PRELIMINARY DESIGN MEMORANDUM

RAVENSWOOD PONDS

South Bay Salt Pond Restoration Project

Coastal Conservancy

MEMORANDUM

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

FROM: URS

DATE: August 21, 2014

RE: **Ravenswood Ponds R3, R4, R5, and S5 Restoration Preliminary Design**

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1. INTRODUCTION

This memorandum documents the preliminary design of the South Bay Salt Pond (SBSP) Restoration Project's Phase 2 actions at the Ravenswood pond complex's Ponds R3, R4, R5, and S5. These ponds are also referred to as the Ravenswood Ponds. This memorandum provides technical 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 Ravenswood pond complex consists of seven ponds on the bay side of the Peninsula, along both sides of State Route (SR) 84 west of the Dumbarton Bridge, and on the bayside of the developed areas of the City of Menlo Park in San Mateo County (see **Appendix A**, Figure A-1). Bayfront Park in Menlo Park is directly west of the pond complex, and a portion of SR 84 and the Dumbarton Rail corridor are along its southern border. The U.S. Fish and Wildlife Service owns and manages the 1,600-acre Ravenswood pond complex (EDAW 2007).

The Phase 2 Ravenswood Ponds restoration 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), USFWS, California Department of Fish and Wildlife (CDFW), Santa Clara Valley Water District (SCVWD) Alameda County Flood Control and Water Conservation District (ACFCWCD), and others.

The Programmatic EIS/R for the SBSP Restoration Project (EDAW at al. 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 habitat mix/managed pond habitat mix for the entire restoration project area (Programmatic Alternative B) to a 90/10 tidal habitat/managed pond habitat mix for the entire restoration project area (Programmatic Alternative C) (see **Appendix A**, Figures A-7 and A-8). 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; however, Phase 1 actions at the Ravenswood Ponds included only interpretive signage at the adjacent Bedwell Bayfront Park (see **Appendix A**, Figure A-9). Note: some Phase 1 actions were conducted at other ponds in the Ravenswood complex that are not the subject of the Phase 2 actions.

A design charrette was held May 13, 2010 to discuss conceptual restoration design ideas. 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 Corporation 2012). From this, three conceptual designs were developed, which varied in the location and size of various restoration components, such as the habitat transition zones (also known in other documents as upland transition zones, transition zone habitats, or ecotones), recreational trails, levee breaches, and water control structures.

This set of three alternatives was developed for conceptual design and analysis in the site-specific Public Draft EIS/EIR. Following the public comment period, a preferred alternative that best meets the project objectives while providing a cost-efficient design would be identified in the Final EIS/EIR. This memorandum describes the design work conducted as part of the conceptual level (approximately 10 percent) design.

1.2 Organization and Scope

This memorandum presents the conceptual (approximately 10%) design for the Ravenswood Ponds restoration. It also briefly documents the design constraints and considerations specific to Ponds R3, R5, R5, and S5 that formed the basis for the conceptual design.

The preliminary design memorandum is organized as follows:

- 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 describes the preliminary design based on available information and our professional judgment pending future engineering analyses. Future design decisions or additional information may change the findings, the mix of design components included in the alternatives themselves, or the corresponding professional judgments presented in this report. Additional engineering will be necessary prior to construction. In the event conclusions or recommendations based on the information in this memorandum are made by others, such conclusions are not the responsibility of URS, 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 Ravenswood Ponds R3, R4, R5, and S5 Phase 2 objectives include a restoration 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, Pond R4 would be restored to tidal marsh habitat, Drainage features in Pond R3 would be improved to improve management flexibility for western snowy plover habitat, and Ponds R5 and S5 are being considered for a variety of managed pond enhancements that would allow them to function as habitat for diving and dabbling birds/ducks, as simulated intertidal mud flats.
- *To provide flood management 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. Some additional reductions in fluvial flood risk could also be addressed by one of the managed pond options for Ponds R5 and S5 (included in Alternative Ravenswood D).
- *To provide wildlife-oriented public access and recreation*. Public access activities may include hiking, wildlife viewing, and other 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.

2.1 Design constraints

- *Flooding.* The primary constraint on the introduction of tidal action is that flooding could occur unless additional flood protection is provided. Thus, in order to introduce tidal action to Pond R4, additional flood protection must be provided. Some locations for construction of flood control levees (e.g. along Highway 84) are logistically impossible within the desired schedule due to ownership and easement considerations.
- *Future restoration activities*. Restoring tidal action in Pond R4 may affect how Pond R3 could be restored and managed in the future. In addition, some design alternatives may be incompatible with others, e.g. a breach at Greco Slough may be incompatible with the creation of a habitat transition zone in the same area.

- *Erosion and scour.* An undersized or non-hardened levee breach may result in erosion and scour of the remaining levee.
- *Volume of fill material.* The size of the habitat transition zones and extent of levee enhancements would likely depend on the volume and type of fill available for reuse. Placement of clean upland soils is already planned in and around the All American Canal, which forms the southern boundary of Pond R4.
- *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 or the required mitigation.
- *Long-term maintenance.* Constructed features such as levees, trails, control gates, and artificial habitat islands would need to be maintained into the future for them to function as designed.
- *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 developed environmental conditions.
- *Water quality*. Water quality in restored tidal Pond R4 and managed Ponds R3/R5/S5 may need to be monitored to ensure that they are functioning optimally.
- *Existing rights-of-way, easements, and utilities.* These features may serve as constraints to installation of control structures, culverts, or other features. The conceptual design would need to consider rights-of-way owned by Caltrans, Cargill 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.

2.2 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, would 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.
- *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.* The primary purpose of habitat transition zones is to provide habitat complexity and refugia for tidal marsh wildlife species during high tides. In addition, the transitional area would provide resiliency to sea level rise and may provide opportunity for improved public education and outreach.
- *Western snowy plover.* Pond R4 currently serves as habitat for nesting western snowy plover; restoring tidal action to Pond R4 would eliminate this habitat function. While enhanced and additional habitat to support this species may be provided (e.g., by enhancing Pond R3's

drainage management and water quality or by building islands in Ponds R5/S5), managed pond habitat would require long-term maintenance. 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 whether to fill or retain existing borrow ditches would influence flow and circulation through the restored ponds. Hydrology was assessed and modeled, where appropriate, to inform the preliminary design.
- *Erosion and scour.* Tidal flows through new breaches are expected to scour channels in the tidal marsh which would improve the efficiency of tidal exchange.
- *Recreation.* Retained levees provide opportunity for recreation and educational signage describing the restoration. Breaches and sensitive wildlife habitat may limit locations for recreational opportunities.
- *Flood retention.* Ponds R5 and S5 provide opportunity to reduce flooding impacts in the Redwood City community by serving as a detention basin for runoff during storm events. Operating control gates to maintain the appropriate capacity for flood detention within Ponds R5 and S5 while providing as much value to wildlife as possible are considered.
- *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.* High salinity in the borrow ditches and slough traces within the Ravenswood Ponds, particularly during the summer and fall may drive decisions regarding the construction schedule for levee breaches and other phasing considerations in order to meet discharge criteria. Adequate circulation, particularly in managed ponds, is necessary to prevent dissolved oxygen (DO) levels from dropping too low. Pond design elements, such as shallower depths, can improve circulation and reduce the risk of low DO.
- *Material quality.* The imported fill material in habitat restoration or improvement projects would require environmental screening for contaminants to assess the cleanliness and quality of the material (USFWS 2012). The "dirt broker" that has been acquiring upland fill and arranging for its transport to and use in other projects on land owned by the USFWS, is assisting USFWS with a Quality Assurance Project Plan and a permit for assuring this cleanliness and quality.

3. AVAILABLE DATA AND PRELIMINARY DESIGN ANALYSES

The preliminary design was prepared based on the following information and analyses. A hydrodynamic analysis of the proposed restoration alternatives was undertaken to determine reasonable breach and culvert sizes for use in the preliminary design. As described below, a two-dimensional hydrodynamic model of the proposed tidal wetland was developed to size breaches and predict levels of wetting and drying within the ponds. A simpler, one-dimensional hydraulic model of the pond system was also developed to determine culvert sizes for Ponds R5 and S5.

Analyses were performed on the three action alternatives (Alternatives Ravenswood B, Ravenswood C, and Ravenswood D). These Alternatives are graphically depicted in **Appendix A** on Figures A-3, A-4, and A-5, and key components are listed in **Table 3.1**.

Table 3.1. Key Components of Action Alternatives

Alternative Ravenswood B	Alternative Ravenswood C	Alternative Ravenswood D
Improve All American Canal Levee	Improve All American Canal Levee	Improve All American Canal Levee
	All American Canal Habitat Transition Zone	All American Canal Habitat Transition Zone
Bedwell Bayfront Park Habitat Transition Zone	Bedwell Bayfront Park Habitat Transition Zone	
		R4 Northwest Habitat Transition Zone
Remove Pond R5 and S5 levees	Remove Pond S5 and R5 levees	Remove Pond R5 and S5 Levees
	Fill Ponds S5/R5	
R4/R5 Control Gate	R4/R5 Control Gate	R4/R5 Control Gate
	R3/S5 Control Gate	R3/S5 Control Gate
	R3/Ravenswood Control Gate	R3/Ravenswood Control Gate
S5/Flood Slough Control Gate	S5/Flood Slough Control Gate	S5/Flood Slough Control Gate
R4 Channel	R4 Channel	
R4 East Breach	R4 East Breach	R4 East Breach
	R4 Northwest Breach	
Lower R4 Northwest Levee	Lower R4 Northwest Levee	
Improve Pond R5 and S5 Nesting Island	Improve Pond R5 and S5 Nesting Island	
Interpretive Platform	Interpretive Platform	Interpretive Platform
	R4 Trail	R4 Trail
	R4 Boardwalk and Viewing Platform	R4 Viewing Platform

3.1 Site Topography and Project Datum

The available site topography is from USGS (2010) which developed a surface elevation dataset derived from high-accuracy Light Detection and Ranging (LiDAR) technology for the USGS San Francisco Coastal LiDAR project area (San Francisco, Marin, Solano, Contra Costa, Alameda, San Mateo, Santa Clara counties, California). The LiDAR data were processed by USGS to a bare-earth digital terrain model (DTM). USGS developed detailed breaklines and bare-earth DEMs and data were formatted according to tiles with each tile covering an area of 1500 m by 1500 m. A total of 712 tiles were produced for the entire survey area encompassing approximately 610 sq. miles. The horizontal spatial reference system for the USGS San Francisco Coastal LiDAR Project is NAD83, UTM Zone 10N, meters and North American Vertical Datum of 1988 (NAVD88), meters.

The below water elevations in the bay adjacent to the project site and deeper sections of Ravenswood Slough were obtained from 2005 Hydrographic Survey of South San Francisco Bay, California by the USGS, published in 2007. These data consisted of xyz data collected in 2005 using a single beam acoustic sampler. The horizontal spatial reference system for the bathymetry is NAD83, UTM Zone 10N with Z-values provided in meters relative to NAVD88.

The site topography was generated by merging the two sets of data. The LiDAR grid was re-sampled to a 20 ft (6-meter) grid spacing, which was determined to be sufficient to represent the pond and channel bathymetry without significantly increasing hydraulic model run times (model runs times are approximately related to grid spacing by a factor of 8, e.g., doubling the grid resolution results in about a 8-fold increase in model run time). The USGS bathymetry data was closely spaced along each transect; transects were spaced at varying intervals. A 20 ft (6-meter) grid was generated from these data which was merged with the LiDAR data grid. The grid has units of meters and is vertically referenced to NAVD88. Since LiDAR does not penetrate water surface, it failed to detect the bathymetry of the channel which runs around the inside boundary of Pond R4 and the channel that runs across the center of the pond. The data show a flat surface at elevation 2.4 feet (0.74 meters) NAVD88, which is likely the water surface elevation on the day of the survey. These channels were assigned to an elevation of -6.6 feet (-2.0 meters) NAVD88 so that the channel beds are always lower than the mean low water and stay wet during the model runs.[1]

Figure 3.1 shows an aerial photo of the model grid extent, and **Figure 3.2** shows the bathymetry used in the model.

Figure 3.1 Aerial photograph showing the extent of model coverage at the Ravenswood Ponds

[1] This is important for model stability but is not a design requirement for implementation of the project.

Figure 3.2 Topographic and bathymetric map showing the ground surface elevations used to represent the Ravenswood Ponds and surrounding ground and water

3.2 Hydrologic Data

Water surface elevations representative of tides at the Ravenswood site were obtained from the Coyote Creek tide gauge near the mouth of Coyote Creek (NOAA gauge 9414575) and were used as the boundary condition in the hydrodynamic and hydraulic models. This gauge is roughly 8 miles (13 kilometers) from Ravenswood. The time series has an increment of 6 minutes and the tide elevation varies between -2.6 feet (-0.8 meters) and 8.9 feet (2.7 meters) during the selected two week modeling period. The modeling period contains typical spring and neap tide conditions. The daily tide data were obtained from National Oceanic Atmospheric Administration's Tides and Currents website and converted to NAVD88 with data available on the SBSP monitoring tide gauge data webpage. **Figure 3.3** shows the tide data used in the model studies and **Figure 3.4** shows the average tide elevations for the Coyote Creek station. There is another gauge on the east end of the Dumbarton Bridge, approximately 4 miles from the project site, with data that has been sporadically reported by NOAA. Data are presently being collected at this gauge by the South Bay Salt Pond Restoration Project and are available from their website. However, the conversion of station datum to the NAVD88 datum is not known so this data could not be used. The difference in tidal range between these two stations in about 0.4 to 0.5 feet, so the use of the Coyote Creek gauge was considered sufficient for the preliminary design.

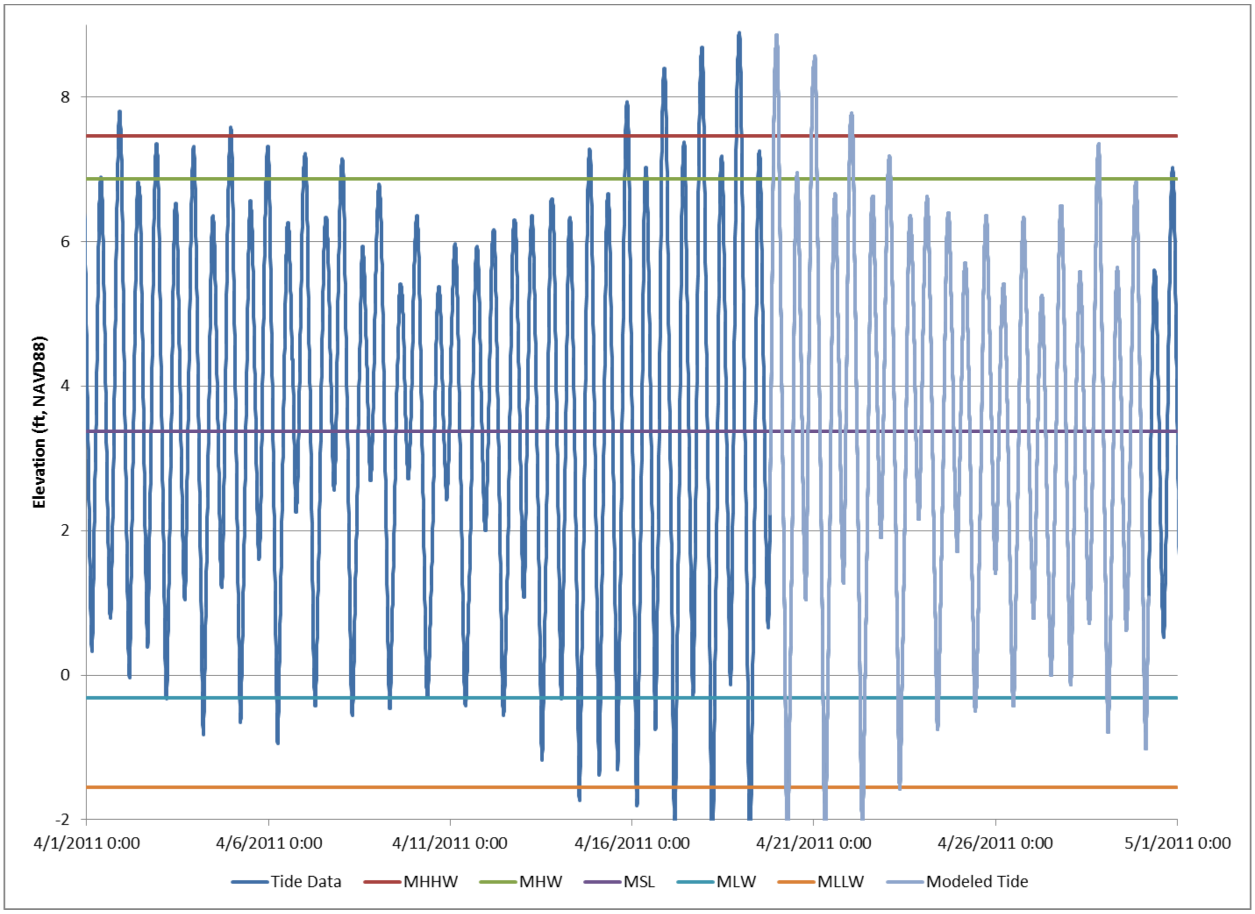
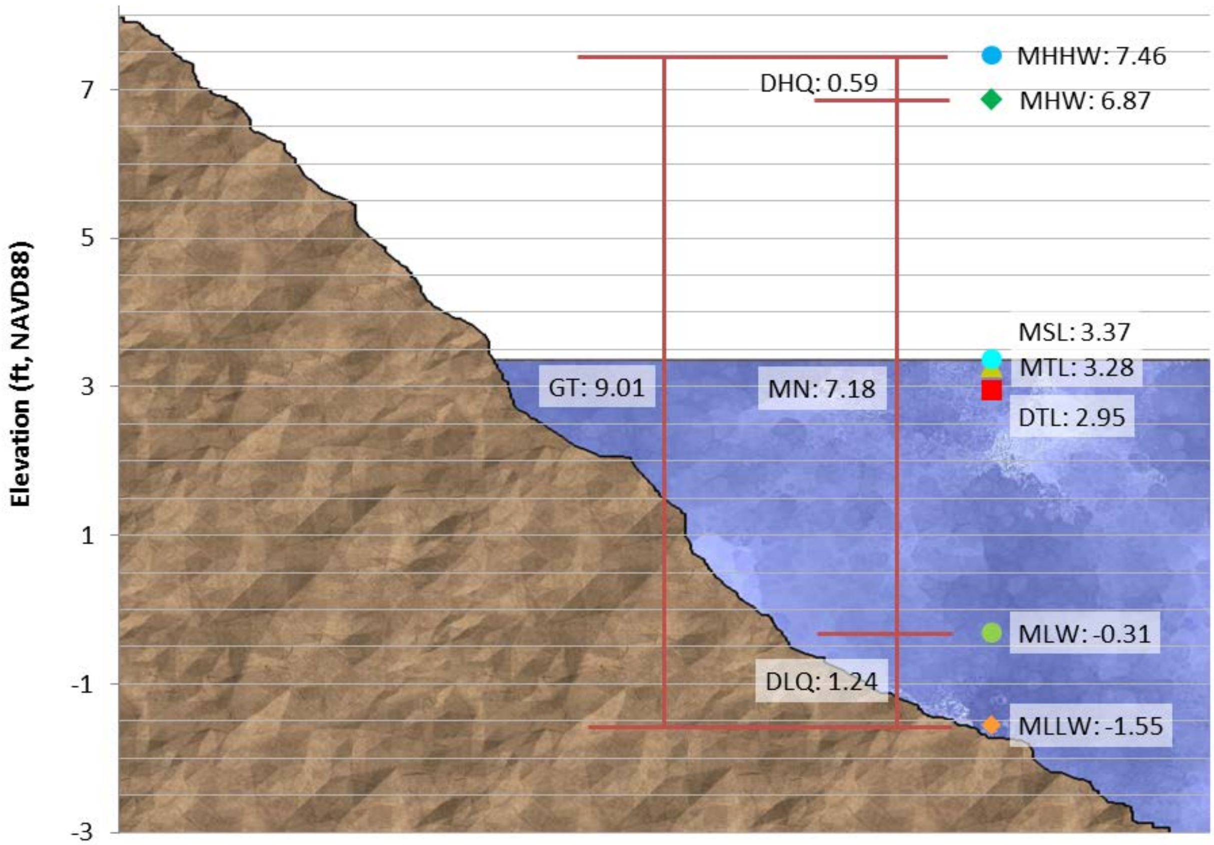


Figure 3.3 Tide data input for model studies



Note:	All elevations in feet, NAVD88	Source: NOAA 2013; SBSP 2013	
Key:	MHHW (mean higher high water)	MHW (mean high water)	MSL (mean sea level)
	MTL (mean tide level)	DTL (mean diurnal tide level)	MLW (mean low water)
	MLLW (mean lower low water)	GT (great diurnal range)	DHQ (mean diurnal high water inequality)
	MN (mean range of tide)	DLQ (mean diurnal low water inequality)	

Figure 3.4 Coyote Creek gauge average tide elevations

3.3 Model Selection and Setup

3.3.1 Pond R4

The MIKE 21 two-dimensional hydrodynamic model was used to simulate flows and water surface elevations in the Ravenswood Salt Ponds. MIKE 21 is a two-dimensional, free-surface flow modeling system developed by the Danish Hydraulic Institute (DHI). It can simulate the changes in water levels and velocities in response to tides, wind, and freshwater inflows in estuaries, coastal waters, and seas where stratification can be neglected. It consists of a hydrodynamic module to which other modules can be added to address different phenomena. For this study, only the hydrodynamic module (MIKE 21 HD) was used to model the breaching of the salt ponds. Water levels and flows are resolved on a rectangular grid as described in Section 3.1. Other inputs include bed resistance (Manning's n roughness coefficient) and hydrographic boundary conditions (e.g., tides and inflows). The tidal boundary extended about 1000 feet (300 meters) into the San Francisco Bay. The model was run for a two-week tide cycle duration.

3.3.2 Ponds R5 and S5

For Ponds R5 and S5, only Alternative Ravenswood C (tidal mud flats; see **Appendix A**, Figure A-4) necessitated modeling during the design. The other action alternatives (Ravenswood B and D) have Ponds R5 and S5 as managed ponds, and the gates and culverts do not require modeling to design.

The U.S. Army Corps of Engineers' Hydraulic Engineering Center's River Analysis System (HEC-RAS) model was used to determine the size of culverts needed in the water control structures between Ponds R5 and R4, between S5 and Pond R3, and between S5 and Flood Slough. Also, different fill volumes were analyzed in Pond R5 to convert it to a potential mud flat.

Cross-sections for Ravenswood Slough and Flood Slough were developed using U.S. Army Corps of Engineers' HEC-GeoRAS and imported into the HEC-RAS program. Ponds R3, R4, R5, S5 and S5 forebay were treated as storage units in the HEC-RAS model. Ponds R3 and R4 have a minimum ground elevation of 4.9 feet (1.5 meters) and a top of levee elevation of 9.4 feet (2.86 meters) NAVD88, resulting in a maximum depth of 4.5 feet (1.36 meters). Storage areas R5, S5a and S5b were combined into one storage area, labeled as R5 in **Figure 3.5** and have a minimum ground elevation of 4.8 feet (1.45 meters) NAVD88.

Two 100-foot (30-meter) wide levee breaches were modeled along Ravenswood Slough at separate locations along the Pond R4 levee to simulate the effects of the two breaches shown in the Alternative Ravenswood C Figure A-4 in **Appendix A**. Culvert connections were added in the following locations:

- Connecting Pond R3 to Ravenswood Slough
- Connecting Pond R5/S5 to Flood Slough
- Connecting Pond R3 to R5/S5
- Connecting Pond R4 to R5/S5

The Unsteady Flow Analysis option was chosen for this HEC-RAS model using the same tidal conditions as described in Section 3.2.

Figure 3.5 Model Setup for HEC-RAS model

3.3.3 Hydraulic Design Criteria

The only design criteria used in this preliminary design was that the breach size be sufficient to allow full draining and filling during most tide cycles. For Ponds R5 and S5, culvert sizes were selected that allowed sufficient ponding and full drainage during each tidal cycle to simulate a mud flat environment.

3.4 Hydraulic Design Results

3.4.1 Breach Sizes for Pond R4

For purposes of the modeling, the only alternatives that require breach size analysis are Alternative Ravenswood B and Alternative Ravenswood C. Alternative Ravenswood D is similar to Alternative Ravenswood B but with an increased amount of habitat transition zone, so the results from Alternative Ravenswood B were used for the design of Alternative Ravenswood D. Alternative Ravenswood B has one breach in Ravenswood Slough that connects to the main historical slough trace in Pond R4. Both 60 and 150 foot wide breaches were analyzed. Alternative Ravenswood C has an additional breach in Westpoint Slough adjacent to Greco Island. For Alternative Ravenswood C two 40-foot breaches were analyzed, one at each breach location. This provides results for conditions of two small breaches, one medium size breach, and one large breach. Other combinations (e.g., one small and one medium sized breach) can be inferred from these results.

The results for water elevation in Pond R4 after breaching are shown in **Figures 3.6** and **3.7**. These figures show the water levels at two points in Pond R4. **Figure 3.6** shows water elevations at a point located in the northeast quadrant of the pond north of the main historical slough trace. **Figure 3.7** shows water surface elevations at a point located in the southwest quadrant of the pond south of the main historical slough trace. Having multiple breaches (Alternative Ravenswood C) provides better filling of the pond than having one large breach. The results indicate that adding a second breach has a greater effect on high water levels in the pond than enlarging the breach on Ravenswood Slough (up to 150 feet). However, draining of Pond R4 is either unaffected (for the northeast quadrant) or somewhat diminished (for the southwest quadrant). The high tide inundation of Pond R4 peaks within 1-2 feet of each peak of the tide, indicating that the pond is sufficiently filling and the modeled breach sizes meet the hydraulic design criteria of allowing sufficient filling of the ponds.

Figure 3.8 shows the pond inundation at low tide. The areas of the pond that remain wet (blue areas in **Figure 3.8**) are shallow, less than about 0.5 feet (0.1 meters) deep. Both Alternative Ravenswood B and C results at low tide are similar so only results for Alternative Ravenswood B are shown at low tide. Because most of the pond area is drained at low tide, the modeled breach sizes meet the hydraulic design criteria of allowing sufficient draining of the ponds.

Alternative Ravenswood B also proposes lowering the levee between Pond R4 and Westpoint Slough to Mean High Water (MHW). The lowered levee would allow more water to flow into the northeastern corner of the pond during the highest tides (higher than MHW) and does not contribute to draining the wetland, so it does not influence the selection of breach size. Therefore, levee lowering is not included in the modeling.

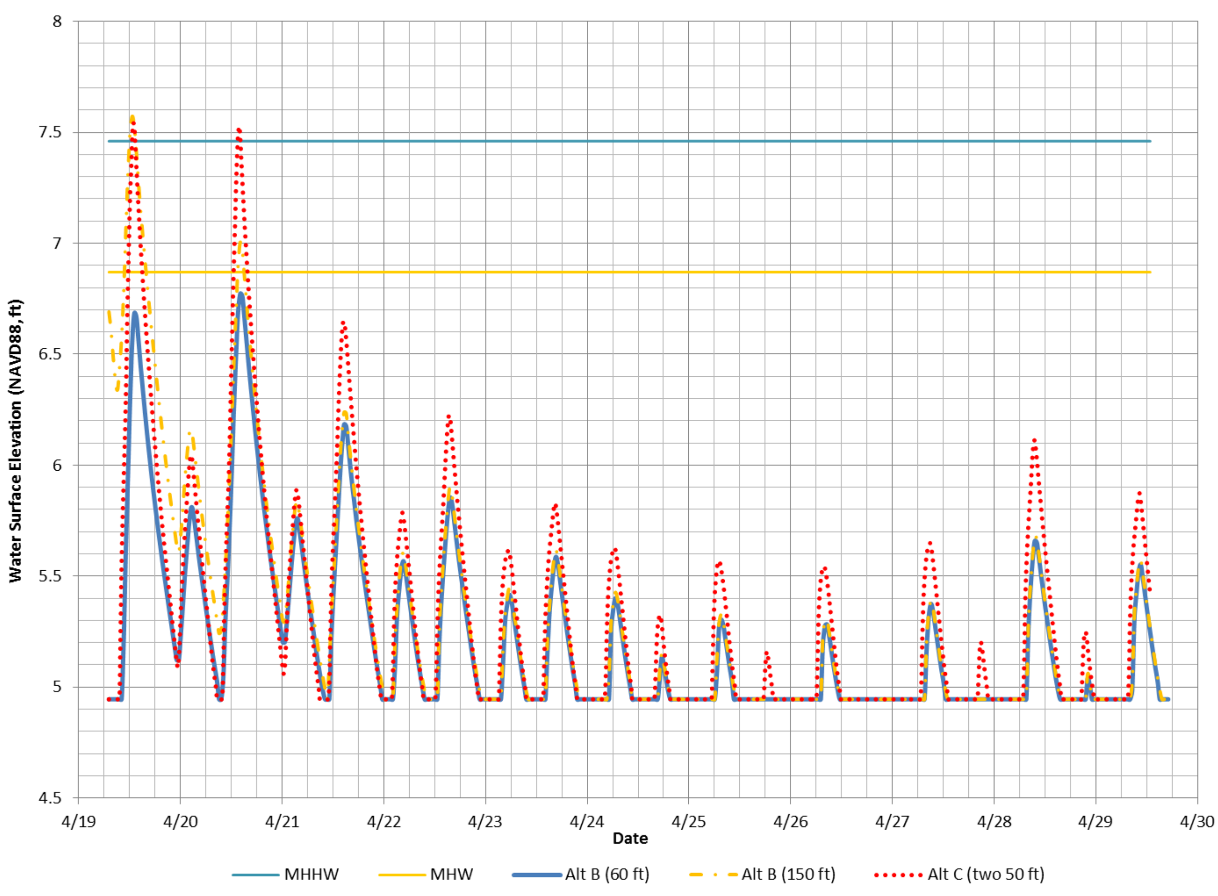


Figure 3.6 Water surface elevations in Pond R4 at a point north of the main historical slough trace

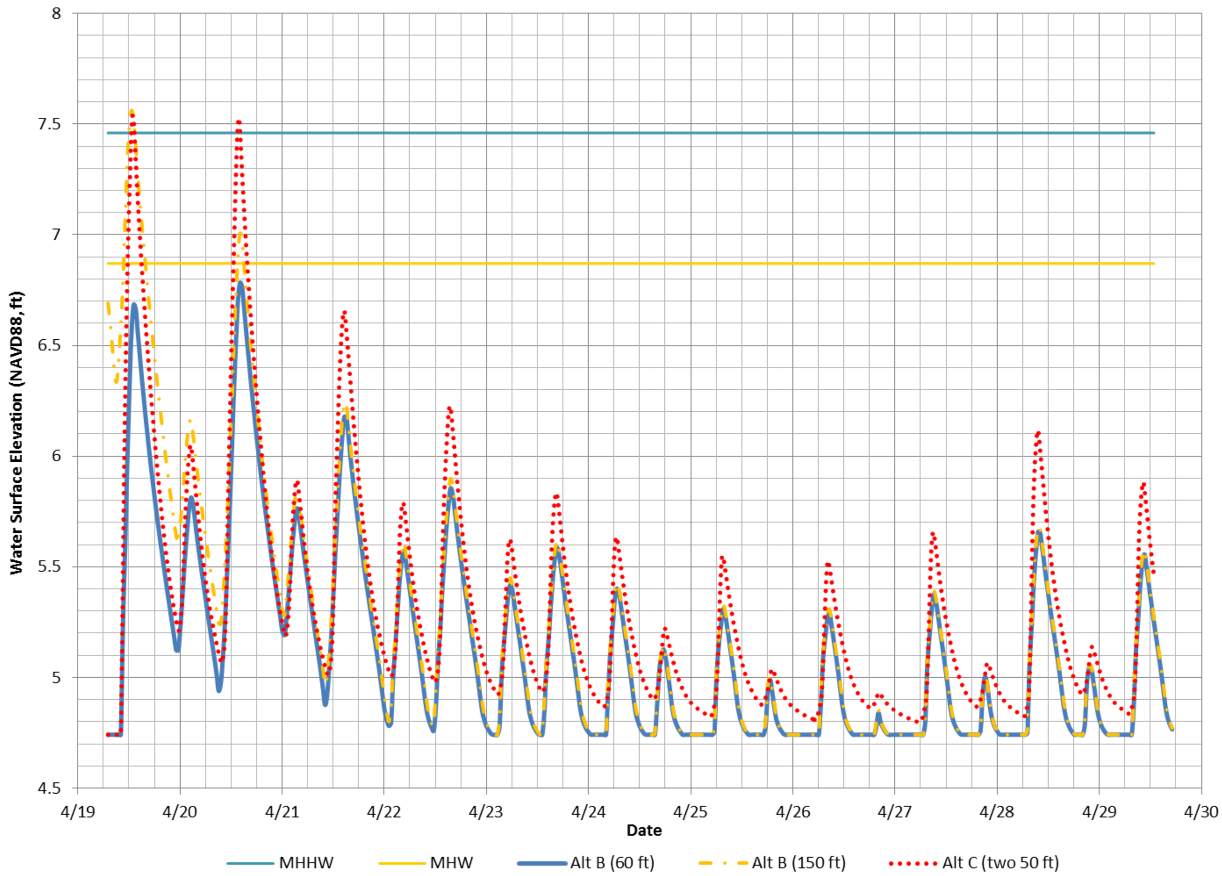


Figure 3.7 Water surface elevations in Pond R4 at a point south of the main historical slough trace

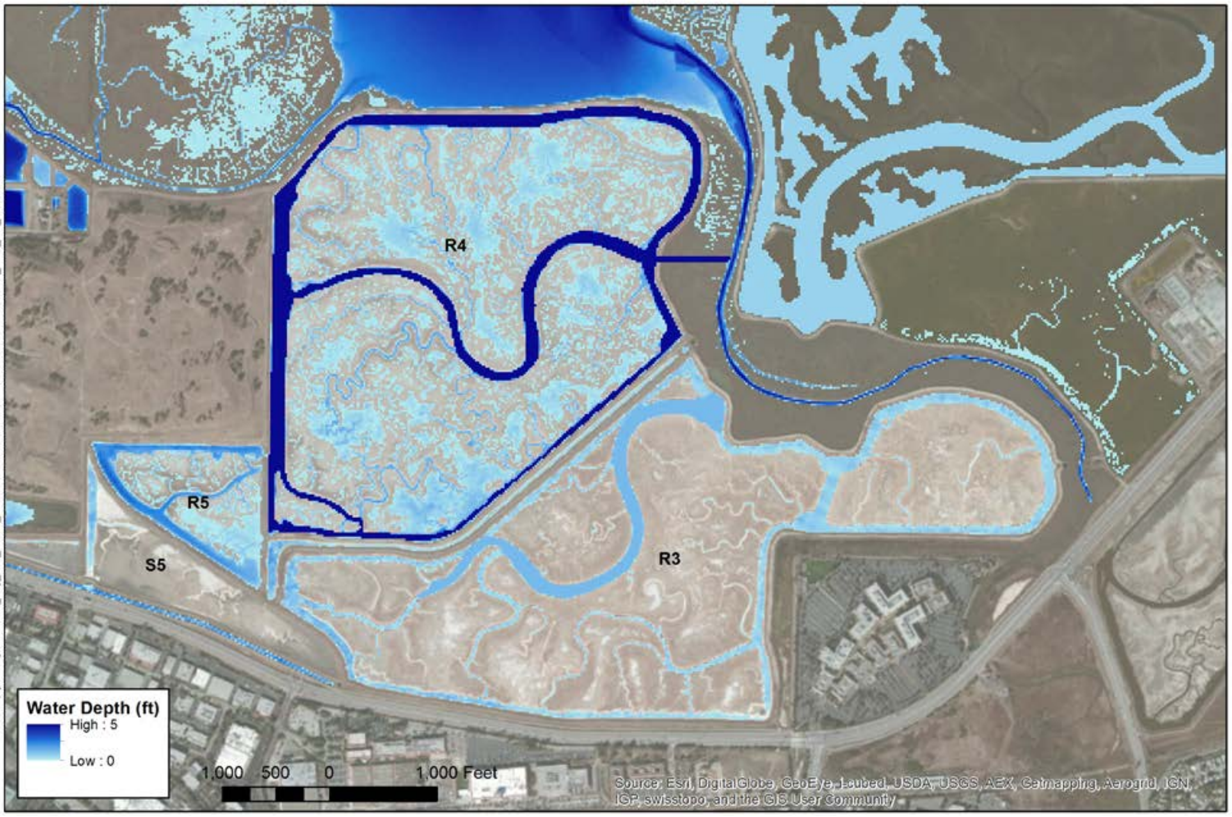


Figure 3.8 Water depth during low tide for Alternative B with one 60-foot breach

3.4.2 Culvert Sizes for Ponds R5 and S5

Under all alternatives, Ponds R5 and S5 are managed ponds and joined together as one pond. The Ponds would be managed as a mud flat in Alternative Ravenswood C and as open water in Alternatives Ravenswood B and D. Because the mud flat requires daily tidal influence, the culverts for Alternative Ravenswood C were modeled as part of the design.

A typical mudflat is exposed twice a day during the low tides and is in equilibrium with its sediment supply (i.e., accretion is equal to erosion). In the bay, mud flats are generally located below mean tide level in elevation. The criterion for selection of culvert size was that the pond bottom should be submerged a minimum of 50% of the tide cycle and thus exposed less than 50% of the time. If the pond bottom is exposed more than 50% of the time it may develop into a tidal marsh because vegetation may be able to root and survive the shallower and shorter tidal inundation. If the pond bottom is submerged most of the time, it would resemble shallow subtidal habitat and likely be less productive.

Several combinations of culvert sizes and gates were simulated. Culvert inverts were typically set at or slightly lower than the corresponding pond bottom elevations. However, for the Pond R5/S5 connection to Flood Slough, the culvert invert on the pond side needed to be set approximately 1.1 feet below the pond bottom. The average pond bottom elevation for Pond R5/S5 is about 4.7 feet (1.45 meters) NAVD88; the culvert inverts on the R5/S5 end need to be at least elevation 3.6 feet (1.1 meters) NAVD88 or lower for the culverts to have sufficient depth of flow to allow and thus capacity to drain the pond volume between tide cycles. In other words, at least a minimal channel network with bottom elevation of 3.6 feet (1.1 meters) NAVD88 or lower is needed to direct flow through the culvert and drain the pond completely. Based on the modeling results, the estimated minimum culvert sizes and inverts to meet the project objectives are shown in **Table 3.2**.

Table 3.2. Minimum culvert sizes and inverts for Pond R5/S5 with drainage to Flood Slough

Location	Types and sizes	Inverts (NAVD 88)
Pond R4 to Pond R5/S5	(1) 3’x3’ concrete box culvert	R4: 4.9 ft (1.5 m) R5/S5: 4.7 ft (1.4 m)
Pond R3 to Pond R5/S5	(1) 3’x3’ concrete box culvert	R3: 4.9 ft (1.5 m) R5/S5: 4.7 ft (1.4 m)
Pond R5/S5 to Flood Slough	(3) 4’x8’ concrete box culverts	R5/S5: 3.6 ft (1.1 m) Flood Sl.: -6.0 ft (-2.0 m)

Note: the culvert sizes and inverts assume drainage to Flood Slough is available.

Should the connection between Pond R5/S5 and Flood Slough be closed or not constructed, in order for Pond R5/S5 to operate as a mud flat (i.e., drain and fill each tide cycle), the bottom elevation of Pond R5/S5 would need to be raised about 0.5 feet. In addition, larger culverts would be needed between R4 and R5/S5 with inverts about 0.3 feet (0.1 meters) lower than the corresponding pond bottom elevations. Under this scenario, the estimated minimum culvert sizes and inverts to meet the project objectives are shown in **Table 3.3**.

Table 3.3. Minimum culvert sizes and inverts for Pond R5/S5 with no drainage to Flood Slough

Location	Types and sizes	Inverts (NAVD 88)
Pond R4 to Pond R5	(4) 4’x4’ concrete box culverts	R4: 4.6 ft (1.4 m) R5/S5: 4.3 ft (1.3 m)
Pond R3 to Pond R5	(1) 3’x3’ concrete box culvert	R3: 4.6 ft (1.4 m) R5/S5: 4.3 ft (1.3 m)

Note: the culvert sizes and inverts assume drainage to Flood Slough is not available.

Figure 3.9 shows the water level in Pond R5/S5 for both cases, with drainage to Flood Slough (open) and without (close). With drainage to Flood Slough, no fill material is needed and the bottom elevation of Pond R5/S5 is the existing 4.74 feet (1.45 meters) NAVD88. The pond is able to drain in almost every tide cycle, and the pond bottom is submerged about 75% of the time. In the second case which assumes no drainage to Flood Slough, the bottom of the pond would be raised by 0.5 feet, and the new bottom elevation would be 5.25 feet (1.6 meters) NAVD88. Under this case the pond is able to drain daily, but the wetting and drying is not as efficient as the first case with drainage to Flood Slough. In the second case, the pond bottom is submerged about 50% of the time.

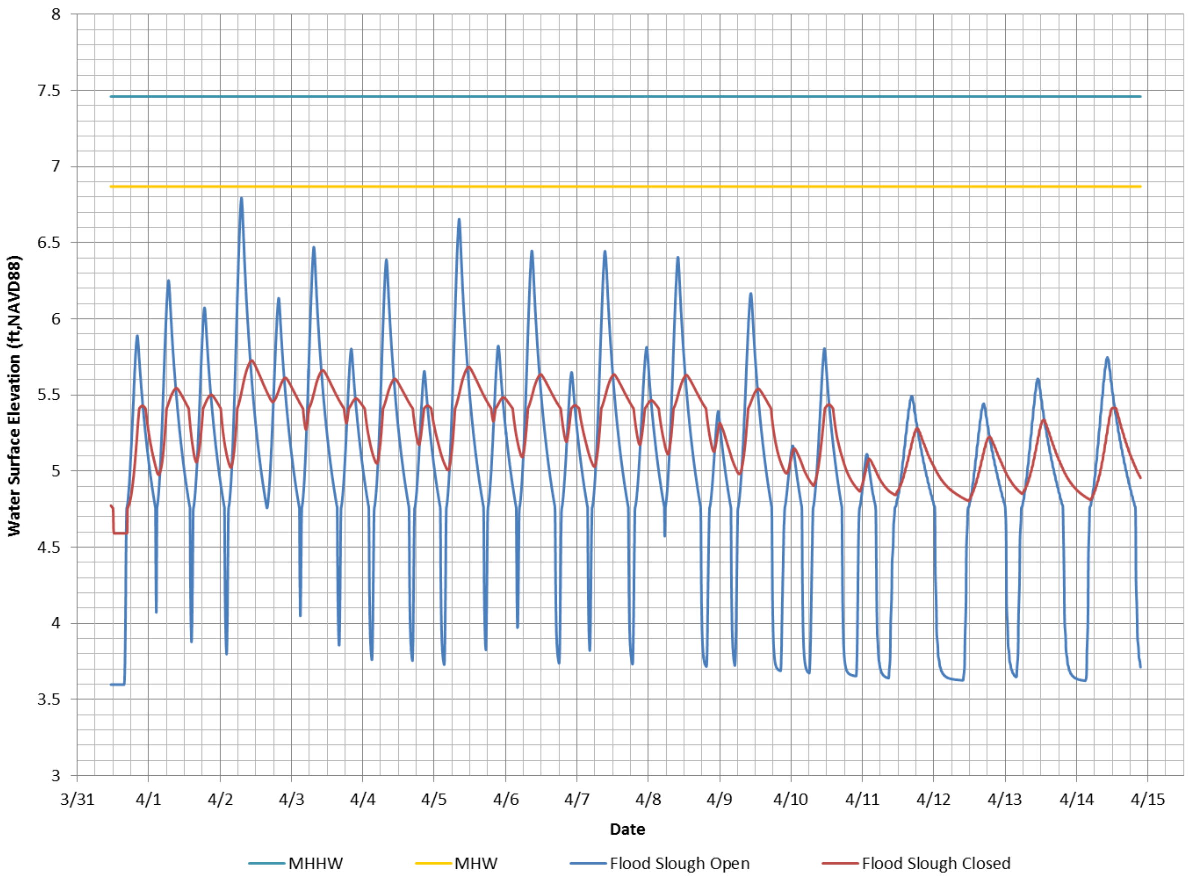


Figure 3.9 Water surface elevations in Pond R5

3.5 Salinity/Water Quality Management Approaches

3.5.1 Salinity

The Ravenswood ponds currently have relatively high salinity compared to salinity in San Francisco Bay, which is about 35 parts per thousand (ppt). Median salinity for all Ravenswood ponds ranges from 127 ppt in the winter and spring to 274 ppt in the summer and fall. Seasonal differences are the result of precipitation and evaporation patterns. Comparing the tidal inflow from the proposed breaches (constructed in the fall) to the volume of water within R4 suggests that it would likely to reach ambient salinity within a few tide cycles. After Pond R4 reaches ambient salinity, it would be expected to stay within that range (about 35 ppt) except where it interacts with the R5/S5 managed ponds. The interaction with R5/S5 ponds and its effect on salinity depends on the action taken. If the R5/S5 ponds are used as managed ponds, they may contribute somewhat higher salinity levels to Pond R4 when gates are opened due to the evaporation that would occur in the R5/S5 ponds, but the volume of the R5/S5 ponds is small compared to that of R4 (333 and 1,509 acre-feet respectively), so the effect is expected to be negligible. If the R5/S5 ponds are used for stormwater management, the R5/S5 ponds may contribute fresher water to R4 during runoff events, but again, the effects are expected to be negligible due to the difference in the volumes of the ponds.

Based on Waste Discharge Requirements (WDRs) for the Phase 1 Project, it is anticipated that the Regional Water Quality Control Board (RWQCB) would limit salinity discharges during ongoing operations to 40 ppt. There may also be separate salinity limits during the initial period after the breach.

3.5.2 Dissolved Oxygen

Adequate circulation and mixing in managed ponds is necessary to maintain high turbidity (which lessens sunlight penetration) in order to prevent formation of algal blooms and subsequent drops in DO. Pond design elements, such as shallower depths, that allow pond bottom sediments to disperse in the water column more effectively to block sunlight, can reduce these risks. Operational elements, such as opening and closing of water control structures, can increase mixing. Water levels in R5/S5 would be dependent on the selected action. If they are used for stormwater management (Alternative Ravenswood D), they would be maintained at a low level during the wet season in order to provide storage capacity for Redwood City storm flows. Depending on how closely managers wish to track storm forecasts and manipulate water levels, R5/S5 may be kept hydrologically isolated for long periods of time waiting for inputs from the storm system. Flood and storm water inputs would be released within 24 to 48 hours to restore capacity. The need to keep water levels low during the wet season would increase turbidity and reduce algal blooms but a possible reduction in mixing for long periods of time could lower DO. If Ponds R5 and S5 are used for mudflat habitat, they would experience daily tidal cycles, and DO would closely match ambient levels in the contributing tidal sloughs and ponds. If R5/S5 ponds are managed ponds (Alternative Ravenswood B), then managers would need to monitor DO conditions and open and close gates at a sufficient frequency and timing to increase mixing and prevent DO problems.

3.5.3 Stormwater Quality

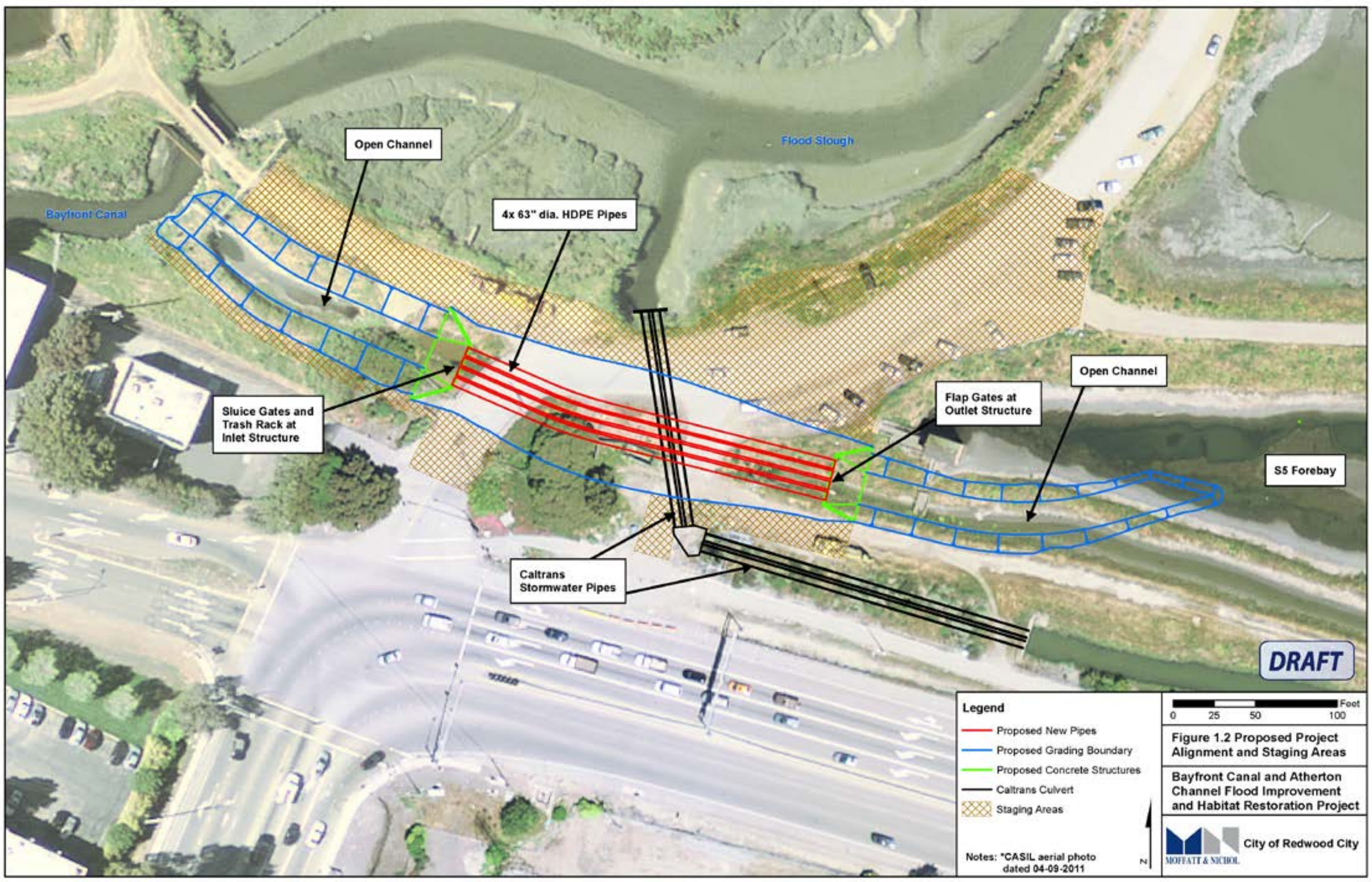
Under Alternative Ravenswood D, improvements associated with Redwood City's Bayfront Canal and Atherton Channel Project would connect to Ponds R5 and S5 to allow for stormwater detention during runoff events to reduce upstream flooding. In addition, stormwater could be used to reduce residual salinity in the Ponds. The design of the flood improvements is being prepared by Redwood City (see **Figure 3.10**). The following text on stormwater quality is excerpted from Section 3.3 of their *Draft Redwood City Bayfront Canal and Atherton Channel Flood Improvement and Habitat Restoration Project Feasibility Study* (Moffat & Nichol 2013).

> *Water quality analysis was performed during three rain events on 2/19/2013, 3/14/2012, and 3/1/2012 at four locations along Bayfront Canal. The rain events were all less than the 1-year 24 hour design storm of 1.62 inches, with recorded totals of 0.32 inches, 0.84 inches, and 0.02 inches, respectively. All four locations were sampled in the 2/19/2013 event, while the BCTG and ATBC sampling locations (below) were sampled for the 2012 events.*
>
> > *BCTG – In Bayfront Canal upstream of the tide gates (upstream Flood Slough; downstream of the Atherton Channel junction with the Canal).*
> >
> > *ATBC – In Atherton Channel upstream [of] the junction with Bayfront Canal*
> >
> > *FSBC – In Flood Slough outside the tide gates (contains Canal and Channel water)*
> >
> > *BCAT – In Bayfront Canal upstream of the junction with Atherton Channel*
>
> *Sampling location BCTG, in Bayfront Canal upstream of the tide gates, is representative of the water that would bypass the tide gates and be directed into the SBSP [Ravenswood Ponds] S5 and R5.*

The tide gate between Bayfront Canal and Flood Slough prevents backflow of tidal water into the Bayfront Canal during high tides and allows outflow of runoff during low tides. Atherton Channel and Bayfront Canal join upstream of the tide gates, limiting outflow during storm conditions, resulting in flooding of nearby properties.

The grab sample results show the water located upstream of the tide gates, at sampling location BCTG, is in compliance with all 1-hr average WQOs [water quality objectives]. *Although grab and 1-hr (composite) average samples cannot be directly compared, the grab samples are a good indication of the water's compliance with the WQOs.*

One exceedance was recorded from the three sampling events in the Atherton Channel upstream of the junction with Bayfront Canal. The dissolved copper concentration on 3/14/12 was 13 µg/L, which exceeded the specified South San Francisco Bay WQO of 10.8 µg/L. All other samples were in compliance.



Source: Moffatt & Nichol 2014

Figure 3.10: Proposed Bayfront Canal and Atherton Channel Flood Improvements Connection to Ponds R5/S5

Under Alternative Ravenswood D, the pond inflow would be managed to avoid first flush urban runoff from entering the pond. The following text on management actions is excerpted from Section 4.1 of the same report:

Stormwater from the first major rain event of each winter season will not be diverted into the Ravenswood Ponds to maintain water and sediment quality within those ponds. The "first flush" of the winter season often carries elevated concentrations of constituents that were deposited during the summer months in the watershed. By allowing the first flood flow to enter Flood Slough without diversion to the ponds, the flooding potential will increase, however the habitat within the ponds will be preserved from elevated urban constituents. This approach will require a manual opening of the diversion gate into the ponds after the first flush event.

Because of the compliant water quality results, the only form of pretreatment that seems to be necessary is treatment of large floating debris. The proposed project should include a trash rack to catch large debris prior to the water entering the ponds. Periodic cleaning of the screens would be required as part of the normal maintenance operations.

3.6 Geotechnical Data

Geotechnical data for the South Bay Salt Pond Restoration Project was provided by the U.S. Army Corps of Engineers and was collected as part of the South San Francisco Bay Shoreline Study (AMEC and Geomatrix Consultants 2007, AMEC Geomatrix Inc. 2009, USACE 2011a, USACE 2011b). The available data include soil borings, cone penetrometer tests (CPTs), and geotechnical data from laboratory tests performed on samples taken from the soil borings. However, data is only available for the Alviso complex pond levees, and no data was collected at the Ravenswood complex.

During future design phases, geotechnical data should be collected along the Ravenswood levees to assess their ability to support construction equipment and additional levee material, where applicable. It may also be desirable to assess the existing pond substrate in areas where habitat transition zones are proposed because the pond substrate is generally weak and may require additional fill material to reach proposed grade. The stability of the landfill slopes in Bedwell Bayfront Park should also be assessed to determine whether they can support habitat transition zone material without damaging the landfill cap.

4. PRELIMINARY DESIGN

The preliminary designs for elements in the Phase 2 alternatives for the Ravenswood Ponds are discussed in the sections below. Where the elements differ between the alternatives, those differences are noted.

4.1 Preliminary Design Components

4.1.1 Site Clearance and Demolition Activities

Areas that would be disturbed by construction activities would be cleared of any existing vegetation which would be disposed off-site. Similarly, sensitive vegetation in the immediate area around the proposed levee breach locations would be handpicked, salvaged and replanted elsewhere as appropriate.

Existing water control structures and material left over from previous Cargill operations on the property are not needed for (and do not hinder or detract from) the restoration (**Figure 4.1**). Water control structures are located between Ponds R3 and the All-American Canal (AAC), R4 and the AAC, R4 and R5, R4 and Ravenswood Slough, R5 and S5, S5 and the AAC, and S5 and R3 and typically consist of a 72-inch diameter corrugated metal pipe through the levee between ponds. There may be structures in addition to those listed here. During construction, these water control structures and all associated support structures would be demolished and disposed off-site or recycled as appropriate. Water control structure demolition locations would be backfilled unless new water control structures are proposed as described in Section 4.1.9.

Figure 4.1. Existing Water Control Structure at Ravenswood Ponds

4.1.2 Levee Modifications

Approximately 4,700 feet of levee along the southern portion of Pond R4 bordering the AAC (from the eastern connection with the R3 eastern perimeter levee to the western connection to Bedwell Bayfront Park) would be modified by either increasing the levee top elevation (Alternative Ravenswood B) or by increasing the levee top elevation and building habitat transition zone along the pond side (Alternatives Ravenswood C and D). See Section 4.1.5 for a discussion of the habitat transition zone design. The levee improvements would provide similar level of flood protection after levee breaching as provided by the existing northern R4 levee (i.e. match existing outboard levee elevations) in order to meet the Maintain Existing Flood Protection Objective in Section 2. These modifications would also provide access along the levee top to enable temporary or long-term transport and storage of fill material within Pond R4. The preliminary design criteria for the levee modification are as follows:

Design Criteria:

- Top elevation: R4 southern perimeter levee would have a minimum crest elevation of 9 feet NAVD88 prior to breaching Pond R4. This would provide free board of 1.5 feet above MHHW.
- Compaction: levee fill would be placed and compacted to 90% of maximum dry density as measured using ASTM D1557.

- Side slope: the improved levee would have side slopes of 4:1 (h:v) along the canal side for stability and 8:1 (h:v) along the Pond R4 side for stability and wave protection.

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

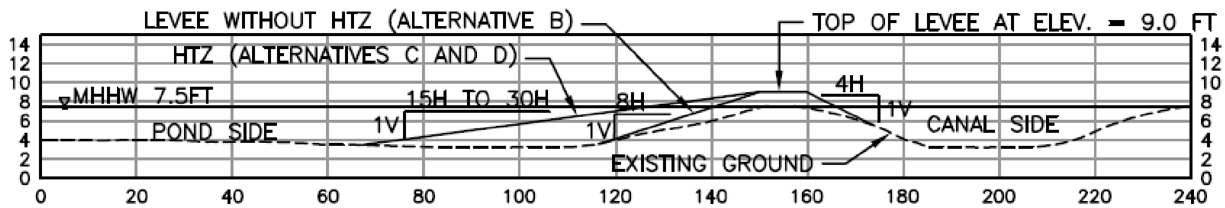


Figure 4.2. Proposed Levee Improvement – Typical Section.

Borrow material may be sourced on-site from levee lowering at Pond R4, internal levee removal at Ponds R5 and S5, from pilot channel excavation, or from off-site upland re-use materials. Levee lowering at Pond R4 would remain at elevations above the MHHW until construction activities within the pond that need to be performed in the dry and all levee improvements are complete.

There are other options that are being discussed for AAC that are beyond the scope of this preliminary design. These options include filling in the AAC and modifying the feature to create one levee as opposed to a canal bordered by levees on either side. The purposes of these options include storing additional upland re-use materials for later use by the SBSP Restoration Project and preparing for future restoration and flood control actions in Pond R3.

4.1.3 Levee Lowering or Removal

Certain portions of the perimeter and internal levees would be lowered to MHW elevation, which is 6.6 feet NAVD88. By reducing the levee height in these areas, tidal waters would overtop the levees at least once per day on an average in order to meet the Habitat Restoration Objective in Section 2. Over time, tidal overtopping is expected to promote additional levee erosion, allowing for improved hydraulic and habitat connectivity between ponds. Levees to be removed would be lowered to match the pond bottom elevation where ponds exist on both sides or to the existing marsh plain elevation if an existing marsh is adjacent to the lowering. Levees to be lowered or removed include:

- Approximately 1,000 feet of perimeter levee lowering along the northwestern edge of Pond R4 bordering Greco Island (Alternatives Ravenswood B and C)
- Approximately 1,500 feet of internal levee removal between Pond R5 and Pond S5 (Alternatives Ravenswood B and C)
- Approximately 2,230 feet of internal levee removal between Pond R5 and Pond S5 (Alternative Ravenswood D)

Design Criteria

- Top elevation (levee lowering): R4 northwest levee would be lowered to MHW elevation of 6.6 feet NAVD88
- Top elevation (levee removal): levee between Pond R5 and Pond S5 and internal levee in Pond S5 would be removed to match the adjacent pond bottom elevations, approximately 4.5 feet NAVD88

Typical cross-sections of the proposed levee lowering and removal are shown in **Figure 4.3** and **Figure 4.4**.

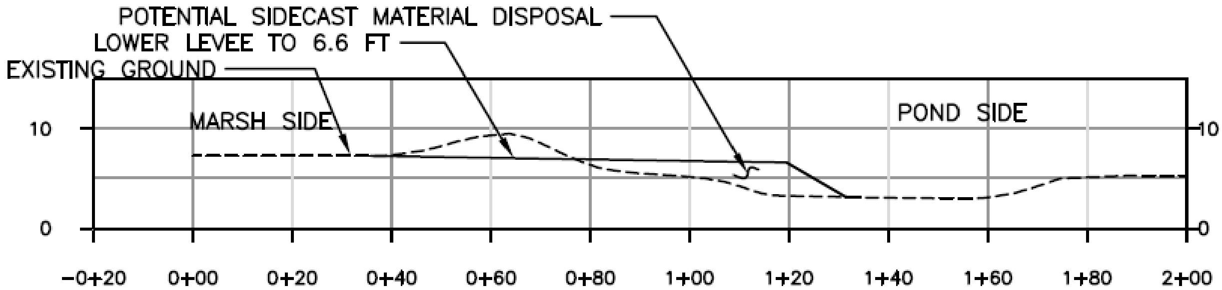


Figure 4.3. Proposed Levee Lowering – Typical Section.

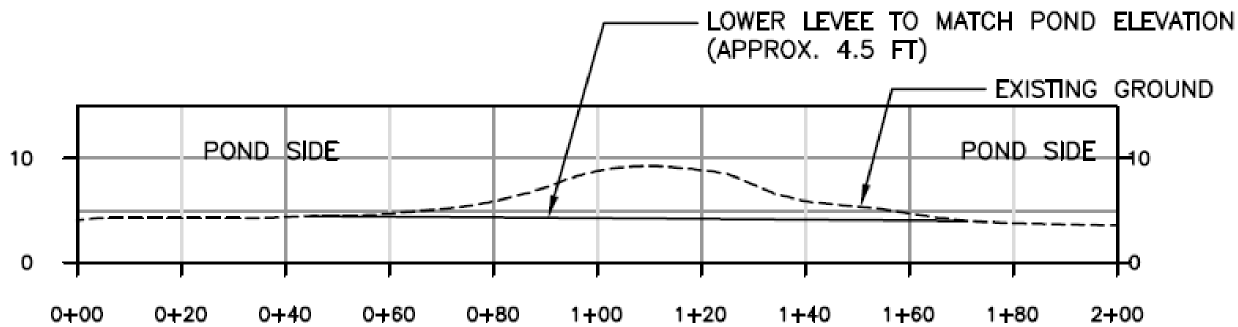


Figure 4.4. Proposed Levee Removal – Typical Section.

4.1.4 Levee Breach

Two breaches would provide connections to the external sloughs and create tidal conditions within the ponds in order to meet the Habitat Restoration Objective in Section 2. The breach locations were selected based on the locations of historical sloughs in Pond R4 shown on the SFEI historical tidal marshland maps primarily based on 19th century U.S. Coast Survey maps (SFEI 2013).

- R4 east breach: levee breach between Pond R4 and Ravenswood Slough (Alternatives Ravenswood B, C, and D)
- R4 northwest breach: levee breach between Pond R4 and Westpoint Slough adjacent to Greco Island (Alternative Ravenswood C)

Breaches into Pond R4 would not be armored and are expected to evolve naturally with erosion or deposition from incoming and outgoing tidal flows. Therefore, the side slopes for these breaches are recommended for construction stability only. The maximum tidal prism[2] for breached Pond R4 is approximately 767 acre-feet; in Alternative Ravenswood C, an additional 166 acre-feet of maximum tidal prism would result from Ponds R5 and S5 becoming tidal.

Design Criteria:

- Bottom width and breach invert (R4 east breach): 40 feet (Alternative Ravenswood C) to 150 feet (Alternatives Ravenswood B and D) with an invert elevation of 2.0 feet NAVD88

[2] The maximum tidal prism (or spring tidal prism) is the MHHW elevation minus the average pond bottom elevation (when higher than MHHW) times the pond surface area.

- Bottom width and breach invert (R4 northwest breach): 40 feet with an invert elevation of 3.0 feet NAVD88 (Alterative Ravenswood C)
- Side slope: All breaches would have side slope ratios of 3:1 (h:v).

A typical cross-section of the proposed levee breach is shown in **Figure 4.5**.

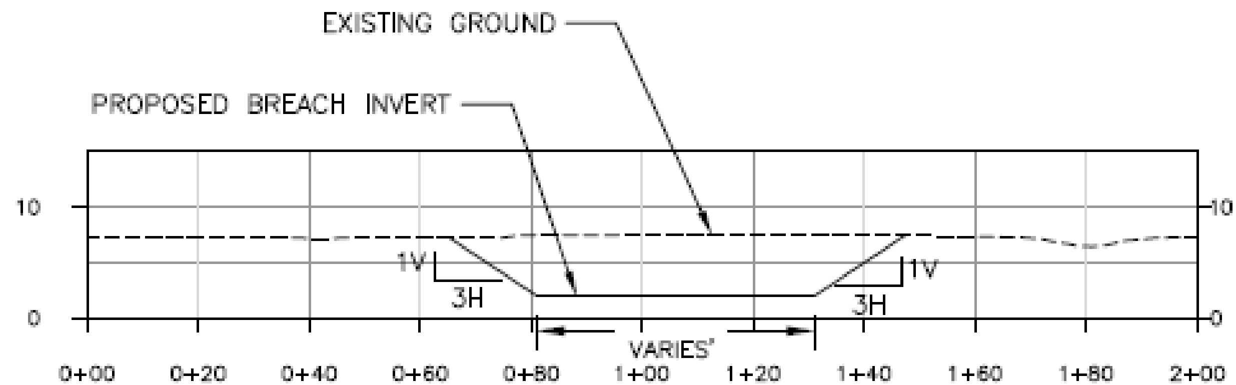


Figure 4.5. Proposed Levee Breach – Typical Section.

Breaching can be accomplished from the existing levee crest using long reach excavators and hauling the material to on-site locations receiving fill for levee improvement or habitat transition zones.

4.1.5 Habitat Transition Zone

habitat transition zones are transitional habitat areas that would increase habitat diversity and complexity by providing a wide transition in elevation from upland zones to tidal marsh zones allowing for low marsh, high marsh, tidal fringe, and upland habitats to develop in order to enhance conditions further under the Habitat Restoration Objective and Maintain Existing Flood Protection Objective in Section 2. The habitat transition zones would make use of upland fill material available from off-site construction projects. It could also serve to protect the landfill immediately to the west of Pond R4 and the levee improvements along the R4 south levee from wave action. Habitat transition zones would be located along the following levee alignments.

- Approximately 5,100 feet of habitat transition zones along the Pond R4 southern levee adjacent to the ACC and west levee adjacent to Pond R5 (Alternatives Ravenswood C and D)
- Approximately 2,300 feet of habitat transition zones along the Pond R4 west levee bordering Bedwell Bayfront Park (Alternatives Ravenswood B and C)
- Approximately 2,300 feet of habitat transition zones along the Pond R4 northwest levee (Alternative Ravenswood D)

These areas would be built with variable slopes to facilitate habitat diversity and erosion protection; they would be sized based on the amount of upland re-use material available. The preliminary design assumes a slope of 30:1 (h:v), which is the flattest slope that would be considered for construction, and thus the maximum fill volume and footprint for the habitat transition zones. This shallow slope would provide a very gradual transition between the pond itself and the adjacent uplands, adding habitat complexity and a larger area over which the transition zone can buffer against sea-level rise, storm surge, wave run-up, and other tidal influences. Future designs may include slopes as steep as 10:1 (h:v), but these would require less fill material and have a smaller footprint. **Figure 4.6** below shows a typical cross-section of the proposed habitat transition zone slopes along the proposed levee alignments.

Slopes varying from 10:1(h:v) to 30:1(h:v) would provide both a wide habitat transition zone as well as a gentle slope for dissipating wave energy and reducing erosion potential.

Design Criteria:

- Habitat transition zone top elevation and slope: From the top of levee elevation at 9.0 feet NAVD88 extending down to pond bottom with slopes of 15:1(h:v) to 30:1(h:v)
- Habitat transition zone compaction: Fill would be placed to a minimum of 70% and a maximum of 80% of dry density as measured using ASTM D1557. It is important to not over-compact the transition zone fill areas. Over-compacting can inhibit the establishment of vegetation by not allowing sufficient growth of root systems.
- Slope protection: Establishment of native vegetation by hydroseeding with native seed mix and planting schema that would successfully transition from upland vegetation to tidal marsh.

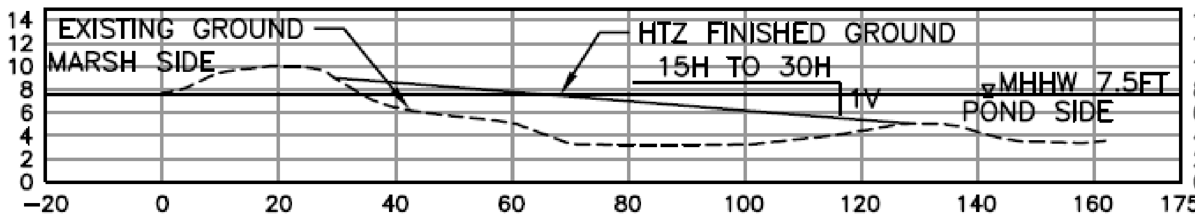


Figure 4.6. Proposed Habitat Transition Zone – Typical Section.

4.1.6 Pilot Channel

The pilot channel would facilitate drainage and flooding in Pond R4 in Alternatives Ravenswood B and C in order to enhance conditions further under the Habitat Restoration Objective in Section 2. The channel alignment would be designed to accelerate hydrologic connection to more distal locations from the Pond R4 east levee breach. The channel alignment would stem off of the remnant historical channel and would be excavated through the existing pond bed. The pilot channel length is currently estimated at approximately 1,500 feet; future designs could extend the pilot channel to the proposed water control structure between Ponds R4 and R5.

Design Criteria:

- Length: The proposed channel alignment would be approximately 1,500 feet
- Invert: The channel invert elevation would be at the same invert elevation as the existing remnant channel, which is approximately 2 feet NAVD88
- Bottom width: The channel bottom width would be approximately 50 feet
- Side slope: The channel side slopes would be excavated at 3:1 (h:v)

A typical cross-section of the proposed pilot channel is shown in **Figure 4.7.**

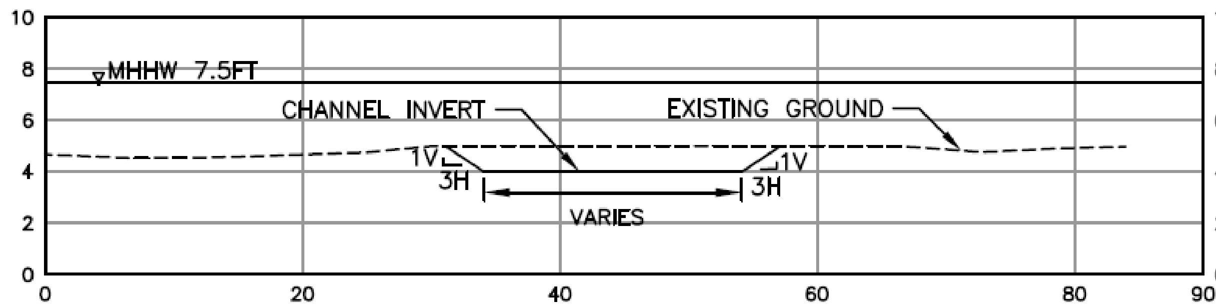


Figure 4.7. Proposed Pilot Channel – Typical Section.

4.1.7 Island Habitat

Island habitat would be built to provide nesting and roosting habitat for migratory birds, diving and dabbling birds or other bird guilds or species, currently inhabiting the site in order to enhance conditions further under the Habitat Restoration Objective in Section 2. The island would be built to an elevation above MHHW to minimize exposure to tidal waters.

The island would be created from the central portion of the existing levee between Ponds R5 and S5, and the levees to either side would be removed to disconnect the island from surrounding upland habitat and predator corridors. The top surface of the levee would be scarified and treated with a 12-inch thick sand layer underlain by a 6-inch thick crushed rock to minimize weed establishment. The sand layer would be covered with 4-inch thick oyster shells to provide a barren landscape that is typically preferred by nesting birds. A typical cross-section of the nesting island is shown on **Figure 4.8**.

Design Criteria:

- Top elevation: The island would have a minimum crest elevation of 9 feet NAVD88 with a minimum top surface area of 17,800 square feet
- Compaction: Fill would be placed at 90% of maximum dry density as measured using ASTM D1557. No compaction is necessary for the oyster shell cover layer.
- Side slope: The island would have side slopes no steeper than 5:1 (h:v) to the pond bottom.

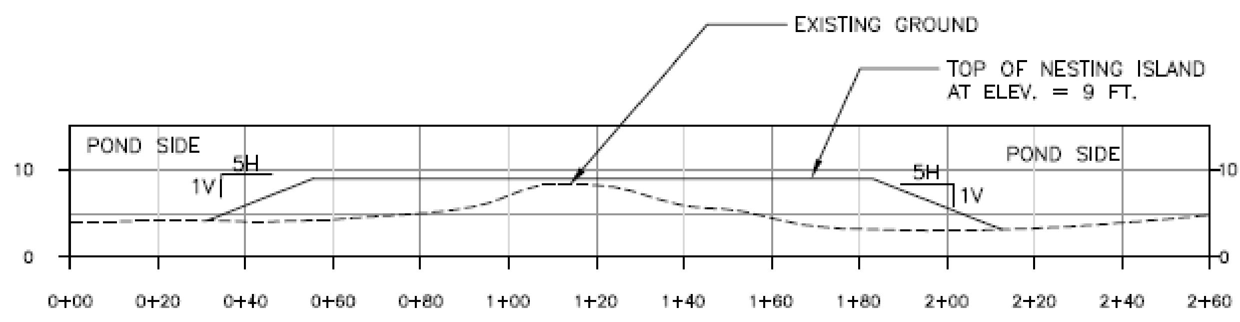


Figure 4.8. Proposed Island Habitat – Typical Section.

4.1.8 Pond Bottom Fill

For Alternative Ravenswood C, where the Ponds R5 and S5 are designed to simulate a tidal mud flat, preliminary hydraulic modeling results indicate that the bottom of Pond R5 and S5 would need to be elevated to roughly 5 to 6 feet NAVD88 for the pond to drain completely and in order to meet the Habitat Restoration Objective in Section 2.

Design Criteria:

- Fill depth: Based on the hydraulic model results, existing pond bottom would be raised to an average elevation of 5.25 feet NAVD88 by placing on average approximately 0.5 feet of fill across the combined R5/S5 pond

4.1.9 Water Control Structures

New water control structures would facilitate the controlled movement of water between the ponds and adjacent Flood Slough to manage water levels in the R3 and R5/S5 ponds in order to meet the Habitat Restoration Objective in Section 2. The water control structures would be gated at the inlet and/or outlet to facilitate this control.

Water control structures would include prefabricated box culverts, circular corrugated metal pipe (CMP), or circular High Density Poly Ethylene (HDPE) installed through levees with headwalls, as required. The preliminary design calls for a concrete box culvert to mitigate corrosion concerns typically expected in brackish water. Alternatively, solid wall HDPE pipes can also be employed since they provide a longer service life (greater than 50 years), but they are typically more expensive.

A typical cross-section of the proposed water control structure is shown on **Figure 4.9**. The design criteria of the different water control structures are shown in **Table 4.1**.

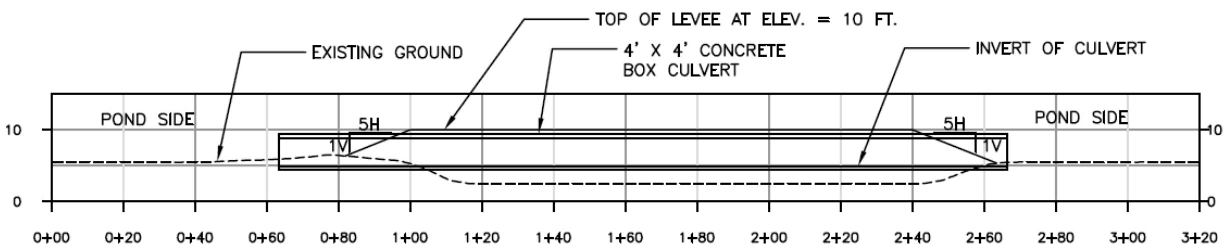


Figure 4.9. Proposed Water Control Structure – Typical Section

Table 4.1. Design Criteria of Water Control Structure for Ravenswood Ponds

Water Control Structure	(Number), Size, Type	Applicable Alternatives	Length ft	Invert Elevation ft (NAVD88)
Pond R4/R5	(1) 4' x 4' Concrete Box Culvert or (1) 30" Diam. HDPE/CMP	Ravenswood B, C and D	100	R4:4.9 R5:5.4
Pond S5/ Flood Slough	(3) 4' x 8' Concrete Box Culvert or (3) 40" Diam. HDPE/CMP	Ravenswood B, C and D	200	R5: 5.4 Flood Slough: 4.9
Pond R3/ Ravenswood Slough	(1) 36" Diam. culvert	Ravenswood C and D	400	R3: 4.9 Ravenswood Slough: 4.4
Pond R3/S5	(1) 4' x 4' Concrete Box Culvert or (1) 30" Diam. HDPE/CMP	Ravenswood C and D	150	R3:4.9 R5: 5.4

Additional Design Criteria:

- Cover: Concrete box culverts would need at least 1.0 foot of cover. HDPE would require more cover than that of concrete box culverts and would be based on the diameter of the pipe and future cover analysis calculations

For the Pond S5/Flood Slough structure, the culverts would pass under the Bedwell Bayfront Park entrance road. This would affect the phasing of the construction of this structure because it is assumed that only a portion of the roadway width could be closed at any given time. The culvert would likely need to be installed along one portion its length and then the remainder, leaving one lane of the entrance road open at all times.

4.1.10 Redwood City Stormwater Connection

The Redwood City (RWC) storm water connection (Alternative Ravenswood D) would occur in coordination with Redwood City and is being designed by Redwood City and their consultants (Moffatt & Nichol 2013, Moffatt & Nichol 2014). The connection would involve storing stormwater runoff in Ponds R5/S5 during high tides to improve drainage conditions along the Bayfront Canal and Atherton Channel. Design specifics can be found in documents prepared by Redwood City.

4.1.11 Recreational Trails

Trails are proposed as part of meeting the Access and Recreation Objective in Section 2. Trails include:

- Approximately 2,700 feet of trail along the eastern levee of Pond R5/S5 adjacent to Ponds R3 and R4 (Alternatives Ravenswood C and D)
- Approximately 1,200 feet trail along the northwest levee of Pond R4 (Alternative Ravenswood D)

Design Criteria

- Width: the trail would be at least 6 feet wide
- Surfacing: the trail would be built on improved or existing levees. Erosion or uneven surfaces on existing levees would be regraded for ADA compliance. Surfacing materials would be decomposed granite with timber or concrete edging

4.1.12 Interpretive Signage and Benches

One interpretive sign would be placed on the internal levee between Ponds R4 and R5 adjacent to Bedwell Bayfront Park (Alternatives Ravenswood B, C, and D) as part of meeting the Access and Recreation Objective in Section 2. The interpretive sign would be 36 inches by 24 inches, with a one-half-inch thick, high-pressure laminant mounted to a steel pedestal with stainless steel, threaded inserts and vandal-resistant screws. The pedestal would be embedded in 36-inch deep concrete footing.

A bench would be located near the interpretive sign. Benches would be 7 or 8 feet long with coated steel supports and wood slat finished surfaces. The supports would be embedded in 30-inch deep concrete footings.

4.1.13 Boardwalk and Viewing Platform

A boardwalk with viewing platform at the end would be built on the Pond R4 northwest levee connecting Bedwell Bayfront Park to the southwest side of the R4 northwest breach (Alternative Ravenswood C) as part of meeting the Access and Recreation Objective in Section 2. The boardwalk and viewing platform would be partially constructed over a portion of the lowered levee, and the deck would be elevated above existing levee and proposed lowered levee grades (see **Figure 4.10** and **Figure 4.11**). The boardwalk and viewing platform would be approximately 8 feet wide and approximately 600 feet long with anti-perch railings to reduce predator perching.

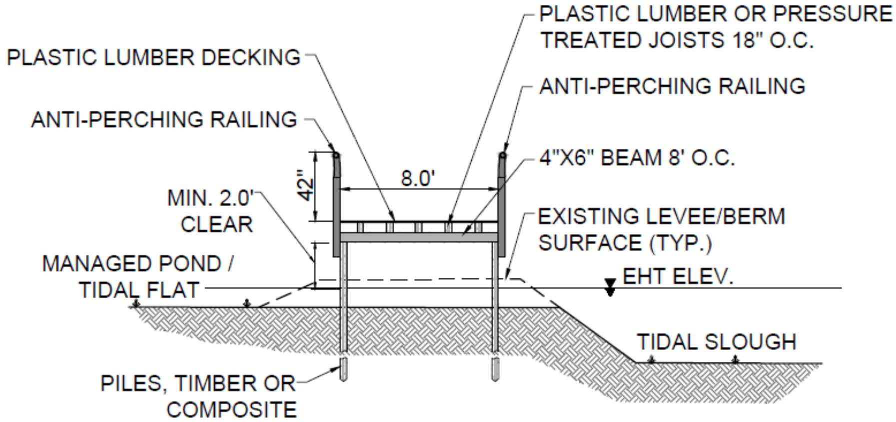


Figure 4.10. Proposed Boardwalk and Viewing Platform – Typical Section

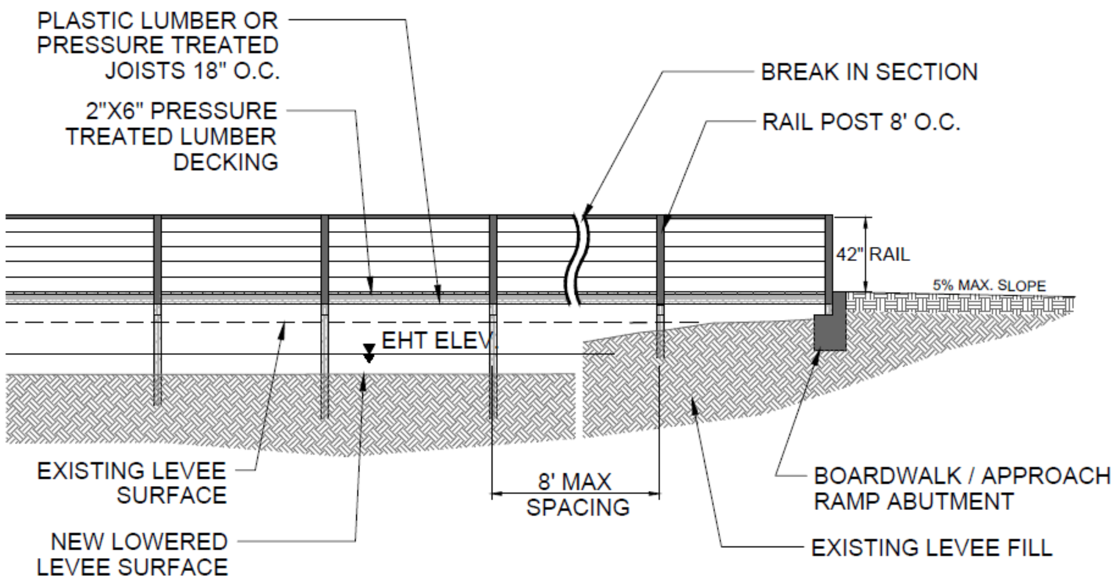


Figure 4.11. Proposed Boardwalk and Viewing Platform – Typical Profile

4.2 Construction Implementation

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

4.2.1 Access

Primary access to the Ravenswood Ponds would be from Marsh Road, which is a named exit from U.S. Highway 101, via the entrance to the City of Menlo Park's Bedwell Bayfront Park. The USFWS has an access easement with the city for this purpose (see **Appendix A**, Figure A-6). Alternate access to the southern edge of R3 is possible from the paved bicycle path/hiking trail just north of SR 84.

The construction areas in and around the ponds themselves may be accessed via existing trails in Bedwell Bayfront Park and on the Refuge's levee crests. The USFWS Refuge staff members frequently drive on the levees for maintenance, cleanup, and other management purposes, and it is assumed that the existing levees are capable of handling heavy construction equipment, but this would need to be confirmed by the contractor prior to construction. Ponds R5, S5, and R4 can be accessed via existing trails on the edge of Bedwell Bayfront Park and the outboard perimeter levee in Ponds R3 and R4. The crests of the berms on either side of the All-American Canal (AAC) may be used to access various construction areas in Ponds R4 and R3, although this would be better achieved as part of the fill of that canal and the raising and improvement of those berms.

Construction crews would typically consist of five to ten people. The pond cluster would likely be accessed by construction crews from U.S. 101, via the entrance to the City of Menlo Park's Bedwell Bayfront Park. Heavy vehicles would avoid crossing structures in the levees if the vehicle exceeds the weight-bearing capacity. If this is not possible, engineer-approved precautions would be taken to avoid damaging the structure.

4.2.2 Schedule

Construction schedule would be driven by the habitat windows, weather conditions, and volume of earthwork quantities to be moved.

4.2.2.1 Habitat Windows

Construction activities would be limited during the following habitat windows that are applicable to the Ravenswood Ponds. The dates provided were developed based on permits obtained during the Phase 1 projects. Future permits for this project could have different construction limitations.

- Bird Nesting Window – From February 1 through August 31 (Work may continue within this window in the presence of biological monitor)
- In-channel work – From April 15 to October 15

4.2.2.2 Construction Schedule

Based on the preliminary design, estimated volumes of earthwork proposed for the Ravenswood alternatives are shown in **Table 4.2**. A list of the equipment, methods and means is shown in **Appendix B**.

Table 4.2. Preliminary earthwork volumes

Alternative	**Estimated Earthwork Volume (cy)**	
	Cut	Fill
Alternative Ravenswood A	--	--
Alternative Ravenswood B	39,700	77,600
Alternative Ravenswood C	45,400	255,800
Alternative Ravenswood D*	56,700	73,000

*In addition to these volumes, in Ravenswood D, excavation planned for Redwood City's Bayfront Canal and Atherton Channel Project (Moffatt & Nichol Engineers, 2014) would generate an additional surplus of 31,200 cy of earth that could be used for levee raising or Habitat transition zone construction.

Installation of walkway, educational exhibits and viewpoints are estimated to take no more than 2 weeks. These activities are not on critical path, do not affect the construction schedule significantly compared to the earthwork disturbance, and are hence unlikely to drive the alternative selection decision. It is also likely that the ponds would remain dry at the beginning of construction season and no draining of ponds is expected.

Construction is expected to begin in the summer of 2016. Assuming best case scenario and a construction window of May 1 through November 15, a preliminary estimate of the duration of construction is shown in Table 4.3. A comprehensive summary of the construction equipment, means and methods is shown in **Appendix B**.

Table 4.3. Preliminary construction durations

Alternative	Duration (months) *◊	Construction Season
Alternative Ravenswood B	5	1
Alternative Ravenswood C	7	1
Alternative Ravenswood D	7	1

*Duration is from initiation of mobilization to final demobilization and includes seasonal down time.
◊ Durations assume that sufficient fill material is available to allow for continuous operation during the construction windows and that work would occur in sequential seasons. 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 these durations be increased if used for permitting or scheduling.

The construction durations for most of the Ravenswood alternatives would be primarily controlled by the availability of fill that can be imported to the project sites. It was assumed that the availability of fill would be sufficient to allow for a continuous operation, but that the quantity available would only allow for one operation at a time. 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.

4.2.3 Preliminary Estimate of Construction Quantities and Probable Implementation Costs

Table 4.3, 4.4 and 4.5 contain preliminary cost estimates for Ravenswood Complex alternatives based on the Ravenswood Ponds Restoration Preliminary Design Details (**Appendix C**). Quantities were measured manually from the drawings or within the AutoCAD Civil3D software utilized in preparation of the drawings. Earthwork quantities were typically calculated based on terrain models of the existing and proposed ground surfaces and using the grid method in Civil3D.

Unit costs were developed based on a combination of previous, similar URS project experience, unit construction costs from a construction contractor experienced in salt marsh restoration construction, the R.S. Means estimate guide, and vendor quotes.

Table 4.3. Preliminary Cost Estimate for Ravenswood – Alternative Ravenswood B

Item	Description	Quantity	Units	Unit Price	Extended Price
1	Mobilization & Demobilization	1	LS	15%	$122,000
2	Improve All American Canal Levee	11,000	CY	$12.00	$132,000
3	Remove Pond R5 and S5 levees	21,100	CY	$4.00	$85,000
4	R4/R5 Control Gate	1	LS	$45,000	$45,000
5	S5/Flood Slough Control Gate	1	LS	$45,000	$45,000
6	Bedwell Park Habitat Transition Zone	44,600	CY	$2.50	$112,000
7	R4 Channel	5,000	CY	$6.50	$33,000
8	R4 East Breach	25,600	CY	$10.20	$262,000
9	Lower R4 NW Levee	9,100	CY	$3.00	$28,000
10	Interpretive Platform	1	LS	$30,000	$30,000
11	Improve Pond R5 and S5 Nesting Island	900	CY	$40.00	$36,000
	Subtotal				$930,000
	Design & Unit Cost Contingency			25%	$233,000
	Total Direct Construction Cost				$1,163,000
	Construction Contingency			30%	$349,000
	Total				**$1,512,000**

Notes: LS = lump sum; CY = cubic yard

Table 4.4. Preliminary Cost Estimate for Ravenswood – Alternative Ravenswood C

Item	Description	Quantity	Units	Unit Price	Extended Price
1	Mobilization & Demobilization	1	LS	15%	$419,000
2	Improve All American Canal Levee	11,000	CY	$12.00	$132,000
3	All American Canal Habitat Transition Zone	39,400	CY	$3.00	$119,000
4	Bedwell Park Habitat Transition Zone	44,600	CY	$2.50	$112,000
5	Remove Pond S5 and R5 levees	21,100	CY	$3.00	$64,000
6	Fill Ponds S5/R5	159,900	CY	$7.60	$1,216,000
7	R4/R5 Control Gate	1	LS	$45,000	$45,000
8	R3/S5 Control Gate	1	LS	$45,000	$45,000
9	R3/Ravenswood Control Gate	1	LS	$100,000	$100,000
10	S5/Flood Slough Control Gate	1	LS	$45,000	$45,000
11	R4 Channel	5,000	CY	$6.50	$33,000
12	R4 East Breach	8,600	CY	$10.20	$88,000
13	R4 Northwest Breach	1,600	CY	$10.20	$17,000
14	R4 Northwest Levee Lowering	9,100	CY	$3.00	$28,000
15	Improve Pond R5 and S5 Nesting Island	900	CY	$40.00	$36,000
16	Interpretive Platform	1	LS	$30,000	$30,000
17	R4 Trail	2,700	LF	$30.00	$81,000
18	R4 Boardwalk and Viewing Platform	600	LF	$1,000	$600,000
	Subtotal				$3,210,000
	Design & Unit Cost Contingency			25%	$803,000
	Total Direct Construction Cost				$4,013,000
	Construction Contingency			30%	$1,204,000
	Total				**$5,217,000**

Notes: LS = lump sum; CY = cubic yard; LF = linear feet

Table 4.5. Preliminary Cost Estimate for Ravenswood – Alternative Ravenswood D*

Item	Description	Quantity	Units	Unit Price	Extended Price
1	Mobilization & Demobilization	1	LS	15%	$194,000
2	Improve All American Canal Levee	11,000	CY	$12.00	$132,000
3	All American Canal Habitat Transition Zone	39,400	CY	$3.00	$119,000
4	R4 Northwest Habitat Transition Zone	22,600	CY	$2.50	$57,000
5	Remove Pond R5 and S5 Levees	31,100	CY	$3.00	$94,000
6	R4/R5 Control Gate	1	LS	$45,000	$45,000
7	R3/S5 Control Gate	1	LS	$45,000	$45,000
8	R3/Ravenswood Control Gate	1	LS	$100,000	$100,000
9	S5/Flood Slough Control Gate	1	LS	$45,000	$45,000
10	R4 East Breach	25,600	CY	$10.20	$262,000
11	Interpretive Platform	1	LS	$30,000	$30,000
12	R4 viewing platform	1	LS	$150,000	$150,000
13	R4 Trail	3,900	LF	$30.00	$117,000
	Subtotal				$1,376,000
	Design & Unit Cost Contingency			25%	$344,000
	Total Direct Construction Cost				$1,720,000
	Construction Contingency			30%	$516,000
	Total				**$2,236,000**

Notes: LS = lump sum; CY = cubic yard; LF = linear feet.
Does not include the Bayfront Canal and Atherton Channel Project, which is being designed separately.

Assumptions:

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

- Water control structures consist of HDPE pipe, combination gates and simple wood catwalks
- Observation and interpretive platforms consist of wood structures on shallow concrete footings. Interpretive platforms would be constructed close to grade.
- Public trials consist of filter fabric, four inches of base rock and four inches of quarry fines.
- Pond bottoms for Ravenswood would be dry during construction and have the ability to support low ground pressure equipment.
- 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.
- 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.

5. REFERENCES

AMEC and Geomatrix Consultants 2007. *Appendix A – Soil Boring Performed for this Study*. For the South San Francisco Bay Shoreline Study, Alameda and Santa Clara Counties, California.

AMEC Geomatrix Inc. 2009. *Appendix A – Soil Boring Performed for this Study*. For the South San Francisco Bay Shoreline Study – Inboard Levees, Santa Clara Counties, California.

EDAW, Philip Williams and Associates (PWA), H.T. Harvey and Assoc., Brown and Caldwell, and Geomatrix. 2007. South Bay Salt Pond Restoration Project, Final EIS/R. December.

Moffatt & Nichol 2013. *Draft Redwood City Bayfront Canal and Atherton Channel Flood Improvement and Habitat Restoration Project Feasibility Study*. Prepared for City of Redwood City. April 18, 2013.

Moffatt & Nichol 2014. *Memorandum on Bayfront Canal Flood Improvements – Project Decsription*. From Chris Potter and Megan Bordelon; to David Halsing (URS). M&N Job No. 7681-03. March 6, 2014.

NOAA 2013. National Oceanic and Atmospheric Administration. Tides and Currents Datums webpage. http://tidesandcurrents.noaa.gov/datums.html?id=9414575. Accessed December 30.

SBSP 2013. South Bay Salt Pond Restoration Project. Monitoring, tide gauge data webpage. http://www.southbayrestoration.org/monitoring/tidegauge/. Accessed on December 30.

SFEI 2013. San Francisco Estuary Institute. *U.S. Coast Survey Maps of California*. http://www.caltsheets.org/. Accessed on March 27.

URS Corporation. 2012. Opportunities and Constraints Memorandum for the Alviso Pond Complex. Prepared for the South Bay Salt Pond Restoration Project's Management Team. June.

USACE 2011a. U.S. Army Corps of Engineers, San Francisco District, Geo-Sciences Section. *Estimated Geotechnical Performance Combining Stability and Seepage*. For the South San Francisco Bay Shoreline Study. Prepared for U.S. Fish and Wildlife Service Levee Maintenance Support. June 15.

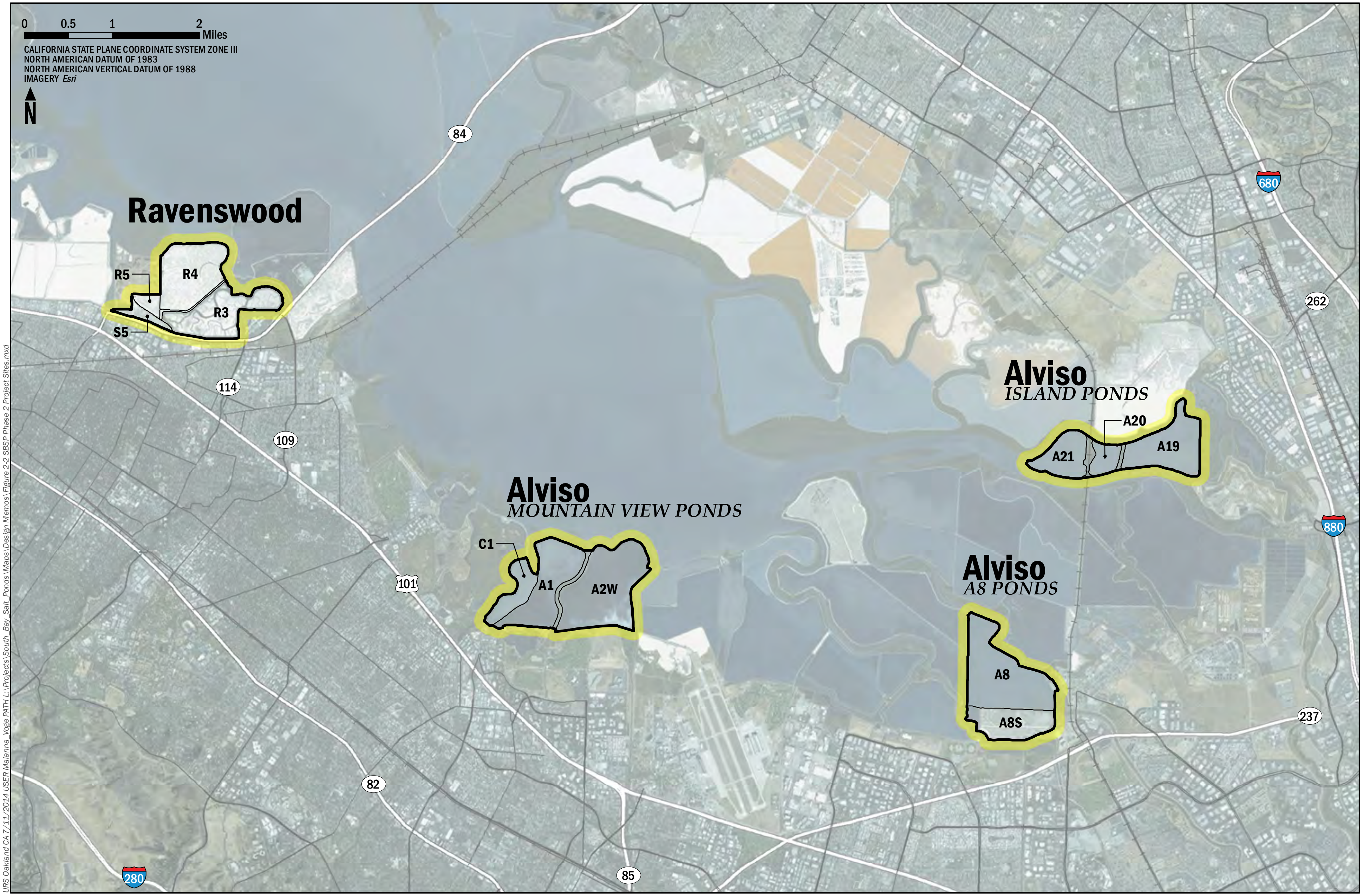
USACE 2011b. U.S. Army Corps of Engineers, San Francisco District, Geo-Sciences Section. *Map of Subsurface Exploration Logs*. For the South San Francisco Bay Shoreline Study. Prepared for U.S. Fish and Wildlife Service Levee Maintenance Support. June 15.

USFWS 2012. U.S. Fish and Wildlife Service. Quality Assurance Project Plan for South Bay Stockpile Fill Import and Placement Projects. June 15. Unpublished draft.

USGS 2007. U.S. Geological Survey. 2005 Hydrographic Survey of South San Francisco Bay, California. Published 2007. Foxgrover, A., Jaffe, B., Hovis, G., Martin, C., Hubbard, J., Samant, M., and Sullivan, S.

USGS 2010. U.S. Geological Survey. San Francisco Coastal LiDAR Project.

APPENDIX A – FIGURES

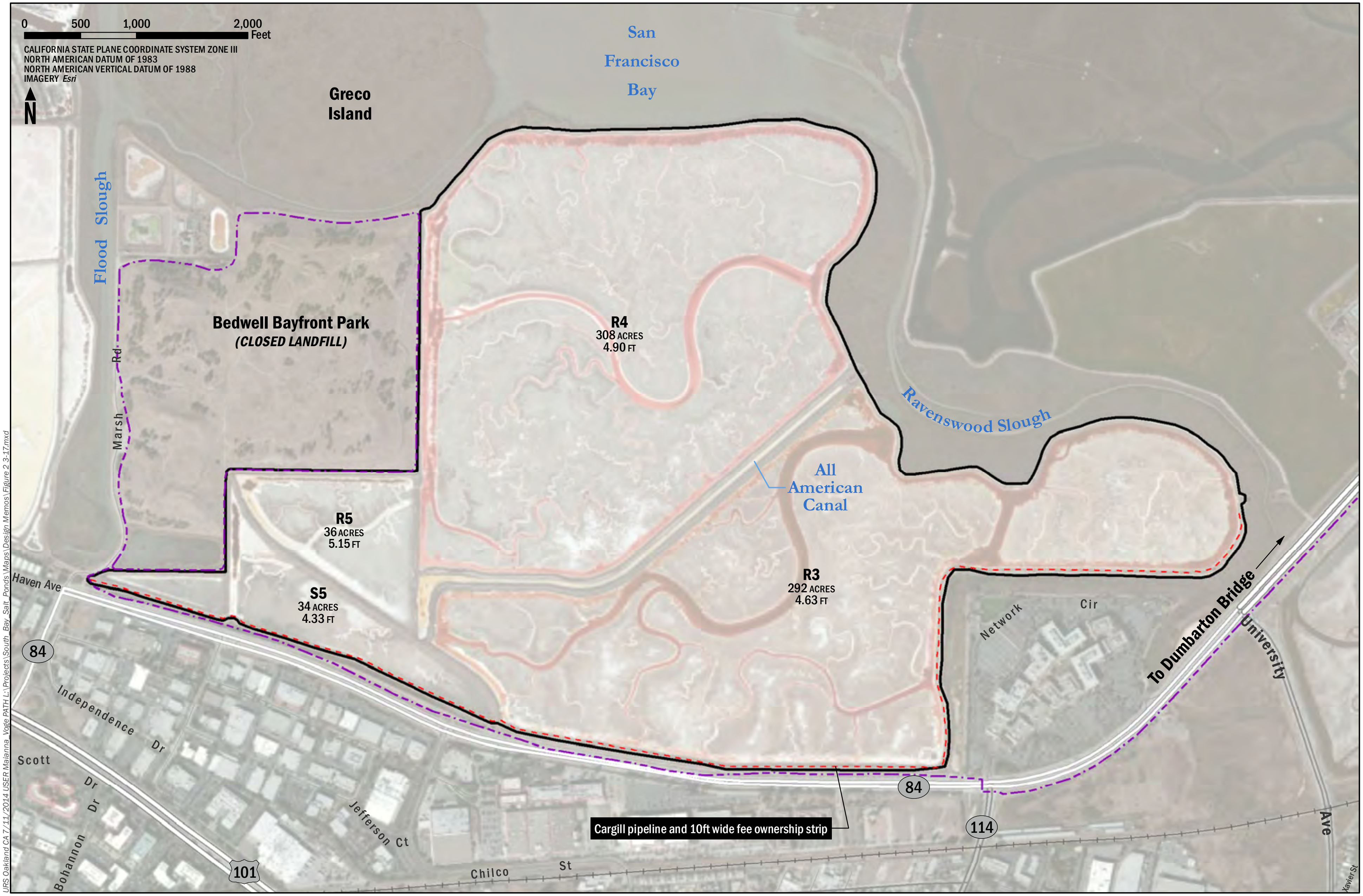


LEGEND

Phase 2 Project Area

URS
South Bay Salt Pond Restoration Project

Figure A-1
SBSP Phase 2 Project Sites

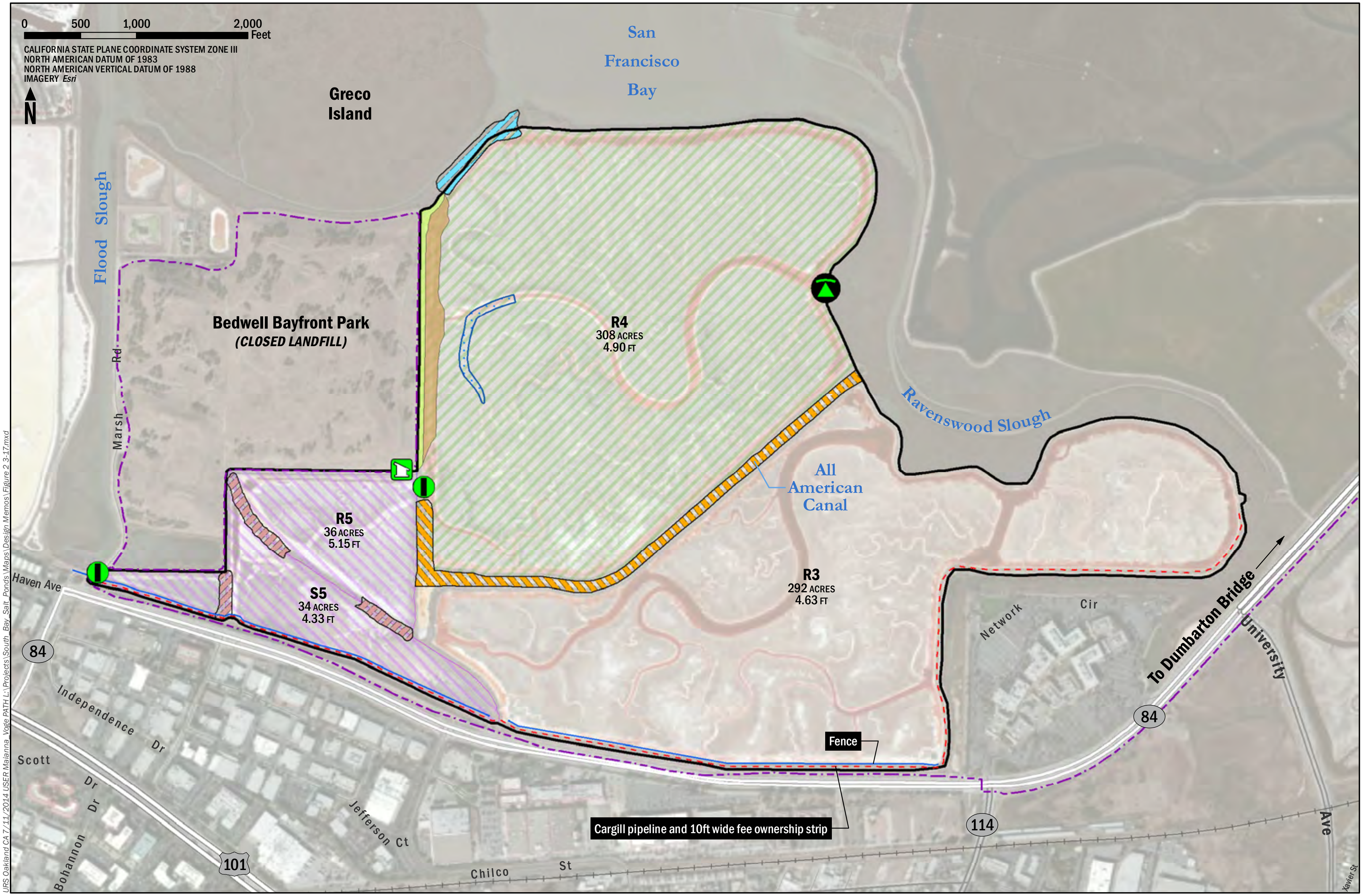


LEGEND

Existing trail
Cargill pipeline
Pond boundary

URS
South Bay Salt Pond Restoration Project

Figure A-2
Alternative Ravenswood A



LEGEND

- Proposed breach
- Proposed control gate
- Interpretive platform
- Existing trail
- Cargill pipeline
- Fence
- Lowered levee
- Removed levee
- Improved levee
- Pilot channel (optional)
- Tidal marsh
- Managed pond
- Pond boundary

Transition Zone Habitat

- High marsh habitat
- Intertidal habitat

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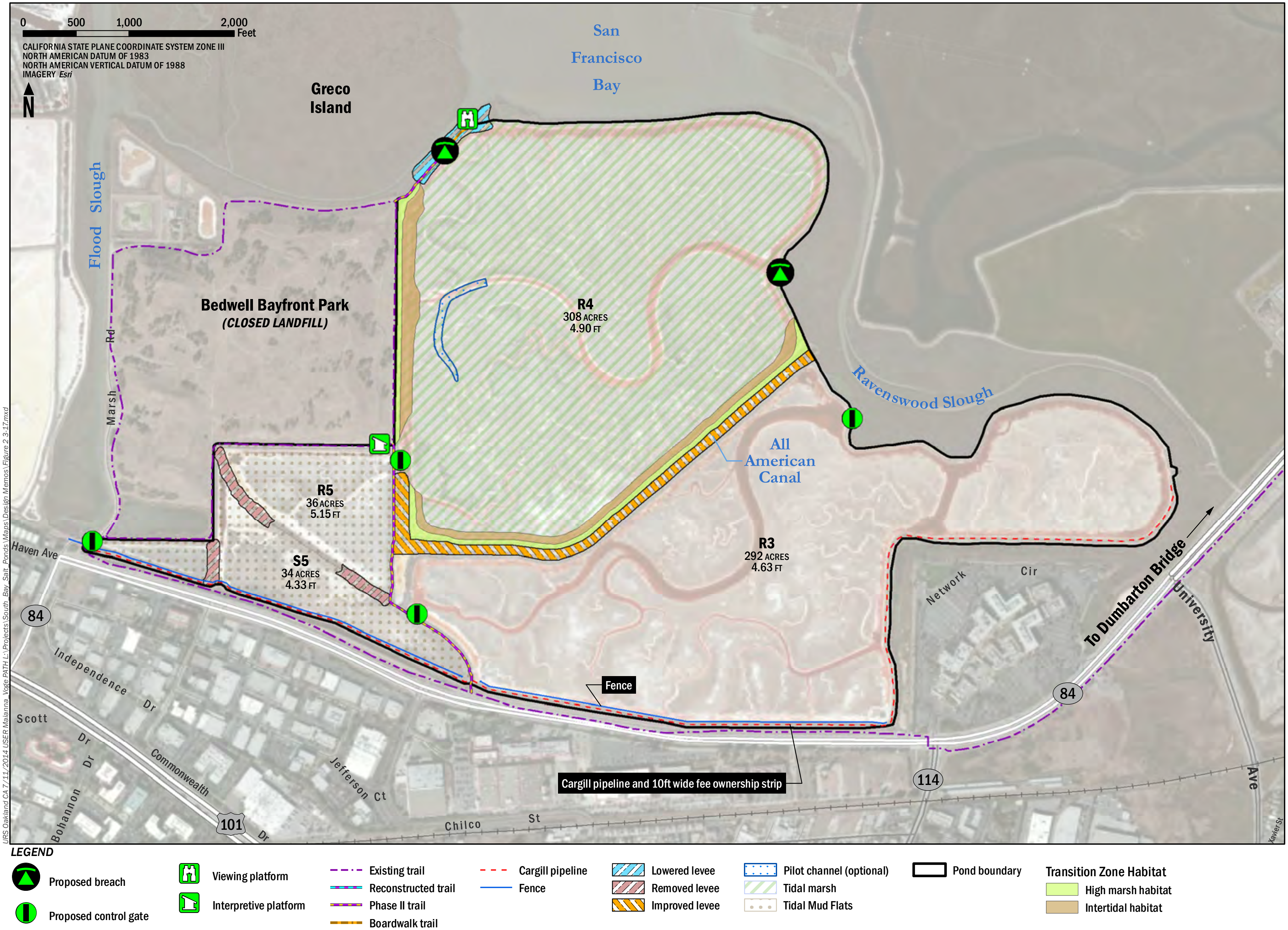
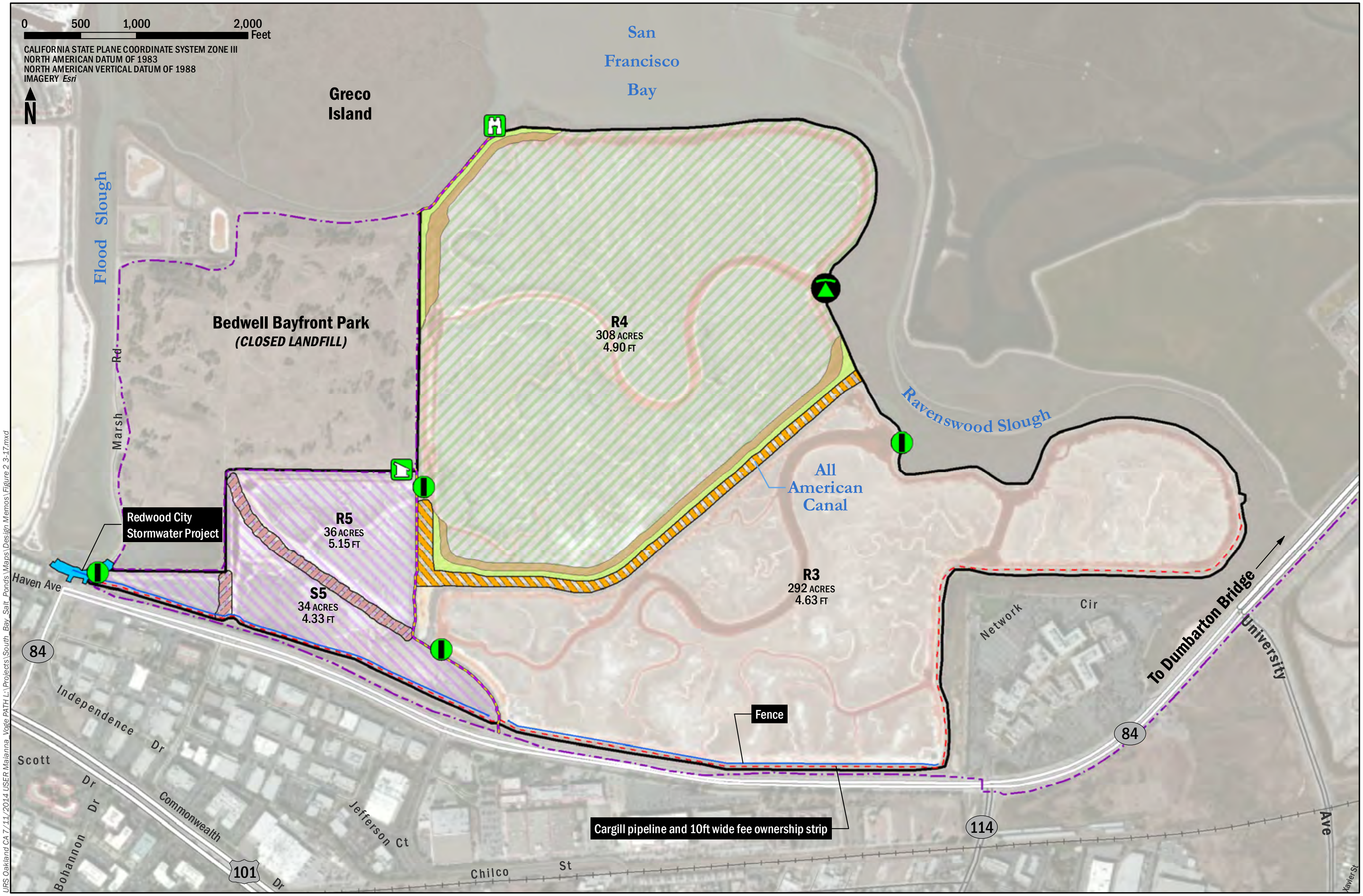
URS
South Bay Salt Pond Restoration Project

Figure A-3
Alternative Ravenswood B



URS
South Bay Salt Pond Restoration Project

Figure A-4
Alternative Ravenswood C



LEGEND

- Proposed breach
- Proposed control gate
- Viewing platform
- Interpretive platform
- Existing trail
- Phase II trail
- Cargill pipeline
- Fence
- RWC Stormwater Project*
- Removed levee
- Improved levee
- Tidal marsh
- Managed pond
- Pond boundary

Transition Zone Habitat

- High marsh habitat
- Intertidal habitat

*Pending property rights/easements

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South Bay Salt Pond Restoration Project

Figure A-5

Alternative Ravenswood D

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LEGEND

- Access Route
- Phase II Project Areas

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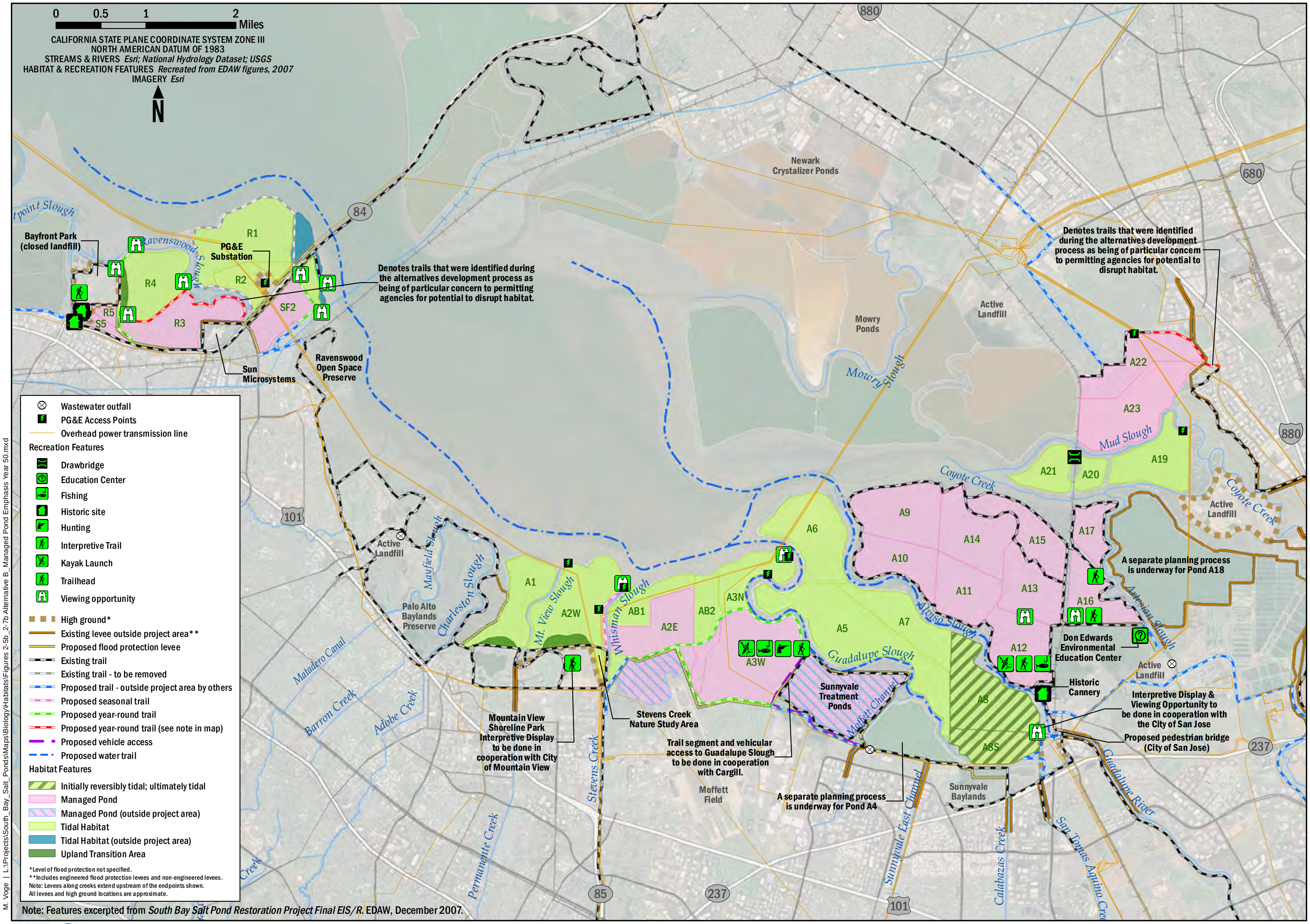
Figure A-6
Ravenswood Ponds Construction Access Routes



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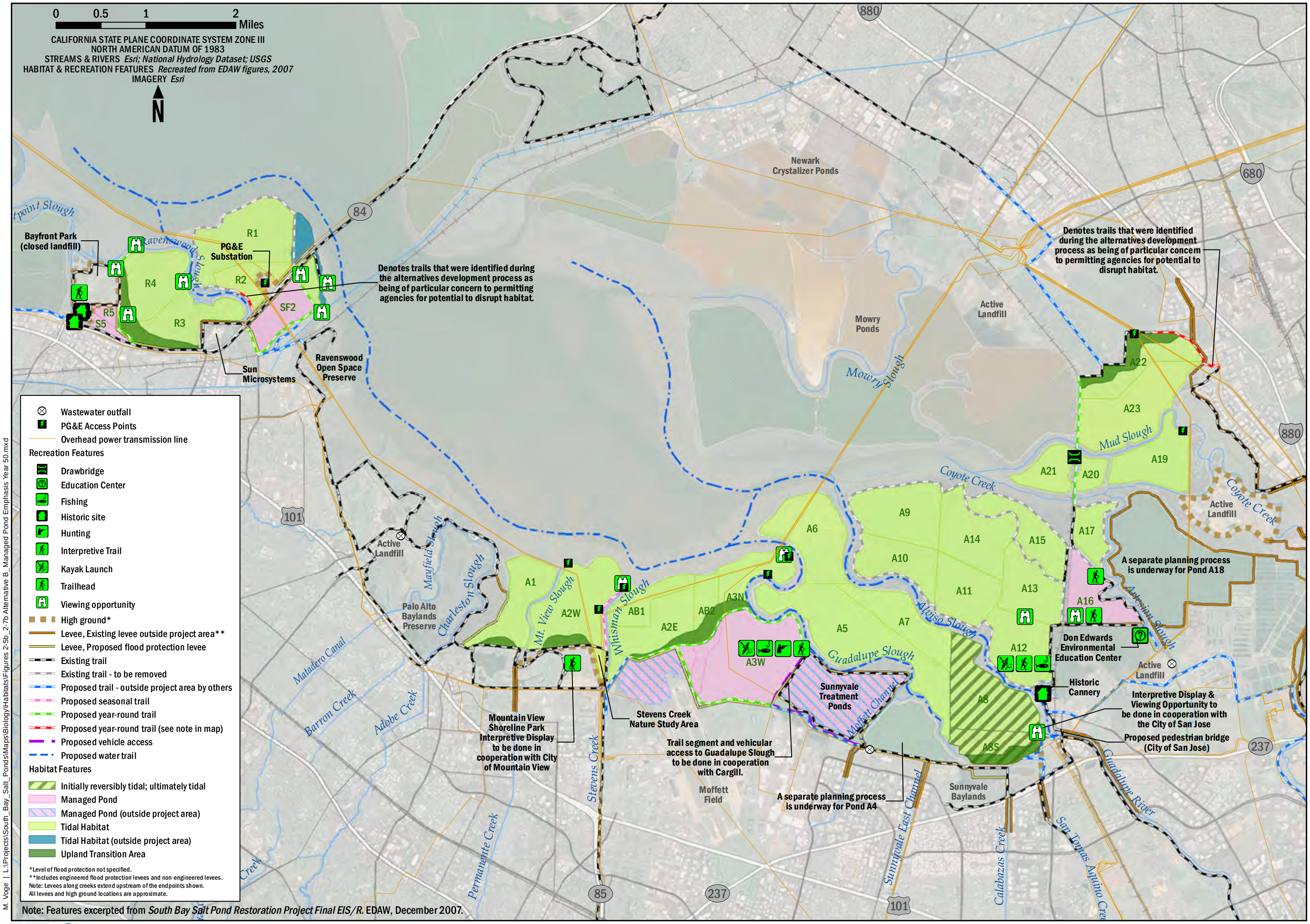
URS
South Bay Salt Pond Restoration Project

FIGURE A-7
Alternative B: Managed Pond Emphasis



URS

South Bay Salt Pond Restoration Project

FIGURE A-8

Alternative C: Tidal Habitat Emphasis

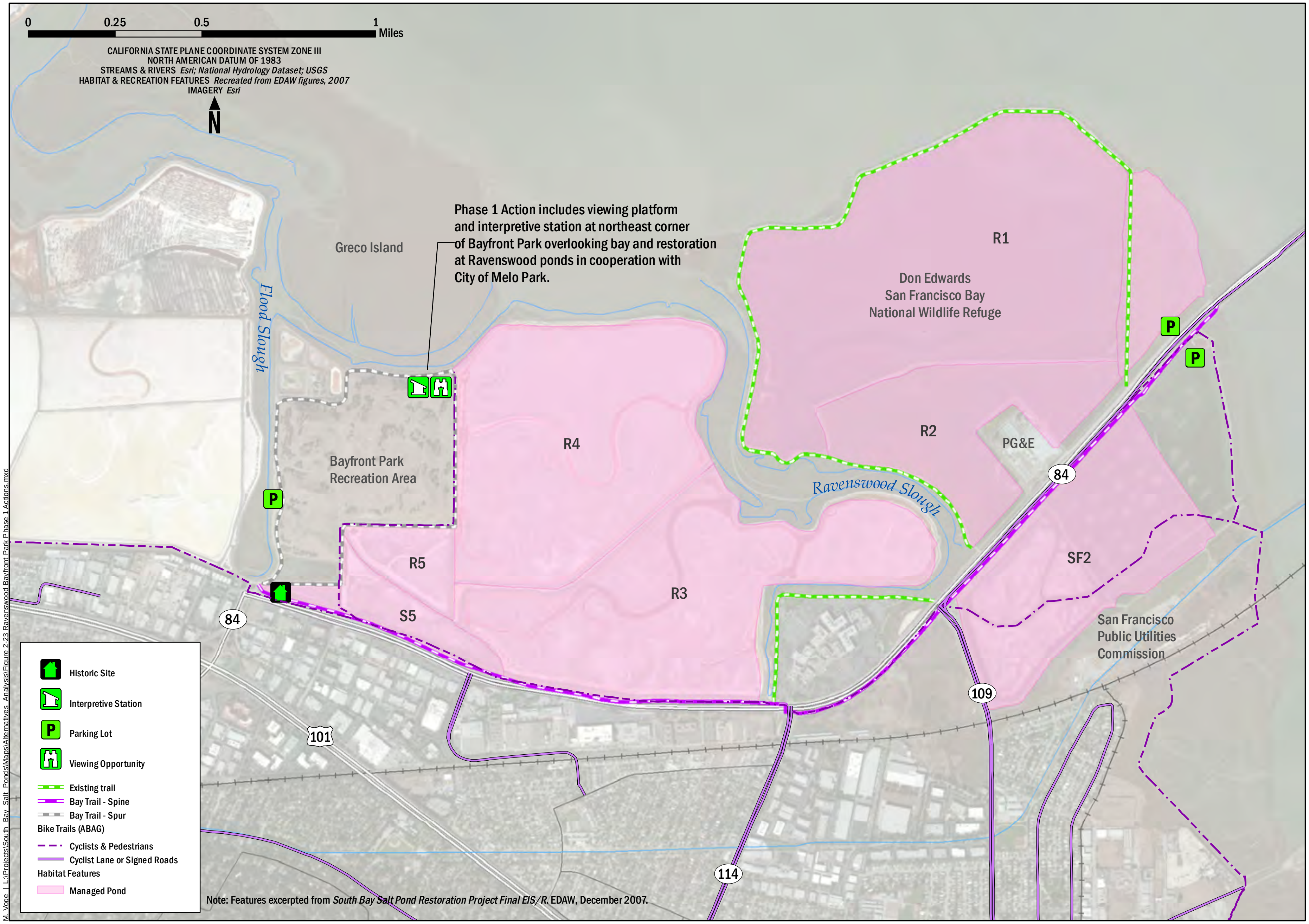


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FIGURE A-9

Ravenswood Bayfront Park Phase 1 Actions

APPENDIX B – MEANS AND METHODS

Appendix B

Anticipated Means, Methods and Durations for the Ravenswood Ponds

Preliminary Design (10 Percent Design Level)

Ravenswood - Alternative B

Basis of Design

1. Ponds may contain approximately four feet of water during construction in borrow ditches and remnant sloughs.
2. A combination of onsite borrow and import fill will be used. All fill will be imported by a dirt marketer at no cost to the project.
3. Fill will be imported at a rate that ensures an efficient construction operation.
4. Superintendent, fuel service, maintenance service, personal vehicles, small tools and small equipment are not included in the list of Resources. Equipment hours are operated hours.

Sequence	Component	Scope	Means & Methods	Resources	Quantity	Total Equip. Hours	Total Labor Hours
1	Mobilization	Develop submittals, staging areas and other facilities. Mobilize and demobilize equipment and labor to and from the site.	Equipment and labor will be brought in by ground transportation.	Lowbed truck Laborer	2 1	48	48 48
2	Improve All American Canal Levee	Improve the northern levee along the All American Canal and the levee between R4 and R5.	A long reach excavator would clear vegetation from the levees and muck from the canal and place it in the adjacent pond. Import fill would be placed starting from one end of the canal. A dozer, sheepsfoot compactor and water truck would condition and compact the material in place. Mud waves produced from the operation would be removed by an excavator and site cast into an adjacent pond.	Long reach excavator Dozer Water truck Compactor Laborer	1 1 1 1 1	230 230 230 230	230 230 230 230 230
3	Remove Pond S5 and R5 levees	Lower portions of S5 and R5 dividing levees to pond bottom elevation. Transport excavated material for use in onsite fill operations	Excavators will remove material and place it in dump truck for onsite transport or side cast material into adjacent borrow ditches or pond areas.	Long reach excavator Dump truck Laborer	1 3 1	210 630	210 630 210
4	Install R4/R5 Control Gate	Supply and install control gate and construct wood catwalks.	A sheet pile coffer dam would be driven around both sides of the control gate site to isolate it from pond and borrow ditch waters and the work area dewatered. An excavator would excavate a trench and set the pipe. Walk behind compactors would compact material in place, with the excavator providing fill in lifts. Excavator would drive wood posts for catwalks and assist laborers in hanging gates. Carpenters would construct catwalks.	Long reach excavator Laborer Carpenter	1 2 2	24	24 48 32
5	Install Flood Slough Control Gate	Supply and install control gate and construct wood catwalks.	A sheet pile coffer dam would be driven around both sides of the control gate site to isolate it from pond, borrow ditch, and tidal waters and the work area dewatered. An excavator would excavate a trench and set the pipe. Walk behind compactors would compact material in place, with the excavator providing fill in lifts. Excavator would drive wood posts for catwalks and assist laborers in hanging gates. Carpenters would construct catwalks.	Long reach excavator Laborer Carpenter	1 2 2	80	80 160 40
6	Install Interpretive Platform	Construct wood platform on shallow concrete footings.	Foundations would be dug with an auger attachment on a bobcat. Concrete would be imported and foundation cast in place. Construction materials would be imported to the site and the platform assembled using small power tools.	Bobcat with Auger Concrete truck Flatbed truck Carpenter	1 1 1 3	16 8 16	16 8 16 240
7	Construct Bedwell Bayfront Park Habitat Transition Zone	Place and grade import fill.	Slopes would be scarified prior to placement. A water truck would be available for moisture conditioning and dust control as required. Fill would be imported and dumped at the placement site by others. A dozer would shape and moderately compact the fill into place.	Dozer Water truck	2 1	130 65	130 65
8	Excavate R4 Channel	Excavate channel (assumes pond is dry).	An excavator on mats would excavate the channel starting from the interior to the pond towards the edge. Material would be site cast in the pond bottom until it could be incorporated into the habitat transition fill.	Long reach excavator	1	40	40

Sequence	Component	Scope	Means & Methods	Resources	Quantity	Total Equip. Hours	Total Labor Hours
9	Install R4 breach	Excavate breach and side cast material into Pond R4	Long reach excavators would excavate the breach and place material in the pond. Dozers would move material laterally down the levee as necessary to dispose of fill.	Long reach excavator Dozer	1 1	170 170	170 170
10	Lower R4 NW Levee	Lower levee and transport material to transition habitat fill.	Long reach excavator would lower levee and place material in a dump truck for transport to the Bedwell transition habitat fill area.	Long reach excavator Dump truck	1 2	65 130	65 130
11	Demobilize	Demobilize equipment and Labor.	Same as mobilization.	Lowbed truck Laborer	2 1	48	48 48

Ravenswood - Alternative C

Basis of Design

1. Ponds may contain approximately four feet of water during construction in borrow ditches and remnant sloughs.
2. A combination of onsite borrow and import fill will be used. All fill will be imported by a dirt marketer at no cost to the project.
3. Fill will be imported at a rate that ensures an efficient construction operation.
4. Superintendent, fuel service, maintenance service, personal vehicles, small tools and small equipment are not included in the list of Resources. Equipment hours are operated hours.

Sequence	Component	Scope	Means & Methods	Resources	Quantity	Total Equip. Hours	Total Labor Hours
1	Mobilization	Develop submittals, staging areas and other facilities. Mobilize and demobilize equipment and labor to and from the site.	Equipment and labor will be brought in by ground transportation.	Lowbed truck Crane, 80 TN Pile Butt	2 1 3	60 16	60 16 48
2	Improve All American Canal Levee	Improve the northern levee along the All American Canal and the levee between R4 and R5.	A long reach excavator would clear vegetation from the levees and muck from the canal and place it in the adjacent pond. Import fill would be placed starting from one end of the canal. A dozer, sheepsfoot compactor and water truck would condition and compact the material in place. Mud waves produced from the operation would be removed by an excavator and site cast into an adjacent pond.	Long reach excavator Dozer Water truck Compactor Laborer	1 1 1 1 1	230 230 230 230	230 230 230 230 230
3	Construct All American Canal Habitat Transition Zone	Place and grade import fill.	Slopes would be scarified prior to placement. A water truck would be available for moisture conditioning and dust control as required. Fill would be imported and dumped at the placement site by others. A dozer would shape and moderately compact the fill into place.	Dozer Water truck	2 1	760 95	760 95
4	Remove Pond S5 and R5 levees	Lower portions of S5 and R5 dividing levees to the proposed pond fill elevation. Transport excavated material for use in onsite fill operations	Excavators will remove material and side cast into adjacent borrow ditches or pond areas.	Long reach excavator Dump truck Laborer	1 3 1	210 630	210 630 210
5	Fill Ponds S5/R5	Raise elevation of pond bottoms using a combination of excavated levee material and imported fill.	Imported fill would be dumped at the edge of the ponds. Excavators on mats and LGP Dozers would spread and slightly compact the fill	Long reach excavator Dozer	1 2	235 470	235 470
6	Install R4/R5 and R3/S5 Control Gates	Supply and install control gate and construct wood catwalks.	A sheet pile coffer dam would be driven around both sides of the control gate site to isolate it from pond and borrow ditch waters and the work area dewatered. An excavator would excavate a trench and set the pipe. Walk behind compactors would compact material in place, with the excavator providing fill in lifts. Excavator would drive wood posts for catwalks and assist laborers in hanging gates. Carpenters would construct catwalks.	Long reach excavator Laborer Carpenter	1 2 2	48	48 96 64
7	Install R3/Ravenswood Control Gate	Supply and install control gate and construct wood catwalks.	A sheet pile coffer dam would be driven around both sides of the control gate site to isolate it from pond and borrow ditch waters and the work area dewatered. An excavator would excavate a trench and set the pipe. Walk behind compactors would compact material in place, with the excavator providing fill in lifts. Excavator would drive wood posts for catwalks and assist laborers in hanging gates. Carpenters would construct catwalks.	Long reach excavator Laborer Carpenter	1 2 2	80	80 160 40
8	Install Interpretive Platform	Construct wood platform on shallow concrete footings.	Foundations would be dug with an auger attachment on a bobcat. Concrete would be imported and foundation cast in place. Construction materials would be imported to the site and the platform assembled using small power tools.	Bobcat with Auger Concrete truck Flatbed truck Carpenter	1 1 1 3	16 8 16	16 8 16 240
9	Install Flood Slough Control Gate	Supply and install control gate and construct wood catwalks.	A sheet pile coffer dam would be driven around both sides of the control gate site to isolate it from pond, borrow ditch, and tidal waters and the work area dewatered. An excavator would excavate a trench and set the pipe. Walk behind compactors would compact material in place, with the	Long reach excavator Laborer Carpenter	1 2 2	80	80 160 40

Sequence	Component	Scope	Means & Methods	Resources	Quantity	Total Equip. Hours	Total Labor Hours
			excavator providing fill in lifts. Excavator would drive wood posts for catwalks and assist laborers in hanging gates. Carpenters would construct catwalks.				
10	Construct Bedwell Bayfront Park Habitat Transition Zone	Place and grade import fill.	Slopes would be scarified prior to placement. A water truck would be available for moisture conditioning and dust control as required. Fill would be imported and dumped at the placement site by others. A dozer would shape and moderately compact the fill into place.	Dozer Water truck	2 1	130 65	130 65
11	Excavate R4 Channel	Excavate channel (assumes pond is dry).	An excavator on mats would excavate the channel starting from the interior to the pond towards the edge. Material would be site cast in the pond bottom until it could be incorporated into the habitat transition zone fill.	Long reach excavator	1	40	40
12	Lower R4 NW Levee and Construct R4 breach in NW corner	Lower levee and transport material to habitat transition zone fill. Excavate breach.	Long reach excavator would lower levee and place material in a dump truck for transport to the Bedwell Bayfront Park habitat transition zone fill area. The breach would be over excavated and material used for transition habitat or side cast into the pond.	Long reach excavator Dump truck	1 2	245 380	245 380
13	Construct R4 viewing platform and boardwalk	Construct wood platform on shallow concrete footings.	Foundations would be dug with an auger attachment on a bobcat. Concrete would be imported and foundation cast in place. Construction materials would be imported to the site and the platform assembled using small power tools.	Bobcat with Auger Concrete truck Flatbed truck Carpenter	1 1 1 3	16 8 16	16 8 16 240
14	Construct R4/R5/R3/S5 Trail	Import and place of 4 inch of quarry fines over 4 inches of base rock over geotextile fabric.	Levees would be graded and compacted. Geotextile fabric would be laid out and gravel imported and compacted in place. Quarry fines would then be compacted over the gravel with a smooth drum compactor to create an accessible surface.	Dozer Compactor Water truck Dump truck Laborer	1 1 1 2 3	40 40 20 40	40 40 20 40 120
15	Construct Ravenswood Slough Breach	Excavate breach and side cast material into Pond R4.	Long reach excavators would excavate the breach and place material in the pond. Dozers would move material laterally down the levee as necessary to dispose of fill.	Long reach excavator Dozer	1 1	170 170	170 170
16	Demobilize	Demobilize equipment and Labor.	Same as mobilization.	Lowbed truck Laborer	2 1	48	48 48

Ravenswood - Alternative D

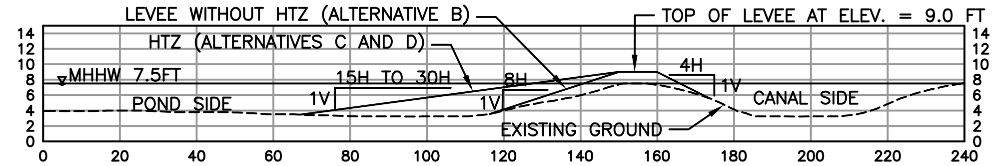
Basis of Design

1. Ponds may contain approximately four feet of water during construction in borrow ditches and remnant sloughs.
2. A combination of onsite borrow and import fill will be used. All fill will be imported by a dirt marketer at no cost to the project.
3. Fill will be imported at a rate that ensures an efficient construction operation.
4. Superintendent, fuel service, maintenance service, personal vehicles, small tools and small equipment are not included in the list of Resources. Equipment hours are operated hours.

Sequence	Component	Scope	Means & Methods	Resources	Quantity	Total Equip. Hours	Total Labor Hours
1	Mobilization	Develop submittals, staging areas and other facilities. Mobilize and demobilize equipment and labor to and from the site.	Equipment and labor will be brought in by ground transportation. This includes portable barges and a crane to offload them. Barge sections will be assembled in the ponds.	Lowbed truck Laborer	2 1	48	48 48
2	Improve All American Canal Levee	Improve the northern levee along the All American Canal and the levee between R4 and R5.	A long reach excavator would clear vegetation from the levees and muck from the canal and place it in the adjacent pond. Import fill would be placed starting from one end of the canal. A dozer, sheepsfoot compactor and water truck would condition and compact the material in place. Mud waves produced from the operation would be removed by an excavator and site cast into an adjacent pond.	Long reach excavator Dozer Water truck Compactor Laborer	1 1 1 1 1	230 230 230 230	230 230 230 230 230
3	Construct All American Canal Upland Transition Zone	Place and grade import fill.	Slopes would be scarified prior to placement. A water truck would be available for moisture conditioning and dust control as required. Fill would be imported and dumped at the placement site by others. A dozer would shape and moderately compact the fill into place.	Dozer Water truck	2 1	760 95	760 95
4	Construct Highway 84 upland transition Zone	Place and grade import fill.	Slopes would be scarified prior to placement. A water truck would be available for moisture conditioning and dust control as required. Fill would be imported and dumped at the placement site by others. A dozer would shape and moderately compact the fill into place.	Dozer Water truck	2 1	760 95	760 95
5	Remove Pond S5 and R5 levees	Lower S5 and R5 dividing levees to pond bottom elevation. Transport excavated material for use in onsite fill operations	Excavators will remove material and place it in dump truck for onsite transport.	Long reach excavator Dump truck Laborer	1 3 1	210 630	210 630 210
6	Install R4/R5 and R3/S5 Control Gates	Supply and install control gate and construct wood catwalks.	A sheet pile coffer dam would be driven around both sides of the control gate site to isolate it from pond and borrow ditch waters and the work area dewatered. An excavator would excavate a trench and set the pipe. Walk behind compactors would compact material in place, with the excavator providing fill in lifts. Excavator would drive wood posts for catwalks and assist laborers in hanging gates. Carpenters would construct catwalks.	Long reach excavator Laborer Carpenter	1 2 2	48	48 96 64
7	Install Interpretive Platform	Construct wood platform on shallow concrete footings.	Foundations would be dug with an auger attachment on a bobcat. Concrete would be imported and foundation cast in place. Construction materials would be imported to the site and the platform assembled using small power tools.	Bobcat with Auger Concrete truck Flatbed truck Carpenter	1 1 1 3	16 8 16	16 8 16 240
8	Install Flood Slough Control Gate (by others)	By others.	By others.				
9	Install R3/Ravenswood Control Gate	Supply and install control gate and construct wood catwalks.	A sheet pile coffer dam would be driven around both sides of the control gate site to isolate it from pond, borrow ditch, and tidal waters and the work area dewatered. An excavator would excavate a trench and set the pipe. Walk behind compactors would compact material in place, with the excavator providing fill in lifts. Excavator would drive wood posts for catwalks and assist laborers in hanging gates. Carpenters would construct catwalks.	Long reach excavator Laborer Carpenter	1 2 2	80	80 160 40
10	Construct R4 NW Corner Habitat Transition Zone	Place and grade import fill.	Slopes would be scarified prior to placement. A water truck would be available for moisture conditioning and dust control as required. Fill would be imported and dumped at the placement site	Dozer Water truck	2 1	200 25	200 25

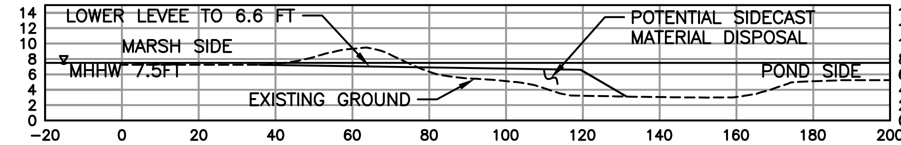
			by others. A dozer would shape and moderately compact the fill into place.				
11	Construct R4 viewing platform	Construct wood platform on shallow concrete footings.	Foundations would be dug with an auger attachment on a bobcat. Concrete would be imported and foundation cast in place. Construction materials would be imported to the 12site and the platform assembled using small power tools.	Bobcat with Auger Concrete truck Flatbed truck Carpenter	1 1 1 3	16 8 16	16 8 16 240
12	Construct R4 NW and R4/R5/R3/S5 Trails	Import and place of 4 inch of quarry fines over 4 inches of base rock over geotextile fabric.	Levees would be graded and compacted. Geotextile fabric would be laid out and gravel imported and compacted in place. Quarry fines would then be compacted over the gravel with a smooth drum compactor to create an accessible surface.	Dozer Compactor Water truck Dump truck Laborer	1 1 1 2 3	40 40 20 40	40 40 20 40 120
13	Construct Ravenswood Slough Breach	Excavate breach and side cast material into Pond R4	Long reach excavators would excavate the breach and place material in the pond. Dozers would move material laterally down the levee as necessary to dispose of fill.	Long reach excavator Dozer	1 1	170 170	170 170
14	Demobilize	Demobilize equipment and Labor.	Same as mobilization.	Lowbed truck Laborer	2 1	48	48 48

APPENDIX C – DESIGN SECTIONS



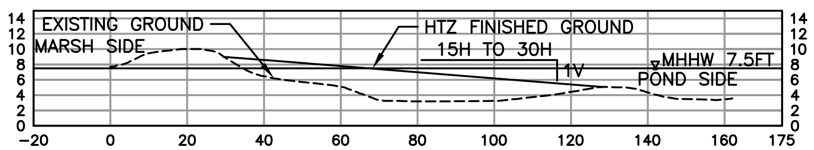
ALL AMERICAN CANAL LEVEE IMPROVEMENT – TYPICAL SECTION (1)

HORIZONTAL SCALE: 1"=50'
VERTICAL SCALE: 1"=25'



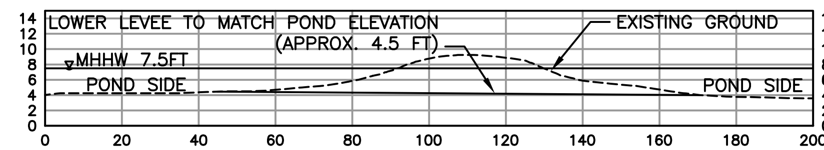
LEVEE LOWERING – TYPICAL SECTION (2)

HORIZONTAL SCALE: 1"=50'
VERTICAL SCALE: 1"=25'



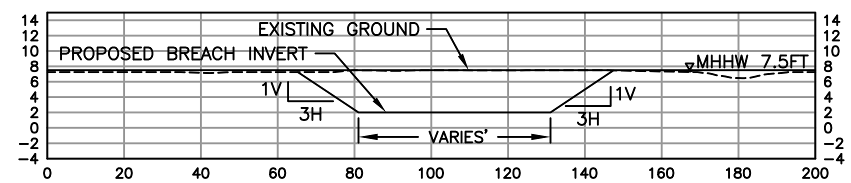
HABITAT TRANSITION ZONE – TYPICAL SECTION (3)

HORIZONTAL SCALE: 1"=50'
VERTICAL SCALE: 1"=25'



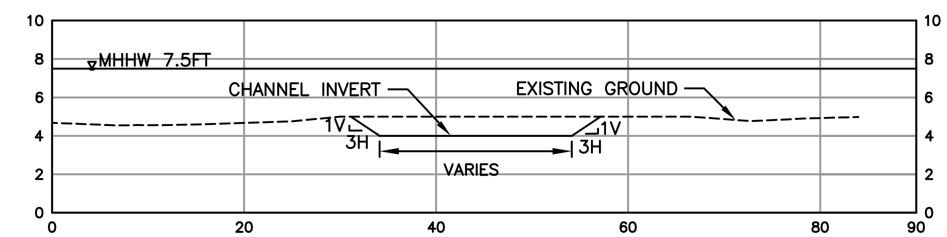
LEVEE REMOVAL – TYPICAL SECTION (4)

HORIZONTAL SCALE: 1"=50'
VERTICAL SCALE: 1"=25'



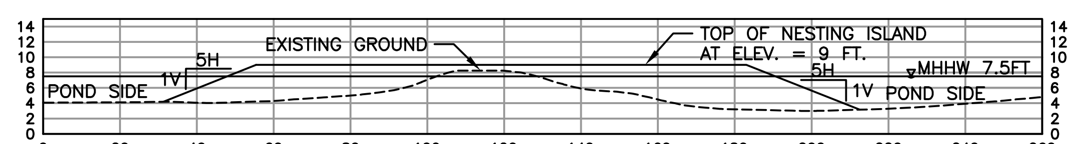
LEVEE BREACH – TYPICAL SECTION (5)

HORIZONTAL SCALE: 1"=50'
VERTICAL SCALE: 1"=25'



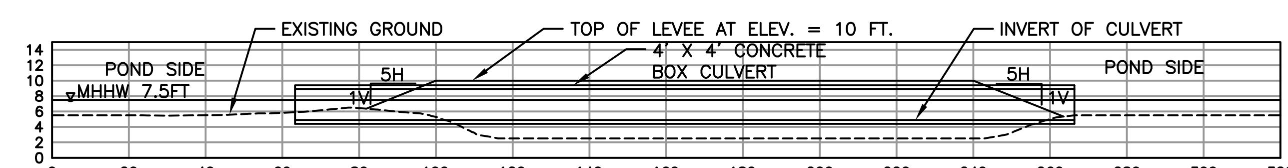
PILOT CHANNEL – TYPICAL SECTION (6)

HORIZONTAL SCALE: 1"=20'
VERTICAL SCALE: 1"=10'



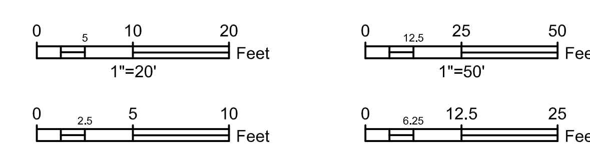
NESTING ISLAND – TYPICAL SECTION (7)

HORIZONTAL SCALE: 1"=50'
VERTICAL SCALE: 1"=25'



WATER CONTROL STRUCTURE – TYPICAL SECTION (8)

HORIZONTAL SCALE: 1"=50'
VERTICAL SCALE: 1"=25'



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CALIFORNIA STATE COASTAL CONSERVANCY
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DESIGNED	SS
DRAWN	SS/VD
CHECKED	SL
PEER REVIEWED	SG
PROJECT MANAGER	TC/DH
DATE	05/06/2014

RAVENSWOOD PONDS DETAILS

REVISION △
PROJECT 26818349
DRAWING
SHEET 1 OF 1