s Ratio Perm		0.05			c0.09							
v/c Ratio		0.43			0.74			0.59	0.55		0.62	0.55
Uniform Delay, d1		42.4			44.3			49.3	9.2		47.9	8.2
Progression Factor		1.00			1.00			1.00	1.00		1.00	1.00
Incremental Delay, d2		0.8			13.6			8.0	0.9		7.4	0.9
Delay (s)		43.2			57.9			57.3	10.2		55.2	9.1
Level of Service		D			E			E	B		E	A
Approach Delay (s)		43.2			57.9				11.8			11.5
Approach LOS		D			E				B			B

Intersection Summary			
HCM 2000 Control Delay	15.4	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	105.0	Sum of lost time (s)	15.1
Intersection Capacity Utilization	66.5%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	18
Future Volume (vph)	18
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.89
Adj. Flow (vph)	20
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	2
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	28%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR2	WBU	WBL2	WBL	WBT	WBR	NBL	NBT	NBR	SBU
Lane Configurations												
Traffic Volume (vph)	86	58	31	8	12	72	20	243	17	745	97	5
Future Volume (vph)	86	58	31	8	12	72	20	243	17	745	97	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.9				4.9	4.9	4.9	4.9	5.3	5.3	
Lane Util. Factor		0.95				1.00	1.00	1.00	1.00	0.95	1.00	
Frpb, ped/bikes		1.00				1.00	1.00	0.98	1.00	1.00	0.98	
Flpb, ped/bikes		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Frt		0.97				1.00	1.00	0.85	1.00	1.00	0.85	
Flt Protected		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (prot)		3363				1746	1863	1518	1770	3471	1529	
Flt Permitted		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (perm)		3363				1746	1863	1518	1770	3471	1529	
Peak-hour factor, PHF	0.83	0.83	0.83	0.71	0.71	0.71	0.71	0.71	0.76	0.76	0.76	0.86
Adj. Flow (vph)	104	70	37	11	17	101	28	342	22	980	128	6
RTOR Reduction (vph)	0	130	0	0	0	0	0	297	0	0	0	0
Lane Group Flow (vph)	0	81	0	0	0	129	28	45	22	980	128	0
Confl. Peds. (#/hr)	13					3		13	3		2	
Confl. Bikes (#/hr)											2	
Heavy Vehicles (%)	2%	2%	2%	0%	2%	4%	2%	4%	2%	4%	4%	0%
Turn Type	Split	NA		Split	Split	Split	NA	Perm	Prot	NA	Perm	Prot
Protected Phases	4	4		8	8	8	8		5	2		1
Permitted Phases								8			2	
Actuated Green, G (s)		8.0				11.9	11.9	11.9	2.4	38.2	38.2	
Effective Green, g (s)		8.0				11.9	11.9	11.9	2.4	38.2	38.2	
Actuated g/C Ratio		0.09				0.13	0.13	0.13	0.03	0.42	0.42	
Clearance Time (s)		4.9				4.9	4.9	4.9	4.9	5.3	5.3	
Vehicle Extension (s)		3.0				2.0	2.0	2.0	2.0	4.0	4.0	
Lane Grp Cap (vph)		296				229	244	199	46	1463	644	
v/s Ratio Prot		c0.02				c0.07	0.02		0.01	c0.28		
v/s Ratio Perm								0.03			0.08	
v/c Ratio		0.27				0.56	0.11	0.23	0.48	0.67	0.20	
Uniform Delay, d1		38.6				36.9	34.7	35.2	43.5	21.1	16.5	
Progression Factor		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2		0.5				1.9	0.1	0.2	2.8	1.3	0.2	
Delay (s)		39.1				38.8	34.8	35.4	46.3	22.4	16.7	
Level of Service		D				D	C	D	D	C	B	
Approach Delay (s)		39.1					36.3			22.2		
Approach LOS		D					D			C		

Intersection Summary			
HCM 2000 Control Delay	25.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	90.6	Sum of lost time (s)	20.0
Intersection Capacity Utilization	71.8%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBL2	SBL	SBT	SBR	NWR2
Lane Configurations					
Traffic Volume (vph)	235	16	814	24	45
Future Volume (vph)	235	16	814	24	45
Ideal Flow (vphpl)	1900	1900	1900	1900	1900
Total Lost time (s)	4.9	4.9	5.3		4.9
Lane Util. Factor	0.91	0.95	0.95		1.00
Frpb, ped/bikes	1.00	1.00	1.00		0.99
Flpb, ped/bikes	1.00	1.00	1.00		1.00
Frt	1.00	1.00	1.00		0.86
Flt Protected	0.95	0.95	1.00		1.00
Satd. Flow (prot)	1582	1653	3456		1589
Flt Permitted	0.95	0.95	1.00		1.00
Satd. Flow (perm)	1582	1653	3456		1589
Peak-hour factor, PHF	0.86	0.86	0.86	0.86	0.75
Adj. Flow (vph)	273	19	947	28	60
RTOR Reduction (vph)	0	0	1	0	52
Lane Group Flow (vph)	148	150	974	0	8
Confl. Peds. (#/hr)	2	2		3	
Confl. Bikes (#/hr)					1
Heavy Vehicles (%)	4%	2%	4%	2%	2%
Turn Type	Prot	Prot	NA		Perm
Protected Phases	1	1	6		
Permitted Phases					8
Actuated Green, G (s)	12.5	12.5	48.3		11.9
Effective Green, g (s)	12.5	12.5	48.3		11.9
Actuated g/C Ratio	0.14	0.14	0.53		0.13
Clearance Time (s)	4.9	4.9	5.3		4.9
Vehicle Extension (s)	1.0	1.0	4.0		2.0
Lane Grp Cap (vph)	218	228	1842		208
v/s Ratio Prot	c0.09	0.09	0.28		
v/s Ratio Perm					0.00
v/c Ratio	0.68	0.66	0.53		0.04
Uniform Delay, d1	37.1	37.0	13.8		34.4
Progression Factor	1.00	1.00	1.00		1.00
Incremental Delay, d2	6.5	5.1	0.4		0.0
Delay (s)	43.6	42.2	14.1		34.4
Level of Service	D	D	B		C
Approach Delay (s)			20.8		
Approach LOS			C		

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBU	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	23	24	16	178	12	5	9	595	143	2	6	936
Future Volume (vph)	23	24	16	178	12	5	9	595	143	2	6	936
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.9		4.9	4.9	4.9	4.9	5.7	5.7		4.9	5.7
Lane Util. Factor		1.00		0.95	0.95	1.00	1.00	0.95	1.00		1.00	0.95
Frpb, ped/bikes		1.00		1.00	1.00	0.98	1.00	1.00	0.98		1.00	1.00
Flpb, ped/bikes		1.00		1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
Frt		0.96		1.00	1.00	0.85	1.00	1.00	0.85		1.00	1.00
Flt Protected		0.98		0.95	0.96	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (prot)		1721		1681	1696	1555	1766	3471	1550		1770	3462
Flt Permitted		0.85		0.83	0.78	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (perm)		1483		1461	1372	1555	1766	3471	1550		1770	3462
Peak-hour factor, PHF	0.78	0.78	0.78	0.68	0.68	0.68	0.74	0.74	0.74	0.79	0.79	0.79
Adj. Flow (vph)	29	31	21	262	18	7	12	804	193	3	8	1185
RTOR Reduction (vph)	0	12	0	0	0	6	0	0	62	0	0	0
Lane Group Flow (vph)	0	69	0	139	141	1	12	804	131	0	11	1190
Confl. Peds. (#/hr)	4					4	7					
Confl. Bikes (#/hr)						1			2			
Heavy Vehicles (%)	9%	2%	2%	2%	2%	2%	2%	4%	2%	2%	2%	4%
Turn Type	Perm	NA		Perm	NA	Perm	Prot	NA	Perm	Prot	Prot	NA
Protected Phases		4			8		5	2		1	1	6
Permitted Phases	4			8		8			2			
Actuated Green, G (s)		11.6		11.6	11.6	11.6	0.8	36.3	36.3		0.8	36.3
Effective Green, g (s)		11.6		11.6	11.6	11.6	0.8	36.3	36.3		0.8	36.3
Actuated g/C Ratio		0.18		0.18	0.18	0.18	0.01	0.57	0.57		0.01	0.57
Clearance Time (s)		4.9		4.9	4.9	4.9	4.9	5.7	5.7		4.9	5.7
Vehicle Extension (s)		2.0		2.0	2.0	2.0	1.0	4.0	4.0		1.0	4.0
Lane Grp Cap (vph)		267		263	247	280	22	1962	876		22	1957
v/s Ratio Prot							c0.01	0.23			0.01	c0.34
v/s Ratio Perm		0.05		0.10	c0.10	0.00			0.08			
v/c Ratio		0.26		0.53	0.57	0.00	0.55	0.41	0.15		0.50	0.61
Uniform Delay, d1		22.6		23.8	24.0	21.6	31.5	7.9	6.6		31.5	9.2
Progression Factor		1.00		1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
Incremental Delay, d2		0.2		0.9	2.0	0.0	14.0	0.2	0.1		6.4	0.6
Delay (s)		22.8		24.7	26.0	21.6	45.5	8.1	6.7		37.9	9.9
Level of Service		C		C	C	C	D	A	A		D	A
Approach Delay (s)		22.8			25.3			8.3				10.1
Approach LOS		C			C			A				B

Intersection Summary			
HCM 2000 Control Delay	11.5	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	64.2	Sum of lost time (s)	15.5
Intersection Capacity Utilization	46.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	4
Future Volume (vph)	4
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.79
Adj. Flow (vph)	5
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	7
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	50%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

HCM Signalized Intersection Capacity Analysis
1: I-880 NB Off-Ramp/Industrial Pkwy & Whipple Rd

Project Alternative D PM

Movement	EBL	EBT	EBR	WBT	WBR	WBR2	NBL2	NBT	NBR	SBU	SBL	SBR
Lane Configurations												
Traffic Volume (vph)	724	765	226	751	208	267	173	635	131	48	179	575
Future Volume (vph)	724	765	226	751	208	267	173	635	131	48	179	575
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	2.6	4.0	4.0	4.0	4.0	4.0			4.0	4.0
Lane Util. Factor	0.97	0.95	1.00	0.95	1.00	1.00	1.00	0.95			1.00	0.88
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.98	1.00	1.00			1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.85	0.85	1.00	0.97			1.00	0.85
Flt Protected	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (prot)	3127	3223	1429	3223	1442	1408	1583	3132			1649	2538
Flt Permitted	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (perm)	3127	3223	1429	3223	1442	1408	1583	3132			1649	2538
Peak-hour factor, PHF	0.88	0.88	0.88	0.95	0.95	0.95	0.89	0.89	0.89	0.94	0.94	0.94
Adj. Flow (vph)	823	869	257	791	219	281	194	713	147	51	190	612
RTOR Reduction (vph)	0	0	0	0	0	112	0	14	0	0	0	40
Lane Group Flow (vph)	823	869	257	791	219	169	194	846	0	0	241	603
Confl. Peds. (#/hr)	9					9			4		4	
Heavy Vehicles (%)	12%	12%	13%	12%	12%	12%	14%	12%	12%	0%	12%	12%
Turn Type	Prot	NA	Free	NA	Prot	Perm	Split	NA		Prot	Prot	pt+ov
Protected Phases	5	2		6	6		8	8		7	7	7 5
Permitted Phases			Free			6						
Actuated Green, G (s)	26.0	62.1	130.0	32.4	32.4	32.4	35.6	35.6			17.4	47.8
Effective Green, g (s)	25.7	63.5	130.0	33.8	33.8	33.8	36.7	36.7			17.8	48.2
Actuated g/C Ratio	0.20	0.49	1.00	0.26	0.26	0.26	0.28	0.28			0.14	0.37
Clearance Time (s)	3.7	5.4		5.4	5.4	5.4	5.1	5.1			4.4	
Vehicle Extension (s)	2.0	4.0		4.0	4.0	4.0	2.0	2.0			2.0	
Lane Grp Cap (vph)	618	1574	1429	837	374	366	446	884			225	941
v/s Ratio Prot	c0.26	0.27		c0.25	0.15		0.12	c0.27			c0.15	0.24
v/s Ratio Perm			0.18			0.12						
v/c Ratio	1.33	0.55	0.18	0.95	0.59	0.46	0.43	0.96			1.07	0.64
Uniform Delay, d1	52.1	23.3	0.0	47.2	42.0	40.5	38.2	45.9			56.1	33.8
Progression Factor	0.72	1.04	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Incremental Delay, d2	156.4	0.9	0.2	20.3	6.6	4.2	0.2	20.3			80.1	1.1
Delay (s)	194.2	25.2	0.2	67.5	48.6	44.6	38.4	66.1			136.2	34.9
Level of Service	F	C	A	E	D	D	D	E			F	C
Approach Delay (s)		93.3		59.3				61.0				
Approach LOS		F		E				E				

Intersection Summary			
HCM 2000 Control Delay	73.0	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.05		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	93.6%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

Movement	SBR2
Lane Configurations	
Traffic Volume (vph)	29
Future Volume (vph)	29
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.94
Adj. Flow (vph)	31
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	
Heavy Vehicles (%)	12%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBU	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	413	506	289	300	97	340	255	866	146	4	479	747
Future Volume (vph)	413	506	289	300	97	340	255	866	146	4	479	747
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		4.0	4.0
Lane Util. Factor	0.91	0.91	1.00	0.95	0.95	1.00	0.97	0.95	1.00		0.97	0.95
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00		1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85		1.00	1.00
Flt Protected	0.95	0.99	1.00	0.95	0.97	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (prot)	1564	3263	1583	1681	1685	1423	3433	3539	1583		3129	3539
Flt Permitted	0.95	0.99	1.00	0.95	0.97	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (perm)	1564	3263	1583	1681	1685	1423	3433	3539	1583		3129	3539
Peak-hour factor, PHF	0.96	0.96	0.96	0.95	0.95	0.95	0.92	0.92	0.92	0.91	0.91	0.91
Adj. Flow (vph)	430	527	301	316	102	358	277	941	159	4	526	821
RTOR Reduction (vph)	0	0	193	0	0	225	0	0	95	0	0	0
Lane Group Flow (vph)	310	647	108	205	213	133	277	941	64	0	530	821
Confl. Peds. (#/hr)							10					
Confl. Bikes (#/hr)						1						
Heavy Vehicles (%)	5%	5%	2%	2%	7%	12%	2%	2%	2%	0%	12%	2%
Turn Type	Split	NA	Perm	Split	NA	Perm	Prot	NA	Perm	Prot	Prot	NA
Protected Phases	7	7		8	8		5	2		1	1	6
Permitted Phases			7			8			2			
Actuated Green, G (s)	29.3	29.3	29.3	19.5	19.5	19.5	14.5	36.6	36.6		24.3	46.4
Effective Green, g (s)	30.6	30.6	30.6	20.4	20.4	20.4	15.2	38.0	38.0		25.0	47.8
Actuated g/C Ratio	0.24	0.24	0.24	0.16	0.16	0.16	0.12	0.29	0.29		0.19	0.37
Clearance Time (s)	5.3	5.3	5.3	4.9	4.9	4.9	4.7	5.4	5.4		4.7	5.4
Vehicle Extension (s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0		2.0	3.0
Lane Grp Cap (vph)	368	768	372	263	264	223	401	1034	462		601	1301
v/s Ratio Prot	0.20	c0.20		0.12	c0.13		0.08	c0.27			c0.17	0.23
v/s Ratio Perm			0.07			0.09			0.04			
v/c Ratio	0.84	0.84	0.29	0.78	0.81	0.60	0.69	0.91	0.14		0.88	0.63
Uniform Delay, d1	47.4	47.4	40.8	52.6	52.9	51.0	55.1	44.4	33.9		51.1	33.8
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		0.95	0.83
Incremental Delay, d2	15.3	8.0	0.2	12.5	15.5	2.8	4.1	13.3	0.6		10.1	1.6
Delay (s)	62.7	55.4	40.9	65.1	68.4	53.8	59.3	57.6	34.6		58.8	29.6
Level of Service	E	E	D	E	E	D	E	E	C		E	C
Approach Delay (s)		53.7			60.8			55.3				41.5
Approach LOS		D			E			E				D

Intersection Summary			
HCM 2000 Control Delay	51.1	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.87		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	16.7
Intersection Capacity Utilization	89.4%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	345
Future Volume (vph)	345
Ideal Flow (vphpl)	1900
Total Lost time (s)	4.0
Lane Util. Factor	1.00
Frpb, ped/bikes	0.97
Flpb, ped/bikes	1.00
Frt	0.85
Flt Protected	1.00
Satd. Flow (prot)	1497
Flt Permitted	1.00
Satd. Flow (perm)	1497
Peak-hour factor, PHF	0.91
Adj. Flow (vph)	379
RTOR Reduction (vph)	240
Lane Group Flow (vph)	139
Confl. Peds. (#/hr)	10
Confl. Bikes (#/hr)	7
Heavy Vehicles (%)	5%
Turn Type	Perm
Protected Phases	
Permitted Phases	6
Actuated Green, G (s)	46.4
Effective Green, g (s)	47.8
Actuated g/C Ratio	0.37
Clearance Time (s)	5.4
Vehicle Extension (s)	3.0
Lane Grp Cap (vph)	550
v/s Ratio Prot	
v/s Ratio Perm	0.09
v/c Ratio	0.25
Uniform Delay, d1	28.7
Progression Factor	1.47
Incremental Delay, d2	0.8
Delay (s)	42.9
Level of Service	D
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL
Lane Configurations												
Traffic Volume (vph)	87	119	70	2	163	34	347	2	17	1342	166	417
Future Volume (vph)	87	119	70	2	163	34	347	2	17	1342	166	417
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			3.3	4.0	4.0		4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	0.95			0.97	1.00	1.00		1.00	0.95	1.00	0.97
Frpb, ped/bikes	1.00	0.99			1.00	1.00	0.98		1.00	1.00	0.99	1.00
Flpb, ped/bikes	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Frt	1.00	0.94			1.00	1.00	0.85		1.00	1.00	0.85	1.00
Flt Protected	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (prot)	1770	3322			3275	1863	1527		1773	3471	1489	3367
Flt Permitted	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (perm)	1770	3322			3275	1863	1527		1773	3471	1489	3367
Peak-hour factor, PHF	0.71	0.71	0.71	0.90	0.90	0.90	0.90	0.89	0.89	0.89	0.89	0.88
Adj. Flow (vph)	123	168	99	2	181	38	386	2	19	1508	187	474
RTOR Reduction (vph)	0	76	0	0	0	0	254	0	0	0	56	0
Lane Group Flow (vph)	123	191	0	0	183	38	132	0	21	1508	131	474
Confl. Peds. (#/hr)	4		4		4		4		3		1	1
Confl. Bikes (#/hr)												
Heavy Vehicles (%)	2%	2%	2%	0%	7%	2%	4%	0%	2%	4%	7%	4%
Turn Type	Prot	NA		Prot	Prot	NA	Perm	Prot	Prot	NA	Perm	Prot
Protected Phases	7	4		3	3	8		5	5	2		1
Permitted Phases							8				2	
Actuated Green, G (s)	14.0	17.6			12.8	16.4	16.4		6.0	55.6	55.6	28.2
Effective Green, g (s)	14.6	18.9			14.1	17.7	17.7		6.6	56.9	56.9	28.8
Actuated g/C Ratio	0.11	0.14			0.11	0.13	0.13		0.05	0.42	0.42	0.21
Clearance Time (s)	4.6	5.3			4.6	5.3	5.3		4.6	5.3	5.3	4.6
Vehicle Extension (s)	3.0	2.0			3.0	2.0	2.0		2.0	4.0	4.0	2.0
Lane Grp Cap (vph)	192	468			344	246	201		87	1473	632	723
v/s Ratio Prot	c0.07	0.06			0.06	0.02			0.01	c0.43		c0.14
v/s Ratio Perm							c0.09				0.09	
v/c Ratio	0.64	0.41			0.53	0.15	0.66		0.24	1.02	0.21	0.66
Uniform Delay, d1	57.2	52.5			56.8	51.5	55.3		61.3	38.5	24.3	48.1
Progression Factor	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2	7.1	0.2			1.6	0.1	5.7		0.5	29.7	0.7	1.6
Delay (s)	64.3	52.7			58.4	51.6	61.0		61.8	68.2	25.1	49.7
Level of Service	E	D			E	D	E		E	E	C	D
Approach Delay (s)		56.3				59.6				63.4		
Approach LOS		E				E				E		

Intersection Summary			
HCM 2000 Control Delay	48.1	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.83		
Actuated Cycle Length (s)	134.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	80.1%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR
Lane Configurations		
Traffic Volume (vph)	1130	10
Future Volume (vph)	1130	10
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	4.0	
Lane Util. Factor	0.95	
Frpb, ped/bikes	1.00	
Flpb, ped/bikes	1.00	
Frt	1.00	
Flt Protected	1.00	
Satd. Flow (prot)	3466	
Flt Permitted	1.00	
Satd. Flow (perm)	3466	
Peak-hour factor, PHF	0.88	0.88
Adj. Flow (vph)	1284	11
RTOR Reduction (vph)	0	0
Lane Group Flow (vph)	1295	0
Confl. Peds. (#/hr)		3
Confl. Bikes (#/hr)		4
Heavy Vehicles (%)	4%	2%
Turn Type	NA	
Protected Phases	6	
Permitted Phases		
Actuated Green, G (s)	77.8	
Effective Green, g (s)	79.1	
Actuated g/C Ratio	0.59	
Clearance Time (s)	5.3	
Vehicle Extension (s)	4.0	
Lane Grp Cap (vph)	2045	
v/s Ratio Prot	0.37	
v/s Ratio Perm		
v/c Ratio	0.63	
Uniform Delay, d1	18.0	
Progression Factor	1.00	
Incremental Delay, d2	1.5	
Delay (s)	19.5	
Level of Service	B	
Approach Delay (s)	27.6	
Approach LOS	C	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL
Lane Configurations												
Traffic Volume (vph)	24	15	31	21	14	22	12	44	1231	26	7	44
Future Volume (vph)	24	15	31	21	14	22	12	44	1231	26	7	44
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0			4.0	4.0			4.0
Lane Util. Factor		1.00			1.00			1.00	0.95			1.00
Frpb, ped/bikes		0.99			0.99			1.00	1.00			1.00
Flpb, ped/bikes		1.00			1.00			1.00	1.00			1.00
Frt		0.94			0.95			1.00	1.00			1.00
Flt Protected		0.98			0.98			0.95	1.00			0.95
Satd. Flow (prot)		1600			1713			1777	3456			1774
Flt Permitted		0.78			0.76			0.95	1.00			0.11
Satd. Flow (perm)		1278			1319			1777	3456			208
Peak-hour factor, PHF	0.75	0.75	0.75	0.65	0.65	0.65	0.93	0.93	0.93	0.93	0.96	0.96
Adj. Flow (vph)	32	20	41	32	22	34	13	47	1324	28	7	46
RTOR Reduction (vph)	0	29	0	0	23	0	0	0	2	0	0	0
Lane Group Flow (vph)	0	64	0	0	65	0	0	60	1350	0	0	53
Confl. Peds. (#/hr)	7		7	7		7		6		22		22
Confl. Bikes (#/hr)						2				1		
Heavy Vehicles (%)	21%	2%	2%	2%	2%	2%	0%	2%	4%	2%	0%	2%
Turn Type	Perm	NA		Perm	NA		Prot	Prot	NA			Prot
Protected Phases		4			8		5	5	2			1
Permitted Phases	4			8								
Actuated Green, G (s)		9.0			9.0			6.6	55.8			35.1
Effective Green, g (s)		9.9			9.9			7.5	57.1			36.0
Actuated g/C Ratio		0.09			0.09			0.07	0.50			0.31
Clearance Time (s)		4.9			4.9			4.9	5.3			4.9
Vehicle Extension (s)		1.5			1.5			1.0	4.0			1.0
Lane Grp Cap (vph)		110			113			115	1715			65
v/s Ratio Prot								0.03	c0.39			
v/s Ratio Perm		c0.05			0.05							c0.26
v/c Ratio		0.58			0.58			0.52	0.79			0.82
Uniform Delay, d1		50.5			50.5			52.0	23.9			36.4
Progression Factor		1.00			1.00			1.00	1.00			1.00
Incremental Delay, d2		4.5			4.4			2.0	3.7			50.2
Delay (s)		55.1			54.9			54.0	27.7			86.6
Level of Service		E			D			D	C			F
Approach Delay (s)		55.1			54.9				28.8			
Approach LOS		E			D				C			

Intersection Summary			
HCM 2000 Control Delay	21.8	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	115.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	57.6%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR
Lane Configurations		
Traffic Volume (vph)	1188	28
Future Volume (vph)	1188	28
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	4.0	
Lane Util. Factor	0.95	
Frpb, ped/bikes	1.00	
Flpb, ped/bikes	1.00	
Frt	1.00	
Flt Protected	1.00	
Satd. Flow (prot)	3446	
Flt Permitted	1.00	
Satd. Flow (perm)	3446	
Peak-hour factor, PHF	0.96	0.96
Adj. Flow (vph)	1238	29
RTOR Reduction (vph)	1	0
Lane Group Flow (vph)	1266	0
Confl. Peds. (#/hr)		6
Confl. Bikes (#/hr)		5
Heavy Vehicles (%)	4%	18%
Turn Type	NA	
Protected Phases	6	
Permitted Phases		
Actuated Green, G (s)	84.3	
Effective Green, g (s)	85.6	
Actuated g/C Ratio	0.74	
Clearance Time (s)	5.3	
Vehicle Extension (s)	4.5	
Lane Grp Cap (vph)	2565	
v/s Ratio Prot	0.37	
v/s Ratio Perm		
v/c Ratio	0.49	
Uniform Delay, d1	5.9	
Progression Factor	1.00	
Incremental Delay, d2	0.7	
Delay (s)	6.6	
Level of Service	A	
Approach Delay (s)	9.8	
Approach LOS	A	

Intersection Summary

HCM Signalized Intersection Capacity Analysis
5: Union City Blvd & Alvarado Blvd

Project Alternative D PM

Movement	EBL	EBT	EBR2	WBU	WBL2	WBL	WBT	WBR	NBL	NBT	NBR	SBU
Lane Configurations												
Traffic Volume (vph)	31	42	8	9	14	40	52	227	12	1007	88	17
Future Volume (vph)	31	42	8	9	14	40	52	227	12	1007	88	17
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0				4.0	4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor		0.95				1.00	1.00	1.00	1.00	0.95	1.00	
Frpb, ped/bikes		1.00				1.00	1.00	0.98	1.00	1.00	0.99	
Flpb, ped/bikes		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Frt		0.99				1.00	1.00	0.85	1.00	1.00	0.85	
Flt Protected		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (prot)		3418				1752	1863	1526	1770	3471	1532	
Flt Permitted		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (perm)		3418				1752	1863	1526	1770	3471	1532	
Peak-hour factor, PHF	0.70	0.70	0.70	0.95	0.95	0.95	0.95	0.95	0.92	0.92	0.92	0.88
Adj. Flow (vph)	44	60	11	9	15	42	55	239	13	1095	96	19
RTOR Reduction (vph)	0	106	0	0	0	0	0	214	0	0	0	0
Lane Group Flow (vph)	0	9	0	0	0	66	55	25	13	1095	96	0
Confl. Peds. (#/hr)	4		2			2		4			1	
Confl. Bikes (#/hr)								1			1	
Heavy Vehicles (%)	2%	2%	2%	0%	2%	4%	2%	4%	2%	4%	4%	0%
Turn Type	Split	NA		Split	Split	Split	NA	Perm	Prot	NA	Perm	Prot
Protected Phases	4	4		8	8	8	8		5	2		1
Permitted Phases								8			2	
Actuated Green, G (s)		6.2				8.4	8.4	8.4	1.1	40.7	40.7	
Effective Green, g (s)		7.1				9.3	9.3	9.3	2.0	42.0	42.0	
Actuated g/C Ratio		0.08				0.10	0.10	0.10	0.02	0.46	0.46	
Clearance Time (s)		4.9				4.9	4.9	4.9	4.9	5.3	5.3	
Vehicle Extension (s)		3.0				2.0	2.0	2.0	2.0	4.0	4.0	
Lane Grp Cap (vph)		267				179	191	156	39	1609	710	
v/s Ratio Prot		c0.00				c0.04	0.03		0.01	c0.32		
v/s Ratio Perm								0.02			0.06	
v/c Ratio		0.03				0.37	0.29	0.16	0.33	0.68	0.14	
Uniform Delay, d1		38.6				37.9	37.6	37.1	43.6	19.0	13.9	
Progression Factor		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2		0.1				0.5	0.3	0.2	1.8	1.3	0.1	
Delay (s)		38.6				38.4	37.9	37.2	45.5	20.3	14.0	
Level of Service		D				D	D	D	D	C	B	
Approach Delay (s)		38.6					37.6			20.1		
Approach LOS		D					D			C		

Intersection Summary			
HCM 2000 Control Delay	25.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	90.6	Sum of lost time (s)	16.0
Intersection Capacity Utilization	75.3%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBL2	SBL	SBT	SBR	NWR2
Lane Configurations					
Traffic Volume (vph)	383	20	733	68	31
Future Volume (vph)	383	20	733	68	31
Ideal Flow (vphpl)	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0
Lane Util. Factor	0.91	0.95	0.95		1.00
Frpb, ped/bikes	1.00	1.00	1.00		1.00
Flpb, ped/bikes	1.00	1.00	1.00		1.00
Frt	1.00	1.00	0.99		0.86
Flt Protected	0.95	0.95	1.00		1.00
Satd. Flow (prot)	1584	1652	3426		1611
Flt Permitted	0.95	0.95	1.00		1.00
Satd. Flow (perm)	1584	1652	3426		1611
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.60
Adj. Flow (vph)	435	23	833	77	52
RTOR Reduction (vph)	0	0	3	0	47
Lane Group Flow (vph)	254	223	907	0	5
Confl. Peds. (#/hr)	1	1			
Confl. Bikes (#/hr)				5	
Heavy Vehicles (%)	4%	2%	4%	2%	2%
Turn Type	Prot	Prot	NA		Perm
Protected Phases	1	1	6		
Permitted Phases					8
Actuated Green, G (s)	15.3	15.3	54.9		8.4
Effective Green, g (s)	16.2	16.2	56.2		9.3
Actuated g/C Ratio	0.18	0.18	0.62		0.10
Clearance Time (s)	4.9	4.9	5.3		4.9
Vehicle Extension (s)	1.0	1.0	4.0		2.0
Lane Grp Cap (vph)	283	295	2125		165
v/s Ratio Prot	c0.16	0.13	0.26		
v/s Ratio Perm					0.00
v/c Ratio	0.90	0.76	0.43		0.03
Uniform Delay, d1	36.4	35.3	8.9		36.6
Progression Factor	1.00	1.00	1.00		1.00
Incremental Delay, d2	27.9	9.4	0.2		0.0
Delay (s)	64.2	44.7	9.1		36.6
Level of Service	E	D	A		D
Approach Delay (s)			24.9		
Approach LOS			C		

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	7	22	6	124	20	2	1	16	1066	390	13	619
Future Volume (vph)	7	22	6	124	20	2	1	16	1066	390	13	619
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0	4.0		4.0	4.0	4.0	3.2	4.0
Lane Util. Factor		1.00		0.95	0.95	1.00		1.00	0.95	1.00	1.00	0.95
Frpb, ped/bikes		1.00		1.00	1.00	0.98		1.00	1.00	0.98	1.00	1.00
Flpb, ped/bikes		1.00		1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00
Frt		0.98		1.00	1.00	0.85		1.00	1.00	0.85	1.00	1.00
Flt Protected		0.99		0.95	0.96	1.00		0.95	1.00	1.00	0.95	1.00
Satd. Flow (prot)		1706		1681	1706	1557		1772	3471	1548	1770	3453
Flt Permitted		0.92		0.93	0.79	1.00		0.95	1.00	1.00	0.95	1.00
Satd. Flow (perm)		1589		1654	1398	1557		1772	3471	1548	1770	3453
Peak-hour factor, PHF	0.57	0.57	0.57	0.91	0.91	0.91	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	12	39	11	136	22	2	1	17	1146	419	14	666
RTOR Reduction (vph)	0	8	0	0	0	2	0	0	0	83	0	0
Lane Group Flow (vph)	0	54	0	72	86	0	0	18	1146	336	14	677
Confl. Peds. (#/hr)	5					5		4		2	2	
Confl. Bikes (#/hr)			3									
Heavy Vehicles (%)	29%	2%	2%	2%	2%	2%	0%	2%	4%	2%	2%	4%
Turn Type	Perm	NA		Perm	NA	Perm	Prot	Prot	NA	Perm	Prot	NA
Protected Phases		4			8		5	5	2		1	6
Permitted Phases	4			8		8				2		
Actuated Green, G (s)		6.9		6.9	6.9	6.9		0.8	33.8	33.8	0.7	33.7
Effective Green, g (s)		7.8		7.8	7.8	7.8		1.7	35.5	35.5	2.4	35.4
Actuated g/C Ratio		0.14		0.14	0.14	0.14		0.03	0.62	0.62	0.04	0.62
Clearance Time (s)		4.9		4.9	4.9	4.9		4.9	5.7	5.7	4.9	5.7
Vehicle Extension (s)		2.0		2.0	2.0	2.0		1.0	4.0	4.0	1.0	4.0
Lane Grp Cap (vph)		217		226	191	213		52	2165	965	74	2148
v/s Ratio Prot								c0.01	c0.33		0.01	0.20
v/s Ratio Perm		0.03		0.04	c0.06	0.00				0.22		
v/c Ratio		0.25		0.32	0.45	0.00		0.35	0.53	0.35	0.19	0.32
Uniform Delay, d1		21.9		22.2	22.6	21.2		27.1	6.0	5.1	26.3	5.1
Progression Factor		1.00		1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2		0.2		0.3	0.6	0.0		1.5	0.3	0.3	0.5	0.1
Delay (s)		22.2		22.4	23.2	21.2		28.5	6.3	5.4	26.8	5.2
Level of Service		C		C	C	C		C	A	A	C	A
Approach Delay (s)		22.2			22.8				6.3			5.6
Approach LOS		C			C				A			A

Intersection Summary			
HCM 2000 Control Delay	7.6	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.52		
Actuated Cycle Length (s)	56.9	Sum of lost time (s)	12.9
Intersection Capacity Utilization	47.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	10
Future Volume (vph)	10
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.93
Adj. Flow (vph)	11
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	4
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	20%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

APPENDIX C
LEVEL OF SERVICE CALCULATION SHEETS
for
WORST CASE SCENARIO

Movement	EBL	EBT	EBR	WBT	WBR	WBR2	NBL2	NBT	NBR	SBU	SBL	SBR
Lane Configurations												
Traffic Volume (vph)	322	751	196	616	255	143	504	421	357	25	209	618
Future Volume (vph)	322	751	196	616	255	143	504	421	357	25	209	618
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.7	5.4	4.0	5.4	5.4	5.4	5.1	5.1			4.4	4.4
Lane Util. Factor	0.97	0.95	1.00	0.95	1.00	1.00	1.00	0.95			1.00	0.88
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.98	1.00	0.99			1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.85	0.85	1.00	0.93			1.00	0.85
Flt Protected	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (prot)	3127	3223	1380	3223	1442	1414	1583	2982			1630	2538
Flt Permitted	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (perm)	3127	3223	1380	3223	1442	1414	1583	2982			1630	2538
Peak-hour factor, PHF	0.89	0.89	0.89	0.91	0.91	0.91	0.92	0.92	0.92	0.87	0.87	0.87
Adj. Flow (vph)	362	844	220	677	280	157	548	458	388	29	240	710
RTOR Reduction (vph)	0	0	0	0	0	117	0	64	0	0	0	47
Lane Group Flow (vph)	362	844	220	677	280	40	548	782	0	0	269	704
Confl. Peds. (#/hr)	6					6			2		2	
Heavy Vehicles (%)	12%	12%	17%	12%	12%	12%	14%	12%	12%	0%	12%	12%
Turn Type	Prot	NA	Free	NA	Prot	Perm	Split	NA		Prot	Prot	pt+ov
Protected Phases	5	2		6	6		8	8		7	7	7 5
Permitted Phases			Free			6						
Actuated Green, G (s)	15.0	49.5	120.0	30.8	30.8	30.8	37.6	37.6			18.0	37.4
Effective Green, g (s)	15.0	49.5	120.0	30.8	30.8	30.8	37.6	37.6			18.0	37.4
Actuated g/C Ratio	0.12	0.41	1.00	0.26	0.26	0.26	0.31	0.31			0.15	0.31
Clearance Time (s)	3.7	5.4		5.4	5.4	5.4	5.1	5.1			4.4	
Vehicle Extension (s)	2.0	4.0		4.0	4.0	4.0	2.0	2.0			2.0	
Lane Grp Cap (vph)	390	1329	1380	827	370	362	496	934			244	791
v/s Ratio Prot	0.12	0.26		c0.21	0.19		c0.35	0.26			c0.16	c0.28
v/s Ratio Perm			0.16			0.03						
v/c Ratio	0.93	0.64	0.16	0.82	0.76	0.11	1.10	0.84			1.10	0.89
Uniform Delay, d1	52.0	28.1	0.0	42.0	41.1	34.1	41.2	38.4			51.0	39.3
Progression Factor	0.74	1.11	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Incremental Delay, d2	22.8	1.8	0.2	8.9	13.5	0.6	72.2	6.3			87.8	11.9
Delay (s)	61.3	33.1	0.2	50.8	54.6	34.7	113.4	44.7			138.8	51.3
Level of Service	E	C	A	D	D	C	F	D			F	D
Approach Delay (s)		35.2		49.5				71.7				
Approach LOS		D		D				E				

Intersection Summary			
HCM 2000 Control Delay	56.7	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.01		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	18.6
Intersection Capacity Utilization	87.4%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	SBR2
Lane Configurations	
Traffic Volume (vph)	36
Future Volume (vph)	36
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.87
Adj. Flow (vph)	41
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	
Heavy Vehicles (%)	12%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	277	185	139	171	181	321	307	588	45	323	615	836
Future Volume (vph)	277	185	139	171	181	321	307	588	45	323	615	836
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.3	5.3	5.3	4.9	4.9	4.9	4.7	5.4	5.4	4.7	5.4	5.4
Lane Util. Factor	0.91	0.91	1.00	0.95	0.95	1.00	0.97	0.95	1.00	0.97	0.95	1.00
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.98	1.00	1.00	1.00	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	0.98	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1521	3121	1583	1681	1658	1411	3433	3539	1583	3127	3539	1519
Flt Permitted	0.95	0.98	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1521	3121	1583	1681	1658	1411	3433	3539	1583	3127	3539	1519
Peak-hour factor, PHF	0.83	0.83	0.83	0.88	0.88	0.88	0.78	0.78	0.78	0.80	0.80	0.80
Adj. Flow (vph)	334	223	167	194	206	365	394	754	58	404	769	1045
RTOR Reduction (vph)	0	0	142	0	0	253	0	0	37	0	0	287
Lane Group Flow (vph)	184	373	25	175	225	112	394	754	21	404	769	758
Confl. Peds. (#/hr)	5					5						
Confl. Bikes (#/hr)												1
Heavy Vehicles (%)	8%	9%	2%	2%	9%	12%	2%	2%	2%	12%	2%	5%
Turn Type	Split	NA	Perm	Split	NA	Perm	Prot	NA	Perm	Prot	NA	Perm
Protected Phases	7	7		8	8		5	2		1	6	
Permitted Phases			7			8			2			6
Actuated Green, G (s)	18.2	18.2	18.2	18.8	18.8	18.8	16.8	44.2	44.2	18.5	45.9	45.9
Effective Green, g (s)	18.2	18.2	18.2	18.8	18.8	18.8	16.8	44.2	44.2	18.5	45.9	45.9
Actuated g/C Ratio	0.15	0.15	0.15	0.16	0.16	0.16	0.14	0.37	0.37	0.15	0.38	0.38
Clearance Time (s)	5.3	5.3	5.3	4.9	4.9	4.9	4.7	5.4	5.4	4.7	5.4	5.4
Vehicle Extension (s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0	2.0	3.0	3.0
Lane Grp Cap (vph)	230	473	240	263	259	221	480	1303	583	482	1353	581
v/s Ratio Prot	c0.12	0.12		0.10	c0.14		0.11	0.21		c0.13	0.22	
v/s Ratio Perm			0.02			0.08			0.01			c0.50
v/c Ratio	0.80	0.79	0.11	0.67	0.87	0.51	0.82	0.58	0.04	0.84	0.57	1.30
Uniform Delay, d1	49.1	49.0	43.9	47.6	49.4	46.4	50.1	30.4	24.3	49.3	29.2	37.1
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	1.00
Incremental Delay, d2	16.9	7.9	0.1	4.9	24.4	0.7	10.3	1.9	0.1	7.0	1.0	144.2
Delay (s)	66.0	56.9	44.0	52.5	73.8	47.0	60.4	32.3	24.4	56.2	29.6	181.0
Level of Service	E	E	D	D	E	D	E	C	C	E	C	F
Approach Delay (s)		56.2			56.1			41.1			105.8	
Approach LOS		E			E			D			F	

Intersection Summary			
HCM 2000 Control Delay	74.9	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.06		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	20.3
Intersection Capacity Utilization	83.0%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL
Lane Configurations												
Traffic Volume (vph)	14	24	13	1	177	149	301	1	82	923	231	416
Future Volume (vph)	14	24	13	1	177	149	301	1	82	923	231	416
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.6	5.3			4.6	5.3	5.3		4.6	5.3	5.3	4.6
Lane Util. Factor	1.00	0.95			0.97	1.00	1.00		1.00	0.95	1.00	0.97
Frpb, ped/bikes	1.00	1.00			1.00	1.00	0.99		1.00	1.00	0.99	1.00
Flpb, ped/bikes	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Frt	1.00	0.95			1.00	1.00	0.85		1.00	1.00	0.85	1.00
Flt Protected	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (prot)	1770	3353			3047	1863	1533		1770	3471	1408	3367
Flt Permitted	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (perm)	1770	3353			3047	1863	1533		1770	3471	1408	3367
Peak-hour factor, PHF	0.91	0.91	0.91	0.93	0.93	0.93	0.93	0.86	0.86	0.86	0.86	0.94
Adj. Flow (vph)	15	26	14	1	190	160	324	1	95	1073	269	443
RTOR Reduction (vph)	0	13	0	0	0	0	269	0	0	0	86	0
Lane Group Flow (vph)	15	27	0	0	191	160	55	0	96	1073	183	443
Confl. Peds. (#/hr)	1						1		1		2	2
Confl. Bikes (#/hr)											1	
Heavy Vehicles (%)	2%	2%	2%	0%	15%	2%	4%	0%	2%	4%	13%	4%
Turn Type	Prot	NA		Prot	Prot	NA	Perm	Prot	Prot	NA	Perm	Prot
Protected Phases	7	4		3	3	8		5	5	2		1
Permitted Phases							8				2	
Actuated Green, G (s)	2.7	9.8			12.9	20.0	20.0		12.4	54.3	54.3	20.7
Effective Green, g (s)	2.7	9.8			12.9	20.0	20.0		12.4	54.3	54.3	20.7
Actuated g/C Ratio	0.02	0.08			0.11	0.17	0.17		0.11	0.46	0.46	0.18
Clearance Time (s)	4.6	5.3			4.6	5.3	5.3		4.6	5.3	5.3	4.6
Vehicle Extension (s)	2.0	2.0			2.0	2.0	2.0		2.0	4.0	4.0	2.0
Lane Grp Cap (vph)	40	279			334	317	260		186	1604	650	593
v/s Ratio Prot	0.01	0.01			c0.06	c0.09			0.05	0.31		c0.13
v/s Ratio Perm							0.04				0.13	
v/c Ratio	0.38	0.10			0.57	0.50	0.21		0.52	0.67	0.28	0.75
Uniform Delay, d1	56.6	49.8			49.7	44.3	42.0		49.7	24.6	19.5	45.9
Progression Factor	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2	2.1	0.1			1.5	0.5	0.1		1.0	1.2	0.3	4.5
Delay (s)	58.7	49.8			51.1	44.7	42.1		50.7	25.8	19.9	50.4
Level of Service	E	D			D	D	D		D	C	B	D
Approach Delay (s)		52.2				45.3				26.3		
Approach LOS		D				D				C		

Intersection Summary			
HCM 2000 Control Delay	31.3	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	117.5	Sum of lost time (s)	19.8
Intersection Capacity Utilization	67.5%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR
Lane Configurations		
Traffic Volume (vph)	1187	43
Future Volume (vph)	1187	43
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	5.3	
Lane Util. Factor	0.95	
Frpb, ped/bikes	1.00	
Flpb, ped/bikes	1.00	
Frt	0.99	
Flt Protected	1.00	
Satd. Flow (prot)	3452	
Flt Permitted	1.00	
Satd. Flow (perm)	3452	
Peak-hour factor, PHF	0.94	0.94
Adj. Flow (vph)	1263	46
RTOR Reduction (vph)	1	0
Lane Group Flow (vph)	1308	0
Confl. Peds. (#/hr)		1
Confl. Bikes (#/hr)		1
Heavy Vehicles (%)	4%	2%
Turn Type	NA	
Protected Phases	6	
Permitted Phases		
Actuated Green, G (s)	62.6	
Effective Green, g (s)	62.6	
Actuated g/C Ratio	0.53	
Clearance Time (s)	5.3	
Vehicle Extension (s)	4.0	
Lane Grp Cap (vph)	1839	
v/s Ratio Prot	c0.38	
v/s Ratio Perm		
v/c Ratio	0.71	
Uniform Delay, d1	20.7	
Progression Factor	1.00	
Incremental Delay, d2	1.4	
Delay (s)	22.1	
Level of Service	C	
Approach Delay (s)	29.2	
Approach LOS	C	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	31	13	25	39	7	60	6	31	978	51	63	1151
Future Volume (vph)	31	13	25	39	7	60	6	31	978	51	63	1151
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.9			4.9			4.9	5.3		4.9	5.3
Lane Util. Factor		1.00			1.00			1.00	0.95		1.00	0.95
Frpb, ped/bikes		0.99			0.97			1.00	1.00		1.00	1.00
Flpb, ped/bikes		0.99			1.00			1.00	1.00		1.00	1.00
Frt		0.95			0.92			1.00	0.99		1.00	1.00
Flt Protected		0.98			0.98			0.95	1.00		0.95	1.00
Satd. Flow (prot)		1486			1641			1775	3409		1770	3399
Flt Permitted		0.64			0.83			0.95	1.00		0.95	1.00
Satd. Flow (perm)		975			1389			1775	3409		1770	3399
Peak-hour factor, PHF	0.74	0.74	0.74	0.58	0.58	0.58	0.81	0.81	0.81	0.81	0.89	0.89
Adj. Flow (vph)	42	18	34	67	12	103	7	38	1207	63	71	1293
RTOR Reduction (vph)	0	23	0	0	52	0	0	0	2	0	0	1
Lane Group Flow (vph)	0	71	0	0	130	0	0	45	1268	0	71	1319
Confl. Peds. (#/hr)	29		11	11		29		2		11	11	
Confl. Bikes (#/hr)			2			1				3		
Heavy Vehicles (%)	35%	2%	2%	2%	2%	2%	0%	2%	5%	2%	2%	5%
Turn Type	Perm	NA		Perm	NA		Prot	Prot	NA		Prot	NA
Protected Phases		4			8		5	5	2		1	6
Permitted Phases	4			8								
Actuated Green, G (s)		13.2			13.2			4.5	69.9		6.8	72.2
Effective Green, g (s)		13.2			13.2			4.5	69.9		6.8	72.2
Actuated g/C Ratio		0.13			0.13			0.04	0.67		0.06	0.69
Clearance Time (s)		4.9			4.9			4.9	5.3		4.9	5.3
Vehicle Extension (s)		1.5			1.5			1.0	4.0		1.0	4.5
Lane Grp Cap (vph)		122			174			76	2269		114	2337
v/s Ratio Prot								0.03	0.37		c0.04	c0.39
v/s Ratio Perm		0.07			c0.09							
v/c Ratio		0.58			0.75			0.59	0.56		0.62	0.56
Uniform Delay, d1		43.3			44.3			49.3	9.3		47.9	8.4
Progression Factor		1.00			1.00			1.00	1.00		1.00	1.00
Incremental Delay, d2		4.5			14.3			8.0	1.0		7.4	1.0
Delay (s)		47.8			58.6			57.3	10.3		55.2	9.4
Level of Service		D			E			E	B		E	A
Approach Delay (s)		47.8			58.6				11.9			11.7
Approach LOS		D			E				B			B

Intersection Summary			
HCM 2000 Control Delay	15.8	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	105.0	Sum of lost time (s)	15.1
Intersection Capacity Utilization	66.9%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	24
Future Volume (vph)	24
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.89
Adj. Flow (vph)	27
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	2
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	46%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR2	WBU	WBL2	WBL	WBT	WBR	NBL	NBT	NBR	SBU
Lane Configurations												
Traffic Volume (vph)	86	58	31	8	12	72	20	243	17	755	97	5
Future Volume (vph)	86	58	31	8	12	72	20	243	17	755	97	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.9				4.9	4.9	4.9	4.9	5.3	5.3	
Lane Util. Factor		0.95				1.00	1.00	1.00	1.00	0.95	1.00	
Frpb, ped/bikes		1.00				1.00	1.00	0.98	1.00	1.00	0.98	
Flpb, ped/bikes		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Frt		0.97				1.00	1.00	0.85	1.00	1.00	0.85	
Flt Protected		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (prot)		3363				1746	1863	1518	1770	3438	1529	
Flt Permitted		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (perm)		3363				1746	1863	1518	1770	3438	1529	
Peak-hour factor, PHF	0.83	0.83	0.83	0.71	0.71	0.71	0.71	0.71	0.76	0.76	0.76	0.86
Adj. Flow (vph)	104	70	37	11	17	101	28	342	22	993	128	6
RTOR Reduction (vph)	0	130	0	0	0	0	0	297	0	0	0	0
Lane Group Flow (vph)	0	81	0	0	0	129	28	45	22	993	128	0
Confl. Peds. (#/hr)	13					3		13	3		2	
Confl. Bikes (#/hr)											2	
Heavy Vehicles (%)	2%	2%	2%	0%	2%	4%	2%	4%	2%	5%	4%	0%
Turn Type	Split	NA		Split	Split	Split	NA	Perm	Prot	NA	Perm	Prot
Protected Phases	4	4		8	8	8	8		5	2		1
Permitted Phases								8			2	
Actuated Green, G (s)		8.0				12.0	12.0	12.0	2.4	38.7	38.7	
Effective Green, g (s)		8.0				12.0	12.0	12.0	2.4	38.7	38.7	
Actuated g/C Ratio		0.09				0.13	0.13	0.13	0.03	0.42	0.42	
Clearance Time (s)		4.9				4.9	4.9	4.9	4.9	5.3	5.3	
Vehicle Extension (s)		3.0				2.0	2.0	2.0	2.0	4.0	4.0	
Lane Grp Cap (vph)		294				229	244	199	46	1457	648	
v/s Ratio Prot		c0.02				c0.07	0.02		0.01	c0.29		
v/s Ratio Perm								0.03			0.08	
v/c Ratio		0.27				0.56	0.11	0.23	0.48	0.68	0.20	
Uniform Delay, d1		38.9				37.2	35.0	35.5	43.8	21.3	16.5	
Progression Factor		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2		0.5				1.9	0.1	0.2	2.8	1.4	0.2	
Delay (s)		39.4				39.1	35.0	35.7	46.7	22.8	16.7	
Level of Service		D				D	D	D	D	C	B	
Approach Delay (s)		39.4					36.5			22.5		
Approach LOS		D					D			C		

Intersection Summary			
HCM 2000 Control Delay	25.4	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	91.3	Sum of lost time (s)	20.0
Intersection Capacity Utilization	72.1%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBL2	SBL	SBT	SBR	NWR2
Lane Configurations					
Traffic Volume (vph)	235	16	824	24	45
Future Volume (vph)	235	16	824	24	45
Ideal Flow (vphpl)	1900	1900	1900	1900	1900
Total Lost time (s)	4.9	4.9	5.3		4.9
Lane Util. Factor	0.91	0.95	0.95		1.00
Frpb, ped/bikes	1.00	1.00	1.00		0.99
Flpb, ped/bikes	1.00	1.00	1.00		1.00
Frt	1.00	1.00	1.00		0.86
Flt Protected	0.95	0.95	1.00		1.00
Satd. Flow (prot)	1582	1653	3424		1589
Flt Permitted	0.95	0.95	1.00		1.00
Satd. Flow (perm)	1582	1653	3424		1589
Peak-hour factor, PHF	0.86	0.86	0.86	0.86	0.75
Adj. Flow (vph)	273	19	958	28	60
RTOR Reduction (vph)	0	0	1	0	52
Lane Group Flow (vph)	148	150	985	0	8
Confl. Peds. (#/hr)	2	2		3	
Confl. Bikes (#/hr)					1
Heavy Vehicles (%)	4%	2%	5%	2%	2%
Turn Type	Prot	Prot	NA		Perm
Protected Phases	1	1	6		
Permitted Phases					8
Actuated Green, G (s)	12.6	12.6	48.9		12.0
Effective Green, g (s)	12.6	12.6	48.9		12.0
Actuated g/C Ratio	0.14	0.14	0.54		0.13
Clearance Time (s)	4.9	4.9	5.3		4.9
Vehicle Extension (s)	1.0	1.0	4.0		2.0
Lane Grp Cap (vph)	218	228	1833		208
v/s Ratio Prot	c0.09	0.09	0.29		
v/s Ratio Perm					0.00
v/c Ratio	0.68	0.66	0.54		0.04
Uniform Delay, d1	37.4	37.3	13.8		34.6
Progression Factor	1.00	1.00	1.00		1.00
Incremental Delay, d2	6.5	5.1	0.4		0.0
Delay (s)	43.9	42.4	14.2		34.6
Level of Service	D	D	B		C
Approach Delay (s)			20.9		
Approach LOS			C		

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBU	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	33	24	16	178	12	5	9	595	143	2	6	936
Future Volume (vph)	33	24	16	178	12	5	9	595	143	2	6	936
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.9		4.9	4.9	4.9	4.9	5.7	5.7		4.9	5.7
Lane Util. Factor		1.00		0.95	0.95	1.00	1.00	0.95	1.00		1.00	0.95
Frpb, ped/bikes		1.00		1.00	1.00	0.98	1.00	1.00	0.98		1.00	1.00
Flpb, ped/bikes		1.00		1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
Frt		0.97		1.00	1.00	0.85	1.00	1.00	0.85		1.00	1.00
Flt Protected		0.98		0.95	0.96	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (prot)		1535		1681	1696	1555	1766	3471	1550		1770	3421
Flt Permitted		0.80		0.78	0.76	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (perm)		1256		1377	1347	1555	1766	3471	1550		1770	3421
Peak-hour factor, PHF	0.78	0.78	0.78	0.68	0.68	0.68	0.74	0.74	0.74	0.79	0.79	0.79
Adj. Flow (vph)	42	31	21	262	18	7	12	804	193	3	8	1185
RTOR Reduction (vph)	0	10	0	0	0	6	0	0	61	0	0	0
Lane Group Flow (vph)	0	84	0	139	141	1	12	804	132	0	11	1203
Confl. Peds. (#/hr)	4					4	7					
Confl. Bikes (#/hr)						1			2			
Heavy Vehicles (%)	36%	2%	2%	2%	2%	2%	2%	4%	2%	2%	2%	4%
Turn Type	Perm	NA		Perm	NA	Perm	Prot	NA	Perm	Prot	Prot	NA
Protected Phases		4			8		5	2		1	1	6
Permitted Phases	4			8		8			2			
Actuated Green, G (s)		11.8		11.8	11.8	11.8	0.8	38.0	38.0		0.8	38.0
Effective Green, g (s)		11.8		11.8	11.8	11.8	0.8	38.0	38.0		0.8	38.0
Actuated g/C Ratio		0.18		0.18	0.18	0.18	0.01	0.57	0.57		0.01	0.57
Clearance Time (s)		4.9		4.9	4.9	4.9	4.9	5.7	5.7		4.9	5.7
Vehicle Extension (s)		2.0		2.0	2.0	2.0	1.0	4.0	4.0		1.0	4.0
Lane Grp Cap (vph)		224		245	240	277	21	1995	891		21	1966
v/s Ratio Prot							c0.01	0.23			0.01	c0.35
v/s Ratio Perm		0.07		0.10	c0.10	0.00			0.09			
v/c Ratio		0.38		0.57	0.59	0.00	0.57	0.40	0.15		0.52	0.61
Uniform Delay, d1		23.9		24.8	24.9	22.3	32.5	7.8	6.5		32.5	9.2
Progression Factor		1.00		1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
Incremental Delay, d2		0.4		1.8	2.4	0.0	21.2	0.2	0.1		10.4	0.7
Delay (s)		24.3		26.6	27.3	22.3	53.7	8.0	6.6		42.9	9.9
Level of Service		C		C	C	C	D	A	A		D	A
Approach Delay (s)		24.3			26.8			8.2				10.2
Approach LOS		C			C			A				B

Intersection Summary			
HCM 2000 Control Delay	11.8	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	66.1	Sum of lost time (s)	15.5
Intersection Capacity Utilization	45.9%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	14
Future Volume (vph)	14
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.79
Adj. Flow (vph)	18
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	7
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	86%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBT	WBR	WBR2	NBL2	NBT	NBR	SBU	SBL	SBR
Lane Configurations												
Traffic Volume (vph)	724	765	233	751	208	267	180	635	131	48	179	575
Future Volume (vph)	724	765	233	751	208	267	180	635	131	48	179	575
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	2.6	4.0	4.0	4.0	4.0	4.0			4.0	4.0
Lane Util. Factor	0.97	0.95	1.00	0.95	1.00	1.00	1.00	0.95			1.00	0.88
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.98	1.00	1.00			1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.85	0.85	1.00	0.97			1.00	0.85
Flt Protected	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (prot)	3127	3223	1392	3223	1442	1408	1543	3132			1649	2538
Flt Permitted	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (perm)	3127	3223	1392	3223	1442	1408	1543	3132			1649	2538
Peak-hour factor, PHF	0.88	0.88	0.88	0.95	0.95	0.95	0.89	0.89	0.89	0.94	0.94	0.94
Adj. Flow (vph)	823	869	265	791	219	281	202	713	147	51	190	612
RTOR Reduction (vph)	0	0	0	0	0	112	0	14	0	0	0	40
Lane Group Flow (vph)	823	869	265	791	219	169	202	846	0	0	241	603
Confl. Peds. (#/hr)	9					9			4		4	
Heavy Vehicles (%)	12%	12%	16%	12%	12%	12%	17%	12%	12%	0%	12%	12%
Turn Type	Prot	NA	Free	NA	Prot	Perm	Split	NA		Prot	Prot	pt+ov
Protected Phases	5	2		6	6		8	8		7	7	7 5
Permitted Phases			Free			6						
Actuated Green, G (s)	26.0	62.1	130.0	32.4	32.4	32.4	35.6	35.6			17.4	47.8
Effective Green, g (s)	25.7	63.5	130.0	33.8	33.8	33.8	36.7	36.7			17.8	48.2
Actuated g/C Ratio	0.20	0.49	1.00	0.26	0.26	0.26	0.28	0.28			0.14	0.37
Clearance Time (s)	3.7	5.4		5.4	5.4	5.4	5.1	5.1			4.4	
Vehicle Extension (s)	2.0	4.0		4.0	4.0	4.0	2.0	2.0			2.0	
Lane Grp Cap (vph)	618	1574	1392	837	374	366	435	884			225	941
v/s Ratio Prot	c0.26	0.27		c0.25	0.15		0.13	c0.27			c0.15	0.24
v/s Ratio Perm			0.19			0.12						
v/c Ratio	1.33	0.55	0.19	0.95	0.59	0.46	0.46	0.96			1.07	0.64
Uniform Delay, d1	52.1	23.3	0.0	47.2	42.0	40.5	38.5	45.9			56.1	33.8
Progression Factor	0.72	1.03	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Incremental Delay, d2	156.3	0.9	0.2	20.3	6.6	4.2	0.3	20.3			80.1	1.1
Delay (s)	194.0	24.8	0.2	67.5	48.6	44.6	38.8	66.1			136.2	34.9
Level of Service	F	C	A	E	D	D	D	E			F	C
Approach Delay (s)		92.6		59.3				60.9				
Approach LOS		F		E				E				

Intersection Summary			
HCM 2000 Control Delay	72.7	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.05		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	93.6%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

Movement	SBR2
Lane Configurations	
Traffic Volume (vph)	29
Future Volume (vph)	29
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.94
Adj. Flow (vph)	31
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	
Heavy Vehicles (%)	12%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBU	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	420	513	289	300	104	340	255	866	146	4	479	747
Future Volume (vph)	420	513	289	300	104	340	255	866	146	4	479	747
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		4.0	4.0
Lane Util. Factor	0.91	0.91	1.00	0.95	0.95	1.00	0.97	0.95	1.00		0.97	0.95
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00		1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85		1.00	1.00
Flt Protected	0.95	0.99	1.00	0.95	0.98	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (prot)	1550	3232	1583	1681	1638	1423	3433	3539	1583		3129	3539
Flt Permitted	0.95	0.99	1.00	0.95	0.98	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (perm)	1550	3232	1583	1681	1638	1423	3433	3539	1583		3129	3539
Peak-hour factor, PHF	0.96	0.96	0.96	0.95	0.95	0.95	0.92	0.92	0.92	0.91	0.91	0.91
Adj. Flow (vph)	438	534	301	316	109	358	277	941	159	4	526	821
RTOR Reduction (vph)	0	0	189	0	0	222	0	0	95	0	0	0
Lane Group Flow (vph)	315	657	112	209	216	136	277	941	64	0	530	821
Confl. Peds. (#/hr)							10					
Confl. Bikes (#/hr)						1						
Heavy Vehicles (%)	6%	6%	2%	2%	13%	12%	2%	2%	2%	0%	12%	2%
Turn Type	Split	NA	Perm	Split	NA	Perm	Prot	NA	Perm	Prot	Prot	NA
Protected Phases	7	7		8	8		5	2		1	1	6
Permitted Phases			7			8			2			
Actuated Green, G (s)	29.7	29.7	29.7	20.0	20.0	20.0	14.5	36.0	36.0		24.0	45.5
Effective Green, g (s)	31.0	31.0	31.0	20.9	20.9	20.9	15.2	37.4	37.4		24.7	46.9
Actuated g/C Ratio	0.24	0.24	0.24	0.16	0.16	0.16	0.12	0.29	0.29		0.19	0.36
Clearance Time (s)	5.3	5.3	5.3	4.9	4.9	4.9	4.7	5.4	5.4		4.7	5.4
Vehicle Extension (s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0		2.0	3.0
Lane Grp Cap (vph)	369	770	377	270	263	228	401	1018	455		594	1276
v/s Ratio Prot	0.20	c0.20		0.12	c0.13		0.08	c0.27			c0.17	0.23
v/s Ratio Perm			0.07			0.10			0.04			
v/c Ratio	0.85	0.85	0.30	0.77	0.82	0.59	0.69	0.92	0.14		0.89	0.64
Uniform Delay, d1	47.3	47.3	40.6	52.3	52.7	50.6	55.1	44.9	34.4		51.4	34.6
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		0.95	0.83
Incremental Delay, d2	16.6	8.8	0.2	11.9	17.5	2.8	4.1	15.0	0.6		11.2	1.7
Delay (s)	63.9	56.1	40.7	64.2	70.2	53.4	59.3	59.9	35.0		59.7	30.5
Level of Service	E	E	D	E	E	D	E	E	D		E	C
Approach Delay (s)		54.4			60.9			56.9				42.5
Approach LOS		D			E			E				D

Intersection Summary			
HCM 2000 Control Delay	52.1	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.88		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	16.7
Intersection Capacity Utilization	89.7%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	352
Future Volume (vph)	352
Ideal Flow (vphpl)	1900
Total Lost time (s)	4.0
Lane Util. Factor	1.00
Frpb, ped/bikes	0.97
Flpb, ped/bikes	1.00
Frt	0.85
Flt Protected	1.00
Satd. Flow (prot)	1469
Flt Permitted	1.00
Satd. Flow (perm)	1469
Peak-hour factor, PHF	0.91
Adj. Flow (vph)	387
RTOR Reduction (vph)	247
Lane Group Flow (vph)	140
Confl. Peds. (#/hr)	10
Confl. Bikes (#/hr)	7
Heavy Vehicles (%)	7%
Turn Type	Perm
Protected Phases	
Permitted Phases	6
Actuated Green, G (s)	45.5
Effective Green, g (s)	46.9
Actuated g/C Ratio	0.36
Clearance Time (s)	5.4
Vehicle Extension (s)	3.0
Lane Grp Cap (vph)	529
v/s Ratio Prot	
v/s Ratio Perm	0.10
v/c Ratio	0.26
Uniform Delay, d1	29.4
Progression Factor	1.49
Incremental Delay, d2	0.8
Delay (s)	44.6
Level of Service	D
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL
Lane Configurations												
Traffic Volume (vph)	87	119	70	2	178	34	347	2	17	1342	181	417
Future Volume (vph)	87	119	70	2	178	34	347	2	17	1342	181	417
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			3.3	4.0	4.0		4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	0.95			0.97	1.00	1.00		1.00	0.95	1.00	0.97
Frpb, ped/bikes	1.00	0.99			1.00	1.00	0.98		1.00	1.00	0.99	1.00
Flpb, ped/bikes	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Frt	1.00	0.94			1.00	1.00	0.85		1.00	1.00	0.85	1.00
Flt Protected	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (prot)	1770	3322			3049	1863	1527		1773	3471	1386	3367
Flt Permitted	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (perm)	1770	3322			3049	1863	1527		1773	3471	1386	3367
Peak-hour factor, PHF	0.71	0.71	0.71	0.90	0.90	0.90	0.90	0.89	0.89	0.89	0.89	0.88
Adj. Flow (vph)	123	168	99	2	198	38	386	2	19	1508	203	474
RTOR Reduction (vph)	0	76	0	0	0	0	253	0	0	0	62	0
Lane Group Flow (vph)	123	191	0	0	200	38	133	0	21	1508	141	474
Confl. Peds. (#/hr)	4		4		4		4		3		1	1
Confl. Bikes (#/hr)												
Heavy Vehicles (%)	2%	2%	2%	0%	15%	2%	4%	0%	2%	4%	15%	4%
Turn Type	Prot	NA		Prot	Prot	NA	Perm	Prot	Prot	NA	Perm	Prot
Protected Phases	7	4		3	3	8		5	5	2		1
Permitted Phases							8				2	
Actuated Green, G (s)	14.0	16.9			13.9	16.8	16.8		6.0	55.2	55.2	28.2
Effective Green, g (s)	14.6	18.2			15.2	18.1	18.1		6.6	56.5	56.5	28.8
Actuated g/C Ratio	0.11	0.14			0.11	0.14	0.14		0.05	0.42	0.42	0.21
Clearance Time (s)	4.6	5.3			4.6	5.3	5.3		4.6	5.3	5.3	4.6
Vehicle Extension (s)	3.0	2.0			3.0	2.0	2.0		2.0	4.0	4.0	2.0
Lane Grp Cap (vph)	192	451			345	251	206		87	1463	584	723
v/s Ratio Prot	c0.07	0.06			0.07	0.02			0.01	c0.43		c0.14
v/s Ratio Perm							c0.09				0.10	
v/c Ratio	0.64	0.42			0.58	0.15	0.64		0.24	1.03	0.24	0.66
Uniform Delay, d1	57.2	53.1			56.4	51.2	54.9		61.3	38.8	25.0	48.1
Progression Factor	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2	7.1	0.2			2.4	0.1	5.1		0.5	31.8	1.0	1.6
Delay (s)	64.3	53.3			58.7	51.3	60.0		61.8	70.5	25.9	49.7
Level of Service	E	D			E	D	E		E	E	C	D
Approach Delay (s)		56.8				59.0				65.2		
Approach LOS		E				E				E		

Intersection Summary			
HCM 2000 Control Delay	49.0	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.83		
Actuated Cycle Length (s)	134.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	80.1%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR
Lane Configurations		
Traffic Volume (vph)	1130	10
Future Volume (vph)	1130	10
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	4.0	
Lane Util. Factor	0.95	
Frpb, ped/bikes	1.00	
Flpb, ped/bikes	1.00	
Frt	1.00	
Flt Protected	1.00	
Satd. Flow (prot)	3466	
Flt Permitted	1.00	
Satd. Flow (perm)	3466	
Peak-hour factor, PHF	0.88	0.88
Adj. Flow (vph)	1284	11
RTOR Reduction (vph)	0	0
Lane Group Flow (vph)	1295	0
Confl. Peds. (#/hr)		3
Confl. Bikes (#/hr)		4
Heavy Vehicles (%)	4%	2%
Turn Type	NA	
Protected Phases	6	
Permitted Phases		
Actuated Green, G (s)	77.4	
Effective Green, g (s)	78.7	
Actuated g/C Ratio	0.59	
Clearance Time (s)	5.3	
Vehicle Extension (s)	4.0	
Lane Grp Cap (vph)	2035	
v/s Ratio Prot	0.37	
v/s Ratio Perm		
v/c Ratio	0.64	
Uniform Delay, d1	18.2	
Progression Factor	1.00	
Incremental Delay, d2	1.5	
Delay (s)	19.7	
Level of Service	B	
Approach Delay (s)	27.8	
Approach LOS	C	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL
Lane Configurations												
Traffic Volume (vph)	30	15	31	21	14	22	12	44	1241	26	7	44
Future Volume (vph)	30	15	31	21	14	22	12	44	1241	26	7	44
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0			4.0	4.0			4.0
Lane Util. Factor		1.00			1.00			1.00	0.95			1.00
Frpb, ped/bikes		0.99			0.99			1.00	1.00			1.00
Flpb, ped/bikes		1.00			1.00			1.00	1.00			1.00
Frt		0.95			0.95			1.00	1.00			1.00
Flt Protected		0.98			0.98			0.95	1.00			0.95
Satd. Flow (prot)		1504			1714			1777	3423			1774
Flt Permitted		0.77			0.78			0.95	1.00			0.12
Satd. Flow (perm)		1186			1360			1777	3423			220
Peak-hour factor, PHF	0.75	0.75	0.75	0.65	0.65	0.65	0.93	0.93	0.93	0.93	0.96	0.96
Adj. Flow (vph)	40	20	41	32	22	34	13	47	1334	28	7	46
RTOR Reduction (vph)	0	25	0	0	23	0	0	0	1	0	0	0
Lane Group Flow (vph)	0	76	0	0	65	0	0	60	1361	0	0	53
Confl. Peds. (#/hr)	7		7	7		7		6		22		22
Confl. Bikes (#/hr)						2				1		
Heavy Vehicles (%)	37%	2%	2%	2%	2%	2%	0%	2%	5%	2%	0%	2%
Turn Type	Perm	NA		Perm	NA		Prot	Prot	NA			Prot
Protected Phases		4			8		5	5	2			1
Permitted Phases	4			8								
Actuated Green, G (s)		10.4			10.4			6.6	56.4			33.1
Effective Green, g (s)		11.3			11.3			7.5	57.7			34.0
Actuated g/C Ratio		0.10			0.10			0.07	0.50			0.30
Clearance Time (s)		4.9			4.9			4.9	5.3			4.9
Vehicle Extension (s)		1.5			1.5			1.0	4.0			1.0
Lane Grp Cap (vph)		116			133			115	1717			65
v/s Ratio Prot								0.03	c0.40			
v/s Ratio Perm		c0.06			0.05							c0.24
v/c Ratio		0.65			0.49			0.52	0.79			0.82
Uniform Delay, d1		50.0			49.1			52.0	23.7			37.6
Progression Factor		1.00			1.00			1.00	1.00			1.00
Incremental Delay, d2		9.6			1.0			2.0	3.8			50.2
Delay (s)		59.6			50.2			54.0	27.5			87.8
Level of Service		E			D			D	C			F
Approach Delay (s)		59.6			50.2				28.7			
Approach LOS		E			D				C			

Intersection Summary			
HCM 2000 Control Delay	22.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	115.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	58.4%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR
Lane Configurations		
Traffic Volume (vph)	1198	34
Future Volume (vph)	1198	34
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	4.0	
Lane Util. Factor	0.95	
Frpb, ped/bikes	1.00	
Flpb, ped/bikes	1.00	
Frt	1.00	
Flt Protected	1.00	
Satd. Flow (prot)	3397	
Flt Permitted	1.00	
Satd. Flow (perm)	3397	
Peak-hour factor, PHF	0.96	0.96
Adj. Flow (vph)	1248	35
RTOR Reduction (vph)	1	0
Lane Group Flow (vph)	1282	0
Confl. Peds. (#/hr)		6
Confl. Bikes (#/hr)		5
Heavy Vehicles (%)	5%	32%
Turn Type	NA	
Protected Phases	6	
Permitted Phases		
Actuated Green, G (s)	82.9	
Effective Green, g (s)	84.2	
Actuated g/C Ratio	0.73	
Clearance Time (s)	5.3	
Vehicle Extension (s)	4.5	
Lane Grp Cap (vph)	2487	
v/s Ratio Prot	0.38	
v/s Ratio Perm		
v/c Ratio	0.52	
Uniform Delay, d1	6.6	
Progression Factor	1.00	
Incremental Delay, d2	0.8	
Delay (s)	7.4	
Level of Service	A	
Approach Delay (s)	10.6	
Approach LOS	B	

Intersection Summary

Movement	EBL	EBT	EBR2	WBU	WBL2	WBL	WBT	WBR	NBL	NBT	NBR	SBU
Lane Configurations												
Traffic Volume (vph)	31	42	8	9	14	40	52	227	12	1017	88	17
Future Volume (vph)	31	42	8	9	14	40	52	227	12	1017	88	17
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0				4.0	4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor		0.95				1.00	1.00	1.00	1.00	0.95	1.00	
Frpb, ped/bikes		1.00				1.00	1.00	0.98	1.00	1.00	0.99	
Flpb, ped/bikes		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Frt		0.99				1.00	1.00	0.85	1.00	1.00	0.85	
Flt Protected		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (prot)		3418				1752	1863	1526	1770	3438	1532	
Flt Permitted		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (perm)		3418				1752	1863	1526	1770	3438	1532	
Peak-hour factor, PHF	0.70	0.70	0.70	0.95	0.95	0.95	0.95	0.95	0.92	0.92	0.92	0.88
Adj. Flow (vph)	44	60	11	9	15	42	55	239	13	1105	96	19
RTOR Reduction (vph)	0	106	0	0	0	0	0	215	0	0	0	0
Lane Group Flow (vph)	0	9	0	0	0	66	55	24	13	1105	96	0
Confl. Peds. (#/hr)	4		2			2		4			1	
Confl. Bikes (#/hr)								1			1	
Heavy Vehicles (%)	2%	2%	2%	0%	2%	4%	2%	4%	2%	5%	4%	0%
Turn Type	Split	NA		Split	Split	Split	NA	Perm	Prot	NA	Perm	Prot
Protected Phases	4	4		8	8	8	8		5	2		1
Permitted Phases								8			2	
Actuated Green, G (s)		6.2				8.4	8.4	8.4	1.1	41.2	41.2	
Effective Green, g (s)		7.1				9.3	9.3	9.3	2.0	42.5	42.5	
Actuated g/C Ratio		0.08				0.10	0.10	0.10	0.02	0.47	0.47	
Clearance Time (s)		4.9				4.9	4.9	4.9	4.9	5.3	5.3	
Vehicle Extension (s)		3.0				2.0	2.0	2.0	2.0	4.0	4.0	
Lane Grp Cap (vph)		266				178	190	155	38	1603	714	
v/s Ratio Prot		c0.00				c0.04	0.03		0.01	c0.32		
v/s Ratio Perm								0.02			0.06	
v/c Ratio		0.03				0.37	0.29	0.16	0.34	0.69	0.13	
Uniform Delay, d1		38.8				38.2	37.8	37.3	43.9	19.1	13.8	
Progression Factor		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2		0.1				0.5	0.3	0.2	2.0	1.4	0.1	
Delay (s)		38.9				38.6	38.2	37.5	45.9	20.5	13.9	
Level of Service		D				D	D	D	D	C	B	
Approach Delay (s)		38.9					37.8			20.2		
Approach LOS		D					D			C		

Intersection Summary			
HCM 2000 Control Delay	25.5	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	91.1	Sum of lost time (s)	16.0
Intersection Capacity Utilization	75.6%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBL2	SBL	SBT	SBR	NWR2
Lane Configurations					
Traffic Volume (vph)	383	20	743	68	31
Future Volume (vph)	383	20	743	68	31
Ideal Flow (vphpl)	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0
Lane Util. Factor	0.91	0.95	0.95		1.00
Frpb, ped/bikes	1.00	1.00	1.00		1.00
Flpb, ped/bikes	1.00	1.00	1.00		1.00
Frt	1.00	1.00	0.99		0.86
Flt Protected	0.95	0.95	1.00		1.00
Satd. Flow (prot)	1584	1652	3367		1611
Flt Permitted	0.95	0.95	1.00		1.00
Satd. Flow (perm)	1584	1652	3367		1611
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.60
Adj. Flow (vph)	435	23	844	77	52
RTOR Reduction (vph)	0	0	3	0	47
Lane Group Flow (vph)	254	223	918	0	5
Confl. Peds. (#/hr)	1	1			
Confl. Bikes (#/hr)				5	
Heavy Vehicles (%)	4%	2%	6%	2%	2%
Turn Type	Prot	Prot	NA		Perm
Protected Phases	1	1	6		
Permitted Phases					8
Actuated Green, G (s)	15.3	15.3	55.4		8.4
Effective Green, g (s)	16.2	16.2	56.7		9.3
Actuated g/C Ratio	0.18	0.18	0.62		0.10
Clearance Time (s)	4.9	4.9	5.3		4.9
Vehicle Extension (s)	1.0	1.0	4.0		2.0
Lane Grp Cap (vph)	281	293	2095		164
v/s Ratio Prot	c0.16	0.13	0.27		
v/s Ratio Perm					0.00
v/c Ratio	0.90	0.76	0.44		0.03
Uniform Delay, d1	36.7	35.6	8.9		36.8
Progression Factor	1.00	1.00	1.00		1.00
Incremental Delay, d2	29.4	10.0	0.2		0.0
Delay (s)	66.1	45.6	9.1		36.9
Level of Service	E	D	A		D
Approach Delay (s)			25.3		
Approach LOS			C		

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	17	22	6	124	20	2	1	16	1066	390	13	619
Future Volume (vph)	17	22	6	124	20	2	1	16	1066	390	13	619
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0	4.0		4.0	4.0	4.0	3.2	4.0
Lane Util. Factor		1.00		0.95	0.95	1.00		1.00	0.95	1.00	1.00	0.95
Frpb, ped/bikes		1.00		1.00	1.00	0.98		1.00	1.00	0.98	1.00	1.00
Flpb, ped/bikes		1.00		1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00
Frt		0.98		1.00	1.00	0.85		1.00	1.00	0.85	1.00	1.00
Flt Protected		0.98		0.95	0.96	1.00		0.95	1.00	1.00	0.95	1.00
Satd. Flow (prot)		1426		1681	1706	1557		1772	3471	1548	1770	3393
Flt Permitted		0.84		0.84	0.83	1.00		0.95	1.00	1.00	0.95	1.00
Satd. Flow (perm)		1220		1485	1461	1557		1772	3471	1548	1770	3393
Peak-hour factor, PHF	0.57	0.57	0.57	0.91	0.91	0.91	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	30	39	11	136	22	2	1	17	1146	419	14	666
RTOR Reduction (vph)	0	6	0	0	0	2	0	0	0	84	0	1
Lane Group Flow (vph)	0	74	0	72	86	0	0	18	1146	335	14	687
Confl. Peds. (#/hr)	5					5		4		2	2	
Confl. Bikes (#/hr)			3									
Heavy Vehicles (%)	71%	2%	2%	2%	2%	2%	0%	2%	4%	2%	2%	4%
Turn Type	Perm	NA		Perm	NA	Perm	Prot	Prot	NA	Perm	Prot	NA
Protected Phases		4			8		5	5	2		1	6
Permitted Phases	4			8		8				2		
Actuated Green, G (s)		7.0		7.0	7.0	7.0		0.8	33.8	33.8	0.7	33.7
Effective Green, g (s)		7.9		7.9	7.9	7.9		1.7	35.5	35.5	2.4	35.4
Actuated g/C Ratio		0.14		0.14	0.14	0.14		0.03	0.62	0.62	0.04	0.62
Clearance Time (s)		4.9		4.9	4.9	4.9		4.9	5.7	5.7	4.9	5.7
Vehicle Extension (s)		2.0		2.0	2.0	2.0		1.0	4.0	4.0	1.0	4.0
Lane Grp Cap (vph)		169		205	202	215		52	2161	964	74	2107
v/s Ratio Prot								c0.01	c0.33		0.01	0.20
v/s Ratio Perm		c0.06		0.05	0.06	0.00				0.22		
v/c Ratio		0.44		0.35	0.43	0.00		0.35	0.53	0.35	0.19	0.33
Uniform Delay, d1		22.5		22.2	22.5	21.2		27.1	6.1	5.2	26.4	5.1
Progression Factor		1.00		1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2		0.7		0.4	0.5	0.0		1.5	0.3	0.3	0.5	0.1
Delay (s)		23.2		22.6	23.0	21.2		28.6	6.4	5.5	26.8	5.3
Level of Service		C		C	C	C		C	A	A	C	A
Approach Delay (s)		23.2			22.8				6.4			5.7
Approach LOS		C			C				A			A

Intersection Summary			
HCM 2000 Control Delay	7.8	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.52		
Actuated Cycle Length (s)	57.0	Sum of lost time (s)	12.9
Intersection Capacity Utilization	47.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	20
Future Volume (vph)	20
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.93
Adj. Flow (vph)	22
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	4
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	60%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBT	WBR	WBR2	NBL2	NBT	NBR	SBU	SBL	SBR
Lane Configurations												
Traffic Volume (vph)	322	751	196	616	255	143	504	421	357	25	209	618
Future Volume (vph)	322	751	196	616	255	143	504	421	357	25	209	618
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.7	5.4	4.0	5.4	5.4	5.4	5.1	5.1			4.4	4.4
Lane Util. Factor	0.97	0.95	1.00	0.95	1.00	1.00	1.00	0.95			1.00	0.88
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.98	1.00	0.99			1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.85	0.85	1.00	0.93			1.00	0.85
Flt Protected	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (prot)	3127	3223	1380	3223	1442	1414	1583	2982			1630	2538
Flt Permitted	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (perm)	3127	3223	1380	3223	1442	1414	1583	2982			1630	2538
Peak-hour factor, PHF	0.89	0.89	0.89	0.91	0.91	0.91	0.92	0.92	0.92	0.87	0.87	0.87
Adj. Flow (vph)	362	844	220	677	280	157	548	458	388	29	240	710
RTOR Reduction (vph)	0	0	0	0	0	117	0	64	0	0	0	47
Lane Group Flow (vph)	362	844	220	677	280	40	548	782	0	0	269	704
Confl. Peds. (#/hr)	6					6			2		2	
Heavy Vehicles (%)	12%	12%	17%	12%	12%	12%	14%	12%	12%	0%	12%	12%
Turn Type	Prot	NA	Free	NA	Prot	Perm	Split	NA		Prot	Prot	pt+ov
Protected Phases	5	2		6	6		8	8		7	7	7 5
Permitted Phases			Free			6						
Actuated Green, G (s)	15.0	49.5	120.0	30.8	30.8	30.8	37.6	37.6			18.0	37.4
Effective Green, g (s)	15.0	49.5	120.0	30.8	30.8	30.8	37.6	37.6			18.0	37.4
Actuated g/C Ratio	0.12	0.41	1.00	0.26	0.26	0.26	0.31	0.31			0.15	0.31
Clearance Time (s)	3.7	5.4		5.4	5.4	5.4	5.1	5.1			4.4	
Vehicle Extension (s)	2.0	4.0		4.0	4.0	4.0	2.0	2.0			2.0	
Lane Grp Cap (vph)	390	1329	1380	827	370	362	496	934			244	791
v/s Ratio Prot	0.12	0.26		c0.21	0.19		c0.35	0.26			c0.16	c0.28
v/s Ratio Perm			0.16			0.03						
v/c Ratio	0.93	0.64	0.16	0.82	0.76	0.11	1.10	0.84			1.10	0.89
Uniform Delay, d1	52.0	28.1	0.0	42.0	41.1	34.1	41.2	38.4			51.0	39.3
Progression Factor	0.74	1.11	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Incremental Delay, d2	22.8	1.8	0.2	8.9	13.5	0.6	72.2	6.3			87.8	11.9
Delay (s)	61.3	33.1	0.2	50.8	54.6	34.7	113.4	44.7			138.8	51.3
Level of Service	E	C	A	D	D	C	F	D			F	D
Approach Delay (s)		35.2		49.5				71.7				
Approach LOS		D		D				E				

Intersection Summary			
HCM 2000 Control Delay	56.7	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.01		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	18.6
Intersection Capacity Utilization	87.4%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	SBR2
Lane Configurations	
Traffic Volume (vph)	36
Future Volume (vph)	36
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.87
Adj. Flow (vph)	41
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	
Heavy Vehicles (%)	12%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	277	185	139	171	181	321	307	588	45	323	615	836
Future Volume (vph)	277	185	139	171	181	321	307	588	45	323	615	836
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.3	5.3	5.3	4.9	4.9	4.9	4.7	5.4	5.4	4.7	5.4	5.4
Lane Util. Factor	0.91	0.91	1.00	0.95	0.95	1.00	0.97	0.95	1.00	0.97	0.95	1.00
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.98	1.00	1.00	1.00	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	0.98	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1521	3121	1583	1681	1658	1411	3433	3539	1583	3127	3539	1519
Flt Permitted	0.95	0.98	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1521	3121	1583	1681	1658	1411	3433	3539	1583	3127	3539	1519
Peak-hour factor, PHF	0.83	0.83	0.83	0.88	0.88	0.88	0.78	0.78	0.78	0.80	0.80	0.80
Adj. Flow (vph)	334	223	167	194	206	365	394	754	58	404	769	1045
RTOR Reduction (vph)	0	0	142	0	0	253	0	0	37	0	0	287
Lane Group Flow (vph)	184	373	25	175	225	112	394	754	21	404	769	758
Confl. Peds. (#/hr)	5					5						
Confl. Bikes (#/hr)												1
Heavy Vehicles (%)	8%	9%	2%	2%	9%	12%	2%	2%	2%	12%	2%	5%
Turn Type	Split	NA	Perm	Split	NA	Perm	Prot	NA	Perm	Prot	NA	Perm
Protected Phases	7	7		8	8		5	2		1	6	
Permitted Phases			7			8			2			6
Actuated Green, G (s)	18.2	18.2	18.2	18.8	18.8	18.8	16.8	44.2	44.2	18.5	45.9	45.9
Effective Green, g (s)	18.2	18.2	18.2	18.8	18.8	18.8	16.8	44.2	44.2	18.5	45.9	45.9
Actuated g/C Ratio	0.15	0.15	0.15	0.16	0.16	0.16	0.14	0.37	0.37	0.15	0.38	0.38
Clearance Time (s)	5.3	5.3	5.3	4.9	4.9	4.9	4.7	5.4	5.4	4.7	5.4	5.4
Vehicle Extension (s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0	2.0	3.0	3.0
Lane Grp Cap (vph)	230	473	240	263	259	221	480	1303	583	482	1353	581
v/s Ratio Prot	c0.12	0.12		0.10	c0.14		0.11	0.21		c0.13	0.22	
v/s Ratio Perm			0.02			0.08			0.01			c0.50
v/c Ratio	0.80	0.79	0.11	0.67	0.87	0.51	0.82	0.58	0.04	0.84	0.57	1.30
Uniform Delay, d1	49.1	49.0	43.9	47.6	49.4	46.4	50.1	30.4	24.3	49.3	29.2	37.1
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	1.00
Incremental Delay, d2	16.9	7.9	0.1	4.9	24.4	0.7	10.3	1.9	0.1	7.0	1.0	144.2
Delay (s)	66.0	56.9	44.0	52.5	73.8	47.0	60.4	32.3	24.4	56.2	29.6	181.0
Level of Service	E	E	D	D	E	D	E	C	C	E	C	F
Approach Delay (s)		56.2			56.1			41.1			105.8	
Approach LOS		E			E			D			F	

Intersection Summary			
HCM 2000 Control Delay	74.9	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.06		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	20.3
Intersection Capacity Utilization	83.0%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL
Lane Configurations												
Traffic Volume (vph)	14	24	13	1	177	149	301	1	82	923	231	416
Future Volume (vph)	14	24	13	1	177	149	301	1	82	923	231	416
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.6	5.3			4.6	5.3	5.3		4.6	5.3	5.3	4.6
Lane Util. Factor	1.00	0.95			0.97	1.00	1.00		1.00	0.95	1.00	0.97
Frpb, ped/bikes	1.00	1.00			1.00	1.00	0.99		1.00	1.00	0.99	1.00
Flpb, ped/bikes	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Frt	1.00	0.95			1.00	1.00	0.85		1.00	1.00	0.85	1.00
Flt Protected	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (prot)	1770	3353			3047	1863	1533		1770	3471	1408	3367
Flt Permitted	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (perm)	1770	3353			3047	1863	1533		1770	3471	1408	3367
Peak-hour factor, PHF	0.91	0.91	0.91	0.93	0.93	0.93	0.93	0.86	0.86	0.86	0.86	0.94
Adj. Flow (vph)	15	26	14	1	190	160	324	1	95	1073	269	443
RTOR Reduction (vph)	0	13	0	0	0	0	269	0	0	0	86	0
Lane Group Flow (vph)	15	27	0	0	191	160	55	0	96	1073	183	443
Confl. Peds. (#/hr)	1						1		1		2	2
Confl. Bikes (#/hr)											1	
Heavy Vehicles (%)	2%	2%	2%	0%	15%	2%	4%	0%	2%	4%	13%	4%
Turn Type	Prot	NA		Prot	Prot	NA	Perm	Prot	Prot	NA	Perm	Prot
Protected Phases	7	4		3	3	8		5	5	2		1
Permitted Phases							8				2	
Actuated Green, G (s)	2.7	9.8			12.9	20.0	20.0		12.4	54.3	54.3	20.7
Effective Green, g (s)	2.7	9.8			12.9	20.0	20.0		12.4	54.3	54.3	20.7
Actuated g/C Ratio	0.02	0.08			0.11	0.17	0.17		0.11	0.46	0.46	0.18
Clearance Time (s)	4.6	5.3			4.6	5.3	5.3		4.6	5.3	5.3	4.6
Vehicle Extension (s)	2.0	2.0			2.0	2.0	2.0		2.0	4.0	4.0	2.0
Lane Grp Cap (vph)	40	279			334	317	260		186	1604	650	593
v/s Ratio Prot	0.01	0.01			c0.06	c0.09			0.05	0.31		c0.13
v/s Ratio Perm							0.04				0.13	
v/c Ratio	0.38	0.10			0.57	0.50	0.21		0.52	0.67	0.28	0.75
Uniform Delay, d1	56.6	49.8			49.7	44.3	42.0		49.7	24.6	19.5	45.9
Progression Factor	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2	2.1	0.1			1.5	0.5	0.1		1.0	1.2	0.3	4.5
Delay (s)	58.7	49.8			51.1	44.7	42.1		50.7	25.8	19.9	50.4
Level of Service	E	D			D	D	D		D	C	B	D
Approach Delay (s)		52.2				45.3				26.3		
Approach LOS		D				D				C		

Intersection Summary			
HCM 2000 Control Delay	31.3	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	117.5	Sum of lost time (s)	19.8
Intersection Capacity Utilization	67.5%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR
Lane Configurations		
Traffic Volume (vph)	1187	43
Future Volume (vph)	1187	43
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	5.3	
Lane Util. Factor	0.95	
Frpb, ped/bikes	1.00	
Flpb, ped/bikes	1.00	
Frt	0.99	
Flt Protected	1.00	
Satd. Flow (prot)	3452	
Flt Permitted	1.00	
Satd. Flow (perm)	3452	
Peak-hour factor, PHF	0.94	0.94
Adj. Flow (vph)	1263	46
RTOR Reduction (vph)	1	0
Lane Group Flow (vph)	1308	0
Confl. Peds. (#/hr)		1
Confl. Bikes (#/hr)		1
Heavy Vehicles (%)	4%	2%
Turn Type	NA	
Protected Phases	6	
Permitted Phases		
Actuated Green, G (s)	62.6	
Effective Green, g (s)	62.6	
Actuated g/C Ratio	0.53	
Clearance Time (s)	5.3	
Vehicle Extension (s)	4.0	
Lane Grp Cap (vph)	1839	
v/s Ratio Prot	c0.38	
v/s Ratio Perm		
v/c Ratio	0.71	
Uniform Delay, d1	20.7	
Progression Factor	1.00	
Incremental Delay, d2	1.4	
Delay (s)	22.1	
Level of Service	C	
Approach Delay (s)	29.2	
Approach LOS	C	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	27	13	25	39	7	60	6	31	981	51	63	1154
Future Volume (vph)	27	13	25	39	7	60	6	31	981	51	63	1154
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.9			4.9			4.9	5.3		4.9	5.3
Lane Util. Factor		1.00			1.00			1.00	0.95		1.00	0.95
Frpb, ped/bikes		0.99			0.97			1.00	1.00		1.00	1.00
Flpb, ped/bikes		0.99			1.00			1.00	1.00		1.00	1.00
Frt		0.95			0.92			1.00	0.99		1.00	1.00
Flt Protected		0.98			0.98			0.95	1.00		0.95	1.00
Satd. Flow (prot)		1549			1641			1775	3409		1770	3412
Flt Permitted		0.68			0.84			0.95	1.00		0.95	1.00
Satd. Flow (perm)		1072			1400			1775	3409		1770	3412
Peak-hour factor, PHF	0.74	0.74	0.74	0.58	0.58	0.58	0.81	0.81	0.81	0.81	0.89	0.89
Adj. Flow (vph)	36	18	34	67	12	103	7	38	1211	63	71	1297
RTOR Reduction (vph)	0	24	0	0	52	0	0	0	2	0	0	1
Lane Group Flow (vph)	0	64	0	0	130	0	0	45	1272	0	71	1318
Confl. Peds. (#/hr)	29		11	11		29		2		11	11	
Confl. Bikes (#/hr)			2			1				3		
Heavy Vehicles (%)	26%	2%	2%	2%	2%	2%	0%	2%	5%	2%	2%	5%
Turn Type	Perm	NA		Perm	NA		Prot	Prot	NA		Prot	NA
Protected Phases		4			8		5	5	2		1	6
Permitted Phases	4			8								
Actuated Green, G (s)		13.2			13.2			4.5	69.9		6.8	72.2
Effective Green, g (s)		13.2			13.2			4.5	69.9		6.8	72.2
Actuated g/C Ratio		0.13			0.13			0.04	0.67		0.06	0.69
Clearance Time (s)		4.9			4.9			4.9	5.3		4.9	5.3
Vehicle Extension (s)		1.5			1.5			1.0	4.0		1.0	4.5
Lane Grp Cap (vph)		134			176			76	2269		114	2346
v/s Ratio Prot								0.03	0.37		c0.04	c0.39
v/s Ratio Perm		0.06			c0.09							
v/c Ratio		0.47			0.74			0.59	0.56		0.62	0.56
Uniform Delay, d1		42.7			44.3			49.3	9.4		47.9	8.3
Progression Factor		1.00			1.00			1.00	1.00		1.00	1.00
Incremental Delay, d2		1.0			13.6			8.0	1.0		7.4	1.0
Delay (s)		43.6			57.9			57.3	10.4		55.2	9.3
Level of Service		D			E			E	B		E	A
Approach Delay (s)		43.6			57.9				12.0			11.7
Approach LOS		D			E				B			B

Intersection Summary			
HCM 2000 Control Delay	15.6	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	105.0	Sum of lost time (s)	15.1
Intersection Capacity Utilization	66.9%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	20
Future Volume (vph)	20
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.89
Adj. Flow (vph)	22
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	2
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	35%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR2	WBU	WBL2	WBL	WBT	WBR	NBL	NBT	NBR	SBU
Lane Configurations												
Traffic Volume (vph)	86	58	31	8	12	72	20	243	17	758	97	5
Future Volume (vph)	86	58	31	8	12	72	20	243	17	758	97	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.9				4.9	4.9	4.9	4.9	5.3	5.3	
Lane Util. Factor		0.95				1.00	1.00	1.00	1.00	0.95	1.00	
Frpb, ped/bikes		1.00				1.00	1.00	0.98	1.00	1.00	0.98	
Flpb, ped/bikes		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Frt		0.97				1.00	1.00	0.85	1.00	1.00	0.85	
Flt Protected		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (prot)		3363				1746	1863	1518	1770	3406	1529	
Flt Permitted		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (perm)		3363				1746	1863	1518	1770	3406	1529	
Peak-hour factor, PHF	0.83	0.83	0.83	0.71	0.71	0.71	0.71	0.71	0.76	0.76	0.76	0.86
Adj. Flow (vph)	104	70	37	11	17	101	28	342	22	997	128	6
RTOR Reduction (vph)	0	131	0	0	0	0	0	297	0	0	0	0
Lane Group Flow (vph)	0	80	0	0	0	129	28	45	22	997	128	0
Confl. Peds. (#/hr)	13					3		13	3		2	
Confl. Bikes (#/hr)											2	
Heavy Vehicles (%)	2%	2%	2%	0%	2%	4%	2%	4%	2%	6%	4%	0%
Turn Type	Split	NA		Split	Split	Split	NA	Perm	Prot	NA	Perm	Prot
Protected Phases	4	4		8	8	8	8		5	2		1
Permitted Phases								8			2	
Actuated Green, G (s)		8.0				12.0	12.0	12.0	2.4	39.1	39.1	
Effective Green, g (s)		8.0				12.0	12.0	12.0	2.4	39.1	39.1	
Actuated g/C Ratio		0.09				0.13	0.13	0.13	0.03	0.43	0.43	
Clearance Time (s)		4.9				4.9	4.9	4.9	4.9	5.3	5.3	
Vehicle Extension (s)		3.0				2.0	2.0	2.0	2.0	4.0	4.0	
Lane Grp Cap (vph)		293				228	243	198	46	1452	651	
v/s Ratio Prot		c0.02				c0.07	0.02		0.01	c0.29		
v/s Ratio Perm								0.03			0.08	
v/c Ratio		0.27				0.57	0.12	0.23	0.48	0.69	0.20	
Uniform Delay, d1		39.1				37.4	35.2	35.7	44.0	21.3	16.5	
Progression Factor		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2		0.5				1.9	0.1	0.2	2.8	1.5	0.2	
Delay (s)		39.6				39.3	35.2	35.9	46.9	22.8	16.7	
Level of Service		D				D	D	D	D	C	B	
Approach Delay (s)		39.6					36.7			22.6		
Approach LOS		D					D			C		

Intersection Summary			
HCM 2000 Control Delay	25.5	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	91.7	Sum of lost time (s)	20.0
Intersection Capacity Utilization	72.2%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBL2	SBL	SBT	SBR	NWR2
Lane Configurations					
Traffic Volume (vph)	235	16	827	24	45
Future Volume (vph)	235	16	827	24	45
Ideal Flow (vphpl)	1900	1900	1900	1900	1900
Total Lost time (s)	4.9	4.9	5.3		4.9
Lane Util. Factor	0.91	0.95	0.95		1.00
Frpb, ped/bikes	1.00	1.00	1.00		0.99
Flpb, ped/bikes	1.00	1.00	1.00		1.00
Frt	1.00	1.00	1.00		0.86
Flt Protected	0.95	0.95	1.00		1.00
Satd. Flow (prot)	1582	1653	3392		1589
Flt Permitted	0.95	0.95	1.00		1.00
Satd. Flow (perm)	1582	1653	3392		1589
Peak-hour factor, PHF	0.86	0.86	0.86	0.86	0.75
Adj. Flow (vph)	273	19	962	28	60
RTOR Reduction (vph)	0	0	1	0	52
Lane Group Flow (vph)	148	150	989	0	8
Confl. Peds. (#/hr)	2	2		3	
Confl. Bikes (#/hr)					1
Heavy Vehicles (%)	4%	2%	6%	2%	2%
Turn Type	Prot	Prot	NA		Perm
Protected Phases	1	1	6		
Permitted Phases					8
Actuated Green, G (s)	12.6	12.6	49.3		12.0
Effective Green, g (s)	12.6	12.6	49.3		12.0
Actuated g/C Ratio	0.14	0.14	0.54		0.13
Clearance Time (s)	4.9	4.9	5.3		4.9
Vehicle Extension (s)	1.0	1.0	4.0		2.0
Lane Grp Cap (vph)	217	227	1823		207
v/s Ratio Prot	c0.09	0.09	0.29		
v/s Ratio Perm					0.00
v/c Ratio	0.68	0.66	0.54		0.04
Uniform Delay, d1	37.6	37.5	13.8		34.8
Progression Factor	1.00	1.00	1.00		1.00
Incremental Delay, d2	6.9	5.5	0.4		0.0
Delay (s)	44.5	43.0	14.3		34.8
Level of Service	D	D	B		C
Approach Delay (s)			21.1		
Approach LOS			C		

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBU	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	36	24	16	178	12	5	9	595	143	2	6	936
Future Volume (vph)	36	24	16	178	12	5	9	595	143	2	6	936
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.9		4.9	4.9	4.9	4.9	5.7	5.7		4.9	5.7
Lane Util. Factor		1.00		0.95	0.95	1.00	1.00	0.95	1.00		1.00	0.95
Frpb, ped/bikes		1.00		1.00	1.00	0.98	1.00	1.00	0.98		1.00	1.00
Flpb, ped/bikes		1.00		1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
Frt		0.97		1.00	1.00	0.85	1.00	1.00	0.85		1.00	1.00
Flt Protected		0.98		0.95	0.96	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (prot)		1490		1681	1696	1555	1766	3471	1550		1770	3410
Flt Permitted		0.79		0.77	0.75	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (perm)		1201		1356	1333	1555	1766	3471	1550		1770	3410
Peak-hour factor, PHF	0.78	0.78	0.78	0.68	0.68	0.68	0.74	0.74	0.74	0.79	0.79	0.79
Adj. Flow (vph)	46	31	21	262	18	7	12	804	193	3	8	1185
RTOR Reduction (vph)	0	9	0	0	0	6	0	0	60	0	0	1
Lane Group Flow (vph)	0	89	0	139	141	1	12	804	133	0	11	1206
Confl. Peds. (#/hr)	4					4	7					
Confl. Bikes (#/hr)						1			2			
Heavy Vehicles (%)	42%	2%	2%	2%	2%	2%	2%	4%	2%	2%	2%	4%
Turn Type	Perm	NA		Perm	NA	Perm	Prot	NA	Perm	Prot	Prot	NA
Protected Phases		4			8		5	2		1	1	6
Permitted Phases	4			8		8			2			
Actuated Green, G (s)		11.8		11.8	11.8	11.8	0.8	38.4	38.4		0.8	38.4
Effective Green, g (s)		11.8		11.8	11.8	11.8	0.8	38.4	38.4		0.8	38.4
Actuated g/C Ratio		0.18		0.18	0.18	0.18	0.01	0.58	0.58		0.01	0.58
Clearance Time (s)		4.9		4.9	4.9	4.9	4.9	5.7	5.7		4.9	5.7
Vehicle Extension (s)		2.0		2.0	2.0	2.0	1.0	4.0	4.0		1.0	4.0
Lane Grp Cap (vph)		213		240	236	275	21	2004	895		21	1969
v/s Ratio Prot							c0.01	0.23			0.01	c0.35
v/s Ratio Perm		0.07		0.10	c0.11	0.00			0.09			
v/c Ratio		0.42		0.58	0.60	0.00	0.57	0.40	0.15		0.52	0.61
Uniform Delay, d1		24.3		25.1	25.2	22.5	32.7	7.7	6.5		32.7	9.2
Progression Factor		1.00		1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
Incremental Delay, d2		0.5		2.1	2.7	0.0	21.2	0.2	0.1		10.4	0.7
Delay (s)		24.8		27.2	27.9	22.5	53.9	7.9	6.6		43.1	9.8
Level of Service		C		C	C	C	D	A	A		D	A
Approach Delay (s)		24.8			27.4			8.2				10.1
Approach LOS		C			C			A				B

Intersection Summary			
HCM 2000 Control Delay	11.8	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	66.5	Sum of lost time (s)	15.5
Intersection Capacity Utilization	46.2%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	17
Future Volume (vph)	17
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.79
Adj. Flow (vph)	22
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	7
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	88%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBT	WBR	WBR2	NBL2	NBT	NBR	SBU	SBL	SBR
Lane Configurations												
Traffic Volume (vph)	724	765	233	751	208	267	180	635	131	48	179	575
Future Volume (vph)	724	765	233	751	208	267	180	635	131	48	179	575
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	2.6	4.0	4.0	4.0	4.0	4.0			4.0	4.0
Lane Util. Factor	0.97	0.95	1.00	0.95	1.00	1.00	1.00	0.95			1.00	0.88
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.98	1.00	1.00			1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.85	0.85	1.00	0.97			1.00	0.85
Flt Protected	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (prot)	3127	3223	1392	3223	1442	1408	1543	3132			1649	2538
Flt Permitted	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (perm)	3127	3223	1392	3223	1442	1408	1543	3132			1649	2538
Peak-hour factor, PHF	0.88	0.88	0.88	0.95	0.95	0.95	0.89	0.89	0.89	0.94	0.94	0.94
Adj. Flow (vph)	823	869	265	791	219	281	202	713	147	51	190	612
RTOR Reduction (vph)	0	0	0	0	0	112	0	14	0	0	0	40
Lane Group Flow (vph)	823	869	265	791	219	169	202	846	0	0	241	603
Confl. Peds. (#/hr)	9					9			4		4	
Heavy Vehicles (%)	12%	12%	16%	12%	12%	12%	17%	12%	12%	0%	12%	12%
Turn Type	Prot	NA	Free	NA	Prot	Perm	Split	NA		Prot	Prot	pt+ov
Protected Phases	5	2		6	6		8	8		7	7	7 5
Permitted Phases			Free			6						
Actuated Green, G (s)	26.0	62.1	130.0	32.4	32.4	32.4	35.6	35.6			17.4	47.8
Effective Green, g (s)	25.7	63.5	130.0	33.8	33.8	33.8	36.7	36.7			17.8	48.2
Actuated g/C Ratio	0.20	0.49	1.00	0.26	0.26	0.26	0.28	0.28			0.14	0.37
Clearance Time (s)	3.7	5.4		5.4	5.4	5.4	5.1	5.1			4.4	
Vehicle Extension (s)	2.0	4.0		4.0	4.0	4.0	2.0	2.0			2.0	
Lane Grp Cap (vph)	618	1574	1392	837	374	366	435	884			225	941
v/s Ratio Prot	c0.26	0.27		c0.25	0.15		0.13	c0.27			c0.15	0.24
v/s Ratio Perm			0.19			0.12						
v/c Ratio	1.33	0.55	0.19	0.95	0.59	0.46	0.46	0.96			1.07	0.64
Uniform Delay, d1	52.1	23.3	0.0	47.2	42.0	40.5	38.5	45.9			56.1	33.8
Progression Factor	0.72	1.03	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Incremental Delay, d2	156.3	0.9	0.2	20.3	6.6	4.2	0.3	20.3			80.1	1.1
Delay (s)	194.0	24.8	0.2	67.5	48.6	44.6	38.8	66.1			136.2	34.9
Level of Service	F	C	A	E	D	D	D	E			F	C
Approach Delay (s)		92.6		59.3				60.9				
Approach LOS		F		E				E				

Intersection Summary			
HCM 2000 Control Delay	72.7	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.05		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	93.6%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

Movement	SBR2
Lane Configurations	
Traffic Volume (vph)	29
Future Volume (vph)	29
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.94
Adj. Flow (vph)	31
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	
Heavy Vehicles (%)	12%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBU	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	420	513	289	300	104	340	255	866	146	4	479	747
Future Volume (vph)	420	513	289	300	104	340	255	866	146	4	479	747
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		4.0	4.0
Lane Util. Factor	0.91	0.91	1.00	0.95	0.95	1.00	0.97	0.95	1.00		0.97	0.95
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00		1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85		1.00	1.00
Flt Protected	0.95	0.99	1.00	0.95	0.98	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (prot)	1550	3232	1583	1681	1638	1423	3433	3539	1583		3129	3539
Flt Permitted	0.95	0.99	1.00	0.95	0.98	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (perm)	1550	3232	1583	1681	1638	1423	3433	3539	1583		3129	3539
Peak-hour factor, PHF	0.96	0.96	0.96	0.95	0.95	0.95	0.92	0.92	0.92	0.91	0.91	0.91
Adj. Flow (vph)	438	534	301	316	109	358	277	941	159	4	526	821
RTOR Reduction (vph)	0	0	189	0	0	222	0	0	95	0	0	0
Lane Group Flow (vph)	315	657	112	209	216	136	277	941	64	0	530	821
Confl. Peds. (#/hr)							10					
Confl. Bikes (#/hr)						1						
Heavy Vehicles (%)	6%	6%	2%	2%	13%	12%	2%	2%	2%	0%	12%	2%
Turn Type	Split	NA	Perm	Split	NA	Perm	Prot	NA	Perm	Prot	Prot	NA
Protected Phases	7	7		8	8		5	2		1	1	6
Permitted Phases			7			8			2			
Actuated Green, G (s)	29.7	29.7	29.7	20.0	20.0	20.0	14.5	36.0	36.0		24.0	45.5
Effective Green, g (s)	31.0	31.0	31.0	20.9	20.9	20.9	15.2	37.4	37.4		24.7	46.9
Actuated g/C Ratio	0.24	0.24	0.24	0.16	0.16	0.16	0.12	0.29	0.29		0.19	0.36
Clearance Time (s)	5.3	5.3	5.3	4.9	4.9	4.9	4.7	5.4	5.4		4.7	5.4
Vehicle Extension (s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0		2.0	3.0
Lane Grp Cap (vph)	369	770	377	270	263	228	401	1018	455		594	1276
v/s Ratio Prot	0.20	c0.20		0.12	c0.13		0.08	c0.27			c0.17	0.23
v/s Ratio Perm			0.07			0.10			0.04			
v/c Ratio	0.85	0.85	0.30	0.77	0.82	0.59	0.69	0.92	0.14		0.89	0.64
Uniform Delay, d1	47.3	47.3	40.6	52.3	52.7	50.6	55.1	44.9	34.4		51.4	34.6
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		0.95	0.83
Incremental Delay, d2	16.6	8.8	0.2	11.9	17.5	2.8	4.1	15.0	0.6		11.2	1.7
Delay (s)	63.9	56.1	40.7	64.2	70.2	53.4	59.3	59.9	35.0		59.7	30.5
Level of Service	E	E	D	E	E	D	E	E	D		E	C
Approach Delay (s)		54.4			60.9			56.9				42.5
Approach LOS		D			E			E				D

Intersection Summary			
HCM 2000 Control Delay	52.1	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.88		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	16.7
Intersection Capacity Utilization	89.7%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	352
Future Volume (vph)	352
Ideal Flow (vphpl)	1900
Total Lost time (s)	4.0
Lane Util. Factor	1.00
Frpb, ped/bikes	0.97
Flpb, ped/bikes	1.00
Frt	0.85
Flt Protected	1.00
Satd. Flow (prot)	1469
Flt Permitted	1.00
Satd. Flow (perm)	1469
Peak-hour factor, PHF	0.91
Adj. Flow (vph)	387
RTOR Reduction (vph)	247
Lane Group Flow (vph)	140
Confl. Peds. (#/hr)	10
Confl. Bikes (#/hr)	7
Heavy Vehicles (%)	7%
Turn Type	Perm
Protected Phases	
Permitted Phases	6
Actuated Green, G (s)	45.5
Effective Green, g (s)	46.9
Actuated g/C Ratio	0.36
Clearance Time (s)	5.4
Vehicle Extension (s)	3.0
Lane Grp Cap (vph)	529
v/s Ratio Prot	
v/s Ratio Perm	0.10
v/c Ratio	0.26
Uniform Delay, d1	29.4
Progression Factor	1.49
Incremental Delay, d2	0.8
Delay (s)	44.6
Level of Service	D
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL
Lane Configurations												
Traffic Volume (vph)	87	119	70	2	178	34	347	2	17	1342	181	417
Future Volume (vph)	87	119	70	2	178	34	347	2	17	1342	181	417
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			3.3	4.0	4.0		4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	0.95			0.97	1.00	1.00		1.00	0.95	1.00	0.97
Frpb, ped/bikes	1.00	0.99			1.00	1.00	0.98		1.00	1.00	0.99	1.00
Flpb, ped/bikes	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Frt	1.00	0.94			1.00	1.00	0.85		1.00	1.00	0.85	1.00
Flt Protected	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (prot)	1770	3322			3049	1863	1527		1773	3471	1386	3367
Flt Permitted	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (perm)	1770	3322			3049	1863	1527		1773	3471	1386	3367
Peak-hour factor, PHF	0.71	0.71	0.71	0.90	0.90	0.90	0.90	0.89	0.89	0.89	0.89	0.88
Adj. Flow (vph)	123	168	99	2	198	38	386	2	19	1508	203	474
RTOR Reduction (vph)	0	76	0	0	0	0	253	0	0	0	62	0
Lane Group Flow (vph)	123	191	0	0	200	38	133	0	21	1508	141	474
Confl. Peds. (#/hr)	4		4		4		4		3		1	1
Confl. Bikes (#/hr)												
Heavy Vehicles (%)	2%	2%	2%	0%	15%	2%	4%	0%	2%	4%	15%	4%
Turn Type	Prot	NA		Prot	Prot	NA	Perm	Prot	Prot	NA	Perm	Prot
Protected Phases	7	4		3	3	8		5	5	2		1
Permitted Phases							8				2	
Actuated Green, G (s)	14.0	16.9			13.9	16.8	16.8		6.0	55.2	55.2	28.2
Effective Green, g (s)	14.6	18.2			15.2	18.1	18.1		6.6	56.5	56.5	28.8
Actuated g/C Ratio	0.11	0.14			0.11	0.14	0.14		0.05	0.42	0.42	0.21
Clearance Time (s)	4.6	5.3			4.6	5.3	5.3		4.6	5.3	5.3	4.6
Vehicle Extension (s)	3.0	2.0			3.0	2.0	2.0		2.0	4.0	4.0	2.0
Lane Grp Cap (vph)	192	451			345	251	206		87	1463	584	723
v/s Ratio Prot	c0.07	0.06			0.07	0.02			0.01	c0.43		c0.14
v/s Ratio Perm							c0.09				0.10	
v/c Ratio	0.64	0.42			0.58	0.15	0.64		0.24	1.03	0.24	0.66
Uniform Delay, d1	57.2	53.1			56.4	51.2	54.9		61.3	38.8	25.0	48.1
Progression Factor	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2	7.1	0.2			2.4	0.1	5.1		0.5	31.8	1.0	1.6
Delay (s)	64.3	53.3			58.7	51.3	60.0		61.8	70.5	25.9	49.7
Level of Service	E	D			E	D	E		E	E	C	D
Approach Delay (s)		56.8				59.0				65.2		
Approach LOS		E				E				E		

Intersection Summary			
HCM 2000 Control Delay	49.0	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.83		
Actuated Cycle Length (s)	134.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	80.1%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR
Lane Configurations		
Traffic Volume (vph)	1130	10
Future Volume (vph)	1130	10
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	4.0	
Lane Util. Factor	0.95	
Frpb, ped/bikes	1.00	
Flpb, ped/bikes	1.00	
Frt	1.00	
Flt Protected	1.00	
Satd. Flow (prot)	3466	
Flt Permitted	1.00	
Satd. Flow (perm)	3466	
Peak-hour factor, PHF	0.88	0.88
Adj. Flow (vph)	1284	11
RTOR Reduction (vph)	0	0
Lane Group Flow (vph)	1295	0
Confl. Peds. (#/hr)		3
Confl. Bikes (#/hr)		4
Heavy Vehicles (%)	4%	2%
Turn Type	NA	
Protected Phases	6	
Permitted Phases		
Actuated Green, G (s)	77.4	
Effective Green, g (s)	78.7	
Actuated g/C Ratio	0.59	
Clearance Time (s)	5.3	
Vehicle Extension (s)	4.0	
Lane Grp Cap (vph)	2035	
v/s Ratio Prot	0.37	
v/s Ratio Perm		
v/c Ratio	0.64	
Uniform Delay, d1	18.2	
Progression Factor	1.00	
Incremental Delay, d2	1.5	
Delay (s)	19.7	
Level of Service	B	
Approach Delay (s)	27.8	
Approach LOS	C	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL
Lane Configurations												
Traffic Volume (vph)	26	15	31	21	14	22	12	44	1244	26	7	44
Future Volume (vph)	26	15	31	21	14	22	12	44	1244	26	7	44
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0			4.0	4.0			4.0
Lane Util. Factor		1.00			1.00			1.00	0.95			1.00
Frpb, ped/bikes		0.99			0.99			1.00	1.00			1.00
Flpb, ped/bikes		1.00			1.00			1.00	1.00			1.00
Frt		0.94			0.95			1.00	1.00			1.00
Flt Protected		0.98			0.98			0.95	1.00			0.95
Satd. Flow (prot)		1565			1713			1777	3423			1774
Flt Permitted		0.78			0.76			0.95	1.00			0.11
Satd. Flow (perm)		1243			1325			1777	3423			215
Peak-hour factor, PHF	0.75	0.75	0.75	0.65	0.65	0.65	0.93	0.93	0.93	0.93	0.96	0.96
Adj. Flow (vph)	35	20	41	32	22	34	13	47	1338	28	7	46
RTOR Reduction (vph)	0	27	0	0	23	0	0	0	1	0	0	0
Lane Group Flow (vph)	0	69	0	0	65	0	0	60	1365	0	0	53
Confl. Peds. (#/hr)	7		7	7		7		6		22		22
Confl. Bikes (#/hr)						2				1		
Heavy Vehicles (%)	27%	2%	2%	2%	2%	2%	0%	2%	5%	2%	0%	2%
Turn Type	Perm	NA		Perm	NA		Prot	Prot	NA			Prot
Protected Phases		4			8		5	5	2			1
Permitted Phases	4			8								
Actuated Green, G (s)		9.5			9.5			6.6	56.5			33.9
Effective Green, g (s)		10.4			10.4			7.5	57.8			34.8
Actuated g/C Ratio		0.09			0.09			0.07	0.50			0.30
Clearance Time (s)		4.9			4.9			4.9	5.3			4.9
Vehicle Extension (s)		1.5			1.5			1.0	4.0			1.0
Lane Grp Cap (vph)		112			119			115	1720			65
v/s Ratio Prot								0.03	c0.40			
v/s Ratio Perm		c0.06			0.05							c0.25
v/c Ratio		0.61			0.55			0.52	0.79			0.82
Uniform Delay, d1		50.4			50.1			52.0	23.7			37.1
Progression Factor		1.00			1.00			1.00	1.00			1.00
Incremental Delay, d2		6.8			2.8			2.0	3.9			50.2
Delay (s)		57.2			52.8			54.0	27.5			87.3
Level of Service		E			D			D	C			F
Approach Delay (s)		57.2			52.8				28.6			
Approach LOS		E			D				C			

Intersection Summary			
HCM 2000 Control Delay	21.9	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	115.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	58.1%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR
Lane Configurations	↑↱	
Traffic Volume (vph)	1201	30
Future Volume (vph)	1201	30
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	4.0	
Lane Util. Factor	0.95	
Frpb, ped/bikes	1.00	
Flpb, ped/bikes	1.00	
Frt	1.00	
Flt Protected	1.00	
Satd. Flow (prot)	3408	
Flt Permitted	1.00	
Satd. Flow (perm)	3408	
Peak-hour factor, PHF	0.96	0.96
Adj. Flow (vph)	1251	31
RTOR Reduction (vph)	1	0
Lane Group Flow (vph)	1281	0
Confl. Peds. (#/hr)		6
Confl. Bikes (#/hr)		5
Heavy Vehicles (%)	5%	23%
Turn Type	NA	
Protected Phases	6	
Permitted Phases		
Actuated Green, G (s)	83.8	
Effective Green, g (s)	85.1	
Actuated g/C Ratio	0.74	
Clearance Time (s)	5.3	
Vehicle Extension (s)	4.5	
Lane Grp Cap (vph)	2521	
v/s Ratio Prot	0.38	
v/s Ratio Perm		
v/c Ratio	0.51	
Uniform Delay, d1	6.2	
Progression Factor	1.00	
Incremental Delay, d2	0.7	
Delay (s)	7.0	
Level of Service	A	
Approach Delay (s)	10.2	
Approach LOS	B	

Intersection Summary

Movement	EBL	EBT	EBR2	WBU	WBL2	WBL	WBT	WBR	NBL	NBT	NBR	SBU
Lane Configurations												
Traffic Volume (vph)	31	42	8	9	14	40	52	227	12	1020	88	17
Future Volume (vph)	31	42	8	9	14	40	52	227	12	1020	88	17
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0				4.0	4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor		0.95				1.00	1.00	1.00	1.00	0.95	1.00	
Frpb, ped/bikes		1.00				1.00	1.00	0.98	1.00	1.00	0.99	
Flpb, ped/bikes		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Frt		0.99				1.00	1.00	0.85	1.00	1.00	0.85	
Flt Protected		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (prot)		3418				1752	1863	1526	1770	3438	1532	
Flt Permitted		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (perm)		3418				1752	1863	1526	1770	3438	1532	
Peak-hour factor, PHF	0.70	0.70	0.70	0.95	0.95	0.95	0.95	0.95	0.92	0.92	0.92	0.88
Adj. Flow (vph)	44	60	11	9	15	42	55	239	13	1109	96	19
RTOR Reduction (vph)	0	106	0	0	0	0	0	215	0	0	0	0
Lane Group Flow (vph)	0	9	0	0	0	66	55	24	13	1109	96	0
Confl. Peds. (#/hr)	4		2			2		4			1	
Confl. Bikes (#/hr)								1			1	
Heavy Vehicles (%)	2%	2%	2%	0%	2%	4%	2%	4%	2%	5%	4%	0%
Turn Type	Split	NA		Split	Split	Split	NA	Perm	Prot	NA	Perm	Prot
Protected Phases	4	4		8	8	8	8		5	2		1
Permitted Phases								8			2	
Actuated Green, G (s)		6.2				8.4	8.4	8.4	1.1	41.3	41.3	
Effective Green, g (s)		7.1				9.3	9.3	9.3	2.0	42.6	42.6	
Actuated g/C Ratio		0.08				0.10	0.10	0.10	0.02	0.47	0.47	
Clearance Time (s)		4.9				4.9	4.9	4.9	4.9	5.3	5.3	
Vehicle Extension (s)		3.0				2.0	2.0	2.0	2.0	4.0	4.0	
Lane Grp Cap (vph)		266				178	189	155	38	1605	715	
v/s Ratio Prot		c0.00				c0.04	0.03		0.01	c0.32		
v/s Ratio Perm								0.02			0.06	
v/c Ratio		0.03				0.37	0.29	0.16	0.34	0.69	0.13	
Uniform Delay, d1		38.9				38.2	37.9	37.4	44.0	19.1	13.8	
Progression Factor		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2		0.1				0.5	0.3	0.2	2.0	1.4	0.1	
Delay (s)		38.9				38.7	38.2	37.5	45.9	20.5	13.9	
Level of Service		D				D	D	D	D	C	B	
Approach Delay (s)		38.9					37.9			20.3		
Approach LOS		D					D			C		

Intersection Summary			
HCM 2000 Control Delay	25.5	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	91.2	Sum of lost time (s)	16.0
Intersection Capacity Utilization	75.7%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBL2	SBL	SBT	SBR	NWR2
Lane Configurations					
Traffic Volume (vph)	383	20	746	68	31
Future Volume (vph)	383	20	746	68	31
Ideal Flow (vphpl)	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0
Lane Util. Factor	0.91	0.95	0.95		1.00
Frpb, ped/bikes	1.00	1.00	1.00		1.00
Flpb, ped/bikes	1.00	1.00	1.00		1.00
Frt	1.00	1.00	0.99		0.86
Flt Protected	0.95	0.95	1.00		1.00
Satd. Flow (prot)	1584	1652	3367		1611
Flt Permitted	0.95	0.95	1.00		1.00
Satd. Flow (perm)	1584	1652	3367		1611
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.60
Adj. Flow (vph)	435	23	848	77	52
RTOR Reduction (vph)	0	0	3	0	47
Lane Group Flow (vph)	254	223	922	0	5
Confl. Peds. (#/hr)	1	1			
Confl. Bikes (#/hr)				5	
Heavy Vehicles (%)	4%	2%	6%	2%	2%
Turn Type	Prot	Prot	NA		Perm
Protected Phases	1	1	6		
Permitted Phases					8
Actuated Green, G (s)	15.3	15.3	55.5		8.4
Effective Green, g (s)	16.2	16.2	56.8		9.3
Actuated g/C Ratio	0.18	0.18	0.62		0.10
Clearance Time (s)	4.9	4.9	5.3		4.9
Vehicle Extension (s)	1.0	1.0	4.0		2.0
Lane Grp Cap (vph)	281	293	2096		164
v/s Ratio Prot	c0.16	0.13	0.27		
v/s Ratio Perm					0.00
v/c Ratio	0.90	0.76	0.44		0.03
Uniform Delay, d1	36.7	35.7	8.9		36.9
Progression Factor	1.00	1.00	1.00		1.00
Incremental Delay, d2	29.4	10.0	0.2		0.0
Delay (s)	66.1	45.7	9.1		36.9
Level of Service	E	D	A		D
Approach Delay (s)			25.3		
Approach LOS			C		

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	20	22	6	124	20	2	1	16	1066	390	13	619
Future Volume (vph)	20	22	6	124	20	2	1	16	1066	390	13	619
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0	4.0		4.0	4.0	4.0	3.2	4.0
Lane Util. Factor		1.00		0.95	0.95	1.00		1.00	0.95	1.00	1.00	0.95
Frpb, ped/bikes		1.00		1.00	1.00	0.98		1.00	1.00	0.98	1.00	1.00
Flpb, ped/bikes		1.00		1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00
Frt		0.98		1.00	1.00	0.85		1.00	1.00	0.85	1.00	0.99
Flt Protected		0.98		0.95	0.96	1.00		0.95	1.00	1.00	0.95	1.00
Satd. Flow (prot)		1380		1681	1706	1557		1772	3471	1548	1770	3378
Flt Permitted		0.83		0.82	0.82	1.00		0.95	1.00	1.00	0.95	1.00
Satd. Flow (perm)		1162		1446	1444	1557		1772	3471	1548	1770	3378
Peak-hour factor, PHF	0.57	0.57	0.57	0.91	0.91	0.91	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	35	39	11	136	22	2	1	17	1146	419	14	666
RTOR Reduction (vph)	0	5	0	0	0	2	0	0	0	84	0	1
Lane Group Flow (vph)	0	80	0	72	86	0	0	18	1146	335	14	690
Confl. Peds. (#/hr)	5					5		4		2	2	
Confl. Bikes (#/hr)			3									
Heavy Vehicles (%)	75%	2%	2%	2%	2%	2%	0%	2%	4%	2%	2%	4%
Turn Type	Perm	NA		Perm	NA	Perm	Prot	Prot	NA	Perm	Prot	NA
Protected Phases		4			8		5	5	2		1	6
Permitted Phases	4			8		8				2		
Actuated Green, G (s)		7.1		7.1	7.1	7.1		0.8	33.9	33.9	0.7	33.8
Effective Green, g (s)		8.0		8.0	8.0	8.0		1.7	35.6	35.6	2.4	35.5
Actuated g/C Ratio		0.14		0.14	0.14	0.14		0.03	0.62	0.62	0.04	0.62
Clearance Time (s)		4.9		4.9	4.9	4.9		4.9	5.7	5.7	4.9	5.7
Vehicle Extension (s)		2.0		2.0	2.0	2.0		1.0	4.0	4.0	1.0	4.0
Lane Grp Cap (vph)		162		202	201	217		52	2160	963	74	2096
v/s Ratio Prot								c0.01	c0.33		0.01	0.20
v/s Ratio Perm		c0.07		0.05	0.06	0.00				0.22		
v/c Ratio		0.49		0.36	0.43	0.00		0.35	0.53	0.35	0.19	0.33
Uniform Delay, d1		22.7		22.3	22.5	21.2		27.2	6.1	5.2	26.5	5.2
Progression Factor		1.00		1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2		0.9		0.4	0.5	0.0		1.5	0.3	0.3	0.5	0.1
Delay (s)		23.6		22.7	23.0	21.2		28.7	6.4	5.5	26.9	5.3
Level of Service		C		C	C	C		C	A	A	C	A
Approach Delay (s)		23.6			22.8				6.4			5.7
Approach LOS		C			C				A			A

Intersection Summary			
HCM 2000 Control Delay	7.8	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.53		
Actuated Cycle Length (s)	57.2	Sum of lost time (s)	12.9
Intersection Capacity Utilization	47.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	23
Future Volume (vph)	23
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.93
Adj. Flow (vph)	25
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	4
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	65%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBT	WBR	WBR2	NBL2	NBT	NBR	SBU	SBL	SBR
Lane Configurations												
Traffic Volume (vph)	322	751	196	616	255	143	504	421	357	25	209	618
Future Volume (vph)	322	751	196	616	255	143	504	421	357	25	209	618
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.7	5.4	4.0	5.4	5.4	5.4	5.1	5.1			4.4	4.4
Lane Util. Factor	0.97	0.95	1.00	0.95	1.00	1.00	1.00	0.95			1.00	0.88
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.98	1.00	0.99			1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.85	0.85	1.00	0.93			1.00	0.85
Flt Protected	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (prot)	3127	3223	1380	3223	1442	1414	1583	2982			1630	2538
Flt Permitted	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (perm)	3127	3223	1380	3223	1442	1414	1583	2982			1630	2538
Peak-hour factor, PHF	0.89	0.89	0.89	0.91	0.91	0.91	0.92	0.92	0.92	0.87	0.87	0.87
Adj. Flow (vph)	362	844	220	677	280	157	548	458	388	29	240	710
RTOR Reduction (vph)	0	0	0	0	0	117	0	64	0	0	0	47
Lane Group Flow (vph)	362	844	220	677	280	40	548	782	0	0	269	704
Confl. Peds. (#/hr)	6					6			2		2	
Heavy Vehicles (%)	12%	12%	17%	12%	12%	12%	14%	12%	12%	0%	12%	12%
Turn Type	Prot	NA	Free	NA	Prot	Perm	Split	NA		Prot	Prot	pt+ov
Protected Phases	5	2		6	6		8	8		7	7	7 5
Permitted Phases			Free			6						
Actuated Green, G (s)	15.0	49.5	120.0	30.8	30.8	30.8	37.6	37.6			18.0	37.4
Effective Green, g (s)	15.0	49.5	120.0	30.8	30.8	30.8	37.6	37.6			18.0	37.4
Actuated g/C Ratio	0.12	0.41	1.00	0.26	0.26	0.26	0.31	0.31			0.15	0.31
Clearance Time (s)	3.7	5.4		5.4	5.4	5.4	5.1	5.1			4.4	
Vehicle Extension (s)	2.0	4.0		4.0	4.0	4.0	2.0	2.0			2.0	
Lane Grp Cap (vph)	390	1329	1380	827	370	362	496	934			244	791
v/s Ratio Prot	0.12	0.26		c0.21	0.19		c0.35	0.26			c0.16	c0.28
v/s Ratio Perm			0.16			0.03						
v/c Ratio	0.93	0.64	0.16	0.82	0.76	0.11	1.10	0.84			1.10	0.89
Uniform Delay, d1	52.0	28.1	0.0	42.0	41.1	34.1	41.2	38.4			51.0	39.3
Progression Factor	0.74	1.11	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Incremental Delay, d2	22.8	1.8	0.2	8.9	13.5	0.6	72.2	6.3			87.8	11.9
Delay (s)	61.3	33.1	0.2	50.8	54.6	34.7	113.4	44.7			138.8	51.3
Level of Service	E	C	A	D	D	C	F	D			F	D
Approach Delay (s)		35.2		49.5				71.7				
Approach LOS		D		D				E				

Intersection Summary			
HCM 2000 Control Delay	56.7	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.01		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	18.6
Intersection Capacity Utilization	87.4%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	SBR2
Lane Configurations	
Traffic Volume (vph)	36
Future Volume (vph)	36
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.87
Adj. Flow (vph)	41
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	
Heavy Vehicles (%)	12%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	277	185	139	171	181	321	307	588	45	323	615	836
Future Volume (vph)	277	185	139	171	181	321	307	588	45	323	615	836
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.3	5.3	5.3	4.9	4.9	4.9	4.7	5.4	5.4	4.7	5.4	5.4
Lane Util. Factor	0.91	0.91	1.00	0.95	0.95	1.00	0.97	0.95	1.00	0.97	0.95	1.00
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.98	1.00	1.00	1.00	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	0.98	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1521	3121	1583	1681	1658	1411	3433	3539	1583	3127	3539	1519
Flt Permitted	0.95	0.98	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1521	3121	1583	1681	1658	1411	3433	3539	1583	3127	3539	1519
Peak-hour factor, PHF	0.83	0.83	0.83	0.88	0.88	0.88	0.78	0.78	0.78	0.80	0.80	0.80
Adj. Flow (vph)	334	223	167	194	206	365	394	754	58	404	769	1045
RTOR Reduction (vph)	0	0	142	0	0	253	0	0	37	0	0	287
Lane Group Flow (vph)	184	373	25	175	225	112	394	754	21	404	769	758
Confl. Peds. (#/hr)	5					5						
Confl. Bikes (#/hr)												1
Heavy Vehicles (%)	8%	9%	2%	2%	9%	12%	2%	2%	2%	12%	2%	5%
Turn Type	Split	NA	Perm	Split	NA	Perm	Prot	NA	Perm	Prot	NA	Perm
Protected Phases	7	7		8	8		5	2		1	6	
Permitted Phases			7			8			2			6
Actuated Green, G (s)	18.2	18.2	18.2	18.8	18.8	18.8	16.8	44.2	44.2	18.5	45.9	45.9
Effective Green, g (s)	18.2	18.2	18.2	18.8	18.8	18.8	16.8	44.2	44.2	18.5	45.9	45.9
Actuated g/C Ratio	0.15	0.15	0.15	0.16	0.16	0.16	0.14	0.37	0.37	0.15	0.38	0.38
Clearance Time (s)	5.3	5.3	5.3	4.9	4.9	4.9	4.7	5.4	5.4	4.7	5.4	5.4
Vehicle Extension (s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0	2.0	3.0	3.0
Lane Grp Cap (vph)	230	473	240	263	259	221	480	1303	583	482	1353	581
v/s Ratio Prot	c0.12	0.12		0.10	c0.14		0.11	0.21		c0.13	0.22	
v/s Ratio Perm			0.02			0.08			0.01			c0.50
v/c Ratio	0.80	0.79	0.11	0.67	0.87	0.51	0.82	0.58	0.04	0.84	0.57	1.30
Uniform Delay, d1	49.1	49.0	43.9	47.6	49.4	46.4	50.1	30.4	24.3	49.3	29.2	37.1
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	1.00
Incremental Delay, d2	16.9	7.9	0.1	4.9	24.4	0.7	10.3	1.9	0.1	7.0	1.0	144.2
Delay (s)	66.0	56.9	44.0	52.5	73.8	47.0	60.4	32.3	24.4	56.2	29.6	181.0
Level of Service	E	E	D	D	E	D	E	C	C	E	C	F
Approach Delay (s)		56.2			56.1			41.1			105.8	
Approach LOS		E			E			D			F	

Intersection Summary			
HCM 2000 Control Delay	74.9	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.06		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	20.3
Intersection Capacity Utilization	83.0%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL
Lane Configurations												
Traffic Volume (vph)	14	24	13	1	177	149	301	1	82	923	231	416
Future Volume (vph)	14	24	13	1	177	149	301	1	82	923	231	416
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.6	5.3			4.6	5.3	5.3		4.6	5.3	5.3	4.6
Lane Util. Factor	1.00	0.95			0.97	1.00	1.00		1.00	0.95	1.00	0.97
Frpb, ped/bikes	1.00	1.00			1.00	1.00	0.99		1.00	1.00	0.99	1.00
Flpb, ped/bikes	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Frt	1.00	0.95			1.00	1.00	0.85		1.00	1.00	0.85	1.00
Flt Protected	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (prot)	1770	3353			3047	1863	1533		1770	3471	1408	3367
Flt Permitted	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (perm)	1770	3353			3047	1863	1533		1770	3471	1408	3367
Peak-hour factor, PHF	0.91	0.91	0.91	0.93	0.93	0.93	0.93	0.86	0.86	0.86	0.86	0.94
Adj. Flow (vph)	15	26	14	1	190	160	324	1	95	1073	269	443
RTOR Reduction (vph)	0	13	0	0	0	0	269	0	0	0	86	0
Lane Group Flow (vph)	15	27	0	0	191	160	55	0	96	1073	183	443
Confl. Peds. (#/hr)	1						1		1		2	2
Confl. Bikes (#/hr)											1	
Heavy Vehicles (%)	2%	2%	2%	0%	15%	2%	4%	0%	2%	4%	13%	4%
Turn Type	Prot	NA		Prot	Prot	NA	Perm	Prot	Prot	NA	Perm	Prot
Protected Phases	7	4		3	3	8		5	5	2		1
Permitted Phases							8				2	
Actuated Green, G (s)	2.7	9.8			12.9	20.0	20.0		12.4	54.3	54.3	20.7
Effective Green, g (s)	2.7	9.8			12.9	20.0	20.0		12.4	54.3	54.3	20.7
Actuated g/C Ratio	0.02	0.08			0.11	0.17	0.17		0.11	0.46	0.46	0.18
Clearance Time (s)	4.6	5.3			4.6	5.3	5.3		4.6	5.3	5.3	4.6
Vehicle Extension (s)	2.0	2.0			2.0	2.0	2.0		2.0	4.0	4.0	2.0
Lane Grp Cap (vph)	40	279			334	317	260		186	1604	650	593
v/s Ratio Prot	0.01	0.01			c0.06	c0.09			0.05	0.31		c0.13
v/s Ratio Perm							0.04				0.13	
v/c Ratio	0.38	0.10			0.57	0.50	0.21		0.52	0.67	0.28	0.75
Uniform Delay, d1	56.6	49.8			49.7	44.3	42.0		49.7	24.6	19.5	45.9
Progression Factor	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2	2.1	0.1			1.5	0.5	0.1		1.0	1.2	0.3	4.5
Delay (s)	58.7	49.8			51.1	44.7	42.1		50.7	25.8	19.9	50.4
Level of Service	E	D			D	D	D		D	C	B	D
Approach Delay (s)		52.2				45.3				26.3		
Approach LOS		D				D				C		

Intersection Summary			
HCM 2000 Control Delay	31.3	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	117.5	Sum of lost time (s)	19.8
Intersection Capacity Utilization	67.5%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR
Lane Configurations		
Traffic Volume (vph)	1187	43
Future Volume (vph)	1187	43
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	5.3	
Lane Util. Factor	0.95	
Frpb, ped/bikes	1.00	
Flpb, ped/bikes	1.00	
Frt	0.99	
Flt Protected	1.00	
Satd. Flow (prot)	3452	
Flt Permitted	1.00	
Satd. Flow (perm)	3452	
Peak-hour factor, PHF	0.94	0.94
Adj. Flow (vph)	1263	46
RTOR Reduction (vph)	1	0
Lane Group Flow (vph)	1308	0
Confl. Peds. (#/hr)		1
Confl. Bikes (#/hr)		1
Heavy Vehicles (%)	4%	2%
Turn Type	NA	
Protected Phases	6	
Permitted Phases		
Actuated Green, G (s)	62.6	
Effective Green, g (s)	62.6	
Actuated g/C Ratio	0.53	
Clearance Time (s)	5.3	
Vehicle Extension (s)	4.0	
Lane Grp Cap (vph)	1839	
v/s Ratio Prot	c0.38	
v/s Ratio Perm		
v/c Ratio	0.71	
Uniform Delay, d1	20.7	
Progression Factor	1.00	
Incremental Delay, d2	1.4	
Delay (s)	22.1	
Level of Service	C	
Approach Delay (s)	29.2	
Approach LOS	C	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	41	13	25	39	7	60	6	31	968	51	63	1141
Future Volume (vph)	41	13	25	39	7	60	6	31	968	51	63	1141
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.9			4.9			4.9	5.3		4.9	5.3
Lane Util. Factor		1.00			1.00			1.00	0.95		1.00	0.95
Frpb, ped/bikes		0.99			0.97			1.00	1.00		1.00	1.00
Flpb, ped/bikes		0.99			1.00			1.00	1.00		1.00	1.00
Frt		0.96			0.92			1.00	0.99		1.00	1.00
Flt Protected		0.97			0.98			0.95	1.00		0.95	1.00
Satd. Flow (prot)		1368			1641			1775	3440		1770	3399
Flt Permitted		0.61			0.82			0.95	1.00		0.95	1.00
Satd. Flow (perm)		854			1375			1775	3440		1770	3399
Peak-hour factor, PHF	0.74	0.74	0.74	0.58	0.58	0.58	0.81	0.81	0.81	0.81	0.89	0.89
Adj. Flow (vph)	55	18	34	67	12	103	7	38	1195	63	71	1282
RTOR Reduction (vph)	0	18	0	0	52	0	0	0	2	0	0	1
Lane Group Flow (vph)	0	89	0	0	130	0	0	45	1256	0	71	1319
Confl. Peds. (#/hr)	29		11	11		29		2		11	11	
Confl. Bikes (#/hr)			2			1				3		
Heavy Vehicles (%)	51%	2%	2%	2%	2%	2%	0%	2%	4%	2%	2%	4%
Turn Type	Perm	NA		Perm	NA		Prot	Prot	NA		Prot	NA
Protected Phases		4			8		5	5	2		1	6
Permitted Phases	4			8								
Actuated Green, G (s)		13.3			13.3			4.5	69.8		6.8	72.1
Effective Green, g (s)		13.3			13.3			4.5	69.8		6.8	72.1
Actuated g/C Ratio		0.13			0.13			0.04	0.66		0.06	0.69
Clearance Time (s)		4.9			4.9			4.9	5.3		4.9	5.3
Vehicle Extension (s)		1.5			1.5			1.0	4.0		1.0	4.5
Lane Grp Cap (vph)		108			174			76	2286		114	2333
v/s Ratio Prot								0.03	0.37		c0.04	c0.39
v/s Ratio Perm		c0.10			0.09							
v/c Ratio		0.82			0.75			0.59	0.55		0.62	0.57
Uniform Delay, d1		44.7			44.2			49.3	9.3		47.9	8.4
Progression Factor		1.00			1.00			1.00	1.00		1.00	1.00
Incremental Delay, d2		35.8			14.3			8.0	1.0		7.4	1.0
Delay (s)		80.5			58.6			57.3	10.2		55.2	9.4
Level of Service		F			E			E	B		E	A
Approach Delay (s)		80.5			58.6				11.9			11.8
Approach LOS		F			E				B			B

Intersection Summary			
HCM 2000 Control Delay	17.1	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	105.0	Sum of lost time (s)	15.1
Intersection Capacity Utilization	66.7%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	34
Future Volume (vph)	34
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.89
Adj. Flow (vph)	38
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	2
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	62%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR2	WBU	WBL2	WBL	WBT	WBR	NBL	NBT	NBR	SBU
Lane Configurations												
Traffic Volume (vph)	86	58	31	8	12	72	20	243	17	745	97	5
Future Volume (vph)	86	58	31	8	12	72	20	243	17	745	97	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.9				4.9	4.9	4.9	4.9	5.3	5.3	
Lane Util. Factor		0.95				1.00	1.00	1.00	1.00	0.95	1.00	
Frpb, ped/bikes		1.00				1.00	1.00	0.98	1.00	1.00	0.98	
Flpb, ped/bikes		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Frt		0.97				1.00	1.00	0.85	1.00	1.00	0.85	
Flt Protected		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (prot)		3363				1746	1863	1518	1770	3471	1529	
Flt Permitted		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (perm)		3363				1746	1863	1518	1770	3471	1529	
Peak-hour factor, PHF	0.83	0.83	0.83	0.71	0.71	0.71	0.71	0.71	0.76	0.76	0.76	0.86
Adj. Flow (vph)	104	70	37	11	17	101	28	342	22	980	128	6
RTOR Reduction (vph)	0	130	0	0	0	0	0	297	0	0	0	0
Lane Group Flow (vph)	0	81	0	0	0	129	28	45	22	980	128	0
Confl. Peds. (#/hr)	13					3		13	3		2	
Confl. Bikes (#/hr)											2	
Heavy Vehicles (%)	2%	2%	2%	0%	2%	4%	2%	4%	2%	4%	4%	0%
Turn Type	Split	NA		Split	Split	Split	NA	Perm	Prot	NA	Perm	Prot
Protected Phases	4	4		8	8	8	8		5	2		1
Permitted Phases								8			2	
Actuated Green, G (s)		8.0				11.9	11.9	11.9	2.4	38.2	38.2	
Effective Green, g (s)		8.0				11.9	11.9	11.9	2.4	38.2	38.2	
Actuated g/C Ratio		0.09				0.13	0.13	0.13	0.03	0.42	0.42	
Clearance Time (s)		4.9				4.9	4.9	4.9	4.9	5.3	5.3	
Vehicle Extension (s)		3.0				2.0	2.0	2.0	2.0	4.0	4.0	
Lane Grp Cap (vph)		296				229	244	199	46	1463	644	
v/s Ratio Prot		c0.02				c0.07	0.02		0.01	c0.28		
v/s Ratio Perm								0.03			0.08	
v/c Ratio		0.27				0.56	0.11	0.23	0.48	0.67	0.20	
Uniform Delay, d1		38.6				36.9	34.7	35.2	43.5	21.1	16.5	
Progression Factor		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2		0.5				1.9	0.1	0.2	2.8	1.3	0.2	
Delay (s)		39.1				38.8	34.8	35.4	46.3	22.4	16.7	
Level of Service		D				D	C	D	D	C	B	
Approach Delay (s)		39.1					36.3			22.2		
Approach LOS		D					D			C		

Intersection Summary			
HCM 2000 Control Delay	25.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	90.6	Sum of lost time (s)	20.0
Intersection Capacity Utilization	71.8%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBL2	SBL	SBT	SBR	NWR2
Lane Configurations					
Traffic Volume (vph)	235	16	814	24	45
Future Volume (vph)	235	16	814	24	45
Ideal Flow (vphpl)	1900	1900	1900	1900	1900
Total Lost time (s)	4.9	4.9	5.3		4.9
Lane Util. Factor	0.91	0.95	0.95		1.00
Frpb, ped/bikes	1.00	1.00	1.00		0.99
Flpb, ped/bikes	1.00	1.00	1.00		1.00
Frt	1.00	1.00	1.00		0.86
Flt Protected	0.95	0.95	1.00		1.00
Satd. Flow (prot)	1582	1653	3456		1589
Flt Permitted	0.95	0.95	1.00		1.00
Satd. Flow (perm)	1582	1653	3456		1589
Peak-hour factor, PHF	0.86	0.86	0.86	0.86	0.75
Adj. Flow (vph)	273	19	947	28	60
RTOR Reduction (vph)	0	0	1	0	52
Lane Group Flow (vph)	148	150	974	0	8
Confl. Peds. (#/hr)	2	2		3	
Confl. Bikes (#/hr)					1
Heavy Vehicles (%)	4%	2%	4%	2%	2%
Turn Type	Prot	Prot	NA		Perm
Protected Phases	1	1	6		
Permitted Phases					8
Actuated Green, G (s)	12.5	12.5	48.3		11.9
Effective Green, g (s)	12.5	12.5	48.3		11.9
Actuated g/C Ratio	0.14	0.14	0.53		0.13
Clearance Time (s)	4.9	4.9	5.3		4.9
Vehicle Extension (s)	1.0	1.0	4.0		2.0
Lane Grp Cap (vph)	218	228	1842		208
v/s Ratio Prot	c0.09	0.09	0.28		
v/s Ratio Perm					0.00
v/c Ratio	0.68	0.66	0.53		0.04
Uniform Delay, d1	37.1	37.0	13.8		34.4
Progression Factor	1.00	1.00	1.00		1.00
Incremental Delay, d2	6.5	5.1	0.4		0.0
Delay (s)	43.6	42.2	14.1		34.4
Level of Service	D	D	B		C
Approach Delay (s)			20.8		
Approach LOS			C		

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBU	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	23	24	16	178	12	5	9	595	143	2	6	936
Future Volume (vph)	23	24	16	178	12	5	9	595	143	2	6	936
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.9		4.9	4.9	4.9	4.9	5.7	5.7		4.9	5.7
Lane Util. Factor		1.00		0.95	0.95	1.00	1.00	0.95	1.00		1.00	0.95
Frpb, ped/bikes		1.00		1.00	1.00	0.98	1.00	1.00	0.98		1.00	1.00
Flpb, ped/bikes		1.00		1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
Frt		0.96		1.00	1.00	0.85	1.00	1.00	0.85		1.00	1.00
Flt Protected		0.98		0.95	0.96	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (prot)		1721		1681	1696	1555	1766	3471	1550		1770	3462
Flt Permitted		0.85		0.83	0.78	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (perm)		1483		1461	1372	1555	1766	3471	1550		1770	3462
Peak-hour factor, PHF	0.78	0.78	0.78	0.68	0.68	0.68	0.74	0.74	0.74	0.79	0.79	0.79
Adj. Flow (vph)	29	31	21	262	18	7	12	804	193	3	8	1185
RTOR Reduction (vph)	0	12	0	0	0	6	0	0	62	0	0	0
Lane Group Flow (vph)	0	69	0	139	141	1	12	804	131	0	11	1190
Confl. Peds. (#/hr)	4					4	7					
Confl. Bikes (#/hr)						1			2			
Heavy Vehicles (%)	9%	2%	2%	2%	2%	2%	2%	4%	2%	2%	2%	4%
Turn Type	Perm	NA		Perm	NA	Perm	Prot	NA	Perm	Prot	Prot	NA
Protected Phases		4			8		5	2		1	1	6
Permitted Phases	4			8		8			2			
Actuated Green, G (s)		11.6		11.6	11.6	11.6	0.8	36.3	36.3		0.8	36.3
Effective Green, g (s)		11.6		11.6	11.6	11.6	0.8	36.3	36.3		0.8	36.3
Actuated g/C Ratio		0.18		0.18	0.18	0.18	0.01	0.57	0.57		0.01	0.57
Clearance Time (s)		4.9		4.9	4.9	4.9	4.9	5.7	5.7		4.9	5.7
Vehicle Extension (s)		2.0		2.0	2.0	2.0	1.0	4.0	4.0		1.0	4.0
Lane Grp Cap (vph)		267		263	247	280	22	1962	876		22	1957
v/s Ratio Prot							c0.01	0.23			0.01	c0.34
v/s Ratio Perm		0.05		0.10	c0.10	0.00			0.08			
v/c Ratio		0.26		0.53	0.57	0.00	0.55	0.41	0.15		0.50	0.61
Uniform Delay, d1		22.6		23.8	24.0	21.6	31.5	7.9	6.6		31.5	9.2
Progression Factor		1.00		1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
Incremental Delay, d2		0.2		0.9	2.0	0.0	14.0	0.2	0.1		6.4	0.6
Delay (s)		22.8		24.7	26.0	21.6	45.5	8.1	6.7		37.9	9.9
Level of Service		C		C	C	C	D	A	A		D	A
Approach Delay (s)		22.8			25.3			8.3				10.1
Approach LOS		C			C			A				B

Intersection Summary			
HCM 2000 Control Delay	11.5	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	64.2	Sum of lost time (s)	15.5
Intersection Capacity Utilization	46.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	4
Future Volume (vph)	4
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.79
Adj. Flow (vph)	5
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	7
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	50%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

WorstCase-Added Scenario
Project Alternative D PM

Movement	EBL	EBT	EBR	WBT	WBR	WBR2	NBL2	NBT	NBR	SBU	SBL	SBR
Lane Configurations												
Traffic Volume (vph)	724	765	233	751	208	267	180	635	131	48	179	575
Future Volume (vph)	724	765	233	751	208	267	180	635	131	48	179	575
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	2.6	4.0	4.0	4.0	4.0	4.0			4.0	4.0
Lane Util. Factor	0.97	0.95	1.00	0.95	1.00	1.00	1.00	0.95			1.00	0.88
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.98	1.00	1.00			1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.85	0.85	1.00	0.97			1.00	0.85
Flt Protected	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (prot)	3127	3223	1392	3223	1442	1408	1543	3132			1649	2538
Flt Permitted	0.95	1.00	1.00	1.00	1.00	1.00	0.95	1.00			0.95	1.00
Satd. Flow (perm)	3127	3223	1392	3223	1442	1408	1543	3132			1649	2538
Peak-hour factor, PHF	0.88	0.88	0.88	0.95	0.95	0.95	0.89	0.89	0.89	0.94	0.94	0.94
Adj. Flow (vph)	823	869	265	791	219	281	202	713	147	51	190	612
RTOR Reduction (vph)	0	0	0	0	0	112	0	14	0	0	0	40
Lane Group Flow (vph)	823	869	265	791	219	169	202	846	0	0	241	603
Confl. Peds. (#/hr)	9					9			4		4	
Heavy Vehicles (%)	12%	12%	16%	12%	12%	12%	17%	12%	12%	0%	12%	12%
Turn Type	Prot	NA	Free	NA	Prot	Perm	Split	NA		Prot	Prot	pt+ov
Protected Phases	5	2		6	6		8	8		7	7	7 5
Permitted Phases			Free			6						
Actuated Green, G (s)	26.0	62.1	130.0	32.4	32.4	32.4	35.6	35.6			17.4	47.8
Effective Green, g (s)	25.7	63.5	130.0	33.8	33.8	33.8	36.7	36.7			17.8	48.2
Actuated g/C Ratio	0.20	0.49	1.00	0.26	0.26	0.26	0.28	0.28			0.14	0.37
Clearance Time (s)	3.7	5.4		5.4	5.4	5.4	5.1	5.1			4.4	
Vehicle Extension (s)	2.0	4.0		4.0	4.0	4.0	2.0	2.0			2.0	
Lane Grp Cap (vph)	618	1574	1392	837	374	366	435	884			225	941
v/s Ratio Prot	c0.26	0.27		c0.25	0.15		0.13	c0.27			c0.15	0.24
v/s Ratio Perm			0.19			0.12						
v/c Ratio	1.33	0.55	0.19	0.95	0.59	0.46	0.46	0.96			1.07	0.64
Uniform Delay, d1	52.1	23.3	0.0	47.2	42.0	40.5	38.5	45.9			56.1	33.8
Progression Factor	0.72	1.03	1.00	1.00	1.00	1.00	1.00	1.00			1.00	1.00
Incremental Delay, d2	156.3	0.9	0.2	20.3	6.6	4.2	0.3	20.3			80.1	1.1
Delay (s)	194.0	24.8	0.2	67.5	48.6	44.6	38.8	66.1			136.2	34.9
Level of Service	F	C	A	E	D	D	D	E			F	C
Approach Delay (s)		92.6		59.3				60.9				
Approach LOS		F		E				E				

Intersection Summary			
HCM 2000 Control Delay	72.7	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.05		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	93.6%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

Movement	SBR2
Lane Configurations	
Traffic Volume (vph)	29
Future Volume (vph)	29
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.94
Adj. Flow (vph)	31
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	
Heavy Vehicles (%)	12%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBU	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	420	513	289	300	104	340	255	866	146	4	479	747
Future Volume (vph)	420	513	289	300	104	340	255	866	146	4	479	747
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		4.0	4.0
Lane Util. Factor	0.91	0.91	1.00	0.95	0.95	1.00	0.97	0.95	1.00		0.97	0.95
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00		1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85		1.00	1.00
Flt Protected	0.95	0.99	1.00	0.95	0.98	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (prot)	1550	3232	1583	1681	1638	1423	3433	3539	1583		3129	3539
Flt Permitted	0.95	0.99	1.00	0.95	0.98	1.00	0.95	1.00	1.00		0.95	1.00
Satd. Flow (perm)	1550	3232	1583	1681	1638	1423	3433	3539	1583		3129	3539
Peak-hour factor, PHF	0.96	0.96	0.96	0.95	0.95	0.95	0.92	0.92	0.92	0.91	0.91	0.91
Adj. Flow (vph)	438	534	301	316	109	358	277	941	159	4	526	821
RTOR Reduction (vph)	0	0	189	0	0	222	0	0	95	0	0	0
Lane Group Flow (vph)	315	657	112	209	216	136	277	941	64	0	530	821
Confl. Peds. (#/hr)							10					
Confl. Bikes (#/hr)						1						
Heavy Vehicles (%)	6%	6%	2%	2%	13%	12%	2%	2%	2%	0%	12%	2%
Turn Type	Split	NA	Perm	Split	NA	Perm	Prot	NA	Perm	Prot	Prot	NA
Protected Phases	7	7		8	8		5	2		1	1	6
Permitted Phases			7			8			2			
Actuated Green, G (s)	29.7	29.7	29.7	20.0	20.0	20.0	14.5	36.0	36.0		24.0	45.5
Effective Green, g (s)	31.0	31.0	31.0	20.9	20.9	20.9	15.2	37.4	37.4		24.7	46.9
Actuated g/C Ratio	0.24	0.24	0.24	0.16	0.16	0.16	0.12	0.29	0.29		0.19	0.36
Clearance Time (s)	5.3	5.3	5.3	4.9	4.9	4.9	4.7	5.4	5.4		4.7	5.4
Vehicle Extension (s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0		2.0	3.0
Lane Grp Cap (vph)	369	770	377	270	263	228	401	1018	455		594	1276
v/s Ratio Prot	0.20	c0.20		0.12	c0.13		0.08	c0.27			c0.17	0.23
v/s Ratio Perm			0.07			0.10			0.04			
v/c Ratio	0.85	0.85	0.30	0.77	0.82	0.59	0.69	0.92	0.14		0.89	0.64
Uniform Delay, d1	47.3	47.3	40.6	52.3	52.7	50.6	55.1	44.9	34.4		51.4	34.6
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		0.95	0.83
Incremental Delay, d2	16.6	8.8	0.2	11.9	17.5	2.8	4.1	15.0	0.6		11.2	1.7
Delay (s)	63.9	56.1	40.7	64.2	70.2	53.4	59.3	59.9	35.0		59.7	30.5
Level of Service	E	E	D	E	E	D	E	E	D		E	C
Approach Delay (s)		54.4			60.9			56.9				42.5
Approach LOS		D			E			E				D

Intersection Summary			
HCM 2000 Control Delay	52.1	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.88		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	16.7
Intersection Capacity Utilization	89.7%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	352
Future Volume (vph)	352
Ideal Flow (vphpl)	1900
Total Lost time (s)	4.0
Lane Util. Factor	1.00
Frpb, ped/bikes	0.97
Flpb, ped/bikes	1.00
Frt	0.85
Flt Protected	1.00
Satd. Flow (prot)	1469
Flt Permitted	1.00
Satd. Flow (perm)	1469
Peak-hour factor, PHF	0.91
Adj. Flow (vph)	387
RTOR Reduction (vph)	247
Lane Group Flow (vph)	140
Confl. Peds. (#/hr)	10
Confl. Bikes (#/hr)	7
Heavy Vehicles (%)	7%
Turn Type	Perm
Protected Phases	
Permitted Phases	6
Actuated Green, G (s)	45.5
Effective Green, g (s)	46.9
Actuated g/C Ratio	0.36
Clearance Time (s)	5.4
Vehicle Extension (s)	3.0
Lane Grp Cap (vph)	529
v/s Ratio Prot	
v/s Ratio Perm	0.10
v/c Ratio	0.26
Uniform Delay, d1	29.4
Progression Factor	1.49
Incremental Delay, d2	0.8
Delay (s)	44.6
Level of Service	D
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL
Lane Configurations												
Traffic Volume (vph)	87	119	70	2	178	34	347	2	17	1342	181	417
Future Volume (vph)	87	119	70	2	178	34	347	2	17	1342	181	417
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			3.3	4.0	4.0		4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	0.95			0.97	1.00	1.00		1.00	0.95	1.00	0.97
Frpb, ped/bikes	1.00	0.99			1.00	1.00	0.98		1.00	1.00	0.99	1.00
Flpb, ped/bikes	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Frt	1.00	0.94			1.00	1.00	0.85		1.00	1.00	0.85	1.00
Flt Protected	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (prot)	1770	3322			3049	1863	1527		1773	3471	1386	3367
Flt Permitted	0.95	1.00			0.95	1.00	1.00		0.95	1.00	1.00	0.95
Satd. Flow (perm)	1770	3322			3049	1863	1527		1773	3471	1386	3367
Peak-hour factor, PHF	0.71	0.71	0.71	0.90	0.90	0.90	0.90	0.89	0.89	0.89	0.89	0.88
Adj. Flow (vph)	123	168	99	2	198	38	386	2	19	1508	203	474
RTOR Reduction (vph)	0	76	0	0	0	0	253	0	0	0	62	0
Lane Group Flow (vph)	123	191	0	0	200	38	133	0	21	1508	141	474
Confl. Peds. (#/hr)	4		4		4		4		3		1	1
Confl. Bikes (#/hr)												
Heavy Vehicles (%)	2%	2%	2%	0%	15%	2%	4%	0%	2%	4%	15%	4%
Turn Type	Prot	NA		Prot	Prot	NA	Perm	Prot	Prot	NA	Perm	Prot
Protected Phases	7	4		3	3	8		5	5	2		1
Permitted Phases							8				2	
Actuated Green, G (s)	14.0	16.9			13.9	16.8	16.8		6.0	55.2	55.2	28.2
Effective Green, g (s)	14.6	18.2			15.2	18.1	18.1		6.6	56.5	56.5	28.8
Actuated g/C Ratio	0.11	0.14			0.11	0.14	0.14		0.05	0.42	0.42	0.21
Clearance Time (s)	4.6	5.3			4.6	5.3	5.3		4.6	5.3	5.3	4.6
Vehicle Extension (s)	3.0	2.0			3.0	2.0	2.0		2.0	4.0	4.0	2.0
Lane Grp Cap (vph)	192	451			345	251	206		87	1463	584	723
v/s Ratio Prot	c0.07	0.06			0.07	0.02			0.01	c0.43		c0.14
v/s Ratio Perm							c0.09				0.10	
v/c Ratio	0.64	0.42			0.58	0.15	0.64		0.24	1.03	0.24	0.66
Uniform Delay, d1	57.2	53.1			56.4	51.2	54.9		61.3	38.8	25.0	48.1
Progression Factor	1.00	1.00			1.00	1.00	1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2	7.1	0.2			2.4	0.1	5.1		0.5	31.8	1.0	1.6
Delay (s)	64.3	53.3			58.7	51.3	60.0		61.8	70.5	25.9	49.7
Level of Service	E	D			E	D	E		E	E	C	D
Approach Delay (s)		56.8				59.0				65.2		
Approach LOS		E				E				E		

Intersection Summary			
HCM 2000 Control Delay	49.0	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.83		
Actuated Cycle Length (s)	134.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	80.1%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR
Lane Configurations		
Traffic Volume (vph)	1130	10
Future Volume (vph)	1130	10
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	4.0	
Lane Util. Factor	0.95	
Frpb, ped/bikes	1.00	
Flpb, ped/bikes	1.00	
Frt	1.00	
Flt Protected	1.00	
Satd. Flow (prot)	3466	
Flt Permitted	1.00	
Satd. Flow (perm)	3466	
Peak-hour factor, PHF	0.88	0.88
Adj. Flow (vph)	1284	11
RTOR Reduction (vph)	0	0
Lane Group Flow (vph)	1295	0
Confl. Peds. (#/hr)		3
Confl. Bikes (#/hr)		4
Heavy Vehicles (%)	4%	2%
Turn Type	NA	
Protected Phases	6	
Permitted Phases		
Actuated Green, G (s)	77.4	
Effective Green, g (s)	78.7	
Actuated g/C Ratio	0.59	
Clearance Time (s)	5.3	
Vehicle Extension (s)	4.0	
Lane Grp Cap (vph)	2035	
v/s Ratio Prot	0.37	
v/s Ratio Perm		
v/c Ratio	0.64	
Uniform Delay, d1	18.2	
Progression Factor	1.00	
Incremental Delay, d2	1.5	
Delay (s)	19.7	
Level of Service	B	
Approach Delay (s)	27.8	
Approach LOS	C	

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL
Lane Configurations												
Traffic Volume (vph)	40	15	31	21	14	22	12	44	1231	26	7	44
Future Volume (vph)	40	15	31	21	14	22	12	44	1231	26	7	44
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0			4.0	4.0			4.0
Lane Util. Factor		1.00			1.00			1.00	0.95			1.00
Frpb, ped/bikes		0.99			0.99			1.00	1.00			1.00
Flpb, ped/bikes		1.00			1.00			1.00	1.00			1.00
Frt		0.95			0.95			1.00	1.00			1.00
Flt Protected		0.98			0.98			0.95	1.00			0.95
Satd. Flow (prot)		1391			1714			1777	3456			1774
Flt Permitted		0.76			0.82			0.95	1.00			0.12
Satd. Flow (perm)		1084			1429			1777	3456			232
Peak-hour factor, PHF	0.75	0.75	0.75	0.65	0.65	0.65	0.93	0.93	0.93	0.93	0.96	0.96
Adj. Flow (vph)	53	20	41	32	22	34	13	47	1324	28	7	46
RTOR Reduction (vph)	0	20	0	0	22	0	0	0	2	0	0	0
Lane Group Flow (vph)	0	94	0	0	66	0	0	60	1350	0	0	53
Confl. Peds. (#/hr)	7		7	7		7		6		22		22
Confl. Bikes (#/hr)						2				1		
Heavy Vehicles (%)	53%	2%	2%	2%	2%	2%	0%	2%	4%	2%	0%	2%
Turn Type	Perm	NA		Perm	NA		Prot	Prot	NA			Prot
Protected Phases		4			8		5	5	2			1
Permitted Phases	4			8								
Actuated Green, G (s)		12.8			12.8			6.6	55.8			31.3
Effective Green, g (s)		13.7			13.7			7.5	57.1			32.2
Actuated g/C Ratio		0.12			0.12			0.07	0.50			0.28
Clearance Time (s)		4.9			4.9			4.9	5.3			4.9
Vehicle Extension (s)		1.5			1.5			1.0	4.0			1.0
Lane Grp Cap (vph)		129			170			115	1715			64
v/s Ratio Prot								0.03	c0.39			
v/s Ratio Perm		c0.09			0.05							c0.23
v/c Ratio		0.73			0.39			0.52	0.79			0.83
Uniform Delay, d1		48.8			46.8			52.0	23.9			38.8
Progression Factor		1.00			1.00			1.00	1.00			1.00
Incremental Delay, d2		15.8			0.5			2.0	3.7			54.0
Delay (s)		64.6			47.3			54.0	27.7			92.8
Level of Service		E			D			D	C			F
Approach Delay (s)		64.6			47.3				28.8			
Approach LOS		E			D				C			

Intersection Summary			
HCM 2000 Control Delay	23.1	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	115.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	59.0%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBT	SBR
Lane Configurations	↑↱	
Traffic Volume (vph)	1188	44
Future Volume (vph)	1188	44
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	4.0	
Lane Util. Factor	0.95	
Frpb, ped/bikes	1.00	
Flpb, ped/bikes	1.00	
Frt	0.99	
Flt Protected	1.00	
Satd. Flow (prot)	3396	
Flt Permitted	1.00	
Satd. Flow (perm)	3396	
Peak-hour factor, PHF	0.96	0.96
Adj. Flow (vph)	1238	46
RTOR Reduction (vph)	1	0
Lane Group Flow (vph)	1283	0
Confl. Peds. (#/hr)		6
Confl. Bikes (#/hr)		5
Heavy Vehicles (%)	4%	48%
Turn Type	NA	
Protected Phases	6	
Permitted Phases		
Actuated Green, G (s)	80.5	
Effective Green, g (s)	81.8	
Actuated g/C Ratio	0.71	
Clearance Time (s)	5.3	
Vehicle Extension (s)	4.5	
Lane Grp Cap (vph)	2415	
v/s Ratio Prot	0.38	
v/s Ratio Perm		
v/c Ratio	0.53	
Uniform Delay, d1	7.7	
Progression Factor	1.00	
Incremental Delay, d2	0.8	
Delay (s)	8.5	
Level of Service	A	
Approach Delay (s)	11.9	
Approach LOS	B	

Intersection Summary

Movement	EBL	EBT	EBR2	WBU	WBL2	WBL	WBT	WBR	NBL	NBT	NBR	SBU
Lane Configurations		↰↑↱				↰	↑	↱	↰	↑↑	↱	
Traffic Volume (vph)	31	42	8	9	14	40	52	227	12	1007	88	17
Future Volume (vph)	31	42	8	9	14	40	52	227	12	1007	88	17
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0				4.0	4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor		0.95				1.00	1.00	1.00	1.00	0.95	1.00	
Frpb, ped/bikes		1.00				1.00	1.00	0.98	1.00	1.00	0.99	
Flpb, ped/bikes		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Frt		0.99				1.00	1.00	0.85	1.00	1.00	0.85	
Flt Protected		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (prot)		3418				1752	1863	1526	1770	3471	1532	
Flt Permitted		0.98				0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (perm)		3418				1752	1863	1526	1770	3471	1532	
Peak-hour factor, PHF	0.70	0.70	0.70	0.95	0.95	0.95	0.95	0.95	0.92	0.92	0.92	0.88
Adj. Flow (vph)	44	60	11	9	15	42	55	239	13	1095	96	19
RTOR Reduction (vph)	0	106	0	0	0	0	0	214	0	0	0	0
Lane Group Flow (vph)	0	9	0	0	0	66	55	25	13	1095	96	0
Confl. Peds. (#/hr)	4		2			2		4			1	
Confl. Bikes (#/hr)								1			1	
Heavy Vehicles (%)	2%	2%	2%	0%	2%	4%	2%	4%	2%	4%	4%	0%
Turn Type	Split	NA		Split	Split	Split	NA	Perm	Prot	NA	Perm	Prot
Protected Phases	4	4		8	8	8	8		5	2		1
Permitted Phases								8			2	
Actuated Green, G (s)		6.2				8.4	8.4	8.4	1.1	40.7	40.7	
Effective Green, g (s)		7.1				9.3	9.3	9.3	2.0	42.0	42.0	
Actuated g/C Ratio		0.08				0.10	0.10	0.10	0.02	0.46	0.46	
Clearance Time (s)		4.9				4.9	4.9	4.9	4.9	5.3	5.3	
Vehicle Extension (s)		3.0				2.0	2.0	2.0	2.0	4.0	4.0	
Lane Grp Cap (vph)		267				179	191	156	39	1609	710	
v/s Ratio Prot		c0.00				c0.04	0.03		0.01	c0.32		
v/s Ratio Perm								0.02			0.06	
v/c Ratio		0.03				0.37	0.29	0.16	0.33	0.68	0.14	
Uniform Delay, d1		38.6				37.9	37.6	37.1	43.6	19.0	13.9	
Progression Factor		1.00				1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2		0.1				0.5	0.3	0.2	1.8	1.3	0.1	
Delay (s)		38.6				38.4	37.9	37.2	45.5	20.3	14.0	
Level of Service		D				D	D	D	D	C	B	
Approach Delay (s)		38.6					37.6			20.1		
Approach LOS		D					D			C		

Intersection Summary			
HCM 2000 Control Delay	25.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	90.6	Sum of lost time (s)	16.0
Intersection Capacity Utilization	75.3%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBL2	SBL	SBT	SBR	NWR2
Lane Configurations					
Traffic Volume (vph)	383	20	733	68	31
Future Volume (vph)	383	20	733	68	31
Ideal Flow (vphpl)	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0
Lane Util. Factor	0.91	0.95	0.95		1.00
Frpb, ped/bikes	1.00	1.00	1.00		1.00
Flpb, ped/bikes	1.00	1.00	1.00		1.00
Frt	1.00	1.00	0.99		0.86
Flt Protected	0.95	0.95	1.00		1.00
Satd. Flow (prot)	1584	1652	3426		1611
Flt Permitted	0.95	0.95	1.00		1.00
Satd. Flow (perm)	1584	1652	3426		1611
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.60
Adj. Flow (vph)	435	23	833	77	52
RTOR Reduction (vph)	0	0	3	0	47
Lane Group Flow (vph)	254	223	907	0	5
Confl. Peds. (#/hr)	1	1			
Confl. Bikes (#/hr)				5	
Heavy Vehicles (%)	4%	2%	4%	2%	2%
Turn Type	Prot	Prot	NA		Perm
Protected Phases	1	1	6		
Permitted Phases					8
Actuated Green, G (s)	15.3	15.3	54.9		8.4
Effective Green, g (s)	16.2	16.2	56.2		9.3
Actuated g/C Ratio	0.18	0.18	0.62		0.10
Clearance Time (s)	4.9	4.9	5.3		4.9
Vehicle Extension (s)	1.0	1.0	4.0		2.0
Lane Grp Cap (vph)	283	295	2125		165
v/s Ratio Prot	c0.16	0.13	0.26		
v/s Ratio Perm					0.00
v/c Ratio	0.90	0.76	0.43		0.03
Uniform Delay, d1	36.4	35.3	8.9		36.6
Progression Factor	1.00	1.00	1.00		1.00
Incremental Delay, d2	27.9	9.4	0.2		0.0
Delay (s)	64.2	44.7	9.1		36.6
Level of Service	E	D	A		D
Approach Delay (s)			24.9		
Approach LOS			C		

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	7	22	6	124	20	2	1	16	1066	390	13	619
Future Volume (vph)	7	22	6	124	20	2	1	16	1066	390	13	619
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0	4.0		4.0	4.0	4.0	3.2	4.0
Lane Util. Factor		1.00		0.95	0.95	1.00		1.00	0.95	1.00	1.00	0.95
Frpb, ped/bikes		1.00		1.00	1.00	0.98		1.00	1.00	0.98	1.00	1.00
Flpb, ped/bikes		1.00		1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00
Frt		0.98		1.00	1.00	0.85		1.00	1.00	0.85	1.00	1.00
Flt Protected		0.99		0.95	0.96	1.00		0.95	1.00	1.00	0.95	1.00
Satd. Flow (prot)		1706		1681	1706	1557		1772	3471	1548	1770	3453
Flt Permitted		0.92		0.93	0.79	1.00		0.95	1.00	1.00	0.95	1.00
Satd. Flow (perm)		1589		1654	1398	1557		1772	3471	1548	1770	3453
Peak-hour factor, PHF	0.57	0.57	0.57	0.91	0.91	0.91	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	12	39	11	136	22	2	1	17	1146	419	14	666
RTOR Reduction (vph)	0	8	0	0	0	2	0	0	0	83	0	0
Lane Group Flow (vph)	0	54	0	72	86	0	0	18	1146	336	14	677
Confl. Peds. (#/hr)	5					5		4		2	2	
Confl. Bikes (#/hr)			3									
Heavy Vehicles (%)	29%	2%	2%	2%	2%	2%	0%	2%	4%	2%	2%	4%
Turn Type	Perm	NA		Perm	NA	Perm	Prot	Prot	NA	Perm	Prot	NA
Protected Phases		4			8		5	5	2		1	6
Permitted Phases	4			8		8				2		
Actuated Green, G (s)		6.9		6.9	6.9	6.9		0.8	33.8	33.8	0.7	33.7
Effective Green, g (s)		7.8		7.8	7.8	7.8		1.7	35.5	35.5	2.4	35.4
Actuated g/C Ratio		0.14		0.14	0.14	0.14		0.03	0.62	0.62	0.04	0.62
Clearance Time (s)		4.9		4.9	4.9	4.9		4.9	5.7	5.7	4.9	5.7
Vehicle Extension (s)		2.0		2.0	2.0	2.0		1.0	4.0	4.0	1.0	4.0
Lane Grp Cap (vph)		217		226	191	213		52	2165	965	74	2148
v/s Ratio Prot								c0.01	c0.33		0.01	0.20
v/s Ratio Perm		0.03		0.04	c0.06	0.00				0.22		
v/c Ratio		0.25		0.32	0.45	0.00		0.35	0.53	0.35	0.19	0.32
Uniform Delay, d1		21.9		22.2	22.6	21.2		27.1	6.0	5.1	26.3	5.1
Progression Factor		1.00		1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2		0.2		0.3	0.6	0.0		1.5	0.3	0.3	0.5	0.1
Delay (s)		22.2		22.4	23.2	21.2		28.5	6.3	5.4	26.8	5.2
Level of Service		C		C	C	C		C	A	A	C	A
Approach Delay (s)		22.2			22.8				6.3			5.6
Approach LOS		C			C				A			A

Intersection Summary			
HCM 2000 Control Delay	7.6	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.52		
Actuated Cycle Length (s)	56.9	Sum of lost time (s)	12.9
Intersection Capacity Utilization	47.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	10
Future Volume (vph)	10
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.93
Adj. Flow (vph)	11
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	4
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	20%
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

APPENDIX I

AIR QUALITY AND GREENHOUSE GAS CALCULATIONS

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APPENDIX I

AIR QUALITY AND GREENHOUSE GAS CALCULATIONS

Part 1

Alternative B1/B2, C1/C2, D1/D2 Construction:

Subsequent Construction

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Table 1. Air Quality Emissions Summary

Emission Sources	ROG	CO	NOX	PM10 (exhaust)	PM2.5 (exhaust)	PM10 (Total)	PM2.5 (Total)
Average Daily Emissions (lbs/day)*							
Alt B	2.89	25.98	29.36	1.29	1.19	14.62	5.84
Alt C	2.75	23.37	27.88	1.25	1.16	7.85	1.99
Alt D	3.31	30.68	32.56	1.39	1.29	16.45	6.58
Total Tons							
Alt B	0.60	5.43	6.14	0.27	0.25	3.06	1.22
Alt C	0.55	4.63	5.52	0.25	0.23	1.55	0.39
Alt D	0.62	5.74	6.09	0.25	0.24	3.08	1.23
Total Tons/Year							
Alt B	0.38	3.43	3.88	0.17	0.16	1.93	0.77
Alt C	0.34	2.92	3.49	0.16	0.15	0.98	0.25
Alt D	0.39	3.62	3.85	0.16	0.15	1.94	0.78
Total Construction Emissions							
Alt B Average Daily Emissions* (lbs/day)	2.89	25.98	29.36	1.29	1.19	14.62	5.84
Alt C Average Daily Emissions* (lbs/day)	2.75	23.37	27.88	1.25	1.16	7.85	1.99
Alt D Average Daily Emissions* (lbs/day)	3.31	30.68	32.56	1.39	1.29	16.45	6.58
Thresholds of Significance	54	-	54	82	54	BMPs	BMPs
Exceeds Thresholds	No	-	No	No	No	_	_

Notes:

*Average Daily Emissions are calculated based on the following construction durations with 22 working days per month: Alt B 19 months; Alt C 18 months; and Alt D 17 months. Detailed modeling outputs provided in Attachment A.

ROG = reactive organic gases; NOX = oxides of nitrogen; PM10 = particulate matter with aerodynamic diameter less than 10 microns; PM2.5 = particulate matter with aerodynamic diameter less than 2.5 microns; lbs/day = pounds per day; BAAQMD = Bay Area Air Quality Management District

Table 2. Project – GHG Construction Emissions

Emissions Source	Proposed Project ($MTCO_2e$)
Alt B	
Total Construction Emissions	665.75
Amortized Construction Emissions*	22.19
Alt C	
Total Construction Emissions	634.68
Amortized Construction Emissions*	21.16
Alt D	
Total Construction Emissions	694.12
Amortized Construction Emissions*	23.14

Note:

* Construction emissions were amortized over the lifetime of the project (assumed to be 30 years) for comparison with thresholds.

Detailed modeling outputs provided in Attachment A.

Table 3. Construction

Alt B

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio-CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
	tons/yr										MT/yr					
2018	**0.60**	**6.14**	**5.43**	**0.01**	**2.79**	**0.27**	**3.06**	**0.97**	**0.25**	**1.22**	**0.00**	**662.88**	**662.88**	**0.14**	**0.00**	**665.75**
Total	**0.60**	**6.14**	**5.43**	**0.01**	**2.79**	**0.27**	**3.06**	**0.97**	**0.25**	**1.22**	**0.00**	**662.88**	**662.88**	**0.14**	**0.00**	**665.75**

Alt C

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio-CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
	tons/yr										MT/yr					
2018	**0.55**	**5.52**	**4.63**	**0.01**	**1.31**	**0.25**	**1.55**	**0.16**	**0.23**	**0.39**	**0.00**	**632.02**	**632.02**	**0.13**	**0.00**	**634.68**
Total	**0.55**	**5.52**	**4.63**	**0.01**	**1.31**	**0.25**	**1.55**	**0.16**	**0.23**	**0.39**	**0.00**	**632.02**	**632.02**	**0.13**	**0.00**	**634.68**

Alt D

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio-CO2	NBio-CO2	Total CO2	CH4	N2O	CO2e
	tons/yr										MT/yr					
2018	**0.62**	**6.09**	**5.74**	**0.01**	**2.82**	**0.26**	**3.08**	**0.99**	**0.24**	**1.23**	**0.00**	**691.35**	**691.35**	**0.13**	**0.00**	**694.12**
Total	**0.62**	**6.09**	**5.74**	**0.01**	**2.82**	**0.26**	**3.08**	**0.99**	**0.24**	**1.23**	**0.00**	**691.35**	**691.35**	**0.13**	**0.00**	**694.12**

Carbon Sequestration

Carbon sequestration rate (g carbon/year) = [(sequestration rate, g C/m2yr)*(proposed project area, m2)]-(fossil fuel emissions, grams carbon/year)

Sequestration rate 79 g C/m2-yr (Callaway et al. 2012)

Area conversion factor 4046.86 m2/acre

Mass conversion factor 907185 g/ton

Table 4. Carbon Sequestration

Pond Cluster	Alternative	Area (acres)	Carbon sequestration rate (g carbon/year)	Carbon sequestration rate (ton carbon/year)
Eden Landing	B	2,270	7.26E+08	800
Eden Landing	C	1,375	4.40E+08	485
Eden Landing	D (Low End Estimate)	1,375	4.40E+08	485
Eden Landing	D (High End Estimate)	2,270	7.26E+08	800

Note: Carbon sequestion rate calculated does not include fossil fuel emissions from operation and maintenance. Values presented are for gross carbon sequestration potential of the pond cluster.

Carbon sequestration potential calculated for the ponds that would become tidal marsh. Assumed tidal marsh ponds by alternative are as follows:

Alt B: ALL 11 of them.

Alt C: Bay Ponds only (E1, E2, E4, E7)

Alt D: Bay Ponds only (E1, E2, E4, E7) in the initial 10-20 years (Low End Estimate), with the potential to restore marsh in the remaining 7 ponds after (High End Estimate).

Table 1-2 Phase 2 Eden Landing Pond Complex Acreage

Pond	Acres
E1	290
E2	680
E4	190
E5	165
E6	200
E7	215
E1C	150
E2C	30
E4C	175
E5C	95
E6C	80
Total Area	**2,270**

APPENDIX I

AIR QUALITY AND GREENHOUSE GAS CALCULATIONS

Part 2

Alternative B1/B2, C1/C2, D1/D2 Construction:

Dredged Material Placement

Subsequent Construction

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Table 1. Construction Emissions Summary – Alternative B

Diesel

	Emissions (lbs)					Metric Tons
Construction Phase/Emissions Source	**ROG**	**NO_X**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**CO_2e**
Mobilization	16.76	120.63	107.47	3.53	3.25	11.24
Site Preparation	1007.59	7970.74	6812.21	315.13	293.92	694.19
Dredged Material Placement	21741.62	293247.11	95310.39	7050.04	6989.67	21582.75
Decomissioning	475.43	3602.96	2906.48	130.57	120.14	290.75
Demobilization	16.76	120.63	107.47	3.53	3.25	11.24
Restoration Project	129.13	1364.39	1256.68	63.11	58.07	86.37
Total Project	23387.30	306426.46	106500.69	7565.90	7468.29	22676.54
Average Emissions (lbs)	**48.08**	**629.91**	**218.93**	**15.55**	**15.35**	
486						
Amortized GHG Emissions						453.53

Electric

	Emissions (lbs/day)					Metric Tons
Construction Phase/Emissions Source	**ROG**	**NO_X**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**CO_2e**
Mobilization	16.76	120.63	107.47	3.53	3.25	11.24
Site Preparation	1007.59	7970.74	6812.21	315.13	293.92	694.19
Dredged Material Placement	2433.34	19324.13	16238.38	755.40	695.03	10330.17
Decomissioning	578.27	4500.08	3471.10	164.23	151.12	351.30
Demobilization	16.76	120.63	107.47	3.53	3.25	11.24
Restoration Project	129.13	1364.39	1256.68	63.11	58.07	86.37
Total Project	4181.85	33400.60	27993.30	1304.92	1204.62	11484.51
Average Daily Emissions (lbs/day)	**8.60**	**68.66**	**57.54**	**2.68**	**2.48**	
Amortized GHG Emissions						229.69

Table 2. Construction Emissions Summary – Alternative C

Diesel

			Emissions (lbs)			Metric Tons
Construction Phase/Emissions Source	**ROG**	**NO_X**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**CO_2e**
Mobilization	16.76	120.63	107.47	3.53	3.25	11.24
Site Preparation	976.32	7694.33	6394.07	300.08	279.33	647.01
Dredged Material Placement	17119.26	230494.97	74900.70	5538.20	5490.80	16967.30
Decomissioning	468.99	3541.31	2793.59	127.74	117.54	276.96
Demobilization	16.76	120.63	107.47	3.53	3.25	11.24
Restoration Project	69.84	737.89	679.63	34.13	31.41	46.71
Total Project	18667.92	242709.75	84982.92	6007.21	5925.57	17960.47
Average Emissions (lbs)	**46.33**	**602.38**	**210.92**	**14.91**	**14.71**	
403						
Amortized GHG Emissions						359.21

Electric

			Emissions (lbs/day)			Metric Tons
Construction Phase/Emissions Source	**ROG**	**NO_X**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**CO_2e**
Mobilization	16.76	120.63	107.47	3.53	3.25	11.24
Site Preparation	976.32	7694.33	6394.07	300.08	279.33	647.01
Dredged Material Placement	1950.51	15298.76	12781.06	593.08	545.68	8127.18
Decomissioning	571.58	4437.13	3346.66	161.38	148.49	335.30
Demobilization	16.76	120.63	107.47	3.53	3.25	11.24
Restoration Project	69.84	737.89	679.63	34.13	31.41	46.71
Total Project	3601.77	28409.37	23416.36	1095.72	1011.40	9178.70
Average Daily Emissions (lbs/day)	**8.94**	**70.51**	**58.12**	**2.72**	**2.51**	
Amortized GHG Emissions						305.96

Table 3. Construction Emissions Summary – Alternative D

Diesel

			Emissions (lbs)			Metric Tons
Construction Phase/Emissions Source	**ROG**	**NO_X**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**CO_2e**
Mobilization	16.57	119.59	98.23	3.51	3.23	9.48
Site Preparation	1021.13	8198.86	6196.22	325.54	303.49	564.77
Dredged Material Placement	21780.52	293993.29	94076.33	7076.07	7014.67	21320.57
Decomissioning	469.66	3572.26	2633.42	130.02	119.63	238.58
Demobilization	16.57	119.59	98.23	3.51	3.23	9.48
Restoration Project	124.62	1326.57	1142.32	61.65	56.72	67.66
Total Project	23429.07	307330.18	104244.75	7600.29	7500.98	22210.53
Average Emissions (lbs)	**48.13**	**631.35**	**214.15**	**15.61**	**15.41**	
487						
Amortized GHG Emissions						444.21

Electric

			Emissions (lbs/day)			Metric Tons
Construction Phase/Emissions Source	**ROG**	**NO_X**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**CO_2e**
Mobilization	16.57	119.59	98.23	3.51	3.23	9.48
Site Preparation	1021.13	8198.86	6196.22	325.54	303.49	564.77
Dredged Material Placement	2430.90	19483.94	14835.06	767.95	706.56	10043.90
Decomissioning	572.26	4468.08	3186.49	163.65	150.59	296.92
Demobilization	16.57	119.59	98.23	3.51	3.23	9.48
Restoration Project	124.62	1326.57	1142.32	61.65	56.72	67.66
Total Project	4182.05	33716.65	25556.55	1325.81	1223.82	10992.21
Average Daily Emissions (lbs/day)	**8.59**	**69.26**	**52.50**	**2.72**	**2.51**	
Amortized GHG Emissions						366.41

Table 4. Emission Factors

Equipment Type	Year	Low HP	High HP	TOG (g/bhp-hr)	ROG (g/bhp-hr)	CO (g/bhp-hr)	NOX (g/bhp-hr)	SO2 (g/bhp-hr)	PM10 (g/bhp-hr)	PM2.5 (g/bhp-hr)	CO2 (g/bhp-hr)	CH4 (g/bhp-hr)
Aerial Lifts	2019	6	15	0.204518	0.1719	3.11451	3.07945	0.0054	0.0417	0.0384	536.7427	0.1698
Aerial Lifts	2019	16	25	0.204518	0.1719	3.11451	3.07945	0.0054	0.0417	0.0384	536.7427	0.1698
Aerial Lifts	2019	26	50	0.204518	0.1719	3.11451	3.07945	0.0054	0.0417	0.0384	536.7427	0.1698
Aerial Lifts	2019	51	120	0.14071	0.1182	3.17254	1.97658	0.0049	0.0485	0.0446	482.6056	0.1527
Aerial Lifts	2019	251	500	0.077988	0.0655	0.94139	0.63586	0.0049	0.0089	0.0082	482.5446	0.1527
Aerial Lifts	2019	501	750	28.429	0.212	1.023	2.117	0.005	0.064	0.064	568.299	0.019
Air Compressors	2019	6	15	1.951	0.748	3.562	4.647	0.008	0.241	0.241	568.299	0.067
Air Compressors	2019	16	25	4.106	0.787	2.501	4.596	0.007	0.222	0.222	568.299	0.071
Air Compressors	2019	26	50	9.076	1.129	5.283	4.546	0.007	0.287	0.287	568.299	0.101
Air Compressors	2019	51	120	9.123	0.538	3.718	3.706	0.006	0.26	0.26	568.299	0.048
Air Compressors	2019	121	175	12.833	0.401	3.204	2.874	0.006	0.15	0.15	568.299	0.036
Air Compressors	2019	176	250	14.416	0.304	1.132	2.469	0.006	0.078	0.078	568.299	0.027
Air Compressors	2019	251	500	24.559	0.293	1.086	2.193	0.005	0.075	0.075	568.299	0.026
Air Compressors	2019	501	750	38.104	0.294	1.086	2.247	0.005	0.076	0.076	568.299	0.026
Air Compressors	2019	751	1000	56.984	0.324	1.182	4.073	0.005	0.102	0.102	568.299	0.029
Bore/Drill Rigs	2019	6	15	0.858717	0.7216	4.49723	4.71795	0.0055	0.3025	0.2783	545.293	0.1725
Bore/Drill Rigs	2019	16	25	0.858717	0.7216	4.49723	4.71795	0.0055	0.3025	0.2783	545.293	0.1725
Bore/Drill Rigs	2019	26	50	0.858717	0.7216	4.49723	4.71795	0.0055	0.3025	0.2783	545.293	0.1725
Bore/Drill Rigs	2019	51	120	0.317934	0.2672	3.33202	3.32102	0.0048	0.1802	0.1658	472.4527	0.1495
Bore/Drill Rigs	2019	121	175	0.215784	0.1813	2.95563	2.01775	0.0049	0.0876	0.0806	487.3552	0.1542
Bore/Drill Rigs	2019	176	250	0.170614	0.1434	1.06058	1.8943	0.0048	0.0537	0.0494	475.7896	0.1505
Bore/Drill Rigs	2019	251	500	0.153732	0.1292	1.03449	1.55098	0.0048	0.0479	0.0441	477.0462	0.1509
Bore/Drill Rigs	2019	501	750	0.138617	0.1165	0.97074	1.44865	0.0049	0.0478	0.044	481.8363	0.1524
Bore/Drill Rigs	2019	751	1000	0.153944	0.1294	0.98342	3.04139	0.0049	0.0609	0.056	482.3593	0.1526
Cement and Mortar Mixers	2019	6	15	1.075	0.661	3.469	4.142	0.008	0.162	0.162	568.299	0.059
Cement and Mortar Mixers	2019	16	25	3.321	0.735	2.417	4.469	0.007	0.196	0.196	568.299	0.066
Concrete/Industrial Saws	2019	16	25	1.532	0.685	2.339	4.332	0.007	0.161	0.161	568.299	0.061
Concrete/Industrial Saws	2019	26	50	3.686	0.899	4.645	4.338	0.007	0.242	0.242	568.299	0.081
Concrete/Industrial Saws	2019	51	120	4.463	0.443	3.55	3.441	0.006	0.22	0.22	568.3	0.04
Concrete/Industrial Saws	2019	121	175	7.177	0.33	3.072	2.618	0.006	0.128	0.128	568.299	0.029
Cranes	2019	26	50	2.434147	2.0454	7.24465	5.95197	0.0053	0.6148	0.5657	529.4626	0.1675

Equipment Type	Year	Low HP	High HP	TOG (g/bhp-hr)	ROG (g/bhp-hr)	CO (g/bhp-hr)	NOX (g/bhp-hr)	SO2 (g/bhp-hr)	PM10 (g/bhp-hr)	PM2.5 (g/bhp-hr)	CO2 (g/bhp-hr)	CH4 (g/bhp-hr)
Cranes	2019	51	120	0.955908	0.8032	4.26491	6.95786	0.0048	0.5005	0.4604	480.3251	0.152
Cranes	2019	121	175	0.675554	0.5677	3.5982	5.94857	0.0049	0.3177	0.2923	485.1817	0.1535
Cranes	2019	176	250	0.50769	0.4266	1.94079	5.0842	0.0049	0.2155	0.1983	483.4616	0.153
Cranes	2019	251	500	0.415431	0.3491	2.96893	4.29654	0.0049	0.173	0.1592	483.1422	0.1529
Cranes	2019	501	750	0.299943	0.252	1.44568	3.42803	0.0049	0.1238	0.1139	481.1192	0.1522
Cranes	2019	1001	9999	0.205078	0.1723	0.9912	2.34854	0.0049	0.0595	0.0547	482.5446	0.1527
Crawler Tractors	2019	26	50	2.648469	2.2254	7.58896	5.85476	0.0053	0.6404	0.5892	525.9767	0.1664
Crawler Tractors	2019	51	120	0.901167	0.7572	4.08842	6.39347	0.0049	0.5347	0.4919	486.9909	0.1541
Crawler Tractors	2019	121	175	0.615173	0.5169	3.37886	5.38191	0.0049	0.2996	0.2756	481.6222	0.1524
Crawler Tractors	2019	176	250	0.45175	0.3796	1.60445	4.9721	0.0049	0.1875	0.1725	483.4489	0.153
Crawler Tractors	2019	251	500	0.37933	0.3187	2.21938	3.93412	0.0049	0.1528	0.1406	485.8645	0.1537
Crawler Tractors	2019	501	750	0.316919	0.2663	1.35585	3.34253	0.0049	0.123	0.1132	483.3879	0.1529
Crawler Tractors	2019	751	1000	0.547243	0.4598	2.02037	7.21215	0.0049	0.2106	0.1938	486.2545	0.1538
Crushing/Proc. Equipment	2019	26	50	2.798	1.064	5.316	4.495	0.007	0.269	0.269	568.299	0.096
Crushing/Proc. Equipment	2019	51	120	2.577	0.519	3.739	3.544	0.006	0.241	0.241	568.299	0.046
Crushing/Proc. Equipment	2019	121	175	3.938	0.394	3.233	2.7	0.006	0.141	0.141	568.299	0.035
Crushing/Proc. Equipment	2019	176	250	4.451	0.304	1.134	2.3	0.006	0.074	0.074	568.299	0.027
Crushing/Proc. Equipment	2019	251	500	6.592	0.295	1.087	2.046	0.005	0.071	0.071	568.299	0.026
Crushing/Proc. Equipment	2019	501	750	10.352	0.294	1.085	2.085	0.005	0.071	0.071	568.299	0.026
Crushing/Proc. Equipment	2019	1001	9999	26.978	0.345	1.173	3.927	0.005	0.098	0.098	568.299	0.031
Dumpers/Tenders	2019	16	25	0.82	0.686	2.339	4.341	0.007	0.167	0.167	568.299	0.061
Excavators	2019	16	25	0.75855	0.6374	4.59698	4.19867	0.0054	0.2503	0.2303	536.9132	0.1699
Excavators	2019	26	50	0.75855	0.6374	4.59698	4.19867	0.0054	0.2503	0.2303	536.9132	0.1699
Excavators	2019	51	120	0.386598	0.3248	3.52421	3.36874	0.0048	0.2107	0.1938	478.2452	0.1513
Excavators	2019	121	175	0.293021	0.2462	3.08163	2.53264	0.0049	0.1221	0.1124	482.6838	0.1527
Excavators	2019	176	250	0.220917	0.1856	1.12671	2.24187	0.0049	0.068	0.0625	482.2503	0.1526
Excavators	2019	251	500	0.192898	0.1621	1.1135	1.77986	0.0049	0.0578	0.0532	481.2361	0.1523
Excavators	2019	501	750	0.209677	0.1762	1.17289	1.98661	0.0048	0.0671	0.0618	479.2876	0.1516
Forklifts	2019	26	50	1.480074	1.2437	5.88034	4.86189	0.0054	0.4009	0.3688	537.1608	0.17
Forklifts	2019	51	120	0.606336	0.5095	3.80391	4.54965	0.0049	0.3525	0.3243	482.0069	0.1525
Forklifts	2019	121	175	0.454984	0.3823	3.28831	3.86458	0.0049	0.2102	0.1934	482.5975	0.1527
Forklifts	2019	176	250	0.445406	0.3743	1.6773	4.2498	0.0049	0.1753	0.1613	483.8438	0.1531

Equipment Type	Year	Low HP	High HP	TOG (g/bhp-hr)	ROG (g/bhp-hr)	CO (g/bhp-hr)	NOX (g/bhp-hr)	SO2 (g/bhp-hr)	PM10 (g/bhp-hr)	PM2.5 (g/bhp-hr)	CO2 (g/bhp-hr)	CH4 (g/bhp-hr)
Forklifts	2019	251	500	0.31829	0.2675	1.814	2.75148	0.0049	0.112	0.103	484.1399	0.1532
Generator Sets	2019	6	15	1.758	0.662	3.562	4.617	0.008	0.224	0.224	568.299	0.059
Generator Sets	2019	16	25	3.356	0.731	2.501	4.596	0.007	0.214	0.214	568.299	0.066
Generator Sets	2019	26	50	6.208	0.779	4.076	4.215	0.007	0.222	0.222	568.299	0.07
Generator Sets	2019	51	120	8.233	0.405	3.396	3.446	0.006	0.206	0.206	568.299	0.036
Generator Sets	2019	121	175	10.727	0.29	2.929	2.669	0.006	0.118	0.118	568.299	0.026
Generator Sets	2019	176	250	11.695	0.211	1.036	2.285	0.006	0.064	0.064	568.299	0.019
Generator Sets	2019	251	500	17.492	0.199	1.015	2.056	0.005	0.062	0.062	568.299	0.018
Generator Sets	2019	501	750	28.675	0.202	1.015	2.104	0.005	0.062	0.062	568.299	0.018
Generator Sets	2019	1001	9999	71.228	0.261	1.103	3.829	0.005	0.087	0.087	568.299	0.023
Graders	2019	26	50	3.11378	2.6164	8.27912	5.94463	0.005	0.7367	0.6778	503.7509	0.1594
Graders	2019	51	120	1.228249	1.0321	4.6424	8.1592	0.0048	0.6653	0.612	479.9011	0.1518
Graders	2019	121	175	0.724541	0.6088	3.65586	6.01354	0.0049	0.3365	0.3096	489.0419	0.1547
Graders	2019	176	250	0.428358	0.3599	1.35927	4.86575	0.0049	0.1562	0.1437	486.3288	0.1539
Graders	2019	251	500	0.384059	0.3227	1.52849	3.21794	0.0049	0.1244	0.1145	482.5879	0.1527
Graders	2019	501	750	13.635	0.335	1.255	2.276	0.005	0.08	0.08	568.299	0.03
Off-Highway Tractors	2019	51	120	0.562974	0.4731	3.79465	4.42145	0.0049	0.3311	0.3046	484.2693	0.1532
Off-Highway Tractors	2019	121	175	0.350048	0.2941	3.21895	3.20755	0.0049	0.1586	0.1459	483.4306	0.153
Off-Highway Tractors	2019	176	250	0.283777	0.2385	1.21832	2.9142	0.0049	0.0976	0.0898	481.2751	0.1523
Off-Highway Tractors	2019	501	750	0.244248	0.2052	1.12934	2.17682	0.0049	0.082	0.0754	482.3091	0.1526
Off-Highway Tractors	2019	751	1000	0.166166	0.1396	1.00978	2.37757	0.0049	0.0616	0.0567	482.5446	0.1527
Off-Highway Trucks	2019	121	175	0.38382	0.3225	3.32598	2.82463	0.0049	0.1494	0.1375	480.3623	0.152
Off-Highway Trucks	2019	176	250	0.365362	0.307	1.46079	2.98481	0.0049	0.119	0.1095	480.1703	0.1519
Off-Highway Trucks	2019	251	500	0.313575	0.2635	1.48346	2.66851	0.0049	0.097	0.0893	485.3832	0.1536
Off-Highway Trucks	2019	501	750	0.389037	0.3269	2.04129	3.32044	0.0049	0.1286	0.1183	483.2182	0.1529
Off-Highway Trucks	2019	751	1000	0.351304	0.2952	1.3561	4.76495	0.0049	0.1242	0.1142	480.3479	0.152
Other Construction Equipment	2019	6	15	1.370834	1.1519	5.54123	5.20338	0.0054	0.4374	0.4024	539.7349	0.1708
Other Construction Equipment	2019	16	25	1.370834	1.1519	5.54123	5.20338	0.0054	0.4374	0.4024	539.7349	0.1708
Other Construction Equipment	2019	26	50	1.370834	1.1519	5.54123	5.20338	0.0054	0.4374	0.4024	539.7349	0.1708
Other Construction Equipment	2019	51	120	0.655004	0.5504	3.7535	5.04831	0.0049	0.3789	0.3486	482.2177	0.1526
Other Construction Equipment	2019	121	175	0.490382	0.4121	3.25619	4.4331	0.0049	0.2335	0.2148	480.4518	0.152
Other Construction Equipment	2019	251	500	0.277883	0.2335	1.66739	2.85547	0.0049	0.1026	0.0944	485.4127	0.1536

Equipment Type	Year	Low HP	High HP	TOG (g/bhp-hr)	ROG (g/bhp-hr)	CO (g/bhp-hr)	NOX (g/bhp-hr)	SO2 (g/bhp-hr)	PM10 (g/bhp-hr)	PM2.5 (g/bhp-hr)	CO2 (g/bhp-hr)	CH4 (g/bhp-hr)
Other General Industrial Equipment	2019	6	15	1.240314	1.0422	5.66186	4.80683	0.0054	0.3737	0.3438	537.8689	0.1702
Other General Industrial Equipment	2019	16	25	1.240314	1.0422	5.66186	4.80683	0.0054	0.3737	0.3438	537.8689	0.1702
Other General Industrial Equipment	2019	26	50	1.240314	1.0422	5.66186	4.80683	0.0054	0.3737	0.3438	537.8689	0.1702
Other General Industrial Equipment	2019	51	120	0.594634	0.4997	3.82128	4.49674	0.0048	0.3429	0.3155	480.4442	0.152
Other General Industrial Equipment	2019	121	175	0.359068	0.3017	3.24129	2.99891	0.0049	0.1565	0.144	482.3357	0.1526
Other General Industrial Equipment	2019	176	250	0.307665	0.2585	1.29893	3.01996	0.0049	0.1058	0.0973	483.7392	0.153
Other General Industrial Equipment	2019	251	500	0.283854	0.2385	1.56115	2.57531	0.0049	0.0923	0.0849	483.4385	0.153
Other General Industrial Equipment	2019	501	750	0.236758	0.1989	1.47441	2.11518	0.0049	0.0758	0.0697	483.9852	0.1531
Other General Industrial Equipment	2019	751	1000	0.31421	0.264	1.07573	4.83364	0.0049	0.1172	0.1079	482.5446	0.1527
Other Material Handling Equipment	2019	26	50	1.5177	1.2753	6.13945	5.17904	0.0054	0.4519	0.4158	535.3468	0.1694
Other Material Handling Equipment	2019	51	120	0.428699	0.3602	3.63634	3.56573	0.0049	0.2307	0.2123	484.1126	0.1532
Other Material Handling Equipment	2019	121	175	0.332757	0.2796	3.1852	2.77369	0.0049	0.1388	0.1277	482.7131	0.1527
Other Material Handling Equipment	2019	176	250	0.357063	0.3	1.34052	3.81716	0.0049	0.1231	0.1133	481.9594	0.1525
Other Material Handling Equipment	2019	251	500	0.346245	0.2909	1.61951	3.37078	0.0049	0.1278	0.1175	480.7483	0.1521
Other Material Handling Equipment	2019	1001	9999	0.226018	0.1899	1.03609	3.58277	0.0049	0.0763	0.0702	482.5446	0.1527
Pavers	2019	16	25	1.687019	1.4176	5.65687	4.91634	0.0054	0.4361	0.4012	538.3246	0.1703
Pavers	2019	26	50	1.687019	1.4176	5.65687	4.91634	0.0054	0.4361	0.4012	538.3246	0.1703
Pavers	2019	51	120	0.589904	0.4957	3.62215	4.67048	0.0048	0.3455	0.3178	480.2509	0.1519
Pavers	2019	121	175	0.355588	0.2988	3.01323	3.24473	0.0049	0.1589	0.1462	483.3938	0.1529

Equipment Type	Year	Low HP	High HP	TOG (g/bhp-hr)	ROG (g/bhp-hr)	CO (g/bhp-hr)	NOX (g/bhp-hr)	SO2 (g/bhp-hr)	PM10 (g/bhp-hr)	PM2.5 (g/bhp-hr)	CO2 (g/bhp-hr)	CH4 (g/bhp-hr)
Pavers	2019	176	250	0.222293	0.1868	1.03181	3.11084	0.0049	0.0842	0.0774	483.5743	0.153
Pavers	2019	251	500	0.198123	0.1665	0.98586	2.26992	0.0048	0.081	0.0746	476.9707	0.1509
Paving Equipment	2019	16	25	0.838543	0.7046	4.40798	4.23779	0.0054	0.2697	0.2481	531.8612	0.1683
Paving Equipment	2019	26	50	0.838543	0.7046	4.40798	4.23779	0.0054	0.2697	0.2481	531.8612	0.1683
Paving Equipment	2019	51	120	0.50594	0.4251	3.59849	4.04152	0.0049	0.2808	0.2584	484.387	0.1533
Paving Equipment	2019	121	175	0.302373	0.2541	3.0109	2.6924	0.0049	0.1336	0.1229	481.2251	0.1523
Paving Equipment	2019	176	250	0.286526	0.2408	1.24449	3.25106	0.0049	0.1116	0.1027	482.6441	0.1527
Plate Compactors	2019	6	15	0.79	0.661	3.469	4.142	0.008	0.161	0.161	568.299	0.059
Pressure Washers	2019	6	15	1.824	0.662	3.562	4.617	0.008	0.224	0.224	568.299	0.059
Pressure Washers	2019	16	25	2.947	0.731	2.501	4.596	0.007	0.214	0.214	568.299	0.066
Pressure Washers	2019	26	50	4.585	0.569	3.457	4.053	0.007	0.184	0.184	568.299	0.051
Pressure Washers	2019	51	120	4.575	0.337	3.24	3.295	0.006	0.174	0.174	568.299	0.03
Pressure Washers	2019	121	175	18.102	0.28	2.907	2.67	0.006	0.117	0.117	568.299	0.025
Pressure Washers	2019	176	250	8.005	0.098	0.986	0.265	0.006	0.009	0.009	568.299	0.008
Pumps	2019	6	15	1.63	0.748	3.562	4.647	0.008	0.241	0.241	568.3	0.067
Pumps	2019	16	25	4.503	0.787	2.501	4.596	0.007	0.222	0.222	568.3	0.071
Pumps	2019	26	50	8.56	0.849	4.284	4.269	0.007	0.235	0.235	568.299	0.076
Pumps	2019	51	120	9.812	0.429	3.449	3.497	0.006	0.217	0.217	568.299	0.038
Pumps	2019	121	175	12.706	0.309	2.974	2.711	0.006	0.124	0.124	568.299	0.027
Pumps	2019	176	250	13.378	0.226	1.052	2.323	0.006	0.067	0.067	568.299	0.02
Pumps	2019	251	500	21.711	0.214	1.027	2.084	0.005	0.064	0.064	568.3	0.019
Pumps	2019	501	750	36.35	0.217	1.027	2.133	0.005	0.065	0.065	568.299	0.019
Pumps	2019	1001	9999	108.825	0.273	1.118	3.873	0.005	0.089	0.089	568.299	0.024
Rollers	2019	6	15	1.156606	0.9719	4.77841	4.64491	0.0054	0.3493	0.3213	537.546	0.1701
Rollers	2019	16	25	1.156606	0.9719	4.77841	4.64491	0.0054	0.3493	0.3213	537.546	0.1701
Rollers	2019	26	50	1.156606	0.9719	4.77841	4.64491	0.0054	0.3493	0.3213	537.546	0.1701
Rollers	2019	51	120	0.502836	0.4225	3.55726	4.17949	0.0049	0.2748	0.2528	484.3362	0.1532
Rollers	2019	121	175	0.27475	0.2309	2.93251	2.69941	0.0049	0.1239	0.114	482.4531	0.1526
Rollers	2019	176	250	0.250477	0.2105	1.24854	2.88327	0.0049	0.0918	0.0844	483.7769	0.1531
Rollers	2019	251	500	0.278634	0.2341	2.10142	2.90839	0.005	0.1109	0.102	489.9774	0.155
Rough Terrain Forklifts	2019	26	50	1.200779	1.009	4.67405	4.55745	0.0054	0.3277	0.3015	537.3287	0.17
Rough Terrain Forklifts	2019	51	120	0.240277	0.2019	3.25848	2.6222	0.0049	0.1168	0.1075	483.3105	0.1529

Equipment Type	Year	Low HP	High HP	TOG (g/bhp-hr)	ROG (g/bhp-hr)	CO (g/bhp-hr)	NOX (g/bhp-hr)	SO2 (g/bhp-hr)	PM10 (g/bhp-hr)	PM2.5 (g/bhp-hr)	CO2 (g/bhp-hr)	CH4 (g/bhp-hr)
Rough Terrain Forklifts	2019	121	175	0.177689	0.1493	2.84092	2.05752	0.0049	0.0753	0.0693	482.1188	0.1525
Rough Terrain Forklifts	2019	176	250	0.130153	0.1094	0.97423	1.63905	0.0049	0.0364	0.0335	483.0882	0.1528
Rough Terrain Forklifts	2019	251	500	0.138302	0.1162	0.95034	1.96109	0.0048	0.0429	0.0395	477.2539	0.151
Rubber Tired Dozers	2019	121	175	0.90312	0.7589	3.94854	7.52037	0.0049	0.4326	0.398	483.5585	0.153
Rubber Tired Dozers	2019	176	250	0.774882	0.6511	2.45855	6.92923	0.0049	0.3379	0.3108	485.172	0.1535
Rubber Tired Dozers	2019	251	500	0.680848	0.5721	4.74309	6.14335	0.0049	0.2828	0.2602	490.383	0.1552
Rubber Tired Dozers	2019	501	750	0.541107	0.4547	2.59814	6.12249	0.0049	0.2181	0.2007	483.5786	0.153
Rubber Tired Dozers	2019	751	1000	8.196	0.547	2.281	5.528	0.005	0.171	0.171	568.299	0.049
Rubber Tired Loaders	2019	16	25	1.906195	1.6017	6.97769	5.43193	0.0054	0.5176	0.4762	536.2254	0.1697
Rubber Tired Loaders	2019	26	50	1.906195	1.6017	6.97769	5.43193	0.0054	0.5176	0.4762	536.2254	0.1697
Rubber Tired Loaders	2019	51	120	0.707701	0.5947	3.97887	5.00611	0.0048	0.402	0.3698	475.8636	0.1506
Rubber Tired Loaders	2019	121	175	0.482139	0.4051	3.38084	3.85918	0.0049	0.2133	0.1962	481.7364	0.1524
Rubber Tired Loaders	2019	176	250	0.368194	0.3094	1.30248	3.74452	0.0048	0.1255	0.1155	480.0997	0.1519
Rubber Tired Loaders	2019	251	500	0.363843	0.3057	1.7248	3.28755	0.0048	0.1227	0.1129	477.0415	0.1509
Rubber Tired Loaders	2019	501	750	0.348958	0.2932	1.45157	3.01875	0.0048	0.1184	0.109	471.1874	0.1491
Rubber Tired Loaders	2019	751	1000	0.384887	0.3234	1.20834	5.45926	0.0049	0.1462	0.1345	480.523	0.152
Scrapers	2019	51	120	0.854498	0.718	4.19661	6.84136	0.005	0.5255	0.4834	494.1	0.1563
Scrapers	2019	121	175	0.606989	0.51	3.53297	5.26356	0.0049	0.2833	0.2606	489.2546	0.1548
Scrapers	2019	176	250	0.596624	0.5013	2.23321	5.83102	0.0048	0.2567	0.2361	479.0317	0.1516
Scrapers	2019	251	500	0.40804	0.3429	2.59466	4.15646	0.0049	0.1629	0.1498	482.7319	0.1527
Scrapers	2019	501	750	0.329384	0.2768	1.82903	3.43103	0.0049	0.1232	0.1133	482.5963	0.1527
Signal Boards	2019	6	15	1.04	0.661	3.47	4.142	0.008	0.161	0.161	568.299	0.059
Signal Boards	2019	26	50	8.189	0.887	4.538	4.272	0.007	0.236	0.236	568.3	0.08
Signal Boards	2019	51	120	8.938	0.437	3.519	3.41	0.006	0.216	0.216	568.299	0.039
Signal Boards	2019	121	175	12.677	0.321	3.043	2.601	0.006	0.125	0.125	568.299	0.029
Signal Boards	2019	176	250	15.682	0.291	1.292	2.676	0.007	0.08	0.08	686.695	0.026
Skid Steer Loaders	2019	16	25	0.531282	0.4464	3.73957	3.75009	0.0054	0.1536	0.1413	539.2667	0.1706
Skid Steer Loaders	2019	26	50	0.531282	0.4464	3.73957	3.75009	0.0054	0.1536	0.1413	539.2667	0.1706
Skid Steer Loaders	2019	51	120	0.2373	0.1994	3.27736	2.65586	0.0049	0.1217	0.1119	482.3844	0.1526
Surfacing Equipment	2019	26	50	0.765383	0.6431	4.0998	4.41999	0.0055	0.2503	0.2303	547.0462	0.1731
Surfacing Equipment	2019	51	120	0.42278	0.3553	3.44856	3.82306	0.0049	0.2256	0.2076	484.0757	0.1532
Surfacing Equipment	2019	121	175	0.425034	0.3571	2.97177	4.23866	0.0048	0.2036	0.1873	479.6717	0.1518

Equipment Type	Year	Low HP	High HP	TOG (g/bhp-hr)	ROG (g/bhp-hr)	CO (g/bhp-hr)	NOX (g/bhp-hr)	SO2 (g/bhp-hr)	PM10 (g/bhp-hr)	PM2.5 (g/bhp-hr)	CO2 (g/bhp-hr)	CH4 (g/bhp-hr)
Surfacing Equipment	2019	176	250	0.257694	0.2165	1.21576	3.39993	0.0049	0.1007	0.0927	486.8417	0.154
Surfacing Equipment	2019	251	500	0.173135	0.1455	1.2143	1.89944	0.0049	0.0681	0.0626	481.8965	0.1525
Surfacing Equipment	2019	501	750	0.168821	0.1419	0.99372	2.17879	0.0049	0.0763	0.0702	480.166	0.1519
Sweepers/Scrubbers	2019	6	15	1.703052	1.431	6.26782	5.22487	0.0054	0.4912	0.4519	537.0023	0.1699
Sweepers/Scrubbers	2019	16	25	1.703052	1.431	6.26782	5.22487	0.0054	0.4912	0.4519	537.0023	0.1699
Sweepers/Scrubbers	2019	26	50	1.703052	1.431	6.26782	5.22487	0.0054	0.4912	0.4519	537.0023	0.1699
Sweepers/Scrubbers	2019	51	120	0.654062	0.5496	3.84602	4.77259	0.0049	0.3872	0.3563	484.6516	0.1533
Sweepers/Scrubbers	2019	121	175	0.62277	0.5233	3.4491	5.30082	0.0049	0.2772	0.255	483.6359	0.153
Sweepers/Scrubbers	2019	176	250	0.279258	0.2347	1.23013	2.86598	0.0049	0.0989	0.091	480.5735	0.152
Tractors/Loaders/Backhoes	2019	16	25	1.095082	0.9202	5.20327	4.60928	0.0053	0.33	0.3036	527.6843	0.167
Tractors/Loaders/Backhoes	2019	26	50	1.095082	0.9202	5.20327	4.60928	0.0053	0.33	0.3036	527.6843	0.167
Tractors/Loaders/Backhoes	2019	51	120	0.437701	0.3678	3.63777	3.69257	0.0049	0.2465	0.2268	485.8548	0.1537
Tractors/Loaders/Backhoes	2019	121	175	0.321856	0.2704	3.12158	2.78412	0.0048	0.1401	0.1289	477.9151	0.1512
Tractors/Loaders/Backhoes	2019	176	250	0.291458	0.2449	1.22027	3.14683	0.0049	0.102	0.0938	481.4206	0.1523
Tractors/Loaders/Backhoes	2019	251	500	0.245176	0.206	1.38918	2.34458	0.0048	0.0816	0.0751	479.0826	0.1516
Tractors/Loaders/Backhoes	2019	501	750	0.311873	0.2621	1.6025	3.12046	0.0048	0.1168	0.1074	478.9216	0.1515
Trenchers	2019	6	15	1.136688	0.9551	4.89183	4.78464	0.0054	0.3767	0.3466	539.1037	0.1706
Trenchers	2019	16	25	1.136688	0.9551	4.89183	4.78464	0.0054	0.3767	0.3466	539.1037	0.1706
Trenchers	2019	26	50	1.136688	0.9551	4.89183	4.78464	0.0054	0.3767	0.3466	539.1037	0.1706
Trenchers	2019	51	120	0.751452	0.6314	3.83677	5.69508	0.0049	0.4306	0.3961	485.3635	0.1536
Trenchers	2019	121	175	0.547248	0.4598	3.34151	4.95976	0.0048	0.2547	0.2343	478.1294	0.1513
Trenchers	2019	176	250	0.481784	0.4048	1.81019	5.04653	0.0049	0.2032	0.187	484.1167	0.1532
Trenchers	2019	251	500	0.302803	0.2544	1.98689	3.12824	0.0049	0.1181	0.1086	482.1648	0.1526
Trenchers	2019	501	750	0.09296	0.0781	0.95644	0.70662	0.0049	0.0152	0.014	484.5422	0.1533
Welders	2019	6	15	1.877	0.748	3.562	4.647	0.008	0.241	0.241	568.299	0.067
Welders	2019	16	25	3.592	0.787	2.501	4.596	0.007	0.222	0.222	568.299	0.071
Welders	2019	26	50	11.071	1.055	4.95	4.449	0.007	0.273	0.273	568.299	0.095
Welders	2019	51	120	8.032	0.503	3.623	3.648	0.006	0.25	0.25	568.299	0.045
Welders	2019	121	175	14.693	0.37	3.122	2.832	0.006	0.143	0.143	568.3	0.033
Welders	2019	176	250	13.284	0.276	1.104	2.432	0.006	0.075	0.075	568.299	0.024
Welders	2019	251	500	17.937	0.264	1.065	2.163	0.005	0.072	0.072	568.3	0.023

Table 5. Offroad Factors

Equipment Type	Year	Low HP	High HP	TOG (g/bhp-hr)	ROG (g/bhp-hr)	CO (g/bhp-hr)	NOX (g/bhp-hr)	SO2 (g/bhp-hr)	PM10 (g/bhp-hr)	PM2.5 (g/bhp-hr)	CO2 (g/bhp-hr)	CH4 (g/bhp-hr)
Rubber Tired Dozers	2019	251	500	0.680848	0.5721	4.74309	6.14335	0.0049	0.2828	0.2602	490.383	0.1552
Excavators	2019	121	175	0.293021	0.2462	3.08163	2.53264	0.0049	0.1221	0.1124	482.6838	0.1527
Plate Compactors	2019	6	15	0.79	0.661	3.469	4.142	0.008	0.161	0.161	568.299	0.059
Cranes	2019	176	250	0.50769	0.4266	1.94079	5.0842	0.0049	0.2155	0.1983	483.4616	0.153
Off-Highway Trucks	2019	251	500	0.313575	0.2635	1.48346	2.66851	0.0049	0.097	0.0893	485.3832	0.1536
Other Construction Equipment	2019	121	175	0.490382	0.4121	3.25619	4.4331	0.0049	0.2335	0.2148	480.4518	0.152
Pumps	2019	51	120	9.812	0.429	3.449	3.497	0.006	0.217	0.217	568.299	0.038
Generator Sets	2019	51	120	8.233	0.405	3.396	3.446	0.006	0.206	0.206	568.299	0.036
Tractors/Loaders/Backhoes	2019	501	750	0.311873	0.2621	1.6025	3.12046	0.0048	0.1168	0.1074	478.9216	0.1515
Pumps >1001 and <9999	2019	1001	9999	108.825	0.273	1.118	3.873	0.005	0.089	0.089	568.299	0.024

	Low HP	High HP	ROG (g/bhp-hr)	CO (g/bhp-hr)	NOX (g/bhp-hr)	PM10 (g/bhp-hr)	PM2.5 (g/bhp-hr)
Tier 3	25	49	0.29	4.1	4.63	0.28	0.28
Tier 3	50	74	0.12	3.7	2.74	0.192	0.192
Tier 3	75	119	0.12	3.7	2.74	0.192	0.192
Tier 3	120	174	0.12	3.7	2.32	0.112	0.112
Tier 3	175	299	0.12	2.6	2.32	0.088	0.088
Tier 3	300	599	0.12	2.6	2.32	0.088	0.088
Tier 3	600	750	0.12	2.6	2.32	0.088	0.088
Tier 3	751	2000	0.12	2.6	2.32	0.088	0.088
Tier 4 Interim	25	49	0.12	4.1	4.55	0.128	0.128
Tier 4 Interim	50	74	0.12	3.7	2.74	0.112	0.112
Tier 4 Interim	75	119	0.11	3.7	2.14	0.008	0.008

Tier 4 Interim	120	174	0.06	3.7	2.15	0.008	0.008
Tier 4 Interim	175	299	0.08	2.6	1.29	0.008	0.008
Tier 4 Interim	300	599	0.08	2.6	1.29	0.008	0.008
Tier 4 Interim	600	750	0.08	2.6	1.29	0.008	0.008
Tier 4 Interim	751	2000	0.12	2.6	2.24	0.048	0.048
Tier 4	25	49	0.12	4.1	2.75	0.008	0.008
Tier 4	50	74	0.12	3.7	2.74	0.008	0.008
Tier 4	75	119	0.06	3.7	0.26	0.008	0.008
Tier 4	120	174	0.06	3.7	0.26	0.008	0.008
Tier 4	175	299	0.06	2.2	0.26	0.008	0.008
Tier 4	300	599	0.06	2.2	0.26	0.008	0.008
Tier 4	600	750	0.06	2.2	0.26	0.008	0.008
Tier 4	751	2000	0.06	2.6	2.24	0.016	0.016

Table 6. Cal EE Mod. Equipment

Equipment Type	HP	Load Factor
Aerial Lifts	63	0.31
Air Compressors	78	0.48
Bore/Drill Rigs	206	0.5
Cement and Mortar Mixers	9	0.56
Concrete/Industrial Saws	81	0.73
Cranes	226	0.29
Crawler Tractors	208	0.43
Crushing/Proc. Equipment	85	0.78
Dumpers/Tenders	16	0.38
Excavators	163	0.38
Forklifts	89	0.2
Generator Sets	84	0.74
Graders	175	0.41
Off-Highway Tractors	123	0.44
Off-Highway Trucks	400	0.38
Other Construction Equipment	172	0.42
Other General Industrial Equipment	88	0.34
Other Material Handling Equipment	167	0.4
Pavers	126	0.42
Paving Equipment	131	0.36
Plate Compactors	8	0.43
Pressure Washers	13	0.3
Pumps	84	0.74
Rollers	81	0.38
Rough Terrain Forklifts	100	0.4
Rubber Tired Dozers	255	0.4
Rubber Tired Loaders	200	0.36
Scrapers	362	0.48
Signal Boards	6	0.82
Skid Steer Loaders	65	0.37
Surfacing Equipment	254	0.3
Sweepers/Scrubbers	64	0.46
Tractors/Loaders/Backhoes	98	0.37
Trenchers	81	0.5
Welders	46	0.45

Table 7. Alameda County 2019 On-Road Emission Factors

Veh_Class	Fuel	MdlYr	Speed (miles/hr)	Population (vehicles)	VMT (miles/day)	Percent VMT	Trips (trips/day)
LDA	GAS	Aggregated	Aggregated	630179.0709	23135044.8	69.96%	3978067.902
LDA	DSL	Aggregated	Aggregated	3135.399386	109528.6651	0.33%	19192.99895
LDT1	GAS	Aggregated	Aggregated	71734.58614	2657830.829	8.04%	434719.7607
LDT1	DSL	Aggregated	Aggregated	101.6956373	3791.303837	0.01%	579.147129
LDT2	GAS	Aggregated	Aggregated	182086.4394	7158606.203	21.65%	1144840.468
LDT2	DSL	Aggregated	Aggregated	90.6234226	3567.077353	0.01%	558.2269126
Total				887327.8149	33068368.88		5577958.504
Average							
Veh_Class	Fuel	MdlYr	Speed	Population	VMT	Trips	
T7 tractor	DSL	Aggregated	Aggregated	3808.477731	617782.042	0	

Veh_Class	ROG_RUNEX (gms/mile)	CO_RUNEX (gms/mile)	NOX_RUNEX (gms/mile)	CO2_RUNEX (gms/mile)	PM10_RUNEX (gms/mile)	PM2_5_RUNEX (gms/mile)
LDA	0.016637189	0.80358625	0.083541126	340.5888828	0.001765757	0.001636861
LDA	0.024529409	0.152328328	0.446035267	355.3985725	0.017213743	0.015836645
LDT1	0.048779122	2.083021626	0.234843306	393.179958	0.003438173	0.003186006
LDT1	0.044211868	0.215668141	0.506244265	359.66517	0.035622524	0.032772721
LDT2	0.02252008	1.118412005	0.140442609	463.7144236	0.001740389	0.001612612
LDT2	0.028100152	0.160580945	0.48394342	355.9157639	0.019345996	0.017798317
Total						
Average	0.020524619	0.972278645	0.109312136	371.5228102	0.001951628	0.001808467
Veh_Class	ROG_RUNEX	CO_RUNEX	NOX_RUNEX	CO2_RUNEX	PM10_RUNEX	PM2_5_RUNEX
T7 tractor	0.226618154	1.024496709	5.340895989	1734.197307	0.079514364	0.073153215

Table 8. Equipment Barge

Assumptions		
Main Generator Engine	300	bhp
	223.7	kW
Aux Generator Engines	0	bhp
	0.0	kW
Number	1.0	

Emissions (pounds per hour)

Activity	Number of Construction Days	Time (hours per day)	ROG	NOx	CO	PM10	PM2.5	CO2e*
Emissions Per Hour	1.00	1.00	0.20	1.47	1.01	0.04	0.04	151.94

*To account for N20 and CH4 emissions, an extra 5% was added to the CO2 emissions.

Main Engine - 2018 Average Emission Factors (g/bhp-hr)

	ROG	NOx	CO	PM10	PM2.5	CO2	Fuel
300 hp	0.68	5.21	3.38	0.17	0.16	652	184.16

Note: CO2 emission factor in g/kWh
Source: ARB Harborcraft Emission Inventory Database

CO2 emissions factor from Port of Long Beach. 2011 Emissions Inventory. Available at http://www.polb.com/environment/air/emissions.asp.

Auxiliary Engine - 2018 Average Emission Factors (g/bhp-hr)

	ROG	NOx	CO	PM10	PM2.5	CO2	Fuel
3300 hp	0.81	3.54	5.21	0.16	0.15	652	184.16

Note: CO_2 emission factor in g/kWh
Source: ARB Harborcraft Emission Inventory Database

CO_2 emissions factor from Port of Long Beach. 2011 Emissions Inventory. Available at http://www.polb.com/environment/air/emissions.asp.

Load Factor

Engine	Load factor
Propulsion	0.45
Auxiliary	0.43

Source: ARB. Appendix B. Emissions Estimation Methodology for Commercial Harbor Craft Operating in California

Calendar Years	Horsepower Range	Model Years	NOx	PM
2007+	All	2011+	0.948	0.852

Source: ARB, Appendix B. Emissions Estimation Methodology for Commercial Harbor Craft Operating in California

Table 9. Work Tug

Assumptions		
Main Generator Engine	1000	bhp
	745.7	kW
Aux Generator Engines	50	bhp
	37.3	kW
Number	1.0	

Emissions (pounds per hour)

Activity	Number of Construction Days	Time (hours per day)	ROG	NOx	CO	PM10	PM2.5	CO2e*
Emissions Per Hour	1.00	1.00	0.70	5.03	3.36	0.18	0.17	530.65

*To account for N20 and CH4 emissions, an extra 5% was added to the CO2 emissions.

Main Engine - 2018 Average Emission Factors (g/bhp-hr)

	ROG	NOx	CO	PM10	PM2.5	CO2	Fuel
1000 hp	0.60	5.16	3.11	0.20	0.18	652	184.16

Note: CO2 emission factor in g/kWh

Source: ARB Harborcraft Emission Inventory Database

CO2 emissions factor from Port of Long Beach. 2011 Emissions Inventory. Available at http://www.polb.com/environment/air/emissions.asp.

Auxiliary Engine - 2018 Average Emission Factors (g/bhp-hr)

	ROG	NOx	CO	PM10	PM2.5	CO2	Fuel
50 hp	2.14	4.09	5.72	0.34	0.31	652	184.16

Note: CO2 emission factor in g/kWh

Source: ARB Harborcraft Emission Inventory Database

CO2 emissions factor from Port of Long Beach. 2011 Emissions Inventory. Available at http://www.polb.com/environment/air/emissions.asp.

Load Factor

Engine	Load factor
Propulsion	0.45
Auxiliary	0.43

Source: ARB. Appendix B. Emissions Estimation Methodology for Commercial Harbor Craft Operating in California

Calendar Years	Horsepower Range	Model Years	NOx	PM
2007+	All	2011+	0.948	0.852

Source: ARB, Appendix B. Emissions Estimation Methodology for Commercial Harbor Craft Operating in California

Table 10. Cable Reel Barge

Assumptions		
Main Generator Engine	240	bhp
	179.0	kW
Aux Generator Engines	0	bhp
	0.0	kW
Number	1.0	

Emissions (pounds per hour)

Activity	Number of Construction Days	Time (hours per day)	ROG	NOx	CO	PM10	PM2.5	CO2e*
SO-6 2012	1.00	1.00	0.16	1.18	0.80	0.03	0.03	121.55

*To account for N20 and CH4 emissions, an extra 5% was added to the CO2 emissions.

Main Engine - 2018 Average Emission Factors (g/bhp-hr)

	ROG	NOx	CO	PM10	PM2.5	CO2	Fuel

240 hp	0.68	5.21	3.38	0.17	0.16	652	184.16

Note: CO_2 emission factor in g/kWh

Source: ARB Harborcraft Emission Inventory Database

CO_2 emissions factor from Port of Long Beach. 2011 Emissions Inventory. Available at http://www.polb.com/environment/air/emissions.asp.

Load Factor

Engine	Load factor
Propulsion	0.45
Auxiliary	0.43

Source: ARB. Appendix B. Emissions Estimation Methodology for Commercial Harbor Craft Operating in California

Calendar Years	Horsepower Range	Model Years	NOx	PM
2007+	All	2011+	0.948	0.852

Source: ARB, Appendix B. Emissions Estimation Methodology for Commercial Harbor Craft Operating in California

Estimated Travel Time	Offshore Placement	Miles	Miles Per Hour	Total Hours
Loaded Barge	SO-6 2012	0.76	0.82	0.924
	SO-6 2001	1.14	0.82	1.386

Note: Assumes average travel speed consistent with information provided by Moffett and Nichol that includes idling and loading/unloading activities.

Total One-Way Trips	8
Construction Days	4
Trips per Day	2

Table 11. Barge Emission Factors

ID	HP Range	HP Category	MaxHP	Model Year	MY HP Group	ME ROG	ME CO	ME NOx	ME PM	AE ROG	AE CO	AE NOx	AE PM	Fuel
1	- Implies 25-50 hp	1	50	1987	MY1987HP1	1.84	3.65	8.142	0.722	2.1896	5.15	6.9	0.638	184.158502
2	- Implies 25-50 hp	1	50	1988	MY1988HP1	1.84	3.65	8.142	0.722	2.1896	5.15	6.9	0.638	184.158502
3	- Implies 25-50 hp	1	50	1989	MY1989HP1	1.84	3.65	8.142	0.722	2.1896	5.15	6.9	0.638	184.158502
4	- Implies 25-50 hp	1	50	1990	MY1990HP1	1.84	3.65	8.142	0.722	2.1896	5.15	6.9	0.638	184.158502
5	- Implies 25-50 hp	1	50	1991	MY1991HP1	1.84	3.65	8.142	0.722	2.1896	5.15	6.9	0.638	184.158502
6	- Implies 25-50 hp	1	50	1992	MY1992HP1	1.84	3.65	8.142	0.722	2.1896	5.15	6.9	0.638	184.158502
7	- Implies 25-50 hp	1	50	1993	MY1993HP1	1.84	3.65	8.142	0.722	2.1896	5.15	6.9	0.638	184.158502
8	- Implies 25-50 hp	1	50	1994	MY1994HP1	1.84	3.65	8.142	0.722	2.1896	5.15	6.9	0.638	184.158502
9	- Implies 25-50 hp	1	50	1995	MY1995HP1	1.84	3.65	8.142	0.722	2.1896	5.15	6.9	0.638	184.158502
10	- Implies 25-50 hp	1	50	1996	MY1996HP1	1.84	3.65	8.142	0.722	2.1896	5.15	6.9	0.638	184.158502
11	- Implies 25-50 hp	1	50	1997	MY1997HP1	1.84	3.65	8.142	0.722	2.1896	5.15	6.9	0.638	184.158502
12	- Implies 25-50 hp	1	50	1998	MY1998HP1	1.8	3.65	8.142	0.722	2.142	5.15	6.9	0.638	184.158502
13	- Implies 25-50 hp	1	50	1999	MY1999HP1	1.8	3.65	8.142	0.722	2.142	5.15	6.9	0.638	184.158502
14	- Implies 25-50 hp	1	50	2000	MY2000HP1	1.8	3.65	7.31	0.722	2.142	5.15	6.9	0.638	184.158502
15	- Implies 25-50 hp	1	50	2001	MY2001HP1	1.8	3.65	7.31	0.722	2.142	5.15	6.9	0.638	184.158502
16	- Implies 25-50 hp	1	50	2002	MY2002HP1	1.8	3.65	7.31	0.722	2.142	5.15	6.9	0.638	184.158502
17	- Implies 25-50 hp	1	50	2003	MY2003HP1	1.8	3.65	7.31	0.722	2.142	5.15	6.9	0.638	184.158502
18	- Implies 25-50 hp	1	50	2004	MY2004HP1	1.8	3.65	7.31	0.722	2.142	5.15	6.9	0.638	184.158502
19	- Implies 25-50 hp	1	50	2005	MY2005HP1	1.8	3.73	5.32	0.3	2.142	3.73	5.32	0.3	184.158502
20	- Implies 25-50 hp	1	50	2006	MY2006HP1	1.8	3.73	5.32	0.3	2.142	3.73	5.32	0.3	184.158502
21	- Implies 25-50 hp	1	50	2007	MY2007HP1	1.8	3.73	5.32	0.3	2.142	3.73	5.32	0.3	184.158502
22	- Implies 25-50 hp	1	50	2008	MY2008HP1	1.8	3.73	5.32	0.3	2.142	3.73	5.32	0.3	184.158502
23	- Implies 25-50 hp	1	50	2009	MY2009HP1	1.8	3.73	5.32	0.22	2.142	3.73	5.32	0.22	184.158502
24	- Implies 25-50 hp	1	50	2010	MY2010HP1	1.8	3.73	5.32	0.22	2.142	3.73	5.32	0.22	184.158502
25	- Implies 25-50 hp	1	50	2011	MY2011HP1	1.8	3.73	5.32	0.22	2.142	3.73	5.32	0.22	184.158502
26	- Implies 25-50 hp	1	50	2012	MY2012HP1	1.8	3.73	5.32	0.22	2.142	3.73	5.32	0.22	184.158502
27	- Implies 25-50 hp	1	50	2013	MY2013HP1	1.8	3.73	5.32	0.22	2.142	3.73	5.32	0.22	184.158502
28	- Implies 25-50 hp	1	50	2014	MY2014HP1	1.8	3.73	5.32	0.22	2.142	3.73	5.32	0.22	184.158502
29	- Implies 25-50 hp	1	50	2015	MY2015HP1	1.8	3.73	5.32	0.22	2.142	3.73	5.32	0.22	184.158502
30	- Implies 25-50 hp	1	50	2016	MY2016HP1	1.8	3.73	5.32	0.22	2.142	3.73	5.32	0.22	184.158502
31	- Implies 25-50 hp	1	50	2017	MY2017HP1	1.8	3.73	5.32	0.22	2.142	3.73	5.32	0.22	184.158502
32	- Implies 25-50 hp	1	50	2018	MY2018HP1	1.8	3.73	5.32	0.22	2.142	3.73	5.32	0.22	184.158502

ID	HP Range	HP Category	MaxHP	Model Year	MY HP Group	ME ROG	ME CO	ME NOx	ME PM	AE ROG	AE CO	AE NOx	AE PM	Fuel
33	- Implies 25-50 hp	1	50	2019	MY2019HP1	1.8	3.73	5.32	0.22	2.142	3.73	5.32	0.22	184.158502
34	- Implies 25-50 hp	1	50	2020	MY2020HP1	1.8	3.73	5.32	0.22	2.142	3.73	5.32	0.22	184.158502
35	- Implies 51-120 hp	2	120	1987	MY1987HP2	1.44	3.504	15.34	0.798	1.7136	4.944	13	0.706	184.158502
36	- Implies 51-120 hp	2	120	1988	MY1988HP2	1.44	3.504	15.34	0.798	1.7136	4.944	13	0.706	184.158502
37	- Implies 51-120 hp	2	120	1989	MY1989HP2	1.44	3.504	15.34	0.798	1.7136	4.944	13	0.706	184.158502
38	- Implies 51-120 hp	2	120	1990	MY1990HP2	1.44	3.504	15.34	0.798	1.7136	4.944	13	0.706	184.158502
39	- Implies 51-120 hp	2	120	1991	MY1991HP2	1.44	3.504	15.34	0.798	1.7136	4.944	13	0.706	184.158502
40	- Implies 51-120 hp	2	120	1992	MY1992HP2	1.44	3.504	15.34	0.798	1.7136	4.944	13	0.706	184.158502
41	- Implies 51-120 hp	2	120	1993	MY1993HP2	1.44	3.504	15.34	0.798	1.7136	4.944	13	0.706	184.158502
42	- Implies 51-120 hp	2	120	1994	MY1994HP2	1.44	3.504	15.34	0.798	1.7136	4.944	13	0.706	184.158502
43	- Implies 51-120 hp	2	120	1995	MY1995HP2	1.44	3.504	15.34	0.798	1.7136	4.944	13	0.706	184.158502
44	- Implies 51-120 hp	2	120	1996	MY1996HP2	1.44	3.504	15.34	0.798	1.7136	4.944	13	0.706	184.158502
45	- Implies 51-120 hp	2	120	1997	MY1997HP2	0.99	2.548	10.325	0.656	1.1781	3.595	8.75	0.58	184.158502
46	- Implies 51-120 hp	2	120	1998	MY1998HP2	0.99	2.548	10.325	0.656	1.1781	3.595	8.75	0.58	184.158502
47	- Implies 51-120 hp	2	120	1999	MY1999HP2	0.99	2.548	10.325	0.656	1.1781	3.595	8.75	0.58	184.158502
48	- Implies 51-120 hp	2	120	2000	MY2000HP2	0.99	2.548	7.31	0.656	1.1781	3.595	7.31	0.58	184.158502
49	- Implies 51-120 hp	2	120	2001	MY2001HP2	0.99	2.548	7.31	0.656	1.1781	3.595	7.31	0.58	184.158502
50	- Implies 51-120 hp	2	120	2002	MY2002HP2	0.99	2.548	7.31	0.656	1.1781	3.595	7.31	0.58	184.158502
51	- Implies 51-120 hp	2	120	2003	MY2003HP2	0.99	2.548	7.31	0.656	1.1781	3.595	7.31	0.58	184.158502
52	- Implies 51-120 hp	2	120	2004	MY2004HP2	0.99	2.548	7.31	0.656	1.1781	3.595	7.31	0.58	184.158502
53	- Implies 51-120 hp	2	120	2005	MY2005HP2	0.99	3.73	5.32	0.3	1.1781	3.73	5.32	0.3	184.158502
54	- Implies 51-120 hp	2	120	2006	MY2006HP2	0.99	3.73	5.32	0.3	1.1781	3.73	5.32	0.3	184.158502
55	- Implies 51-120 hp	2	120	2007	MY2007HP2	0.99	3.73	5.32	0.3	1.1781	3.73	5.32	0.3	184.158502
56	- Implies 51-120 hp	2	120	2008	MY2008HP2	0.99	3.73	5.32	0.3	1.1781	3.73	5.32	0.3	184.158502
57	- Implies 51-120 hp	2	120	2009	MY2009HP2	0.99	3.73	5.32	0.22	1.1781	3.73	5.32	0.22	184.158502
58	- Implies 51-120 hp	2	120	2010	MY2010HP2	0.99	3.73	5.32	0.22	1.1781	3.73	5.32	0.22	184.158502
59	- Implies 51-120 hp	2	120	2011	MY2011HP2	0.99	3.73	5.32	0.22	1.1781	3.73	5.32	0.22	184.158502
60	- Implies 51-120 hp	2	120	2012	MY2012HP2	0.99	3.73	5.32	0.22	1.1781	3.73	5.32	0.22	184.158502
61	- Implies 51-120 hp	2	120	2013	MY2013HP2	0.99	3.73	5.32	0.22	1.1781	3.73	5.32	0.22	184.158502
62	- Implies 51-120 hp	2	120	2014	MY2014HP2	0.99	3.73	5.32	0.22	1.1781	3.73	5.32	0.22	184.158502
63	- Implies 51-120 hp	2	120	2015	MY2015HP2	0.99	3.73	5.32	0.22	1.1781	3.73	5.32	0.22	184.158502
64	- Implies 51-120 hp	2	120	2016	MY2016HP2	0.99	3.73	5.32	0.22	1.1781	3.73	5.32	0.22	184.158502
65	- Implies 51-120 hp	2	120	2017	MY2017HP2	0.99	3.73	5.32	0.22	1.1781	3.73	5.32	0.22	184.158502
66	- Implies 51-120 hp	2	120	2018	MY2018HP2	0.99	3.73	5.32	0.22	1.1781	3.73	5.32	0.22	184.158502
67	- Implies 51-120 hp	2	120	2019	MY2019HP2	0.99	3.73	5.32	0.22	1.1781	3.73	5.32	0.22	184.158502

ID	HP Range	HP Category	MaxHP	Model Year	MY HP Group	ME ROG	ME CO	ME NOx	ME PM	AE ROG	AE CO	AE NOx	AE PM	Fuel
68	- Implies 51-120 hp	2	120	2020	MY2020HP2	0.99	3.73	5.32	0.22	1.1781	3.73	5.32	0.22	184.158502
69	- Implies 121-175 hp	3	175	1969	MY1969HP3	1.32	3.212	16.52	0.732	1.5708	4.532	14	0.647	184.158502
70	- Implies 121-175 hp	3	175	1970	MY1970HP3	1.32	3.212	16.52	0.732	1.5708	4.532	14	0.647	184.158502
71	- Implies 121-175 hp	3	175	1971	MY1971HP3	1.1	3.212	15.34	0.627	1.309	4.532	13	0.554	184.158502
72	- Implies 121-175 hp	3	175	1972	MY1972HP3	1.1	3.212	15.34	0.627	1.309	4.532	13	0.554	184.158502
73	- Implies 121-175 hp	3	175	1973	MY1973HP3	1.1	3.212	15.34	0.627	1.309	4.532	13	0.554	184.158502
74	- Implies 121-175 hp	3	175	1974	MY1974HP3	1.1	3.212	15.34	0.627	1.309	4.532	13	0.554	184.158502
75	- Implies 121-175 hp	3	175	1975	MY1975HP3	1.1	3.212	15.34	0.627	1.309	4.532	13	0.554	184.158502
76	- Implies 121-175 hp	3	175	1976	MY1976HP3	1.1	3.212	15.34	0.627	1.309	4.532	13	0.554	184.158502
77	- Implies 121-175 hp	3	175	1977	MY1977HP3	1.1	3.212	15.34	0.627	1.309	4.532	13	0.554	184.158502
78	- Implies 121-175 hp	3	175	1978	MY1978HP3	1.1	3.212	15.34	0.627	1.309	4.532	13	0.554	184.158502
79	- Implies 121-175 hp	3	175	1979	MY1979HP3	1	3.212	14.16	0.523	1.19	4.532	12	0.462	184.158502
80	- Implies 121-175 hp	3	175	1980	MY1980HP3	1	3.212	14.16	0.523	1.19	4.532	12	0.462	184.158502
81	- Implies 121-175 hp	3	175	1981	MY1981HP3	1	3.212	14.16	0.523	1.19	4.532	12	0.462	184.158502
82	- Implies 121-175 hp	3	175	1982	MY1982HP3	1	3.212	14.16	0.523	1.19	4.532	12	0.462	184.158502
83	- Implies 121-175 hp	3	175	1983	MY1983HP3	1	3.212	14.16	0.523	1.19	4.532	12	0.462	184.158502
84	- Implies 121-175 hp	3	175	1984	MY1984HP3	0.94	3.139	12.98	0.523	1.1186	4.429	11	0.462	184.158502
85	- Implies 121-175 hp	3	175	1985	MY1985HP3	0.94	3.139	12.98	0.523	1.1186	4.429	11	0.462	184.158502
86	- Implies 121-175 hp	3	175	1986	MY1986HP3	0.94	3.139	12.98	0.523	1.1186	4.429	11	0.462	184.158502
87	- Implies 121-175 hp	3	175	1987	MY1987HP3	0.88	3.066	12.98	0.523	1.0472	4.326	11	0.462	184.158502
88	- Implies 121-175 hp	3	175	1988	MY1988HP3	0.88	3.066	12.98	0.523	1.0472	4.326	11	0.462	184.158502
89	- Implies 121-175 hp	3	175	1989	MY1989HP3	0.88	3.066	12.98	0.523	1.0472	4.326	11	0.462	184.158502
90	- Implies 121-175 hp	3	175	1990	MY1990HP3	0.88	3.066	12.98	0.523	1.0472	4.326	11	0.462	184.158502
91	- Implies 121-175 hp	3	175	1991	MY1991HP3	0.88	3.066	12.98	0.523	1.0472	4.326	11	0.462	184.158502
92	- Implies 121-175 hp	3	175	1992	MY1992HP3	0.88	3.066	12.98	0.523	1.0472	4.326	11	0.462	184.158502
93	- Implies 121-175 hp	3	175	1993	MY1993HP3	0.88	3.066	12.98	0.523	1.0472	4.326	11	0.462	184.158502
94	- Implies 121-175 hp	3	175	1994	MY1994HP3	0.88	3.066	12.98	0.523	1.0472	4.326	11	0.462	184.158502
95	- Implies 121-175 hp	3	175	1995	MY1995HP3	0.88	3.066	12.98	0.523	1.0472	4.326	11	0.462	184.158502
96	- Implies 121-175 hp	3	175	1996	MY1996HP3	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
97	- Implies 121-175 hp	3	175	1997	MY1997HP3	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
98	- Implies 121-175 hp	3	175	1998	MY1998HP3	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
99	- Implies 121-175 hp	3	175	1999	MY1999HP3	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
100	- Implies 121-175 hp	3	175	2000	MY2000HP3	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
101	- Implies 121-175 hp	3	175	2001	MY2001HP3	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
102	- Implies 121-175 hp	3	175	2002	MY2002HP3	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502

ID	HP Range	HP Category	MaxHP	Model Year	MY HP Group	ME ROG	ME CO	ME NOx	ME PM	AE ROG	AE CO	AE NOx	AE PM	Fuel
103	- Implies 121-175 hp	3	175	2003	MY2003HP3	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
104	- Implies 121-175 hp	3	175	2004	MY2004HP3	0.68	3.73	5.1015	0.22	0.8092	3.73	5.102	0.22	184.158502
105	- Implies 121-175 hp	3	175	2005	MY2005HP3	0.68	3.73	5.1015	0.22	0.8092	3.73	5.102	0.22	184.158502
106	- Implies 121-175 hp	3	175	2006	MY2006HP3	0.68	3.73	5.1015	0.22	0.8092	3.73	5.102	0.22	184.158502
107	- Implies 121-175 hp	3	175	2007	MY2007HP3	0.68	3.73	5.1015	0.22	0.8092	3.73	5.102	0.22	184.158502
108	- Implies 121-175 hp	3	175	2008	MY2008HP3	0.68	3.73	5.1015	0.22	0.8092	3.73	5.102	0.22	184.158502
109	- Implies 121-175 hp	3	175	2009	MY2009HP3	0.68	3.73	5.1015	0.22	0.8092	3.73	5.102	0.22	184.158502
110	- Implies 121-175 hp	3	175	2010	MY2010HP3	0.68	3.73	5.1015	0.22	0.8092	3.73	5.102	0.22	184.158502
111	- Implies 121-175 hp	3	175	2011	MY2011HP3	0.68	3.73	5.1015	0.22	0.8092	3.73	5.102	0.22	184.158502
112	- Implies 121-175 hp	3	175	2012	MY2012HP3	0.68	3.73	5.1015	0.22	0.8092	3.73	5.102	0.22	184.158502
113	- Implies 121-175 hp	3	175	2013	MY2013HP3	0.68	3.73	3.8	0.09	0.8092	3.73	3.8	0.09	184.158502
114	- Implies 121-175 hp	3	175	2014	MY2014HP3	0.68	3.73	3.8	0.09	0.8092	3.73	3.8	0.09	184.158502
115	- Implies 121-175 hp	3	175	2015	MY2015HP3	0.68	3.73	3.8	0.09	0.8092	3.73	3.8	0.09	184.158502
116	- Implies 121-175 hp	3	175	2016	MY2016HP3	0.68	3.73	3.8	0.09	0.8092	3.73	3.8	0.09	184.158502
117	- Implies 121-175 hp	3	175	2017	MY2017HP3	0.68	3.73	3.8	0.09	0.8092	3.73	3.8	0.09	184.158502
118	- Implies 121-175 hp	3	175	2018	MY2018HP3	0.68	3.73	3.8	0.09	0.8092	3.73	3.8	0.09	184.158502
119	- Implies 121-175 hp	3	175	2019	MY2019HP3	0.68	3.73	3.8	0.09	0.8092	3.73	3.8	0.09	184.158502
120	- Implies 121-175 hp	3	175	2020	MY2020HP3	0.68	3.73	3.8	0.09	0.8092	3.73	3.8	0.09	184.158502
121	- Implies 176-250 hp	4	250	1969	MY1969HP4	1.32	3.212	16.52	0.732	1.5708	4.532	14	0.647	184.158502
122	- Implies 176-250 hp	4	250	1970	MY1970HP4	1.32	3.212	16.52	0.732	1.5708	4.532	14	0.647	184.158502
123	- Implies 176-250 hp	4	250	1971	MY1971HP4	1.1	3.212	15.34	0.627	1.309	4.532	13	0.554	184.158502
124	- Implies 176-250 hp	4	250	1972	MY1972HP4	1.1	3.212	15.34	0.627	1.309	4.532	13	0.554	184.158502
125	- Implies 176-250 hp	4	250	1973	MY1973HP4	1.1	3.212	15.34	0.627	1.309	4.532	13	0.554	184.158502
126	- Implies 176-250 hp	4	250	1974	MY1974HP4	1.1	3.212	15.34	0.627	1.309	4.532	13	0.554	184.158502
127	- Implies 176-250 hp	4	250	1975	MY1975HP4	1.1	3.212	15.34	0.627	1.309	4.532	13	0.554	184.158502
128	- Implies 176-250 hp	4	250	1976	MY1976HP4	1.1	3.212	15.34	0.627	1.309	4.532	13	0.554	184.158502
129	- Implies 176-250 hp	4	250	1977	MY1977HP4	1.1	3.212	15.34	0.627	1.309	4.532	13	0.554	184.158502
130	- Implies 176-250 hp	4	250	1978	MY1978HP4	1.1	3.212	15.34	0.627	1.309	4.532	13	0.554	184.158502
131	- Implies 176-250 hp	4	250	1979	MY1979HP4	1	3.212	14.16	0.523	1.19	4.532	12	0.462	184.158502
132	- Implies 176-250 hp	4	250	1980	MY1980HP4	1	3.212	14.16	0.523	1.19	4.532	12	0.462	184.158502
133	- Implies 176-250 hp	4	250	1981	MY1981HP4	1	3.212	14.16	0.523	1.19	4.532	12	0.462	184.158502
134	- Implies 176-250 hp	4	250	1982	MY1982HP4	1	3.212	14.16	0.523	1.19	4.532	12	0.462	184.158502
135	- Implies 176-250 hp	4	250	1983	MY1983HP4	1	3.212	14.16	0.523	1.19	4.532	12	0.462	184.158502
136	- Implies 176-250 hp	4	250	1984	MY1984HP4	0.94	3.139	12.98	0.523	1.1186	4.429	11	0.462	184.158502
137	- Implies 176-250 hp	4	250	1985	MY1985HP4	0.94	3.139	12.98	0.523	1.1186	4.429	11	0.462	184.158502

ID	HP Range	HP Category	MaxHP	Model Year	MY HP Group	ME ROG	ME CO	ME NOx	ME PM	AE ROG	AE CO	AE NOx	AE PM	Fuel
138	- Implies 176-250 hp	4	250	1986	MY1986HP4	0.94	3.139	12.98	0.523	1.1186	4.429	11	0.462	184.158502
139	- Implies 176-250 hp	4	250	1987	MY1987HP4	0.88	3.066	12.98	0.523	1.0472	4.326	11	0.462	184.158502
140	- Implies 176-250 hp	4	250	1988	MY1988HP4	0.88	3.066	12.98	0.523	1.0472	4.326	11	0.462	184.158502
141	- Implies 176-250 hp	4	250	1989	MY1989HP4	0.88	3.066	12.98	0.523	1.0472	4.326	11	0.462	184.158502
142	- Implies 176-250 hp	4	250	1990	MY1990HP4	0.88	3.066	12.98	0.523	1.0472	4.326	11	0.462	184.158502
143	- Implies 176-250 hp	4	250	1991	MY1991HP4	0.88	3.066	12.98	0.523	1.0472	4.326	11	0.462	184.158502
144	- Implies 176-250 hp	4	250	1992	MY1992HP4	0.88	3.066	12.98	0.523	1.0472	4.326	11	0.462	184.158502
145	- Implies 176-250 hp	4	250	1993	MY1993HP4	0.88	3.066	12.98	0.523	1.0472	4.326	11	0.462	184.158502
146	- Implies 176-250 hp	4	250	1994	MY1994HP4	0.88	3.066	12.98	0.523	1.0472	4.326	11	0.462	184.158502
147	- Implies 176-250 hp	4	250	1995	MY1995HP4	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
148	- Implies 176-250 hp	4	250	1996	MY1996HP4	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
149	- Implies 176-250 hp	4	250	1997	MY1997HP4	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
150	- Implies 176-250 hp	4	250	1998	MY1998HP4	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
151	- Implies 176-250 hp	4	250	1999	MY1999HP4	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
152	- Implies 176-250 hp	4	250	2000	MY2000HP4	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
153	- Implies 176-250 hp	4	250	2001	MY2001HP4	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
154	- Implies 176-250 hp	4	250	2002	MY2002HP4	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
155	- Implies 176-250 hp	4	250	2003	MY2003HP4	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
156	- Implies 176-250 hp	4	250	2004	MY2004HP4	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
157	- Implies 176-250 hp	4	250	2005	MY2005HP4	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
158	- Implies 176-250 hp	4	250	2006	MY2006HP4	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
159	- Implies 176-250 hp	4	250	2007	MY2007HP4	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
160	- Implies 176-250 hp	4	250	2008	MY2008HP4	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
161	- Implies 176-250 hp	4	250	2009	MY2009HP4	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
162	- Implies 176-250 hp	4	250	2010	MY2010HP4	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
163	- Implies 176-250 hp	4	250	2011	MY2011HP4	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
164	- Implies 176-250 hp	4	250	2012	MY2012HP4	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
165	- Implies 176-250 hp	4	250	2013	MY2013HP4	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
166	- Implies 176-250 hp	4	250	2014	MY2014HP4	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
167	- Implies 176-250 hp	4	250	2015	MY2015HP4	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
168	- Implies 176-250 hp	4	250	2016	MY2016HP4	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
169	- Implies 176-250 hp	4	250	2017	MY2017HP4	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
170	- Implies 176-250 hp	4	250	2018	MY2018HP4	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
171	- Implies 176-250 hp	4	250	2019	MY2019HP4	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
172	- Implies 176-250 hp	4	250	2020	MY2020HP4	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502

ID	HP Range	HP Category	MaxHP	Model Year	MY HP Group	ME ROG	ME CO	ME NOx	ME PM	AE ROG	AE CO	AE NOx	AE PM	Fuel
173	- Implies 251-500 hp	5	500	1969	MY1969HP5	1.26	3.066	16.52	0.703	1.4994	4.326	14	0.622	184.158502
174	- Implies 251-500 hp	5	500	1970	MY1970HP5	1.26	3.066	16.52	0.703	1.4994	4.326	14	0.622	184.158502
175	- Implies 251-500 hp	5	500	1971	MY1971HP5	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
176	- Implies 251-500 hp	5	500	1972	MY1972HP5	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
177	- Implies 251-500 hp	5	500	1973	MY1973HP5	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
178	- Implies 251-500 hp	5	500	1974	MY1974HP5	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
179	- Implies 251-500 hp	5	500	1975	MY1975HP5	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
180	- Implies 251-500 hp	5	500	1976	MY1976HP5	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
181	- Implies 251-500 hp	5	500	1977	MY1977HP5	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
182	- Implies 251-500 hp	5	500	1978	MY1978HP5	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
183	- Implies 251-500 hp	5	500	1979	MY1979HP5	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
184	- Implies 251-500 hp	5	500	1980	MY1980HP5	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
185	- Implies 251-500 hp	5	500	1981	MY1981HP5	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
186	- Implies 251-500 hp	5	500	1982	MY1982HP5	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
187	- Implies 251-500 hp	5	500	1983	MY1983HP5	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
188	- Implies 251-500 hp	5	500	1984	MY1984HP5	0.9	3.066	12.98	0.504	1.071	4.326	11	0.445	184.158502
189	- Implies 251-500 hp	5	500	1985	MY1985HP5	0.9	3.066	12.98	0.504	1.071	4.326	11	0.445	184.158502
190	- Implies 251-500 hp	5	500	1986	MY1986HP5	0.9	3.066	12.98	0.504	1.071	4.326	11	0.445	184.158502
191	- Implies 251-500 hp	5	500	1987	MY1987HP5	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
192	- Implies 251-500 hp	5	500	1988	MY1988HP5	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
193	- Implies 251-500 hp	5	500	1989	MY1989HP5	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
194	- Implies 251-500 hp	5	500	1990	MY1990HP5	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
195	- Implies 251-500 hp	5	500	1991	MY1991HP5	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
196	- Implies 251-500 hp	5	500	1992	MY1992HP5	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
197	- Implies 251-500 hp	5	500	1993	MY1993HP5	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
198	- Implies 251-500 hp	5	500	1994	MY1994HP5	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
199	- Implies 251-500 hp	5	500	1995	MY1995HP5	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
200	- Implies 251-500 hp	5	500	1996	MY1996HP5	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
201	- Implies 251-500 hp	5	500	1997	MY1997HP5	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
202	- Implies 251-500 hp	5	500	1998	MY1998HP5	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
203	- Implies 251-500 hp	5	500	1999	MY1999HP5	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
204	- Implies 251-500 hp	5	500	2000	MY2000HP5	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
205	- Implies 251-500 hp	5	500	2001	MY2001HP5	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
206	- Implies 251-500 hp	5	500	2002	MY2002HP5	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
207	- Implies 251-500 hp	5	500	2003	MY2003HP5	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502

ID	HP Range	HP Category	MaxHP	Model Year	MY HP Group	ME ROG	ME CO	ME NOx	ME PM	AE ROG	AE CO	AE NOx	AE PM	Fuel
208	- Implies 251-500 hp	5	500	2004	MY2004HP5	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
209	- Implies 251-500 hp	5	500	2005	MY2005HP5	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
210	- Implies 251-500 hp	5	500	2006	MY2006HP5	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
211	- Implies 251-500 hp	5	500	2007	MY2007HP5	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
212	- Implies 251-500 hp	5	500	2008	MY2008HP5	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
213	- Implies 251-500 hp	5	500	2009	MY2009HP5	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
214	- Implies 251-500 hp	5	500	2010	MY2010HP5	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
215	- Implies 251-500 hp	5	500	2011	MY2011HP5	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
216	- Implies 251-500 hp	5	500	2012	MY2012HP5	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
217	- Implies 251-500 hp	5	500	2013	MY2013HP5	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
218	- Implies 251-500 hp	5	500	2014	MY2014HP5	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
219	- Implies 251-500 hp	5	500	2015	MY2015HP5	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
220	- Implies 251-500 hp	5	500	2016	MY2016HP5	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
221	- Implies 251-500 hp	5	500	2017	MY2017HP5	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
222	- Implies 251-500 hp	5	500	2018	MY2018HP5	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
223	- Implies 251-500 hp	5	500	2019	MY2019HP5	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
224	- Implies 251-500 hp	5	500	2020	MY2020HP5	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
225	- Implies 501-750 hp	6	750	1969	MY1969HP6	1.26	3.066	16.52	0.703	1.4994	4.326	14	0.622	184.158502
226	- Implies 501-750 hp	6	750	1970	MY1970HP6	1.26	3.066	16.52	0.703	1.4994	4.326	14	0.622	184.158502
227	- Implies 501-750 hp	6	750	1971	MY1971HP6	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
228	- Implies 501-750 hp	6	750	1972	MY1972HP6	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
229	- Implies 501-750 hp	6	750	1973	MY1973HP6	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
230	- Implies 501-750 hp	6	750	1974	MY1974HP6	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
231	- Implies 501-750 hp	6	750	1975	MY1975HP6	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
232	- Implies 501-750 hp	6	750	1976	MY1976HP6	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
233	- Implies 501-750 hp	6	750	1977	MY1977HP6	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
234	- Implies 501-750 hp	6	750	1978	MY1978HP6	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
235	- Implies 501-750 hp	6	750	1979	MY1979HP6	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
236	- Implies 501-750 hp	6	750	1980	MY1980HP6	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
237	- Implies 501-750 hp	6	750	1981	MY1981HP6	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
238	- Implies 501-750 hp	6	750	1982	MY1982HP6	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
239	- Implies 501-750 hp	6	750	1983	MY1983HP6	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
240	- Implies 501-750 hp	6	750	1984	MY1984HP6	0.9	3.066	12.98	0.504	1.071	4.326	11	0.445	184.158502
241	- Implies 501-750 hp	6	750	1985	MY1985HP6	0.9	3.066	12.98	0.504	1.071	4.326	11	0.445	184.158502
242	- Implies 501-750 hp	6	750	1986	MY1986HP6	0.9	3.066	12.98	0.504	1.071	4.326	11	0.445	184.158502

ID	HP Range	HP Category	MaxHP	Model Year	MY HP Group	ME ROG	ME CO	ME NOx	ME PM	AE ROG	AE CO	AE NOx	AE PM	Fuel
243	- Implies 501-750 hp	6	750	1987	MY1987HP6	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
244	- Implies 501-750 hp	6	750	1988	MY1988HP6	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
245	- Implies 501-750 hp	6	750	1989	MY1989HP6	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
246	- Implies 501-750 hp	6	750	1990	MY1990HP6	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
247	- Implies 501-750 hp	6	750	1991	MY1991HP6	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
248	- Implies 501-750 hp	6	750	1992	MY1992HP6	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
249	- Implies 501-750 hp	6	750	1993	MY1993HP6	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
250	- Implies 501-750 hp	6	750	1994	MY1994HP6	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
251	- Implies 501-750 hp	6	750	1995	MY1995HP6	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
252	- Implies 501-750 hp	6	750	1996	MY1996HP6	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
253	- Implies 501-750 hp	6	750	1997	MY1997HP6	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
254	- Implies 501-750 hp	6	750	1998	MY1998HP6	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
255	- Implies 501-750 hp	6	750	1999	MY1999HP6	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
256	- Implies 501-750 hp	6	750	2000	MY2000HP6	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
257	- Implies 501-750 hp	6	750	2001	MY2001HP6	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
258	- Implies 501-750 hp	6	750	2002	MY2002HP6	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
259	- Implies 501-750 hp	6	750	2003	MY2003HP6	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
260	- Implies 501-750 hp	6	750	2004	MY2004HP6	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
261	- Implies 501-750 hp	6	750	2005	MY2005HP6	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
262	- Implies 501-750 hp	6	750	2006	MY2006HP6	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
263	- Implies 501-750 hp	6	750	2007	MY2007HP6	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
264	- Implies 501-750 hp	6	750	2008	MY2008HP6	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
265	- Implies 501-750 hp	6	750	2009	MY2009HP6	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
266	- Implies 501-750 hp	6	750	2010	MY2010HP6	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
267	- Implies 501-750 hp	6	750	2011	MY2011HP6	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
268	- Implies 501-750 hp	6	750	2012	MY2012HP6	0.68	3.73	5.1015	0.15	0.8092	3.73	5.102	0.15	184.158502
269	- Implies 501-750 hp	6	750	2013	MY2013HP6	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
270	- Implies 501-750 hp	6	750	2014	MY2014HP6	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
271	- Implies 501-750 hp	6	750	2015	MY2015HP6	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
272	- Implies 501-750 hp	6	750	2016	MY2016HP6	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
273	- Implies 501-750 hp	6	750	2017	MY2017HP6	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
274	- Implies 501-750 hp	6	750	2018	MY2018HP6	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
275	- Implies 501-750 hp	6	750	2019	MY2019HP6	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
276	- Implies 501-750 hp	6	750	2020	MY2020HP6	0.68	3.73	3.99	0.08	0.8092	3.73	3.99	0.08	184.158502
277	- Implies 751-1900 hp	7	1900	1969	MY1969HP7	1.26	3.066	16.52	0.703	1.4994	4.326	14	0.622	184.158502

ID	HP Range	HP Category	MaxHP	Model Year	MY HP Group	ME ROG	ME CO	ME NOx	ME PM	AE ROG	AE CO	AE NOx	AE PM	Fuel
278	- Implies 751-1900 hp	7	1900	1970	MY1970HP7	1.26	3.066	16.52	0.703	1.4994	4.326	14	0.622	184.158502
279	- Implies 751-1900 hp	7	1900	1971	MY1971HP7	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
280	- Implies 751-1900 hp	7	1900	1972	MY1972HP7	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
281	- Implies 751-1900 hp	7	1900	1973	MY1973HP7	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
282	- Implies 751-1900 hp	7	1900	1974	MY1974HP7	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
283	- Implies 751-1900 hp	7	1900	1975	MY1975HP7	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
284	- Implies 751-1900 hp	7	1900	1976	MY1976HP7	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
285	- Implies 751-1900 hp	7	1900	1977	MY1977HP7	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
286	- Implies 751-1900 hp	7	1900	1978	MY1978HP7	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
287	- Implies 751-1900 hp	7	1900	1979	MY1979HP7	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
288	- Implies 751-1900 hp	7	1900	1980	MY1980HP7	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
289	- Implies 751-1900 hp	7	1900	1981	MY1981HP7	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
290	- Implies 751-1900 hp	7	1900	1982	MY1982HP7	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
291	- Implies 751-1900 hp	7	1900	1983	MY1983HP7	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
292	- Implies 751-1900 hp	7	1900	1984	MY1984HP7	0.9	3.066	12.98	0.504	1.071	4.326	11	0.445	184.158502
293	- Implies 751-1900 hp	7	1900	1985	MY1985HP7	0.9	3.066	12.98	0.504	1.071	4.326	11	0.445	184.158502
294	- Implies 751-1900 hp	7	1900	1986	MY1986HP7	0.9	3.066	12.98	0.504	1.071	4.326	11	0.445	184.158502
295	- Implies 751-1900 hp	7	1900	1987	MY1987HP7	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
296	- Implies 751-1900 hp	7	1900	1988	MY1988HP7	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
297	- Implies 751-1900 hp	7	1900	1989	MY1989HP7	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
298	- Implies 751-1900 hp	7	1900	1990	MY1990HP7	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
299	- Implies 751-1900 hp	7	1900	1991	MY1991HP7	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
300	- Implies 751-1900 hp	7	1900	1992	MY1992HP7	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
301	- Implies 751-1900 hp	7	1900	1993	MY1993HP7	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
302	- Implies 751-1900 hp	7	1900	1994	MY1994HP7	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
303	- Implies 751-1900 hp	7	1900	1995	MY1995HP7	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
304	- Implies 751-1900 hp	7	1900	1996	MY1996HP7	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
305	- Implies 751-1900 hp	7	1900	1997	MY1997HP7	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
306	- Implies 751-1900 hp	7	1900	1998	MY1998HP7	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
307	- Implies 751-1900 hp	7	1900	1999	MY1999HP7	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
308	- Implies 751-1900 hp	7	1900	2000	MY2000HP7	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
309	- Implies 751-1900 hp	7	1900	2001	MY2001HP7	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
310	- Implies 751-1900 hp	7	1900	2002	MY2002HP7	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
311	- Implies 751-1900 hp	7	1900	2003	MY2003HP7	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
312	- Implies 751-1900 hp	7	1900	2004	MY2004HP7	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502

ID	HP Range	HP Category	MaxHP	Model Year	MY HP Group	ME ROG	ME CO	ME NOx	ME PM	AE ROG	AE CO	AE NOx	AE PM	Fuel
313	- Implies 751-1900 hp	7	1900	2005	MY2005HP7	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
314	- Implies 751-1900 hp	7	1900	2006	MY2006HP7	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
315	- Implies 751-1900 hp	7	1900	2007	MY2007HP7	0.68	3.73	5.529	0.2	0.8092	3.73	5.529	0.2	184.158502
316	- Implies 751-1900 hp	7	1900	2008	MY2008HP7	0.68	3.73	5.529	0.2	0.8092	3.73	5.529	0.2	184.158502
317	- Implies 751-1900 hp	7	1900	2009	MY2009HP7	0.68	3.73	5.529	0.2	0.8092	3.73	5.529	0.2	184.158502
318	- Implies 751-1900 hp	7	1900	2010	MY2010HP7	0.68	3.73	5.529	0.2	0.8092	3.73	5.529	0.2	184.158502
319	- Implies 751-1900 hp	7	1900	2011	MY2011HP7	0.68	3.73	5.529	0.2	0.8092	3.73	5.529	0.2	184.158502
320	- Implies 751-1900 hp	7	1900	2012	MY2012HP7	0.68	3.73	4.085	0.08	0.8092	3.73	4.085	0.08	184.158502
321	- Implies 751-1900 hp	7	1900	2013	MY2013HP7	0.68	3.73	4.085	0.08	0.8092	3.73	4.085	0.08	184.158502
322	- Implies 751-1900 hp	7	1900	2014	MY2014HP7	0.68	3.73	4.085	0.08	0.8092	3.73	4.085	0.08	184.158502
323	- Implies 751-1900 hp	7	1900	2015	MY2015HP7	0.68	3.73	4.085	0.08	0.8092	3.73	4.085	0.08	184.158502
324	- Implies 751-1900 hp	7	1900	2016	MY2016HP7	0.68	3.73	4.085	0.08	0.8092	3.73	4.085	0.08	184.158502
325	- Implies 751-1900 hp	7	1900	2017	MY2017HP7	0.177295	3.73	1.3	0.03	0.177295	3.73	1.3	0.03	184.158502
326	- Implies 751-1900 hp	7	1900	2018	MY2018HP7	0.177295	3.73	1.3	0.03	0.177295	3.73	1.3	0.03	184.158502
327	- Implies 751-1900 hp	7	1900	2019	MY2019HP7	0.177295	3.73	1.3	0.03	0.177295	3.73	1.3	0.03	184.158502
328	- Implies 751-1900 hp	7	1900	2020	MY2020HP7	0.177295	3.73	1.3	0.03	0.177295	3.73	1.3	0.03	184.158502
329	- Implies 1901-3300 hp	8	3300	1969	MY1969HP8	1.26	3.066	16.52	0.703	1.4994	4.326	14	0.622	184.158502
330	- Implies 1901-3300 hp	8	3300	1970	MY1970HP8	1.26	3.066	16.52	0.703	1.4994	4.326	14	0.622	184.158502
331	- Implies 1901-3300 hp	8	3300	1971	MY1971HP8	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
332	- Implies 1901-3300 hp	8	3300	1972	MY1972HP8	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
333	- Implies 1901-3300 hp	8	3300	1973	MY1973HP8	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
334	- Implies 1901-3300 hp	8	3300	1974	MY1974HP8	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
335	- Implies 1901-3300 hp	8	3300	1975	MY1975HP8	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
336	- Implies 1901-3300 hp	8	3300	1976	MY1976HP8	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
337	- Implies 1901-3300 hp	8	3300	1977	MY1977HP8	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
338	- Implies 1901-3300 hp	8	3300	1978	MY1978HP8	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
339	- Implies 1901-3300 hp	8	3300	1979	MY1979HP8	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
340	- Implies 1901-3300 hp	8	3300	1980	MY1980HP8	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
341	- Implies 1901-3300 hp	8	3300	1981	MY1981HP8	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
342	- Implies 1901-3300 hp	8	3300	1982	MY1982HP8	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
343	- Implies 1901-3300 hp	8	3300	1983	MY1983HP8	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
344	- Implies 1901-3300 hp	8	3300	1984	MY1984HP8	0.9	3.066	12.98	0.504	1.071	4.326	11	0.445	184.158502
345	- Implies 1901-3300 hp	8	3300	1985	MY1985HP8	0.9	3.066	12.98	0.504	1.071	4.326	11	0.445	184.158502
346	- Implies 1901-3300 hp	8	3300	1986	MY1986HP8	0.9	3.066	12.98	0.504	1.071	4.326	11	0.445	184.158502
347	- Implies 1901-3300 hp	8	3300	1987	MY1987HP8	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502

ID	HP Range	HP Category	MaxHP	Model Year	MY HP Group	ME ROG	ME CO	ME NOx	ME PM	AE ROG	AE CO	AE NOx	AE PM	Fuel
348	- Implies 1901-3300 hp	8	3300	1988	MY1988HP8	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
349	- Implies 1901-3300 hp	8	3300	1989	MY1989HP8	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
350	- Implies 1901-3300 hp	8	3300	1990	MY1990HP8	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
351	- Implies 1901-3300 hp	8	3300	1991	MY1991HP8	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
352	- Implies 1901-3300 hp	8	3300	1992	MY1992HP8	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
353	- Implies 1901-3300 hp	8	3300	1993	MY1993HP8	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
354	- Implies 1901-3300 hp	8	3300	1994	MY1994HP8	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
355	- Implies 1901-3300 hp	8	3300	1995	MY1995HP8	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
356	- Implies 1901-3300 hp	8	3300	1996	MY1996HP8	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
357	- Implies 1901-3300 hp	8	3300	1997	MY1997HP8	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
358	- Implies 1901-3300 hp	8	3300	1998	MY1998HP8	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
359	- Implies 1901-3300 hp	8	3300	1999	MY1999HP8	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
360	- Implies 1901-3300 hp	8	3300	2000	MY2000HP8	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
361	- Implies 1901-3300 hp	8	3300	2001	MY2001HP8	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
362	- Implies 1901-3300 hp	8	3300	2002	MY2002HP8	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
363	- Implies 1901-3300 hp	8	3300	2003	MY2003HP8	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
364	- Implies 1901-3300 hp	8	3300	2004	MY2004HP8	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
365	- Implies 1901-3300 hp	8	3300	2005	MY2005HP8	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
366	- Implies 1901-3300 hp	8	3300	2006	MY2006HP8	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
367	- Implies 1901-3300 hp	8	3300	2007	MY2007HP8	0.68	3.73	5.529	0.2	0.8092	3.73	5.529	0.2	184.158502
368	- Implies 1901-3300 hp	8	3300	2008	MY2008HP8	0.68	3.73	5.529	0.2	0.8092	3.73	5.529	0.2	184.158502
369	- Implies 1901-3300 hp	8	3300	2009	MY2009HP8	0.68	3.73	5.529	0.2	0.8092	3.73	5.529	0.2	184.158502
370	- Implies 1901-3300 hp	8	3300	2010	MY2010HP8	0.68	3.73	5.529	0.2	0.8092	3.73	5.529	0.2	184.158502
371	- Implies 1901-3300 hp	8	3300	2011	MY2011HP8	0.68	3.73	5.529	0.2	0.8092	3.73	5.529	0.2	184.158502
372	- Implies 1901-3300 hp	8	3300	2012	MY2012HP8	0.68	3.73	5.529	0.2	0.8092	3.73	5.529	0.2	184.158502
373	- Implies 1901-3300 hp	8	3300	2013	MY2013HP8	0.68	3.73	4.37	0.1	0.8092	3.73	4.37	0.1	184.158502
374	- Implies 1901-3300 hp	8	3300	2014	MY2014HP8	0.68	3.73	4.37	0.1	0.8092	3.73	4.37	0.1	184.158502
375	- Implies 1901-3300 hp	8	3300	2015	MY2015HP8	0.68	3.73	4.37	0.1	0.8092	3.73	4.37	0.1	184.158502
376	- Implies 1901-3300 hp	8	3300	2016	MY2016HP8	0.177295	3.73	1.3	0.03	0.177295	3.73	1.3	0.03	184.158502
377	- Implies 1901-3300 hp	8	3300	2017	MY2017HP8	0.177295	3.73	1.3	0.03	0.177295	3.73	1.3	0.03	184.158502
378	- Implies 1901-3300 hp	8	3300	2018	MY2018HP8	0.177295	3.73	1.3	0.03	0.177295	3.73	1.3	0.03	184.158502
379	- Implies 1901-3300 hp	8	3300	2019	MY2019HP8	0.177295	3.73	1.3	0.03	0.177295	3.73	1.3	0.03	184.158502
380	- Implies 1901-3300 hp	8	3300	2020	MY2020HP8	0.177295	3.73	1.3	0.03	0.177295	3.73	1.3	0.03	184.158502
381	- Implies >3301-5000 hp	9	5000	1969	MY1969HP9	1.26	3.066	16.52	0.703	1.4994	4.326	14	0.622	184.158502
382	- Implies >3301-5000 hp	9	5000	1970	MY1970HP9	1.26	3.066	16.52	0.703	1.4994	4.326	14	0.622	184.158502

ID	HP Range	HP Category	MaxHP	Model Year	MY HP Group	ME ROG	ME CO	ME NOx	ME PM	AE ROG	AE CO	AE NOx	AE PM	Fuel
383	- Implies >3301-5000 hp	9	5000	1971	MY1971HP9	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
384	- Implies >3301-5000 hp	9	5000	1972	MY1972HP9	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
385	- Implies >3301-5000 hp	9	5000	1973	MY1973HP9	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
386	- Implies >3301-5000 hp	9	5000	1974	MY1974HP9	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
387	- Implies >3301-5000 hp	9	5000	1975	MY1975HP9	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
388	- Implies >3301-5000 hp	9	5000	1976	MY1976HP9	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
389	- Implies >3301-5000 hp	9	5000	1977	MY1977HP9	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
390	- Implies >3301-5000 hp	9	5000	1978	MY1978HP9	1.05	3.066	15.34	0.599	1.2495	4.326	13	0.529	184.158502
391	- Implies >3301-5000 hp	9	5000	1979	MY1979HP9	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
392	- Implies >3301-5000 hp	9	5000	1980	MY1980HP9	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
393	- Implies >3301-5000 hp	9	5000	1981	MY1981HP9	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
394	- Implies >3301-5000 hp	9	5000	1982	MY1982HP9	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
395	- Implies >3301-5000 hp	9	5000	1983	MY1983HP9	0.95	3.066	14.16	0.504	1.1305	4.326	12	0.445	184.158502
396	- Implies >3301-5000 hp	9	5000	1984	MY1984HP9	0.9	3.066	12.98	0.504	1.071	4.326	11	0.445	184.158502
397	- Implies >3301-5000 hp	9	5000	1985	MY1985HP9	0.9	3.066	12.98	0.504	1.071	4.326	11	0.445	184.158502
398	- Implies >3301-5000 hp	9	5000	1986	MY1986HP9	0.9	3.066	12.98	0.504	1.071	4.326	11	0.445	184.158502
399	- Implies >3301-5000 hp	9	5000	1987	MY1987HP9	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
400	- Implies >3301-5000 hp	9	5000	1988	MY1988HP9	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
401	- Implies >3301-5000 hp	9	5000	1989	MY1989HP9	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
402	- Implies >3301-5000 hp	9	5000	1990	MY1990HP9	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
403	- Implies >3301-5000 hp	9	5000	1991	MY1991HP9	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
404	- Implies >3301-5000 hp	9	5000	1992	MY1992HP9	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
405	- Implies >3301-5000 hp	9	5000	1993	MY1993HP9	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
406	- Implies >3301-5000 hp	9	5000	1994	MY1994HP9	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
407	- Implies >3301-5000 hp	9	5000	1995	MY1995HP9	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
408	- Implies >3301-5000 hp	9	5000	1996	MY1996HP9	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
409	- Implies >3301-5000 hp	9	5000	1997	MY1997HP9	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
410	- Implies >3301-5000 hp	9	5000	1998	MY1998HP9	0.84	2.993	12.98	0.504	0.9996	4.223	11	0.445	184.158502
411	- Implies >3301-5000 hp	9	5000	1999	MY1999HP9	0.68	1.971	9.6406	0.361	0.8092	2.781	8.17	0.319	184.158502
412	- Implies >3301-5000 hp	9	5000	2000	MY2000HP9	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
413	- Implies >3301-5000 hp	9	5000	2001	MY2001HP9	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
414	- Implies >3301-5000 hp	9	5000	2002	MY2002HP9	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
415	- Implies >3301-5000 hp	9	5000	2003	MY2003HP9	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
416	- Implies >3301-5000 hp	9	5000	2004	MY2004HP9	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
417	- Implies >3301-5000 hp	9	5000	2005	MY2005HP9	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502

ID	HP Range	HP Category	MaxHP	Model Year	MY HP Group	ME ROG	ME CO	ME NOx	ME PM	AE ROG	AE CO	AE NOx	AE PM	Fuel
418	- Implies >3301-5000 hp	9	5000	2006	MY2006HP9	0.68	1.971	7.31	0.361	0.8092	2.781	7.31	0.319	184.158502
419	- Implies >3301-5000 hp	9	5000	2007	MY2007HP9	0.68	3.73	5.529	0.2	0.8092	3.73	5.529	0.2	184.158502
420	- Implies >3301-5000 hp	9	5000	2008	MY2008HP9	0.68	3.73	5.529	0.2	0.8092	3.73	5.529	0.2	184.158502
421	- Implies >3301-5000 hp	9	5000	2009	MY2009HP9	0.68	3.73	5.529	0.2	0.8092	3.73	5.529	0.2	184.158502
422	- Implies >3301-5000 hp	9	5000	2010	MY2010HP9	0.68	3.73	5.529	0.2	0.8092	3.73	5.529	0.2	184.158502
423	- Implies >3301-5000 hp	9	5000	2011	MY2011HP9	0.68	3.73	5.529	0.2	0.8092	3.73	5.529	0.2	184.158502
424	- Implies >3301-5000 hp	9	5000	2012	MY2012HP9	0.68	3.73	5.529	0.2	0.8092	3.73	5.529	0.2	184.158502
425	- Implies >3301-5000 hp	9	5000	2013	MY2013HP9	0.68	3.73	5.529	0.2	0.8092	3.73	5.529	0.2	184.158502
426	- Implies >3301-5000 hp	9	5000	2014	MY2014HP9	0.68	3.73	4.94	0.25	0.8092	3.75	4.94	0.25	184.158502
427	- Implies >3301-5000 hp	9	5000	2015	MY2015HP9	0.68	3.73	4.94	0.25	0.8092	3.75	4.94	0.25	184.158502
428	- Implies >3301-5000 hp	9	5000	2016	MY2016HP9	0.177295	3.73	1.3	0.03	0.177295	3.75	1.3	0.03	184.158502
429	- Implies >3301-5000 hp	9	5000	2017	MY2017HP9	0.177295	3.73	1.3	0.03	0.177295	3.75	1.3	0.03	184.158502
430	- Implies >3301-5000 hp	9	5000	2018	MY2018HP9	0.177295	3.73	1.3	0.03	0.177295	3.75	1.3	0.03	184.158502
431	- Implies >3301-5000 hp	9	5000	2019	MY2019HP9	0.177295	3.73	1.3	0.03	0.177295	3.75	1.3	0.03	184.158502
432	- Implies >3301-5000 hp	9	5000	2020	MY2020HP9	0.177295	3.73	1.3	0.03	0.177295	3.75	1.3	0.03	184.158502

Fleet Average

			ME ROG	ME CO	ME NOx	ME PM	AE ROG	AE CO	AE NOx	AE PM	Fuel
		50	1.80	3.71	5.82	0.36	2.14	4.09	5.72	0.34	184.16
2018 Avg. Emission Factors	500 hp	500	0.68	3.38	5.21	0.17	0.81	3.54	5.21	0.16	184.16
	1000 hp	1000	0.60	3.11	5.16	0.20	0.71	3.40	5.16	0.19	184.16
		3300	0.58	3.11	5.13	0.21	0.68	3.40	5.13	0.19	184.16
		5000	0.58	3.11	5.25	0.23	0.68	3.40	5.25	0.21	184.16

		ME ROG	ME CO	ME NOx	ME PM	AE ROG	AE CO	AE NOx	AE PM	Fuel
2020 Avg. Emission Factors	500	0.68	3.47	5.04	0.16	0.81	3.59	5.04	0.15	184.16
	1000	0.58	3.20	4.86	0.18	0.68	3.45	4.86	0.17	184.16
	3300	0.55	3.20	4.83	0.19	0.65	3.45	4.83	0.18	184.16
	5000	0.55	3.20	4.95	0.21	0.65	3.45	4.95	0.20	184.16

Mitigated Emission Factors		ME ROG	ME CO	ME NOx	ME PM	AE ROG	AE CO	AE NOx	AE PM	Fuel
	Tier 2	0.39		4.17	0.16	0.39		4.17	0.16	

Table 12. Tier Emission Factors

	Low HP	High HP	ROG (g/bhp-hr)	CO (g/bhp-hr)	NOX (g/bhp-hr)	PM10 (g/bhp-hr)	PM2.5 (g/bhp-hr)
Tier 1	25	49	1.74	4.1	5.26	0.48	0.48
Tier 1	50	74	1.19	6.9	6.54	0.552	0.552
Tier 1	75	119	1.19	6.9	6.54	0.552	0.552
Tier 1	120	174	0.82	6.9	6.54	0.274	0.274
Tier 1	175	299	0.38	6.9	5.93	0.108	0.108
Tier 1	300	599	0.38	6.9	5.93	0.108	0.108
Tier 1	600	750	0.38	6.9	5.93	0.108	0.108
Tier 1	751	2000	0.38	6.9	5.93	0.108	0.108
Tier 2	25	49	0.29	4.1	4.63	0.28	0.28
Tier 2	50	74	0.23	3.7	4.75	0.192	0.192
Tier 2	75	119	0.23	3.7	4.75	0.192	0.192
Tier 2	120	174	0.19	3.7	4.17	0.128	0.128
Tier 2	175	299	0.12	2.6	4.15	0.088	0.088
Tier 2	300	599	0.12	2.6	3.79	0.088	0.088
Tier 2	600	750	0.12	2.6	3.79	0.088	0.088
Tier 2	751	2000	0.12	2.6	3.79	0.088	0.088
Tier 3	25	49	0.29	4.1	4.63	0.28	0.28
Tier 3	50	74	0.12	3.7	2.74	0.192	0.192
Tier 3	75	119	0.12	3.7	2.74	0.192	0.192
Tier 3	120	174	0.12	3.7	2.32	0.112	0.112
Tier 3	175	299	0.12	2.6	2.32	0.088	0.088
Tier 3	300	599	0.12	2.6	2.32	0.088	0.088
Tier 3	600	750	0.12	2.6	2.32	0.088	0.088
Tier 3	751	2000	0.12	2.6	2.32	0.088	0.088
Tier 4 Interim	25	49	0.12	4.1	4.55	0.128	0.128
Tier 4 Interim	50	74	0.12	3.7	2.74	0.112	0.112
Tier 4 Interim	75	119	0.11	3.7	2.14	0.008	0.008
Tier 4 Interim	120	174	0.06	3.7	2.15	0.008	0.008
Tier 4 Interim	175	299	0.08	2.6	1.29	0.008	0.008
Tier 4 Interim	300	599	0.08	2.6	1.29	0.008	0.008
Tier 4 Interim	600	750	0.08	2.6	1.29	0.008	0.008
Tier 4 Interim	751	2000	0.12	2.6	2.24	0.048	0.048
Tier 4	25	49	0.12	4.1	2.75	0.008	0.008
Tier 4	50	74	0.12	3.7	2.74	0.008	0.008
Tier 4	75	119	0.06	3.7	0.26	0.008	0.008
Tier 4	120	174	0.06	3.7	0.26	0.008	0.008
Tier 4	175	299	0.06	2.2	0.26	0.008	0.008
Tier 4	300	599	0.06	2.2	0.26	0.008	0.008
Tier 4	600	750	0.06	2.2	0.26	0.008	0.008
Tier 4	751	2000	0.06	2.6	2.24	0.016	0.016

APPENDIX I

AIR QUALITY AND GREENHOUSE GAS CALCULATIONS

Part 3

Alternative B1/B2, C1/C2, D1/D2 Mitigated Construction:

Dredged Material Placement

Subsequent Construction

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Table 1. Construction Emissions Summary – Alternative B

Diesel

	Emissions (lbs)					Metric Tons
Construction Phase/Emissions Source	**ROG**	**NO_X**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**CO_2e**
Mobilization	16.76	120.63	107.47	3.53	3.25	11.24
Site Preparation	794.15	6023.25	7121.07	187.30	172.86	694.19
Dredged Material Placement	21245.39	287546.08	92846.11	6783.75	6745.28	21582.75
Decomissioning	437.42	3120.51	3003.00	108.19	99.64	290.75
Demobilization	16.76	120.63	107.47	3.53	3.25	11.24
Restoration Project	18.91	83.85	874.53	2.45	2.44	86.37
Total Project	22529.40	297014.97	104059.65	7088.75	7026.71	22676.54
Average Daily Emissions (lbs/day)	**46.31**	**610.56**	**213.91**	**14.57**	**14.44**	
Average Annual Emissions (tons)	**2.55**	**33.62**	**11.78**	**0.80**	**0.80**	
Amortized GHG Emissions						755.88
CEQA Construction Days	**486**					
NEPA Construction Months	**53**					

Electric

	Emissions (lbs/day)					Metric Tons
Construction Phase/Emissions Source	**ROG**	**NO_X**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**CO_2e**
Mobilization	16.76	120.63	107.47	3.53	3.25	11.24
Site Preparation	794.15	6023.25	7121.07	187.30	172.86	694.19
Dredged Material Placement	1937.11	13623.10	13774.10	489.11	450.64	10330.17
Decomissioning	504.55	3577.21	3671.51	123.94	114.23	351.30
Demobilization	16.76	120.63	107.47	3.53	3.25	11.24
Restoration Project	18.91	83.85	874.53	2.45	2.44	86.37
Total Project	3288.24	23548.68	25656.15	809.86	746.66	11484.51
Average Daily Emissions (lbs/day)	**6.76**	**48.41**	**52.74**	**1.66**	**1.53**	
Average Annual Emissions (tons)	**0.37**	**2.67**	**2.90**	**0.09**	**0.08**	
Amortized GHG Emissions						382.82

Table 2. Construction Emissions Summary – Alternative C

Diesel

	Emissions (lbs)					Metric Tons
Construction Phase/Emissions Source	**ROG**	**NO_X**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**CO_2e**
Mobilization	16.76	120.63	107.47	3.53	3.25	11.24
Site Preparation	783.65	5876.08	6663.36	186.37	171.95	647.01
Dredged Material Placement	16770.01	226482.52	73166.31	5350.79	5318.80	16967.30
Decomissioning	435.15	3109.76	2876.26	107.92	99.38	276.96
Demobilization	16.76	120.63	107.47	3.53	3.25	11.24
Restoration Project	10.23	45.35	472.96	1.32	1.32	46.71
Total Project	18032.56	235754.97	83393.84	5653.46	5597.94	17960.47
Average Daily Emissions (lbs/day)	**44.75**	**585.12**	**206.97**	**14.03**	**13.89**	
Average Annual Emissions (tons)	**2.58**	**33.68**	**11.91**	**0.81**	**0.80**	
Amortized GHG Emissions						598.68
CEQA Construction Days	**403**					
NEPA Construction Months	**42**					

Electric

	Emissions (lbs/day)					Metric Tons
Construction Phase/Emissions Source	**ROG**	**NO_X**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**CO_2e**
Mobilization	16.76	120.63	107.47	3.53	3.25	11.24
Site Preparation	783.65	5876.08	6663.36	186.37	171.95	647.01
Dredged Material Placement	1601.26	11286.31	11046.67	405.66	373.68	8127.18
Decomissioning	502.03	3565.16	3533.22	123.65	113.95	335.30
Demobilization	16.76	120.63	107.47	3.53	3.25	11.24
Restoration Project	10.23	45.35	472.96	1.32	1.32	46.71
Total Project	2930.69	21014.16	21931.16	724.07	667.39	9178.70
Average Daily Emissions (lbs/day)	**7.27**	**52.15**	**54.43**	**1.80**	**1.66**	
Average Annual Emissions (tons)	**0.42**	**3.00**	**3.13**	**0.10**	**0.10**	
Amortized GHG Emissions						305.96

Table 3. Construction Emissions Summary – Alternative D

Diesel

	Emissions (lbs)					Metric Tons
Construction Phase/Emissions Source	**ROG**	**NO_X**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**CO_2e**
Mobilization	16.57	119.59	98.23	3.51	3.23	9.48
Site Preparation	783.96	5971.71	6550.91	186.72	172.39	564.77
Dredged Material Placement	21256.12	287968.72	91472.20	6794.67	6756.42	21320.57
Decomissioning	431.66	3089.82	2729.94	107.64	99.13	238.58
Demobilization	16.57	119.59	98.23	3.51	3.23	9.48
Restoration Project	16.65	72.17	767.98	2.22	2.22	67.66
Total Project	22521.53	297341.61	101717.48	7098.27	7036.62	22210.53
Average Daily Emissions (lbs/day)	**46.27**	**610.83**	**208.96**	**14.58**	**14.46**	
Average Annual Emissions (tons)	**2.55**	**33.66**	**11.52**	**0.80**	**0.80**	
Amortized GHG Emissions						740.35
CEQA Construction Days	**487**					
NEPA Construction Months	**53**					

Electric

	Emissions (lbs/day)					Metric Tons
Construction Phase/Emissions Source	**ROG**	**NO_X**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**CO_2e**
Mobilization	16.57	119.59	98.23	3.51	3.23	9.48
Site Preparation	783.96	5971.71	6550.91	186.72	172.39	564.77
Dredged Material Placement	1906.51	13459.37	12230.92	486.56	448.30	10043.90
Decomissioning	498.54	3545.21	3386.90	123.37	113.70	296.92
Demobilization	16.57	119.59	98.23	3.51	3.23	9.48
Restoration Project	16.65	72.17	767.98	2.22	2.22	67.66
Total Project	3238.79	23287.66	23133.17	805.89	743.07	10992.21
Average Daily Emissions (lbs/day)	**6.65**	**47.84**	**47.52**	**1.66**	**1.53**	
Average Annual Emissions (tons)	**0.37**	**2.64**	**2.62**	**0.09**	**0.08**	
Amortized GHG Emissions						366.41