Appendix B

Supporting Planning and Environmental Documentation and Information

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Appendix B1

Shoreline Study Preliminary Alternatives and Landscape Evolution Memo

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memorandum

date February 10, 2012

to Brenda Buxton

from Jeremy Lowe, Mark Lindley, Lindsey Sheehan, Matt Brennan and Michelle Orr

subject **Shoreline Study Preliminary Alternatives and Landscape Evolution**

Introduction

ESA PWA is developing ecosystem restoration options for Ponds A9 to A15 and Pond A18 as part of the habitat evolution assessment for the U.S. Army Corps of Engineers (USACE) Shoreline Study. Six preliminary alternatives are being developed for habitat evolution assessment based on three Ecosystem Restoration options (No, Medium and Large Fill) combined with two Flood Risk Management alignments provided by the Shoreline Study. Professional judgment has been used to develop the candidate alternatives; no modeling has occurred at this stage.

To provide a means of comparison between the six preliminary alternatives, their habitats are being evaluated for two points in time, Time 0 (2017) and Time 50 (2067). Each alternative will be evaluated for one sea level rise curve (NRC-III curve) and three suspended sediment concentrations (including one calibrated to the Island Pond sedimentation data and two lower values). Projected pond topography in 2067 is shown in a GIS map based on existing topography and calculated accretion rates using modified Krone sedimentation equations (Krone 1985).

The first version of this memorandum, dated November 14, 2011, presented scenarios where all ponds would be restored to tidal action together beginning in 2017, 2027, and 2037. We also presented a phased scenario (West Area First) where the western most ponds (A9-11) were restored to tidal action in 2017, the east area pond (A18) was restored in 2027, and the central area ponds (A12-15) were restored in 2037. This revised memorandum presents an alternate phasing scheme (Pond A12 First) that would restore tidal action to Pond A12 in 2017, followed by the western most ponds (A9-11) in 2022, the eastern pond (A18) in 2027, and the remaining central ponds (A13-15) in 2030. The intent of this alternate Pond A12 First phasing scheme is to restore tidal action to Pond A12 as soon as possible to maximize accretion in the lowest pond in the study area.

Ecosystem Restoration Goals

The intent of the ecosystem restoration is to create 'complete' marshes – from subtidal through mudflats, low, mid and high marsh to transitional and upland – a true cross-section of the Bay shore. However simply providing a mix of habitats is insufficient – the marshes need to be physically and biologically 'healthy'. To create healthy marshes requires the restoration of physical complexity - developing the natural drainage networks, natural levees, marsh pannes, and other features that are seen in ancient marshes such as those at China Camp and on the Petaluma River. These habitats also need to be connected both across shore and along shore between each other and with adjacent marshes. To create these complex and connected marshes requires larger parcels than has been the norm for restoration in the Bay, parcels which are carefully located in the landscape – 'a few very large parcels close together are better for Bay wildlife than many small parcels farther apart' (*The State of San Francisco Bay 2011*, p28).

Challenges

There have been paradigm shifts in the scientific recognition of the risk of abrupt climate change and accelerating sea level rise (OPC 2011) and of the risk of fine sediment availability as the erodible sediment pool is depleted (Schoellhamer 2011). After 3,000 years of relatively stable sea level and 150 years of a turbid estuary, San Francisco Bay is returning to a norm of rapid sea level rise and clear water where the landscape will be more dynamic and the bayshore will be less marsh plain and more fringing marsh. This is a dynamic landscape in which there may be downshifting of high marsh to low marsh and to mudflat over the next century; there may be landward movement of the marshes and mudflats; there may be the need to actively manage marshes more than in the past to maintain their ecosystem services.

However, the dynamic landscape reflected by these paradigm shifts is, in many ways, complementary to the ecosystem restoration goals. Wide transitional and upland areas adjacent to high marsh will allow the transgression of wetlands with rising sea level, as opposed to being squeezed against steep-sided levees. Healthy transitional and upland areas transport surface and subsurface flows of water and other materials, maintain water quality, provide macrodetritus, stabilize shorelines, store flood waters, all of which are affected by their width. Lowering outboard levees to marsh elevation, in addition to breaching, will reconnect marsh to mudflat for water, sediment, and organisms while also allowing future transgression of the outboard marshes and mudflats. The mid elevation marsh plain will play a more prominent role in attenuating waves and reducing storm surges. But a dynamic landscape implies movement and the need for space – something that is lacking on the urbanized shore of the South Bay. However the very fact that there is a juxtaposition of natural wetlands and urbanized shore creates opportunities for multi-objective restoration projects which have value for flood risk management, levee stability and stormwater channel maintenance.

Alternatives

Three Ecosystem Restoration (ER) options for Ponds A9 to A15 and Pond A18 have been developed. It is assumed that once tidal flows have been restored by breaching the outboard levees, natural sedimentation will allow the evolution of a marsh plain in the ponds. The ER options have some common features, such as number and location of levee breaches. Measures in the marshplain such as pilot channels, starter channels, side cast natural levees and ditch blocks will be used to accelerate the evolution of the ponds and to enhance the habitat. The ER options differ mainly in the amount of fill which is used to create upland and transitional habitat adjacent to the inboard levees along Pond A12 and A13 and along Pond A18: the ER options are named No, Medium and Large Fill. Using fill to create long transitional slopes provides large areas of upland habitat that has been missing from the Bay, attenuates waves and reduces run-up, and increases resiliency to sea level rise. Increasing amounts of fill also increase the cost of the project and increase the demand for dredged (or other fill) material. The ER options therefore bookend the project in terms of cost, volume of fill, habitat quality, flood risk management benefits, and resiliency to sea level rise.

The Flood Risk Management options for Ponds A9 to A15 and Pond A18 are described in the Draft FRM Option Development Memorandum (HDR 2011). For Ponds A9 to A15 the FRM options follow two alignments: either along existing levees bordering Pond A12 and A13 (FRM options 1A, 1B, 1C, 1D and 2) or along existing levee bordering pond A12, and then west along the existing railroad line to Grand Boulevard (FRM options 3 and 4). For Pond A18 the FRM options also follow two alignments: either along existing levees bordering Pond A18 (FRM options 2 and 4) or along a new alignment cutting across Pond A18 (FRM options 1A, 1B, 1C, 1D, and 3). FRM options along Pond A16 and in New Chicago Marsh will not impact the ER options for Ponds A9 to A15 and Pond A18 and so are not considered further in this memo.

The six preliminary alternatives are a combination of the FRM and ER options as shown in table 1 below. Pond A9-A15 and Pond A18 are physically separated and considered to be independent of each other; any of the alternatives chosen for Pond A9-A15 could be matched with any of the alternatives for Pond A18. The benefits of applying the other ER measures, such as starter channels and ditch blocks, are being studied as part of the Island Ponds and Pond A6 monitoring which are Phase 1 actions of the SBSP Project. The inclusion of such measures in the preliminary alternatives should be based upon information from this monitoring.

Figures 1 to 3 show the fill footprint for Preliminary Alternatives 1 to 3, where the FRM alignment follows the existing levee, together with the existing topography. Topographic shading reflects the initial habitat types that would be expected based on tidal inundation regimes if the Ponds were all breached in 2017. The levees, fill footprint and other measures are described in the next section.

Table 1: Preliminary alternatives for Ponds A9-A15 and Pond A18

Preliminary Alternative	ER option	Other ER measures	FRM alignment Pond A12 and A13	FRM alignment Pond A18
1	No Fill	Outboard levee breaches, pilot channels, and internal berm breaches	Existing levee	Existing levee
2	Medium Fill	Outboard levee breaches, pilot channels, outboard levee lowering, ditch blocks, internal berm breaches, internal berm lowering, and starter channels with side cast natural berms	Existing levee	Existing levee
3	Large Fill	Outboard levee breaches, pilot channels, outboard levee lowering, ditch blocks, internal berm breaches, internal berm lowering, and starter channels with side cast natural berms	Existing levee	Existing levee
4	No Fill	Outboard levee breaches, pilot channels, and internal berm breaches	Existing levee along Pond A12, and then along the existing railroad line	New alignment cutting across Pond A18
5	Medium Fill	Outboard levee breaches, pilot channels, outboard levee lowering, ditch blocks, internal berm breaches, internal berm lowering, and starter channels with side cast natural berms	Existing levee along Pond A12, and along the existing railroad line	New alignment cutting across Pond A18
6	Large Fill	Outboard levee breaches, pilot channels, outboard levee lowering, ditch blocks, internal berm breaches, internal berm lowering, and starter channels with side cast natural berms	Existing levee along Pond A12, and then along the existing railroad line	New alignment cutting across Pond A18

Measures

Flood Risk Management Levees

To estimate the fill footprint an approximation of levee crest heights is required. PWA (2006) documents concept level designs for levees in the Alviso pond complex classified into a number of categories the following of which are relevant to the present study:

- New levee constructed on existing pond-bottom elevations
- Upgraded levee constructed on existing perimeter levees (typically the “inboard” levee located on the landward side of the ponds)

In addition, each typical flood control levee category was separated into three different exposure levels:

- Exposed levee landward of tidal marsh
- Exposed levee landward of an upland-transition area
- Reduced exposure levee landward of a managed-pond area

Table 2 shows conceptual design levee crest elevations from the SBSP Flood Analysis Report (PWA 2006). The conceptual design elevations are based on 100-year “total water levels” with an additional 1 ft allowance for freeboard. The total water level is defined as the combination of a high bay-water level and wind-wave runup. For this preliminary analysis, the joint occurrence of a 100-year bay-water level and a 10-year wind wave event was used to estimate the total water levels and required levee crest elevations for each exposure level. Levees landward of tidal marsh and upland-transition areas are assumed to be more exposed than levees landward of managed ponds. Long and short wave modeling by the USACE and Delta Modeling Associates will provide better estimates of total water levels at the levees following breaching and in 2067 and levee design crest elevations should be updated.

Table 2 Alviso Levee Design Crest Elevation from PWA Flood Analysis Report (2006)

Levee Exposure Category	Levee Design Crest Elevation (ft, NAVD88)
With Outboard Marsh / Upland Transition	16.5
With Outboard Managed Ponds	15.5

New and upgraded levee cross-sections are assumed to have inboard and outboard slope of 3:1 (H:V) and a crest width of 20 ft. To prevent levee erosion, new and upgraded levees that are fronted with either tidal marsh or managed ponds are assumed to be armored with rock. The armoring design used in the cost estimate is a rock revetment to be placed between the top elevation of the stability berm or upland transition area and the crest of the levee.

Elevations for existing perimeter levees for Alviso and Ravenswood are from Moffatt & Nichol (2005). Table 3 summarizes the elevation data used in estimating fill volumes for design levee cross-sections.

Table 3 Typical Existing Elevations in Alviso; crest elevations from Moffatt & Nichol (2005)

Levee Exposure Category	Elevation (ft, NAVD88)
Average Pond A12 Elevation	-0.5
Average Pond A18 Elevation	0.5
Internal Managed-Pond Berm Crests	6
Existing Perimeter Levee Crests	9

Stability berms may be required to prevent subgrade failure potentially resulting from the rapid placement of between 10 and 20 feet of soil. If required, these berms would be needed on both sides of a flood control levee that is exposed to either a tidal-marsh area or a managed pond. For a flood control levee that is exposed to an upland-transition area, only the landward side of the levee will need a stability berm. Stability berms are assumed to have crest elevations approximately 2 feet above mean higher high water (MHHW). The widths of the stability berms would vary depending on the type of levee and will have assumed side slopes of 3:1 (H:V). Due to differences in fill thickness and subgrade strength, the width of the stability berms for a new levee, an upgraded internal managed-pond berm and an upgraded existing perimeter levee would be 50 ft, 40 ft and 30 ft, respectively. The locations of drainage and borrow ditches will need to be considered and may alter the alignment. Alternative methods may be available which could be less expensive. These include soil reinforcement with geotextile fabric, stone column or foundation over-excavation, or replacement with stronger soil.

Initial fill volumes will likely include an "over-build" to compensate for the initial subsidence and an allowance should be made for placing additional earth (or other action such as a flood wall) as the levees subside. Initial subsidence is anticipated to be greatest for new levees constructed on existing pond bottoms.

Transitional-Upland Slopes

Three different cross-sectional designs for the transitional-upland areas adjacent to the levees are used, which correspond to the three ER options of No, Medium and Large Fill, and described in Table 4. For each design, the top of the transitional-upland area was assumed to be the same as the proposed levee crest elevations from Table 2 and the bottom of the transitional-upland area was assumed to be about 2 feet below MHHW within the lower range of cordgrass grass dominated marsh. Below the flat transition slope, the berm would slope down to the respective average pond-bottom elevations as shown in Table 3 at a steeper 3:1 to 5:1 (H:V) slope.

Table 4 Transitional-Upland Slope Design

ER Option	Design
No Fill	3:1 (H:V) front slope of the levee and stability berms (if required) form the transitional zone.
Medium Fill	30:1 (H:V) slope for the transitional zone. The zone begins at the approximate upgraded flood-control levee crest and maintains a 30:1 slope to the pond-bed elevation. It is assumed that the upper slope of the transitional zone will need planting or hydro-seeding.
Large Fill	100:1 (H:V) slope for the transitional zone. The zone begins at the approximate upgraded flood-control levee crest and maintains a 100:1 slope to the pond-bed elevation. It is assumed that the upper slope of the transitional zone will need planting or hydro-seeding.

The 30:1 and 100:1 (H:V) slopes in the Medium and Large Fill options represent idealized slopes. During final design and construction, the slopes would include some variation both in planform to create a more natural shoreline and along the slope to create benches and shallow depressions to form pannes at a variety of elevations. The intent is to work within the overall idealized slope to create an upland transitional zone with some complexity.

To reduce the initial fill requirements it may be possible to construct the transitional-upland slopes of the Medium Fill and Large Fill options in stages. An initial, smaller, berm would be built at the outboard edge of the transitional-upland zone, followed by breaching the ponds to tidal action, then filling behind it over time as material becomes available to bring the transition areas to final grade. An alternative may be to maintain a 3:1 slope to a horizontal bench located one-foot above MHHW. The levee bench could receive fine grading to create backshore pans and a 30:1 (or 100:1) slope will continue downward from the bench to about 2 feet below MHHW within the lower range of cordgrass colonization elevations. Additional fill would be placed on the bench as required to maintain its position in the tidal frame with sea level rise.

Outboard Levee Breaches

Outboard levee breaches are excavations through the perimeter levees that open the site to tidal inundation from the adjacent tidal sloughs. Breaches through the outboard levee and pilot channels through the outboard marsh will be excavated at the locations of the major remnant historic tidal channels (Figure 4). These locations would be the same for all the Preliminary Alternatives.

The levee breaches are sized using empirical relationships between tidal channel dimensions and marsh drainage area (hydraulic geometry relationships). Hydraulic geometry relationships from Williams et al (2002) are based on data from tidal channels in mature natural marshes located throughout the San Francisco Bay. A subset of the Williams et al (2002) data from South Bay marshes, including Laumeister, Newark Slough, and Ravenswood Slough, was used to develop hydraulic geometry relationships for the South Bay.

The hydraulic geometry relationships provide expected channel dimensions once a pond has developed into a mature marsh. The breaches were sized to long-term equilibrium dimensions to balance excavation costs, scour potential, and tidal drainage (see section below). This approach is consistent with the Design Guidelines for Tidal Wetland Restoration in San Francisco Bay (PWA 2004). These dimensions are adjusted to give a trapezoidal breach cross section with side slopes (H:V) of approximately 4:1 to 5:1 and a minimum bottom width of approximately 10 ft. On the inboard side of the levee, the breach excavation will extend to the levee toe

The breaches are expected to be undersized compared to restored tidal flows due to the larger tidal prism of the subsided ponds. The large tidal flows are expected to scour and enlarge the breaches until equilibrium between the tidal prism and channel dimensions is reached. The tidal prism will decrease as the pond fills in due to sedimentation and vegetation establishment.

Undersized breaches may initially constrict tidal flows to the restoration site and cause water to “back-up” in the site on the ebb tide, delaying drainage and increasing the low water level in the site. The pilot channel connecting the levee breach and the adjacent slough through the outboard marsh (pilot channel) may limit tidal drainage in a similar manner. Over time, tidal flows are expected to scour undersized levee breaches and pilot channels, thus improving tidal drainage.

Outboard Levee Breach Sizing

The historic channels layer from SFEI was examined in GIS to analyze historic watersheds on the site (Figure 4). The area of each restored tidal watershed was calculated in GIS and used to find long-term channel equilibrium dimensions for that watershed using Williams *et al*, 2002 (). The order of each channel was determined from Williams *et al*, 1995 (). These dimensions can be applied to the historic channel network shown in Figure 4.

Table 5. Long-Term Equilibrium Channel Dimensions

Watersheds	Area [ac]	Breach Depth [ft]	Breach Top Width [ft]	Breach Cross-Sectional Area [ft^2]	Channel Order
Pond A9	454	16.1	188	1303	6
Pond A10	228	13.5	138	820	5
Pond A11	246	13.8	143	864	5
Pond A12	265	14.0	147	907	5
Ponds A13-15	914	19.1	257	2081	6
North A18	116	11.4	101	521	5
Central A18	221	13.4	136	805	5
Southwest A18	258	13.9	146	892	5
East A18	255	13.9	145	886	5

Pilot Channels

Wide mudflats outboard of breaches may limit tidal drainage; however, the pond breaches drain to deep tidal sloughs across relatively narrow mudflat channel banks. Pilot channels will be excavated through the outboard marsh to connect each outboard levee breach to the adjacent tidal slough. The ponds will be breached at the location of historic marsh channels and so the pilot channels would also follow the historic channels (Figure 4). These locations would be the same for all the Preliminary Alternatives.

The Design Guidelines (PWA 2004) recommend excavating breaches and pilot channels to long-term equilibrium dimensions to allow for adequate tidal exchange to quickly erode breaches and improve tidal drainage. Pilot channels will be excavated to the long-term equilibrium channel depth and 60 to 80% of the long-term channel width (i.e., narrower than the breach width at MHHW) (see above). The pilot channel side slopes will be approximately 3:1. The pilot channels are somewhat undersized to reduce the amount of excavation and are expected to scour and enlarge. Marsh vegetation will be excavated down to the root zone over the long-term equilibrium width to reduce the resistance to pilot channel bank erosion.

Tidal drainage for the pond restoration is likely to be adequate in the long-term, but may be restricted within the first few years after restoration. An assessment of Island Ponds monitoring data (PWA 2007) indicates that after the under-sized Island Pond breaches scoured to long-term equilibrium widths, the breaches provided adequate tidal drainage. These monitoring data suggest that breaches sized to long-term equilibrium dimensions for ponds with marshplain elevations similar to the Island Ponds can be expected to provide adequate tidal drainage. The elevation of the ponds is on average 3 feet lower than the Island Ponds and will initially have a larger restored tidal prism, which will tend to slow drainage at low tides. However, the number of breaches per acre of restored marsh will be greater than the Island Ponds, which will tend to improve drainage. If the pilot channels do not scour and enlarge as expected, excavation could be pursued as part of adaptive management.

Outboard Levee Lowering

Levee lowering would occur in the Medium and Large Fill Preliminary Alternatives. The majority of the outboard levee will be lowered by excavation to MHHW to create pickleweed marsh habitat, restore hydraulic and habitat connectivity between the sloughs and the marshplain, and provide material for ditch block construction. Portions of the outboard levees will not be lowered to limit wave action and to provide initial high tide refugia. The bayfront levee between Pond A9, and Coyote Creek is expected to limit wave action in Pond A9 until the bayfront levee completely erodes.

Borrow Ditch Blocks

Ditch blocks inhibit flow though the existing borrow ditches to promote scour and flow through the remnant historic channels. The desired elevation of the top of the ditch blocks is MHHW; at this elevation the ditch blocks are expected to provide pickleweed habitat. The initial fill elevation needed to achieve this elevation and account for settlement will be determined during final design. Material excavated from the levee breaches and levee lowering will be used to construct ditch blocks. To reduce the potential for fish stranding, the ditch blocks will be located such that the borrow ditch on both sides of the block connects directly to a breach.

Internal Berm Breaches

The internal berms within the ponds will be breached in several locations to reconnect remnant historic channels and restore the hydraulic connection across the site (figure 4). Breaches will be sized in a similar manner to the breaches in the outboard levee. The breach excavations will extend beyond the levee toe into either the internal borrow ditch or the remnant historic channel. The existing internal berm between Ponds A9 and A14 does cut across the historical watershed (Figure 4). It is suggested that this berm is realigned further into Pond A14 so that the tidal prism will be sufficient to maintain the channels in Pond A9. The benefits and costs of adjusting the internal berm alignment need to be addressed at a later stage in the design.

Internal Berm Lowering

Internal berms within the ponds would serve as wave-break berms to limit wave action, enhance sedimentation, and create vegetated marsh habitat (on the berm crests) in the short term while the ponds develop from mudflat to vegetated marsh. The existing low internal berms separating the ponds would be lowered by excavation to MHHW to create pickleweed marsh habitat and act as a wave-break berms. This is the concept used in the adjacent Pond A6 and monitoring of sedimentation rates following restoration will test its effectiveness. Construction of additional wave-break berms is not included at this point because the benefits to the pond restoration may be small relative to the cost of construction. Short wave modeling by USACE may indicate the need for wave-break berms.

The extent and location of internal berm lowering would be determined during project design to match project construction to funding availability.

Starter Channels with Side Cast Berms

Natural levees adjacent to tidal channels in historic marshes support pickleweed and marsh gumplant which serve as critical high tide refugia for Salt Marsh Harvest Mouse and California Clapper Rail. Excavation of the shallow remnant historic tidal channels within the ponds would provide material to create side cast berms adjacent to the channels to emulate natural levee features seen adjacent to channels in historic marshes. These low berms would create topographic complexity within the otherwise plainer intertidal mudflat.

In addition, excavating the shallow remnant historic tidal channels within the pond would re-create tidal channel habitat and improve tidal drainage more rapidly following restoration. Tidal drainage is affected by the density, complexity, and form of the channel network. As water drains off the marshplain, flows are conveyed through tidal channels within the site. Silted-in portions of the remnant historic tidal channels (Figure 4) may be too shallow to efficiently convey tidal flows, causing more flow over the marshplain. Shallow flow and friction over the marshplain may delay low tide drainage. Tidal drainage is expected to improve as remnant channels scour in response to tidal flows. Ponds with a gypsum layer on the pond bed may also require excavation of channels to convey tidal exchange – the only ponds in the Alviso complex known to have gypsum layers are the Island Ponds.

Using a similar hydraulic geometry analysis as for pilot channels, starter channels could be excavated that are sized to the long-term equilibrium channel depth and 60 to 80% of the long-term channel width. The ultimate location and extent of starter channel excavation to create side cast berms would be determined during final design to balance the habitat benefits with project funding. For instance, in Ponds A15 and A13, existing internal berms are located adjacent to the large tidal channel through those ponds, so the need for excavation to create side cast berms would be a lower priority within those ponds. By comparison, within Pond A18 there are no internal berms within a large 850 acre pond, and starter channel excavation to create side cast berms would be a much higher priority in Pond A18 because these berms would serve a number of critical functions – as wave-break berms to enhance sedimentation, to provide topographic complexity to support vegetation colonization, and to provide high tide refugia for critical special status species.

Experience in the Island Ponds indicated that material sidecast too close to the excavated channels was liable to be eroded as the channels scoured and enlarged. In Pond A6 starter channels were not included in the design due to the cost of construction and the expected low benefits. A comparison of natural levee evolution from the Island Ponds and Pond A6 monitoring would be a useful guide for evaluating the desirability of side-casting.

Landscape Evolution

Marsh accretion was predicted using the Marsh98 analysis, a procedure that has been used widely to examine marsh sustainability to sea level rise across San Francisco Bay (e.g. Orr et al., 2003). The Marsh98 analysis is based on the mass balance calculations described by Krone (1987). This procedure assumes that the elevation of a marsh plain rises to colonization elevations at rates that depend on the (1) availability of suspended sediment and (2) depth and periods of inundation by high tides. When the level of an evolving marsh surface is low with respect to the tidal range, sedimentation rates may be high if the suspended sediment supply is sufficient. However, as the marsh surface rises through the tidal range, the frequency and duration of flooding by high tides is diminished so that the rate of sediment accumulation declines. Marsh98 implements these physical processes by calculating the amount of suspended sediment that deposits during each period of tidal inundation and sums that amount of deposition over the period of record.

Two revisions have been made to Marsh98 to more accurately represent physical conditions. These revisions include:

- Accelerating, nonlinear sea level rise is included. The sea level rise curves that were implemented were originally proposed by the National Research Council and modified by the USACE (2009), specifically NRC-I, -II and –III curves.
- Organic material is now added directly to the bed elevation at each tidal cycle. This method more accurately reflects the physical process with nonlinear sea level rise. Accretion due to organic material occurs when the marsh plain reaches a specified vegetation colonization elevation.

Model Input Parameters

Tidal Boundary Condition

The modeling was conducted relative to the tidal datum of NAVD88. The tidal boundary condition used for all model runs was a tidal month which has statistical characteristics identical to the observed tides at the Golden Gate. This boundary condition was then amplified using the Coyote Creek tidal datums to create a time series that could be applied to the Coyote Creek area. The title datums are shown in Table 6.

Table 6. Coyote Creek Tidal Datums

Datums	ft MLLW	ft NAVD	m NAVD
MHHW	9.01	7.49	2.27
MHW	8.42	6.90	2.10
MSL	4.92	3.40	1.04
MTL	4.83	3.31	1.01
NAVD88	1.52	0.00	0.00
MLW	1.24	-0.28	-0.09
MLLW	0.00	-1.52	-0.46

*NOAA Tides & Currents. Station ID: 9414575. MLLW to NAVD conversions are from NOAA unpublished (2005).

Habitat Zones

Seven habitat zones were chosen to represent different elevation within each breached pond. Table 7 presents these zones and elevations.

Table 7. Habitat Zones and Elevations

Habitat Zone	Elevation (relative to datums)	2017 Elevation (ft NAVD)	2017 Elevation (m NAVD)
Deep Subtidal	6 m below MLLW and deeper	< -21.16	< -6.45
Shallow Subtidal A	2 to 6 m below MLLW	-21.16 to -8.04	-6.45 to -2.45
Shallow Subtidal B	2 m below MLLW to MLLW	-8.04 to -1.48	-2.45 to -0.45
Intertidal Mudflat	MLLW to MTL + 0.3 m	-1.48 to 4.33	-0.45 to 1.32
Cordgrass Dominated	MTL + 0.3 m to MHW	4.33 to 6.96	1.32 to 2.12
Pickleweed Dominated	MHW to MHHW	6.96 to 7.51	2.12 to 2.29
Upland*	MHHW and above	> 7.51	> 2.29

*HTH provided the elevations for the all of the subtidal and tidal habitat zones. NAVD elevations refer to 2017.

Suspended Sediment Concentration

Suspended sediment concentration (SSC) varies throughout San Francisco Bay because of variations in wave conditions, proximity to mudflats, and river inputs. Monitoring data from Pond A21, just north of the site, were used to calibrate the SSC to be used in the model. The data was divided by starting elevations into three categories and then elevations over time were averaged for each group. Marsh98 was run with the three averaged starting elevations from the data and with three potential SSC (100, 200, and 300 mg/L).

For the first 6 to 12 months after breaching, the Island Ponds data tracks with the 300 mg/L suspended sediment concentration curve. However, the later elevation measurements show little increase in between time steps and track better with the 100 mg/L and 200 mg/L SSC curves. It is possible that the Pond A21 mudflats accreted rapidly in the first year as easily eroded material was remobilized, perhaps from the breach and outboard marsh, which increased the local SSC. Over time this supply of easily eroded material was exhausted and the subsequent accretion rate reflects more the ambient suspended sediment concentration in Coyote Creek. We are investigating the calibration data more closely and looking for evidence to test the variable SSC hypothesis. To represent the range of SSC, all three concentrations were modeled to bracket the possibilities. Subsequent runs will focus on the

100, 200 mg/L range and will also include a better description of the initial high rates following breaching. Long term decline in SSC should also be incorporated (Schoellhamer 2011).

Organic Matter

Marshes with high rates of organic matter production have been observed to accrete at faster rates than marshes composed primary of inorganic sediments (Orr et al., 2003). Marshes associated with the highest organic matter accretion rates are typically found in brackish or freshwater environments. Based on guidance from HTH, an organic matter accretion rate of 1 mm/yr was modeled for all scenarios when the marsh plain elevation reached MTL + 1ft (MTL + 0.3 m).

Rate of Sea Level Rise

A nonlinear sea level rise scenario based on the guidance provided by the USACE (2009) was used. This document recommends scenarios modifying curves proposed by the National Research Council to extrapolate intermediate and high sea level rise projections ("NRC-I" and "NRC-III", respectively). These scenarios project 0.5 m and 1.5 m of sea level rise over the next century depending on emissions. The high rate is similar to the draft State of California planning guidelines, which recommends planning for 16" of rise in the next 50 years and 55" in the next 100 years. For the Preliminary Alternatives reported here the NRC-III curve was used.

Phasing

Two phasing schemes were examined. The West Area First phasing scheme examined phased restoration beginning in the western most ponds. The Pond A12 First phasing scheme illustrates a phased restoration beginning with Pond A12 which is the lowest pond in the study area.

West Area First phasing scheme: the site evolution projections were phased by pond area with the west region (Ponds A9-A11) beginning in 2017, the east region (Pond A18) beginning in 2027, and the central region (Pond A12-A15) beginning in 2037. The division between the west and central region includes the realignment of the internal berm between Pond A9 and A11 which more accurately reflects the historic watershed.

Pond A12 First phasing scheme: site evolution projections were phased with restoration of Pond A12 beginning in 2017, followed by the westernmost ponds (A9-11) beginning in 2022, the eastern pond (Pond A18) beginning in 2027, and the remaining central ponds (Ponds A13-15) beginning in 2030. The intent of this alternate Pond A12 First phasing scheme is to restore tidal action to the Pond A12 as soon as possible to maximize accretion in the lowest pond in the study area. This phasing also accelerates restoration of the central area ponds (Pond A13-A15) by seven years as compared to the West Area First phasing scheme.

All runs ended in 2067. The different starting times place each region on a different part of the sea level rise curve. This means that without substantial suspended sediment, the central region will end up at lower elevations than the west (or east region) because it has fewer years to accrete and it begins on a steeper part of the sea level rise curve so sea level is increasing more rapidly.

Landscape Evolution Results

In general we have found with previous Marsh98 analysis in the South Bay (Orr, et.al., 2003) that:

- SSC of 25 mg/L are unlikely to sustain marshes for all scenarios, regardless of the input parameters. These concentrations are unlikely based on the Island Ponds monitoring data.
- SSC of 50 mg/L are unlikely to sustain marshes for all scenarios except for most favorable conditions (high initial bed elevation and organic accretion rate; intermediate rate of sea level rise). These concentrations are unlikely based on the Island Ponds monitoring data.
- SSC of 100 or 150 mg/L can sustain marshes only for particular combinations of initial bed elevation, organic accretion rate and rate of sea level rise. Varying any one of these four parameters can alter whether the model predicts vegetated or unvegetated Year 100 conditions. These are the likely range of concentrations based on the Island Ponds monitoring data.
- SSC of 300 mg/L are likely to sustain marshes for all scenarios but are unlikely to occur after the initial period of tidal restoration, as shown by the Island Pond monitoring data.

The model input parameters and predicted 2067 bed elevations for the 54 combinations of initial bed elevation, SSC, and phasing are summarized in Appendix A. The colors in the last column represent the habitat zone of that elevation where blue is subtidal, brown is mudflat, light green is cordgrass, and dark green is pickleweed.

The results presented here provide a first order estimate of marsh accretion rates for San Francisco Bay under a range of input conditions. However, it should be recognized that significant uncertainties remain with respect to future changes in sea level rise as well as the physical and biological processes which affect marsh accretion. In particular, the analysis does not include the influence of waves, which become more important as site size increases and availability of sediment diminishes. Sites that are more vulnerable to waves include those with bed elevations between vegetation colonization elevation and MHHW, e.g. those elevations close to cordgrass dominated elevations.

Spatial Evolution

The results summarized in Appendix A were used to create digital elevation models (DEMs) of the site in 2067 years for different SSC and different start years (Figures 5 to 10). Phasing was not used in these figures to provide understanding of the evolution of the individual ponds. The ability to reach colonization elevation is controlled by both SSC and the start year. The start year has two influences, firstly there is less time to accrete sediment before the end of the project in 2067, and secondly the tidal inundation starts at a higher sea level and at a time when the sea level is rising faster.

Start Year 2017: Figure 5 and 6 show the likely evolution of the ponds by 2067 for a SSC of 100 and 200mg/L and a start date of 2017. It clearly shows for 100 mg/L none of the ponds attain elevations that allow for colonization and remain mudflats – all the sedimentation that is shown is due to inorganic sediment deposition at lower elevations, which is well-produced in Marsh98. The spatial pattern within the ponds reflects the initial start elevation and reflects how deeply subsided Pond A12 is, particularly adjacent to Alviso Slough and the Pond A12 inboard levee. For SSC of 200 mg/L nearly all the ponds reach colonization elevation, either cordgrass or pickleweed elevations.

Start Year 2027: Figure 7 and 8 show the likely evolution of the ponds by 2067 with a start date of 2027. For SSC of 100mg/L the mudflats within the ponds are lower than with a start date of 2017, as there has been less time to accrete. For SSC of 200 mg/L nearly all the ponds reach colonization elevation, but only attain cordgrass elevations.

Start Year 2037: Figure 9 and 10 show the likely evolution of the ponds by 2067 with a start date of 2037, a period of only 30 years. The pattern for both SSCs are the same as before but shifted lower in elevation. With the 200mg/L plot (Figure 10) there are areas in Pond A12 which do not achieve vegetation colonization elevation and remain mudflat.

Phased Evolution

Figures 11 and 12 show projections of the evolution of the site for the West Area First phasing scheme with varying start dates for the different Ponds with the west region (Ponds A9-A11) beginning in 2017, the east region (Pond A18) beginning in 2027, and the central region (Pond A12-A15) beginning in 2037. Figure 11 (SSC=100 mg/L) shows the impact of restoring tidal influence to the most deeply subsided ponds last; the elevation in Pond A12 remains low mudflat and shallow subtidal. Figure 12 (SSC=200 mg/L) shows the same basic pattern but all the elevations are higher, mostly achieving colonization elevations, except for Pond A12. This clearly shows the influence of phasing on the success in restoring a complete marsh in Ponds A9 to A15. Changing the order of restoration will have a significant impact on the outcome of the project in 2067.

Figures 13 and 14 illustrate the evolutionary projections for the Pond A12 First phasing scheme with the start dates for Pond A12 beginning in 2017, followed by west region (Pond A9-A11) in 2022, eastern region (Pond A18) in 2027, and the remaining central region ponds (Ponds A13-15) in 2030. Figure 13 (SSC=100 mg/L) shows the results of restoring the deeply subsided Pond A12 first and moving the restoration of Ponds A13-A15 up to 2030. Areas in Pond A12 that remained as shallow subtidal in the West Area First phasing scheme become low mudflat. Figure 14 (SSC=200 mg/L) illustrates that with higher sediment concentrations, restoration of Pond A12 beginning in 2017 allows this pond to reach cordgrass and pickleweed colonization elevations by 2067. Moving restoration of the remaining central area ponds (Ponds A13-15) up to 2030 allows areas of these ponds that remained as intertidal mudflat when restored in 2037, to reach low cordgrass colonization elevations by 2067.

Figures 15 and 16 present medium and large fill transitional alternatives with the projected evolution under Pond A12 First phasing scheme with the higher (200 mg/L) suspended sediment concentration.

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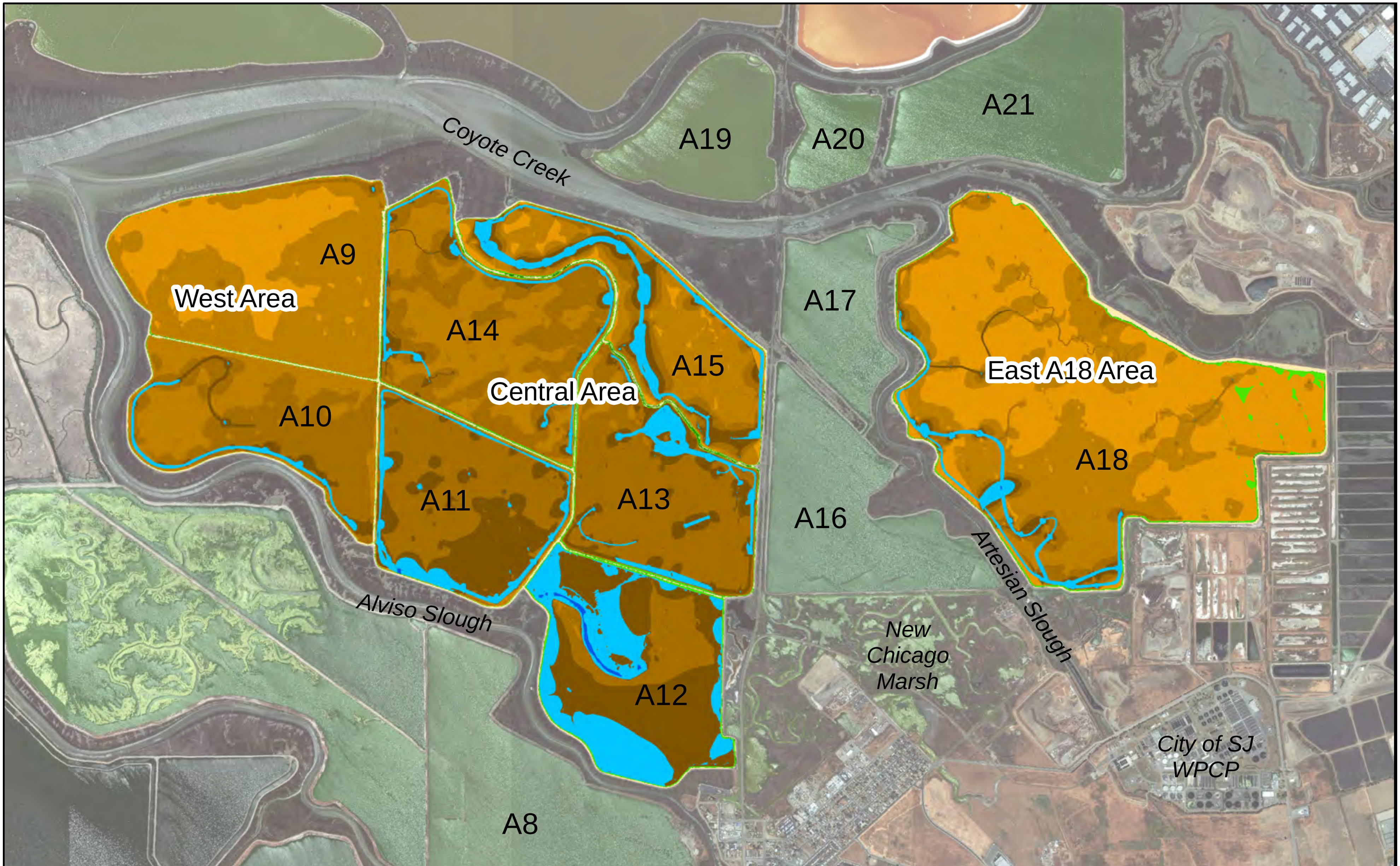
Appendix A

Summary of Landscape Evolution Projections

Habitat Zone	Elevation (relative to datums)
Deep Subtidal	6 m below MLLW and deeper
Shallow Subtidal A	2 to 6 m below MLLW
Shallow Subtidal B	2 m below MLLW to MLLW
Intertidal Mudflat	MLLW to MTL + 0.3 m
Cordgrass Dominated	MTL + 0.3 m to MHW
Pickleweed Dominated	MHW to MHHW

Run ID	Start Year	Co (mg/L)	2017 Elevations (ft NAVD)	2067 Elevation (ft NAVD)	Change in Elevation (ft)	MHHW 2067 (ft NAVD)	2067 Elevations - MHHW (ft)
1	2017	100	-12.30	-8.48	3.82	9.62	-18.10
2	2017	100	-3.28	0.54	3.82	9.62	-9.07
3	2017	100	0.00	3.53	3.53	9.62	-6.08
4	2017	100	5.74	7.55	1.81	9.62	-2.06
5	2017	100	7.38	8.58	1.20	9.62	-1.04
6	2017	100	9.84	9.62	-0.22	9.62	0.00
7	2017	200	-12.30	2.99	15.29	9.62	-6.62
8	2017	200	-3.28	8.31	11.59	9.62	-1.30
9	2017	200	0.00	9.03	9.03	9.62	-0.58
10	2017	200	5.74	9.62	3.88	9.62	0.00
11	2017	200	7.38	9.62	2.24	9.62	0.00
12	2017	200	9.84	9.62	-0.22	9.62	0.00
13	2017	300	-12.30	9.62	21.92	9.62	0.00
14	2017	300	-3.28	9.62	12.90	9.62	0.00
15	2017	300	0.00	9.62	9.62	9.62	0.00
16	2017	300	5.74	9.62	3.88	9.62	0.00
17	2017	300	7.38	9.62	2.24	9.62	0.00
18	2017	300	9.84	9.62	-0.22	9.62	0.00
19	2027	100	-12.30	-9.25	3.05	9.61	-18.86
20	2027	100	-3.28	-0.22	3.06	9.61	-9.83
21	2027	100	0.00	2.87	2.87	9.61	-6.74
22	2027	100	5.74	7.22	1.48	9.61	-2.39
23	2027	100	7.38	8.34	0.96	9.61	-1.27
24	2027	100	9.84	9.61	-0.23	9.61	0.00

Run ID	Start Year	Co (mg/L)	2017 Elevations (ft NAVD)	2067 Elevation (ft NAVD)	Change in Elevation (ft)	MHHW 2067 (ft NAVD)	2067 Elevations - MHHW (ft)
25	2027	200	-12.30	-0.05	12.25	9.61	-9.66
26	2027	200	-3.28	7.04	10.32	9.61	-2.57
27	2027	200	0.00	8.15	8.15	9.61	-1.46
28	2027	200	5.74	9.39	3.65	9.61	-0.22
29	2027	200	7.38	9.61	2.23	9.61	0.00
30	2027	200	9.84	9.61	-0.23	9.61	0.00
31	2027	300	-12.30	8.81	21.11	9.61	-0.80
32	2027	300	-3.28	9.61	12.89	9.61	0.00
33	2027	300	0.00	9.61	9.61	9.61	0.00
34	2027	300	5.74	9.61	3.87	9.61	0.00
35	2027	300	7.38	9.61	2.23	9.61	0.00
36	2027	300	9.84	9.61	-0.23	9.61	0.00
37	2037	100	-12.30	-10.01	2.29	9.61	-19.63
38	2037	100	-3.28	-0.99	2.29	9.61	-10.60
39	2037	100	0.00	2.17	2.17	9.61	-7.44
40	2037	100	5.74	6.86	1.12	9.61	-2.75
41	2037	100	7.38	8.10	0.72	9.61	-1.52
42	2037	100	9.84	9.61	-0.23	9.61	0.00
43	2037	200	-12.30	-3.13	9.17	9.61	-12.74
44	2037	200	-3.28	5.24	8.52	9.61	-4.38
45	2037	200	0.00	6.91	6.91	9.61	-2.70
46	2037	200	5.74	8.77	3.03	9.61	-0.84
47	2037	200	7.38	9.26	1.88	9.61	-0.35
48	2037	200	9.84	9.61	-0.23	9.61	0.00
49	2037	300	-12.30	6.15	18.45	9.61	-3.47
50	2037	300	-3.28	9.01	12.29	9.61	-0.61
51	2037	300	0.00	9.40	9.40	9.61	-0.21
52	2037	300	5.74	9.61	3.87	9.61	0.00
53	2037	300	7.38	9.61	2.23	9.61	0.00
54	2037	300	9.84	9.61	-0.23	9.61	0.00



Initial conditions. No Marsh98 run. No fill.

N

0 550 1,100 2,200 3,300 4,400 5,500 Feet

Habitat Zones (ft NAVD)

- Deep Subtidal (< -21.2)
- Shallow Subtidal A (-21.2 to -8.0)
- Shallow Subtidal B (-8.0 to -1.5)
- Intertidal Mudflat low (-1.5 to 0)
- Intertidal Mudflat mid low (0 to 1.3)
- Intertidal Mudflat mid high (1.3 to 3.0)
- Intertidal Mudflat high (3.0 to 4.3)
- Cordgrass Dominated low (4.3 to 5.6)
- Cordgrass Dominated high (5.6 to 7.0)
- Pickleweed Dominated (7.0 to 7.5)
- Upland (> 7.5)

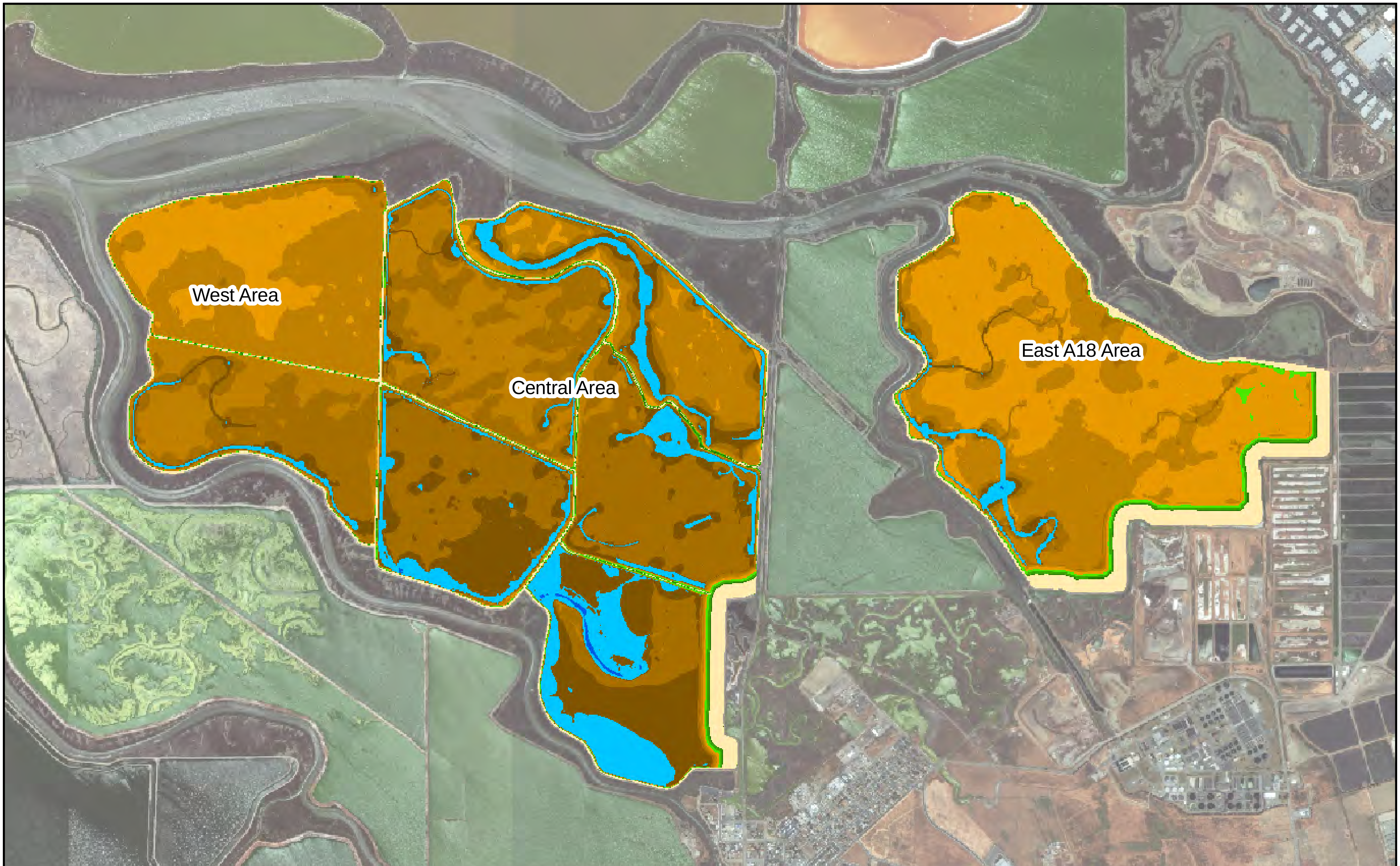
figure 1

Shoreline Study Alternatives

Preliminary Alternative 1 Transitional - Upland Fill Footprint

Proj. # 211259

ESA PWA



Initial conditions. No Marsh98 run. Fill 1:30.

N

0 550 1,100 2,200 3,300 4,400 5,500 Feet

Habitat Zones (ft NAVD)

- Deep Subtidal (< -21.2)
- Shallow Subtidal A (-21.2 to -8.0)
- Shallow Subtidal B (-8.0 to -1.5)
- Intertidal Mudflat low (-1.5 to 0)
- Intertidal Mudflat mid low (0 to 1.3)
- Intertidal Mudflat mid high (1.3 to 3.0)
- Intertidal Mudflat high (3.0 to 4.3)
- Cordgrass Dominated low (4.3 to 5.6)
- Cordgrass Dominated high (5.6 to 7.0)
- Pickleweed Dominated (7.0 to 7.5)
- Upland (> 7.5)

figure 2

Shoreline Study Alternatives

Preliminary Alternative 2 Transitional - Upland Fill Footprint

Proj. # 211259

ESA PWA

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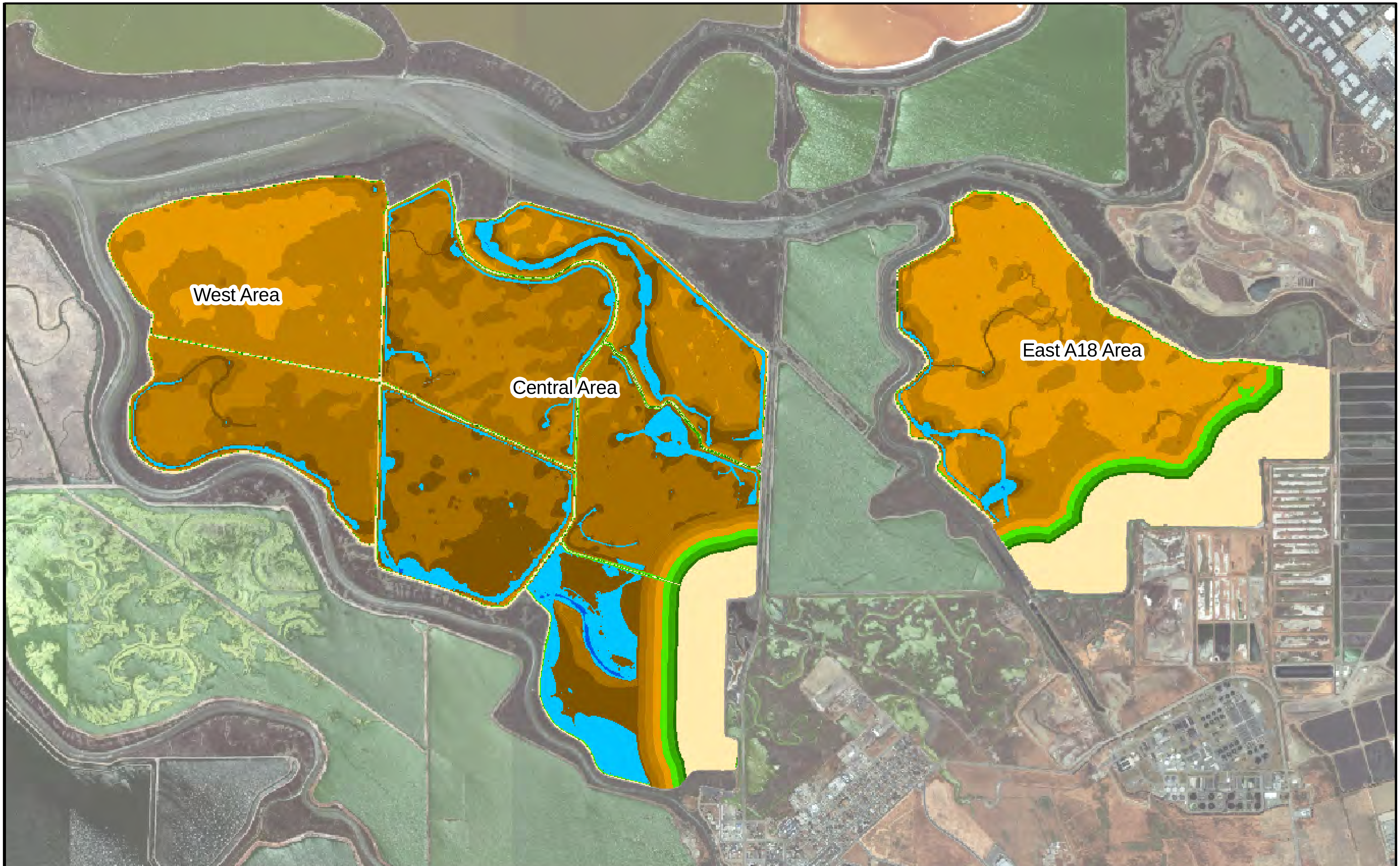

Initial conditions. No Marsh98 run. Fill 1:100.

N

0 550 1,100 2,200 3,300 4,400 5,500 Feet

Habitat Zones (ft NAVD)

- Deep Subtidal (< -21.2)
- Shallow Subtidal A (-21.2 to -8.0)
- Shallow Subtidal B (-8.0 to -1.5)
- Intertidal Mudflat low (-1.5 to 0)
- Intertidal Mudflat mid low (0 to 1.3)
- Intertidal Mudflat mid high (1.3 to 3.0)
- Intertidal Mudflat high (3.0 to 4.3)
- Cordgrass Dominated low (4.3 to 5.6)
- Cordgrass Dominated high (5.6 to 7.0)
- Pickleweed Dominated (7.0 to 7.5)
- Upland (> 7.5)

figure 3

Shoreline Study Alternatives

Preliminary Alternative 3 Transitional - Upland Fill Footprint

Proj. # 211259

ESA PWA

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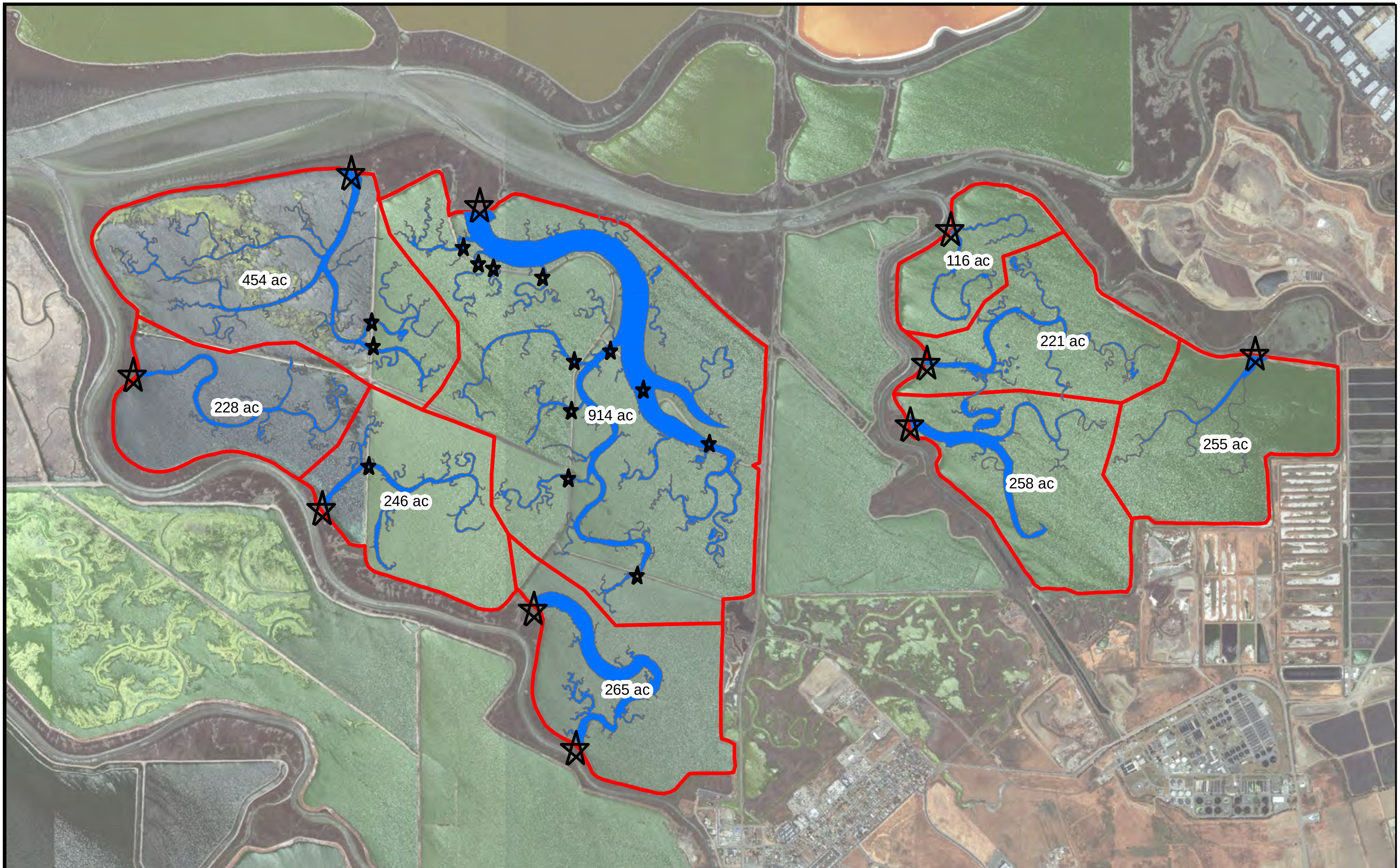

N

0 500 1,000 2,000 3,000 4,000 5,000 Feet

Watersheds (ac)

Historic channels

Outboard Levee Breach

Internal Levee Breach

figure 4

Shoreline Study Alternatives

Historic Tidal Watersheds and Channels

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ESA PWA

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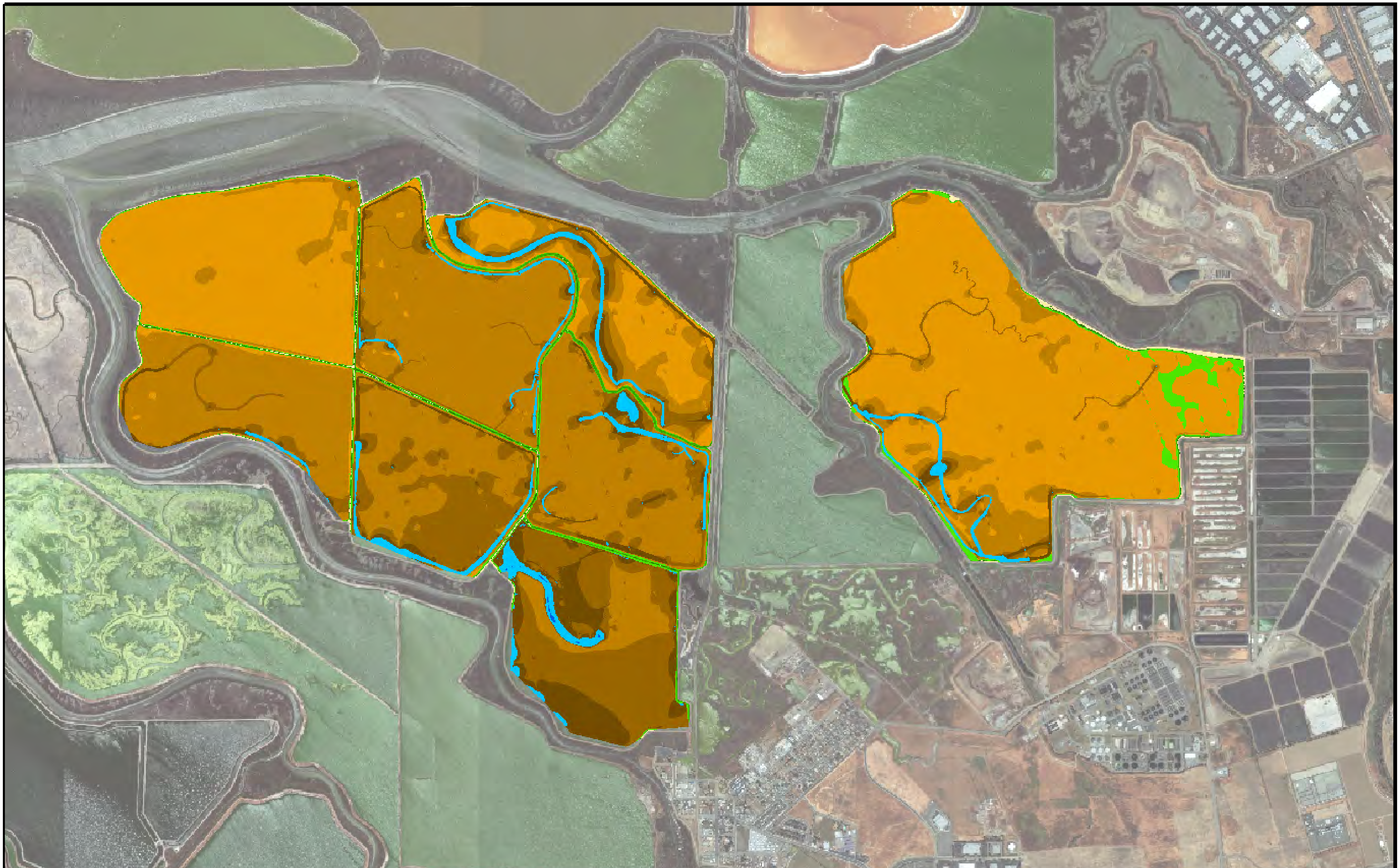

C0 = 100 mg/L, NRC-III, organics = 1 mm/yr
Start all areas in 2017

N

0 1,000 2,000 4,000 6,000 Feet

Habitat Zones

- Deep Subtidal
- Shallow Subtidal A
- Shallow Subtidal B
- Intertidal Mudflat low
- Intertidal Mudflat mid low
- Intertidal Mudflat mid high
- Intertidal Mudflat high
- Cordgrass Dominated low
- Cordgrass Dominated high
- Pickleweed Dominated
- Upland

figure 5

Shoreline Study Alternatives

2067 Marsh Elevations with C0 = 100 mg/L and 2017 Start

Proj. # 211259

ESA PWA

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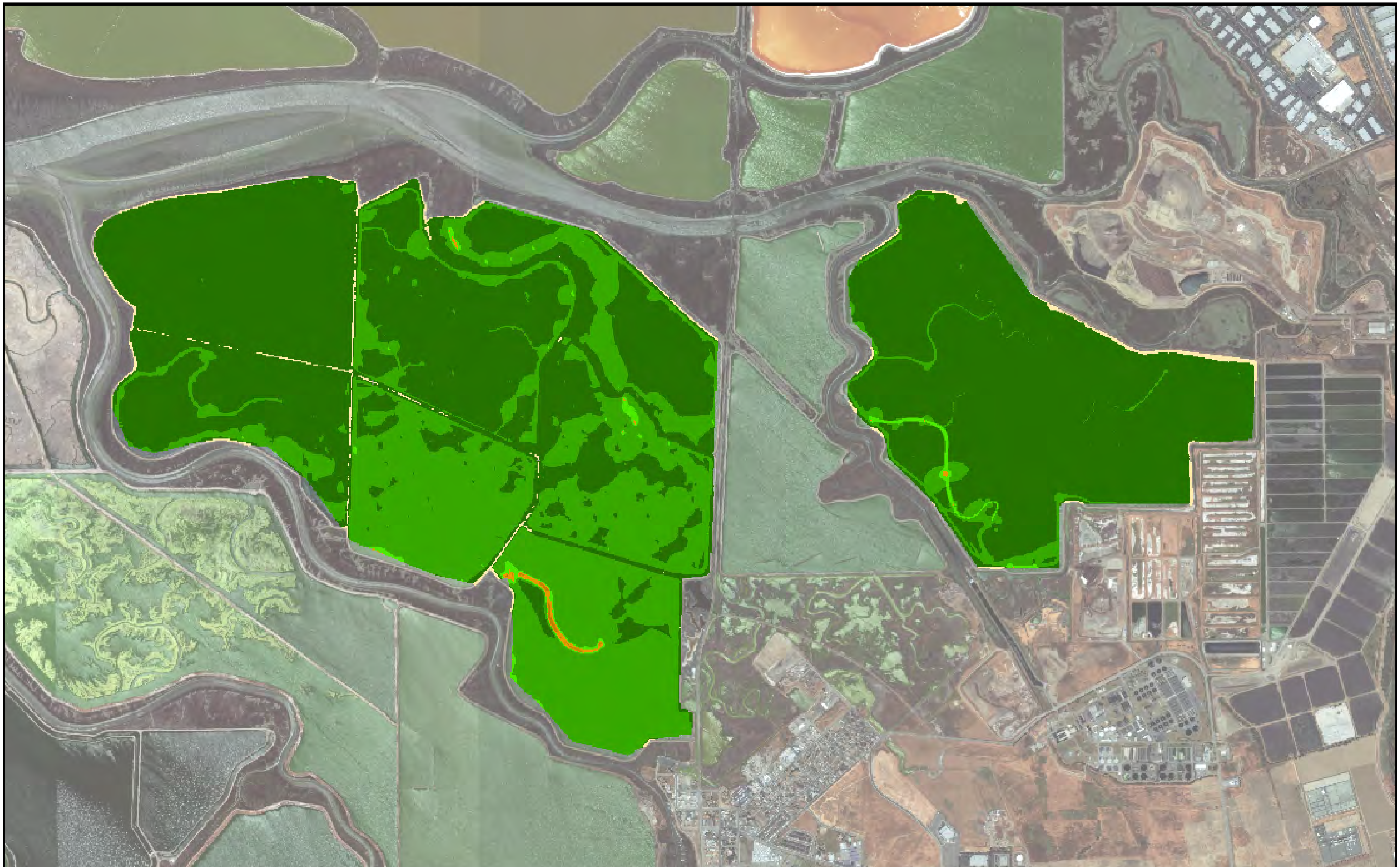

C0 = 200 mg/L, NRC-III, organics = 1 mm/yr
Start all areas in 2017

N

0 1,000 2,000 4,000 6,000 Feet

Habitat Zones

- Deep Subtidal
- Shallow Subtidal A
- Shallow Subtidal B
- Intertidal Mudflat low
- Intertidal Mudflat mid low
- Intertidal Mudflat mid high
- Intertidal Mudflat high
- Cordgrass Dominated low
- Cordgrass Dominated high
- Pickleweed Dominated
- Upland

figure 6

Shoreline Study Alternatives

2067 Marsh Elevations with C0 = 200 mg/L and 2017 Start

Proj. # 211259

ESA PWA

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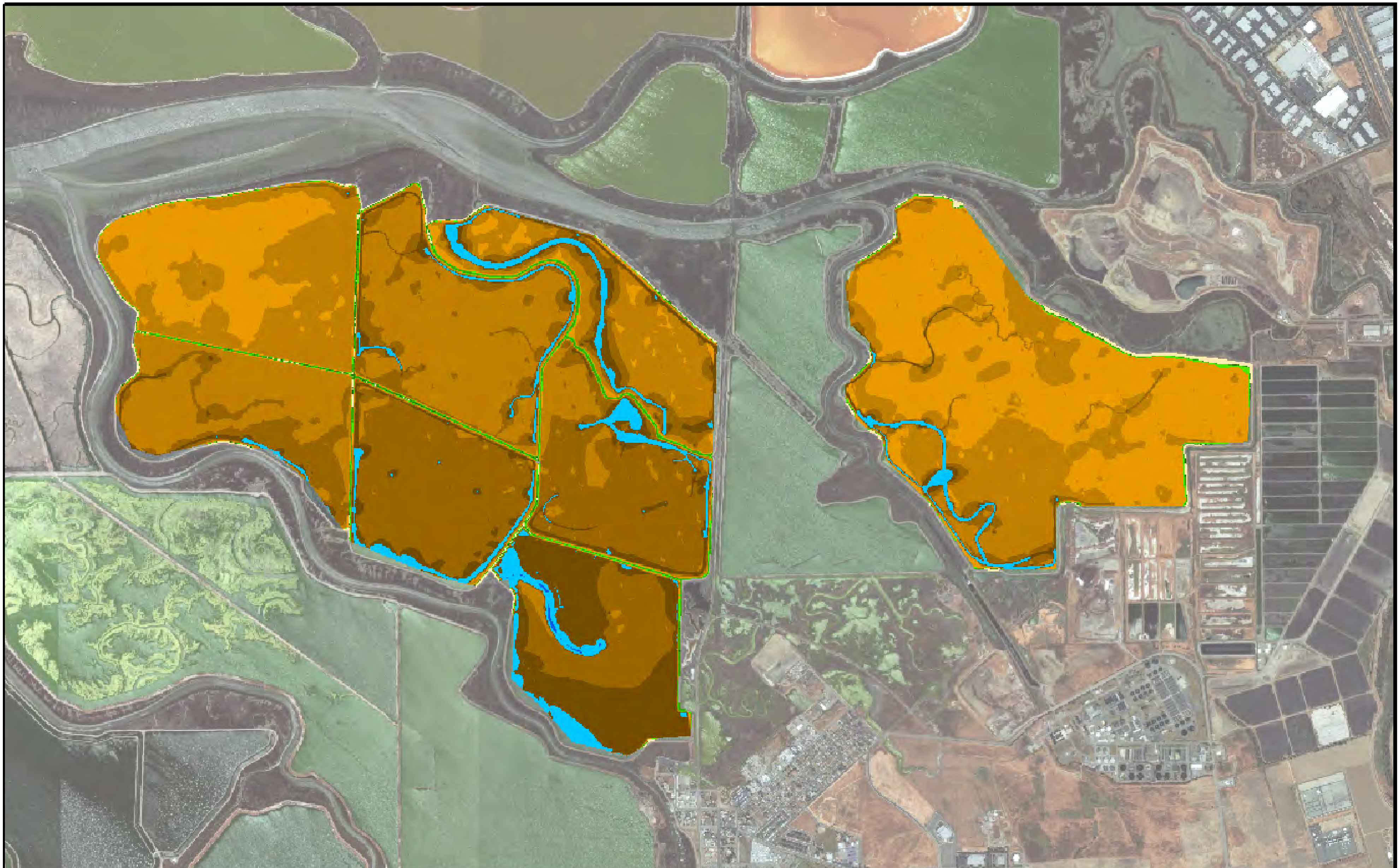

C0 = 100 mg/L, NRC-III, organics = 1 mm/yr
Start all areas in 2027

N

0 1,000 2,000 4,000 6,000 Feet

Habitat Zones

- Deep Subtidal
- Shallow Subtidal A
- Shallow Subtidal B
- Intertidal Mudflat low
- Intertidal Mudflat mid low
- Intertidal Mudflat mid high
- Intertidal Mudflat high
- Cordgrass Dominated low
- Cordgrass Dominated high
- Pickleweed Dominated
- Upland

figure 7

Shoreline Study Alternatives

2067 Marsh Elevations with C0 = 100 mg/L and 2027 Start

Proj. # 211259

ESA PWA

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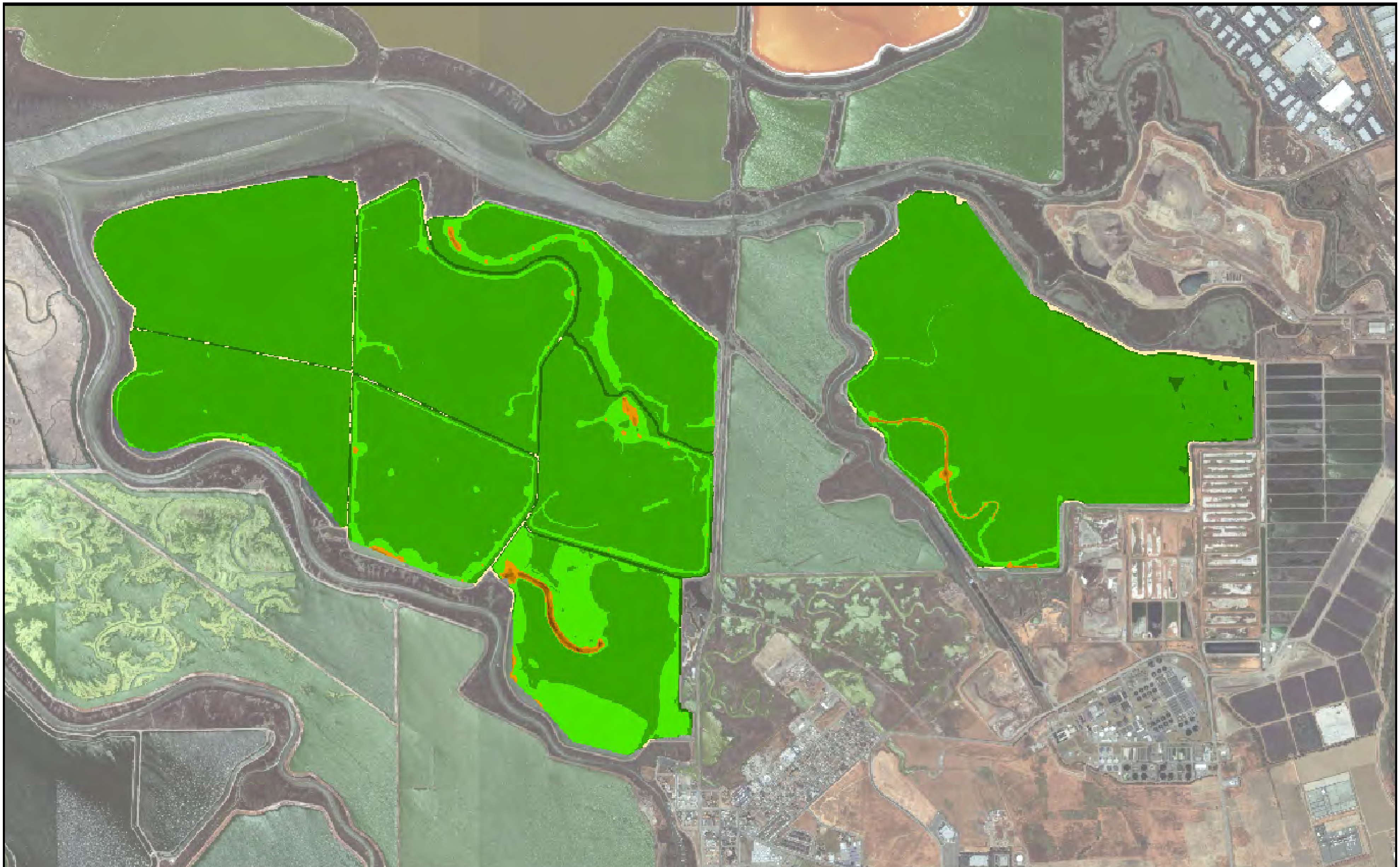

C0 = 200 mg/L, NRC-III, organics = 1 mm/yr
Start all areas in 2027

Habitat Zones

- Deep Subtidal
- Shallow Subtidal A
- Shallow Subtidal B
- Intertidal Mudflat low
- Intertidal Mudflat mid low
- Intertidal Mudflat mid high
- Intertidal Mudflat high
- Cordgrass Dominated low
- Cordgrass Dominated high
- Pickleweed Dominated
- Upland

figure 8

Shoreline Study Alternatives

2067 Marsh Elevations with C0 = 200 mg/L and 2027 Start

Proj. # 211259

ESA PWA

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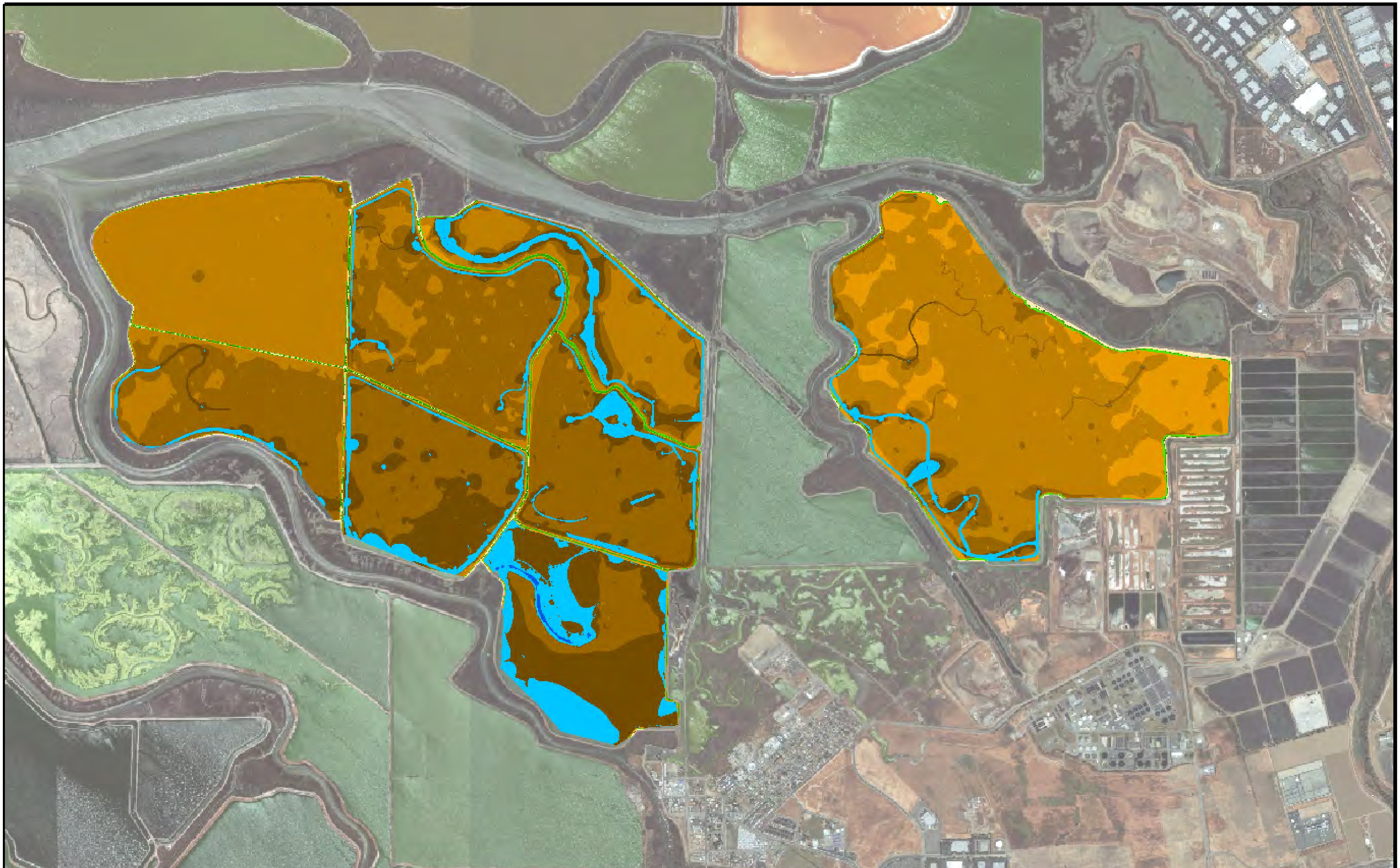

C0 = 100 mg/L, NRC-III, organics = 1 mm/yr
Start all areas in 2037

N

0 1,000 2,000 4,000 6,000 Feet

Habitat Zones

- Deep Subtidal
- Shallow Subtidal A
- Shallow Subtidal B
- Intertidal Mudflat low
- Intertidal Mudflat mid low
- Intertidal Mudflat mid high
- Intertidal Mudflat high
- Cordgrass Dominated low
- Cordgrass Dominated high
- Pickleweed Dominated
- Upland

figure 9

Shoreline Study Alternatives

2067 Marsh Elevations with C0 = 100 mg/L and 2037 Start

Proj. # 211259

ESA PWA

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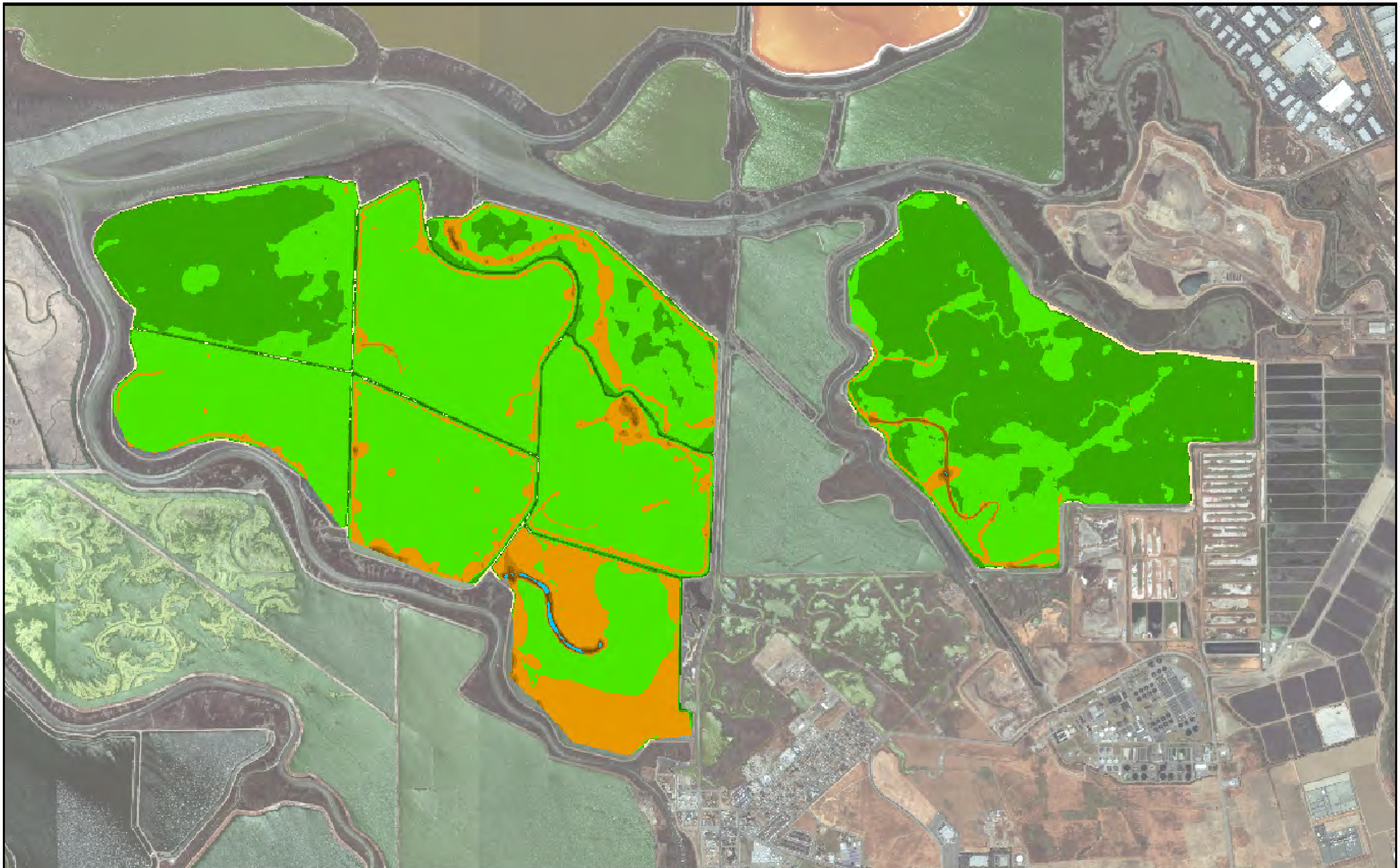

C0 = 200 mg/L, NRC-III, organics = 1 mm/yr
Start all areas in 2037

Habitat Zones

- Deep Subtidal
- Shallow Subtidal A
- Shallow Subtidal B
- Intertidal Mudflat low
- Intertidal Mudflat mid low
- Intertidal Mudflat mid high
- Intertidal Mudflat high
- Cordgrass Dominated low
- Cordgrass Dominated high
- Pickleweed Dominated
- Upland

figure 10

Shoreline Study Alternatives
2067 Marsh Elevations with C0 = 200 mg/L and 2037 Start

Proj. # 211259

ESA PWA

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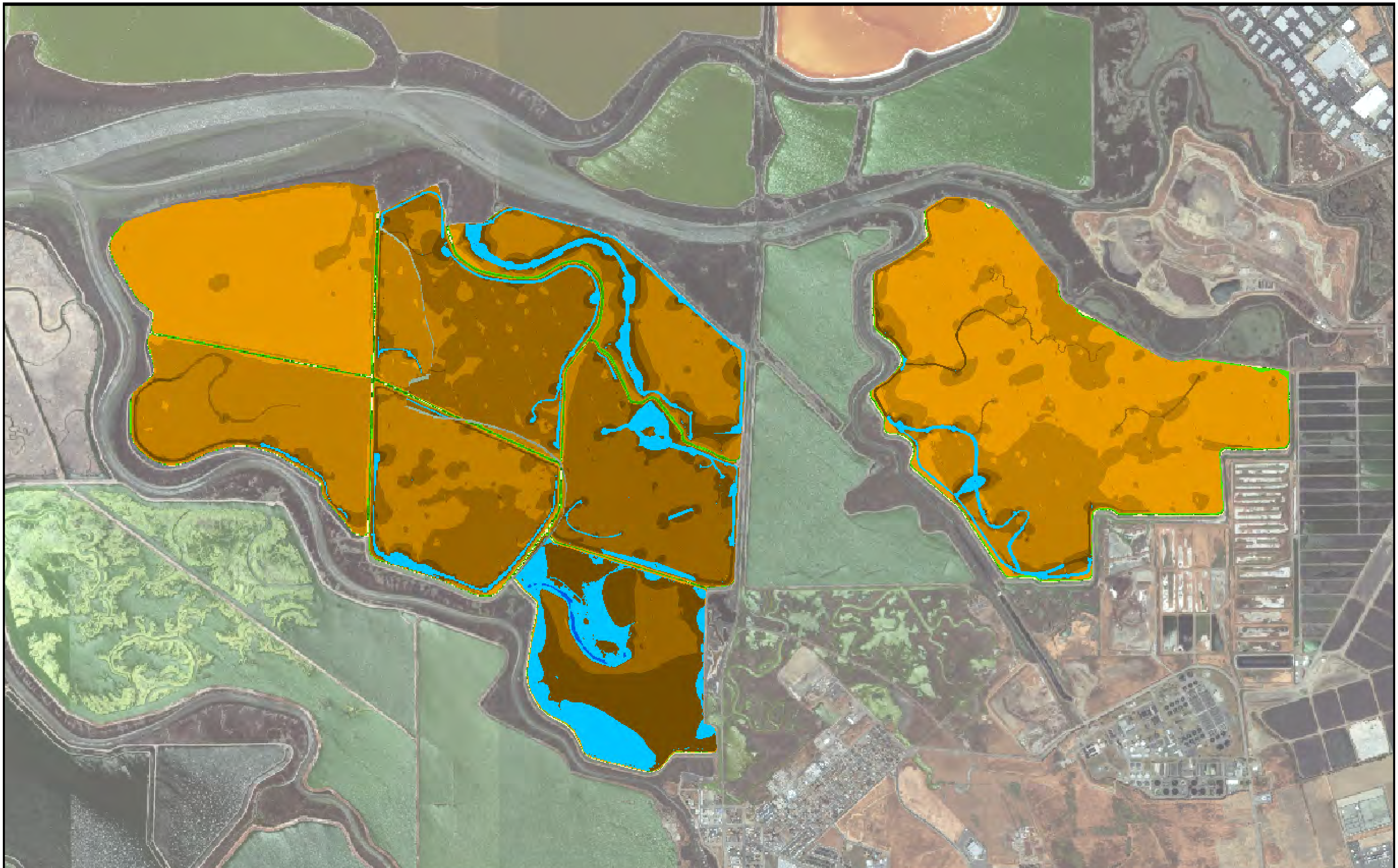

C0 = 100 mg/L, NRC-III, organics = 1 mm/yr
Start West Area in 2017, East Area (A18) in 2027, and Central Area in 2037

N

0 1,000 2,000 4,000 6,000 Feet

Habitat Zones

- Deep Subtidal
- Shallow Subtidal A
- Shallow Subtidal B
- Intertidal Mudflat low
- Intertidal Mudflat mid low
- Intertidal Mudflat mid high
- Intertidal Mudflat high
- Cordgrass Dominated low
- Cordgrass Dominated high
- Pickleweed Dominated
- Upland

figure 11

Shoreline Study Alternatives

2067 Marsh Elevations with C0 = 100 mg/L

Proj. # 211259

ESA PWA

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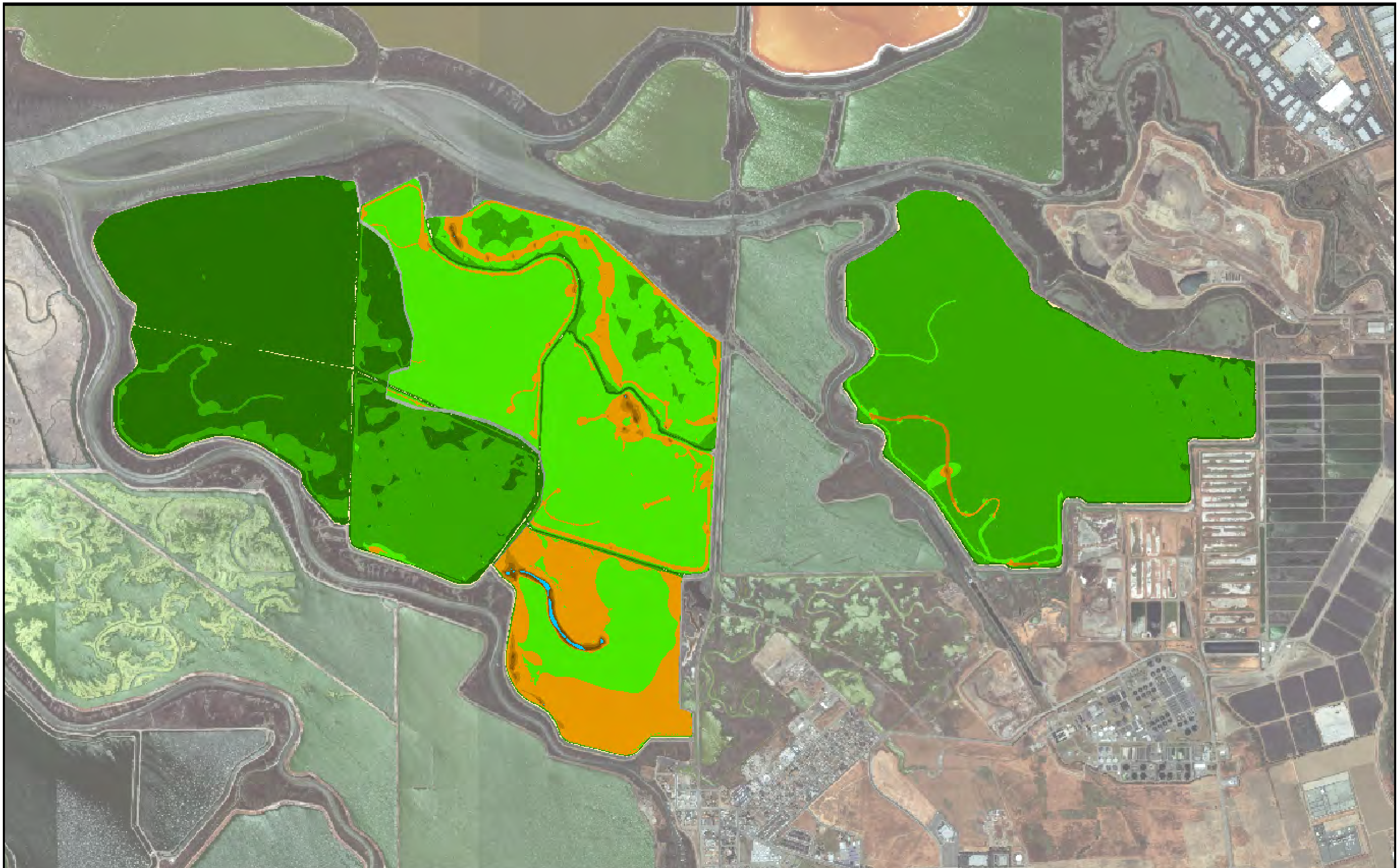

C0 = 200 mg/L, NRC-III, organics = 1 mm/yr
Start West Area in 2017, East Area (A18) in 2027,
and Central Area in 2037

N

0 1,000 2,000 4,000 6,000 Feet

Habitat Zones

- Deep Subtidal
- Shallow Subtidal A
- Shallow Subtidal B
- Intertidal Mudflat low
- Intertidal Mudflat mid low
- Intertidal Mudflat mid high
- Intertidal Mudflat high
- Cordgrass Dominated low
- Cordgrass Dominated high
- Pickleweed Dominated
- Upland

figure 12

Shoreline Study Alternatives

2067 Marsh Elevations with C0 = 200 mg/L

Proj. # 211259

ESA PWA

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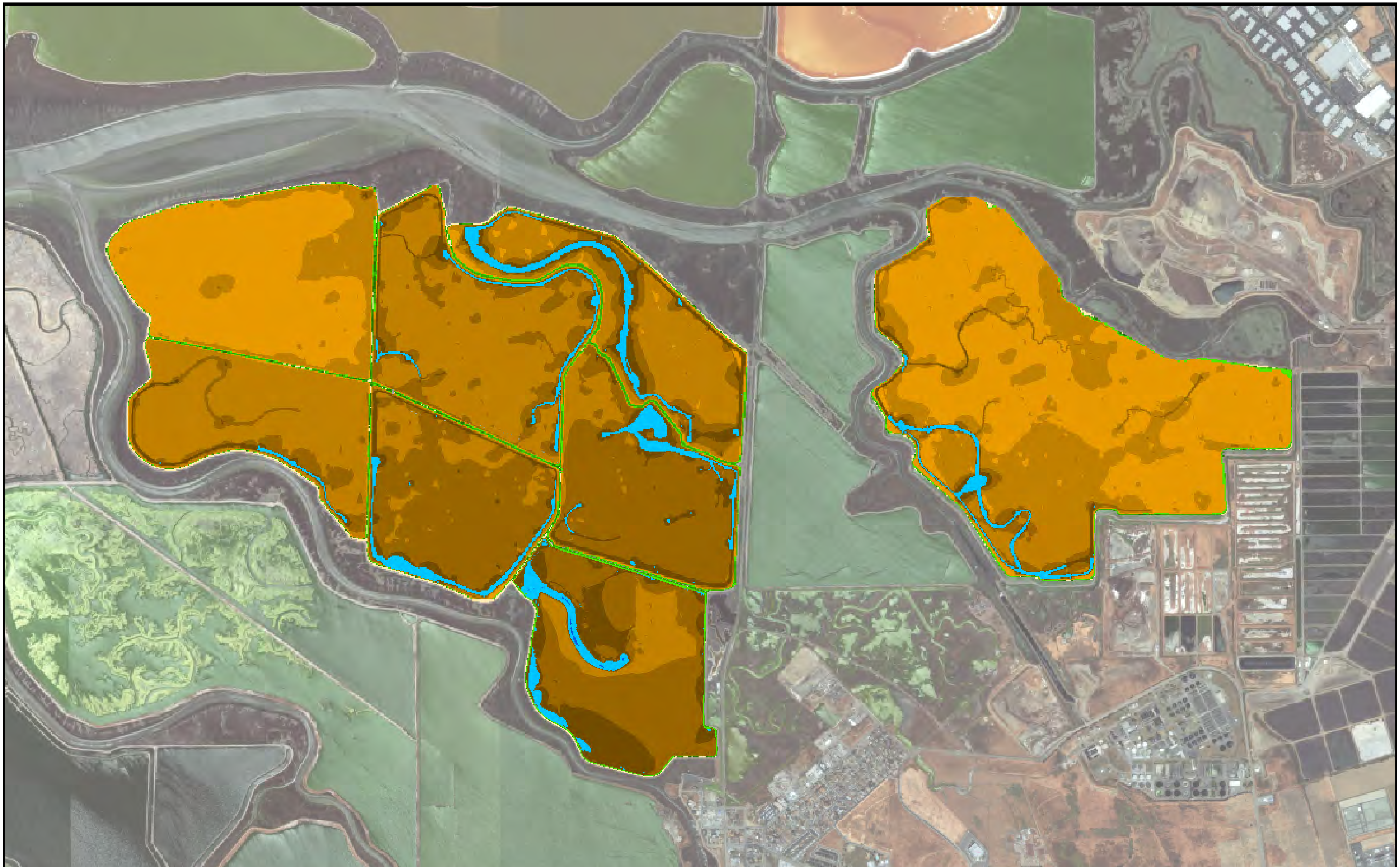


C0 = 100 mg/L, NRC-III, organics = 1 mm/yr
Start A12 in 2017, A9-11 in 2022, A18 in 2027, and A13-15 in 2030

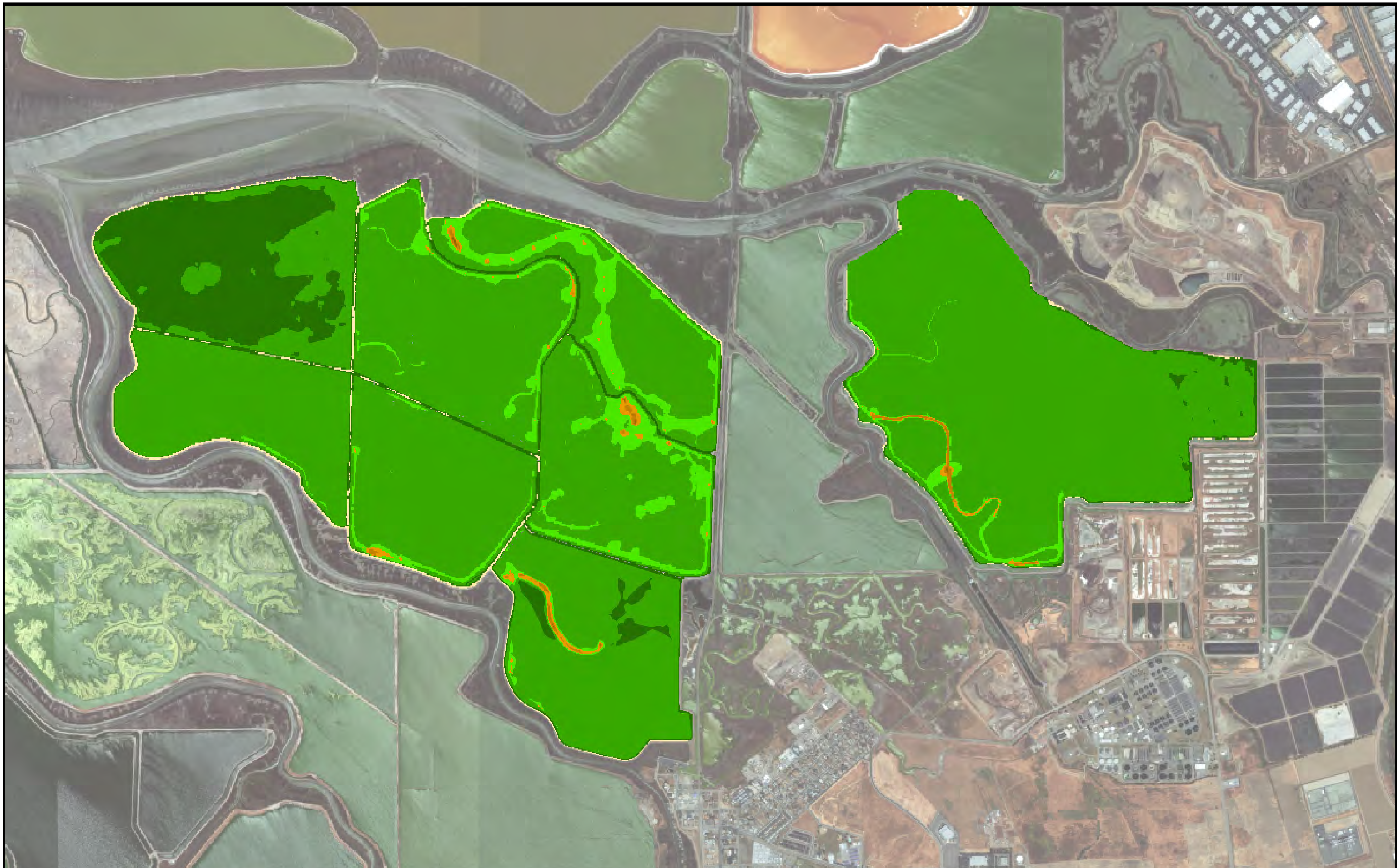
Deep Subtidal
Shallow Subtidal A
Shallow Subtidal B
Intertidal Mudflat low
Intertidal Mudflat mid low
Intertidal Mudflat mid high
Intertidal Mudflat high
Cordgrass Dominated low
Cordgrass Dominated high
Pickleweed Dominated
Upland

figure 13

Shoreline Study Alternatives

2067 Marsh Elevations with C0 = 100 mg/L

Proj. # 211259



C0 = 200 mg/L, NRC-III, organics = 1 mm/yr
Start A12 in 2017, A9-11 in 2022, A18 in 2027,
and A13-15 in 2030

Deep Subtidal	Intertidal Mudflat high
Shallow Subtidal A	Cordgrass Dominated low
Shallow Subtidal B	Cordgrass Dominated high
Intertidal Mudflat low	Pickleweed Dominated
Intertidal Mudflat mid low	Upland
Intertidal Mudflat mid high	

figure 14

Shoreline Study Alternatives

2067 Marsh Elevations with C0 = 200 mg/L

Proj. # 211259

ESA PWA

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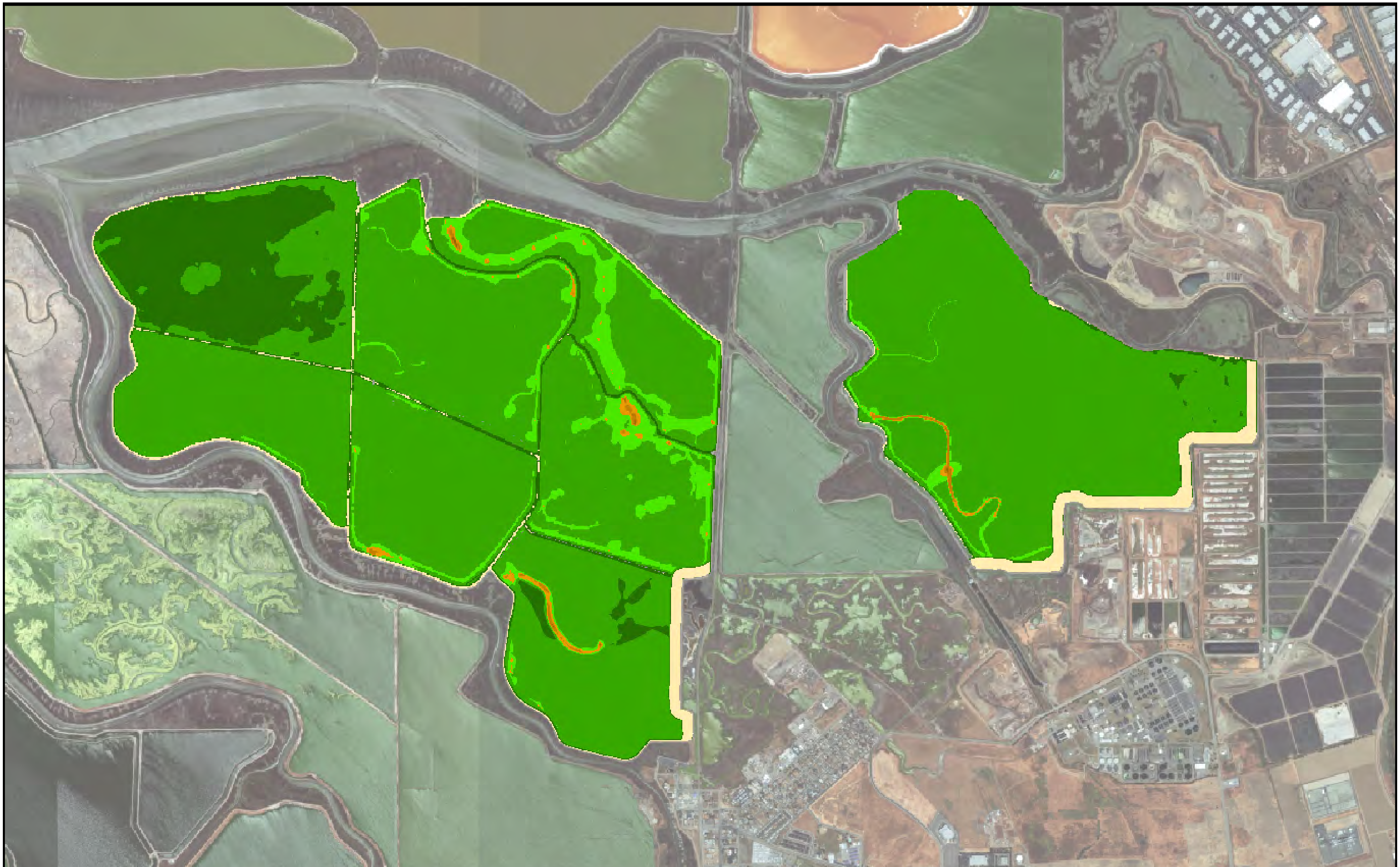

C0 = 200 mg/L, NRC-III, organics = 1 mm/yr
Start A12 in 2017, A9-11 in 2022, A18 in 2027, and A13-15 in 2030. Fill 1:30

Deep Subtidal	Intertidal Mudflat high
Shallow Subtidal A	Cordgrass Dominated low
Shallow Subtidal B	Cordgrass Dominated high
Intertidal Mudflat low	Pickleweed Dominated
Intertidal Mudflat mid low	Upland
Intertidal Mudflat mid high	

figure 15

Shoreline Study Alternatives
2067 Marsh Elevations with Prelim Alt 2 Transitional - Upland Fill Footprint

Proj. # 211259

ESA PWA

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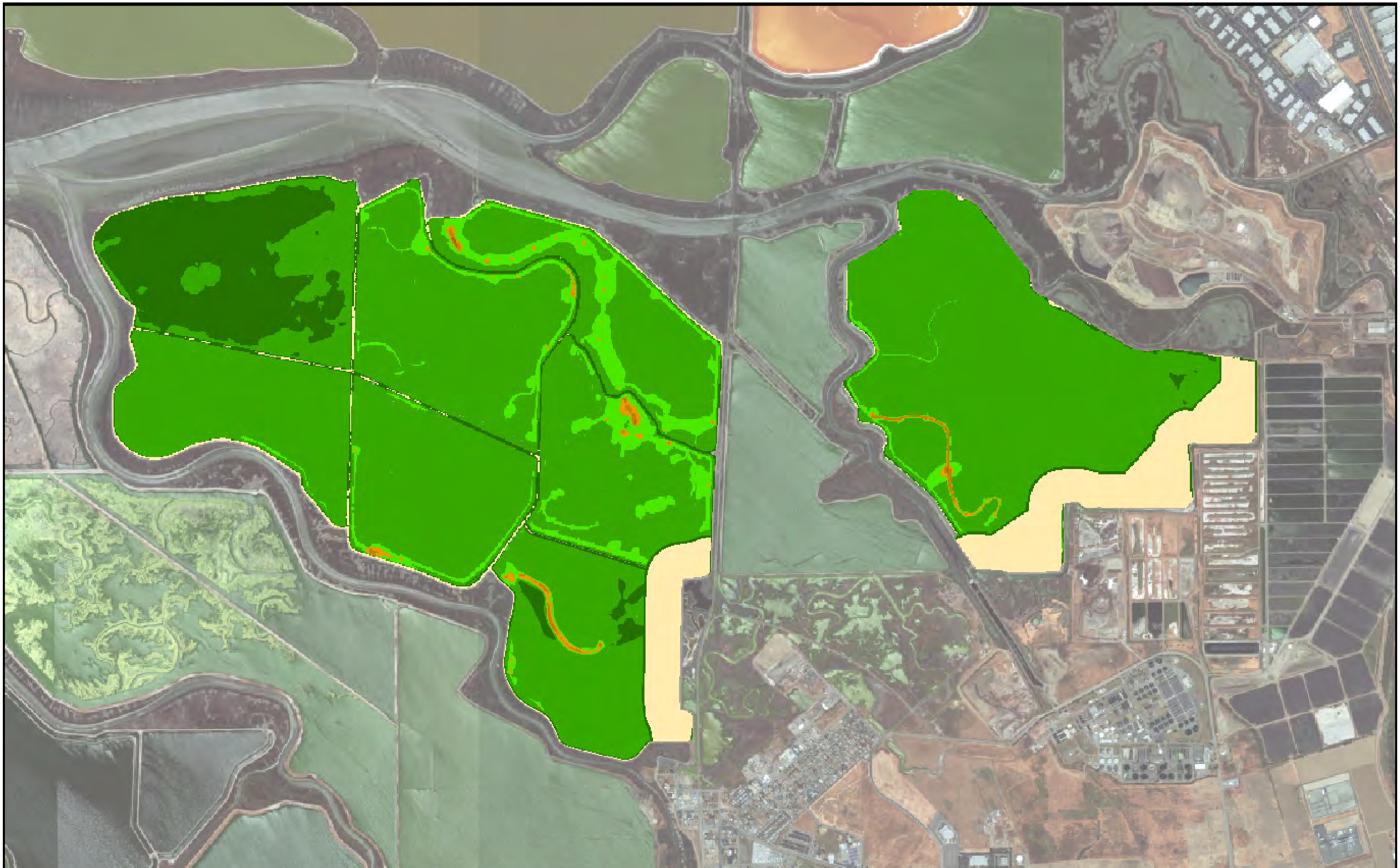

C0 = 200 mg/L, NRC-III, organics = 1 mm/yr
Start A12 in 2017, A9-11 in 2022, A18 in 2027,
and A13-15 in 2030. Fill 1:100

N

0 1,000 2,000 4,000 6,000 Feet

- Deep Subtidal
- Shallow Subtidal A
- Shallow Subtidal B
- Intertidal Mudflat low
- Intertidal Mudflat mid low
- Intertidal Mudflat mid high
- Intertidal Mudflat high
- Cordgrass Dominated low
- Cordgrass Dominated high
- Pickleweed Dominated
- Upland

figure 16

Shoreline Study Alternatives

2067 Marsh Elevations with Prelim
Alt 3 Transitional - Upland Fill Footprint

Proj. # 211259

ESA PWA

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Appendix B2

Environmental Benefits Analysis (CHAP) Summary and Model Outputs

South San Francisco Bay Shoreline Study

COMBINED HABITAT ASSESSMENT PROTOCOLS (CHAP) RESULTS FOR THE WITH-PROJECT AND WITHOUT-PROJECT CONDITIONS

San Francisco District, U.S. Army Corps of Engineers

July 22, 2015

1.0 Introduction

1.1 Study and Study Area

The San Francisco Estuary, including San Francisco Bay and adjoining bays, has lost approximately 90 percent of its tidal marshes over the last 165 years due to diking, filling, and other human activities. This has resulted in substantial loss of tidal marsh functions and wildlife habitat, and has led to listing of several species under the Endangered Species Act. In the south portion of San Francisco Bay (the South Bay), a large portion of these tidal marsh losses were due to conversion of tidal marsh to commercial salt ponds decades ago. Many of these ponds were acquired for conservation purposes by Federal and State agencies in 2003.

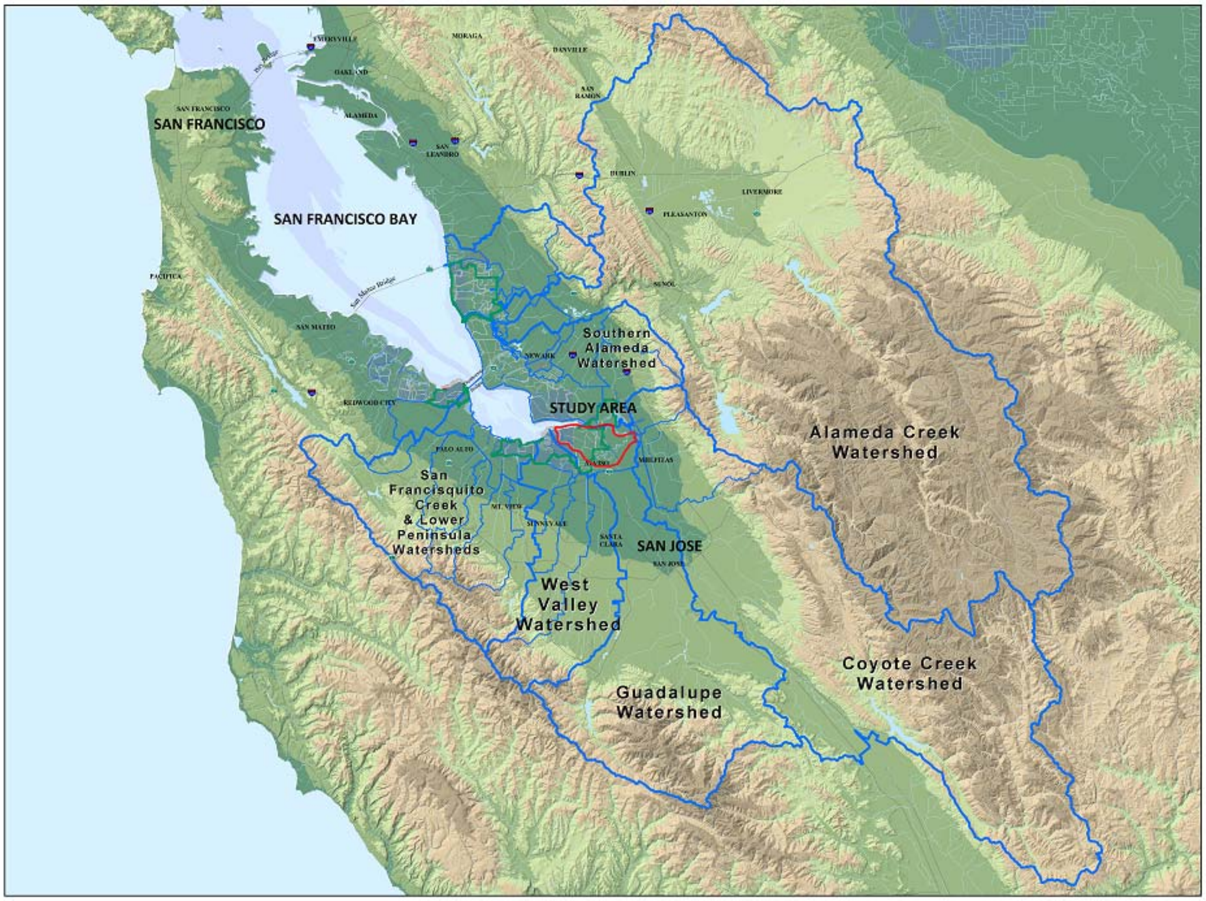
The South San Francisco Bay Shoreline Study is considering flood risk management (FRM) and ecosystem restoration (ER) actions in the Alviso area in the South Bay. FRM actions under consideration would cause loss of a small portion of existing habitats, and conversion of managed ponds into tidal and transitional habitats for ER purposes would affect existing habitat values by replacing one kind of habitat with several other types. Figure 1 shows the general location of the study area in the context of San Francisco Bay and local watersheds.

U.S. Army Corps of Engineers (USACE) planning policy requires a cost-effectiveness analysis of potential ER measures to determine the optimal components to be included in the final array of alternatives and to assist in the selection of the preferred alternative. In addition, various environmental laws and regulations require analysis of environmental impacts from a project including effects on fish and wildlife habitat. Thus, quantifying effects on fish and wildlife habitat is an important task for this study. Additional habitat and species analyses, such as acres of habitat types and effect on endangered species, were handled separately using other methods and are reported in other documents such as the Final Integrated Report for this study.

1.2 Selection of Habitat Goals

The key issue in considering the future of existing managed ponds along the shoreline of San Francisco Bay is the habitat and wildlife tradeoff between retaining or improving these ponds as habitat for water birds (waterfowl and shorebirds) versus restoring these sites to tidal action with their associated habitats, fish, and wildlife. A planning effort by federal and state agencies, the South Bay Salt Pond Restoration Study, has determined that some of the managed ponds in the South Bay should be converted to tidal habitats, primarily tidal marsh, to restore marsh functions and to further the recovery of endangered species that use these habitats (South Bay Salt Pond Project, 2007). This decision has been made with the full understanding that considerable existing habitat value for water birds will be lost in order to obtain the needed tidal habitat benefits. The South Bay Salt Pond Project has subsequently breached some ponds while enhancing other ponds for bird use to offset losses of habitat value for birds.

Figure 1: Study Area



2.0 Methods

2.1 Value and Limitations of Habitat Evaluation Methods

Habitat evaluation methods are intended to quantify the relative values of different areas whose ecological value may be lost, degraded, or improved by project activities. Determining the ecological value of an area is a complex matter, in part because any area that serves as fish or wildlife habitat will have a number of ecological functions and values in the context of a larger landscape. In a very limited context it may be relatively easy to determine what would improve habitat values in a small area, but local optimization of habitat value may not always be optimal in a landscape context. This issue will be discussed further later on in this report.

2.2 Tidal vs. Non-Tidal Habitats

Given the findings of the South Bay Salt Pond Restoration Study, the Shoreline Study has examined the feasibility of converting existing managed pond habitat to tidal habitats, with the understanding that such restoration efforts would convert one valuable habitat into another. In such cases, comparing the habitat outputs of study alternatives to the without-project condition may not show any net gain, and is not useful in comparing the cost-effectiveness of these alternatives.

Thus, *only for purposes of evaluating the cost-effectiveness of ER measures and alternatives*, this study set the habitat units for non-tidal habitats to zero. The gross tidal habitat outputs under CHAP from within the restoration area are counted as ecosystem restoration benefits for USACE planning purposes. This issue is addressed again in Section 4.

2.3 Overview of Habitat Evaluation Methods Selected for this Study

The Combined Habitat Assessment Protocols (CHAP) was selected, in consultation with the South Pacific Division of USACE, for quantifying ecosystem restoration benefits for the South San Francisco Bay Shoreline Study. CHAP is a method for quantifying the value of habitat for wildlife developed by the Northwest Habitat Institute (NHI). It builds upon older methods such as the FWS' Habitat Evaluation Procedures (HEP) and the Habitat Accounting and Appraisal (HAB) method. Unlike HEP it evaluates all the vertebrate species found in a given habitat area, and can be expanded to cover selected invertebrate species. CHAP habitat units are not comparable to HEP habitat units and should not be directly compared due to their different scaling.

CHAP looks at both the requirements of individual species (key ecological correlates or KECs) as well as the functions these species provide for their ecosystem (key ecological functions or KEFs). Given these areas of emphasis, CHAP generally gives higher scores for locations with higher biodiversity and more complex habitat structure within a given habitat type. CHAP operates within a geographic information system (GIS) environment.

A habitat study using the California Rapid Assessment Method (CRAM) was also performed. While this study provided very useful projections of future habitat conditions, it was not able to produce annualized benefits for assessing the cost-effectiveness of ecosystem restoration efforts and was not used to evaluate alternatives.

2.4 Method for Determining Baseline Conditions

The CHAP approach involves four steps: 1) preliminary mapping, 2) field inventory, 3) data compilation and analysis, and 4) production of GIS maps, spreadsheets, and report. Detailed information on methods used and the baseline findings are available in Northwest Habitat Institute (2015a). Results are provided here in summary form for reference. Habitat types are listed in Table 1 and mapped in Figure 2. The species numbers selected are listed by class in Table 2. Key ecological correlates (KECs) and key ecological functions (KEFs) were identified for each species and are presented in Northwest Habitat Institute (2015a).

To complete the determination of baseline CHAP information, GIS maps were generated that depict the habitat values (HUs) of each polygon. Supporting maps illustrated: a) study area boundaries; b) polygon numbering; c) corrected habitat value per acre; d) habitat units; e) amounts of non-native plant species by polygon; f) wildlife habitat types by polygon; and g) structural conditions by polygon. Spreadsheets were developed that contain the polygon calculations of the species-functions and habitat-functions matrices, along with an overall site or area habitat value.

2.5 Forecast of Future Without-Project Habitat Conditions

Existing wetland habitats in the south portion of San Francisco Bay are artificially fragmented and degraded, which raises the question of whether all existing wildlife species and populations in the area are sustainable in the long term. The habitat evaluation team reviewed the species included in the CHAP analysis and projected loss of four species over the course of the habitat evaluation period, in the absence of an ecosystem restoration project.

Several external factors could affect future habitat values in the absence of a project. These include sea level rise, climate change, invasive species, or other unforeseen environmental changes. However, other than land use changes guided by existing land use plans, such changes are highly uncertain as described below. Future habitat conditions were therefore assumed to be the same as current conditions in the absence of a project, except as noted below.

Table 1: Habitat Types		
Tidal Habitats	*Non-Tidal Habitats*	
Saline Marsh	Batch Pond	Parks / Upland Grassland
Brackish Marsh	Managed Pond	Levee
Freshwater Marsh	Muted Tidal / Diked Marsh	Water / Sewage Treatment
Tidal Flats/Mudflats	Seasonal Wetland	Landfill
Open Water/Slough Channel	Upland Vegetation	Developed
	Riparian/Creek Corridor	

Table 2: Number of Vertebrate Species Included in the CHAP Analysis						
Class	Fish	Amphibians	Reptiles	Birds	Mammals	Total
Number of Species	51	0	6	177	17	251

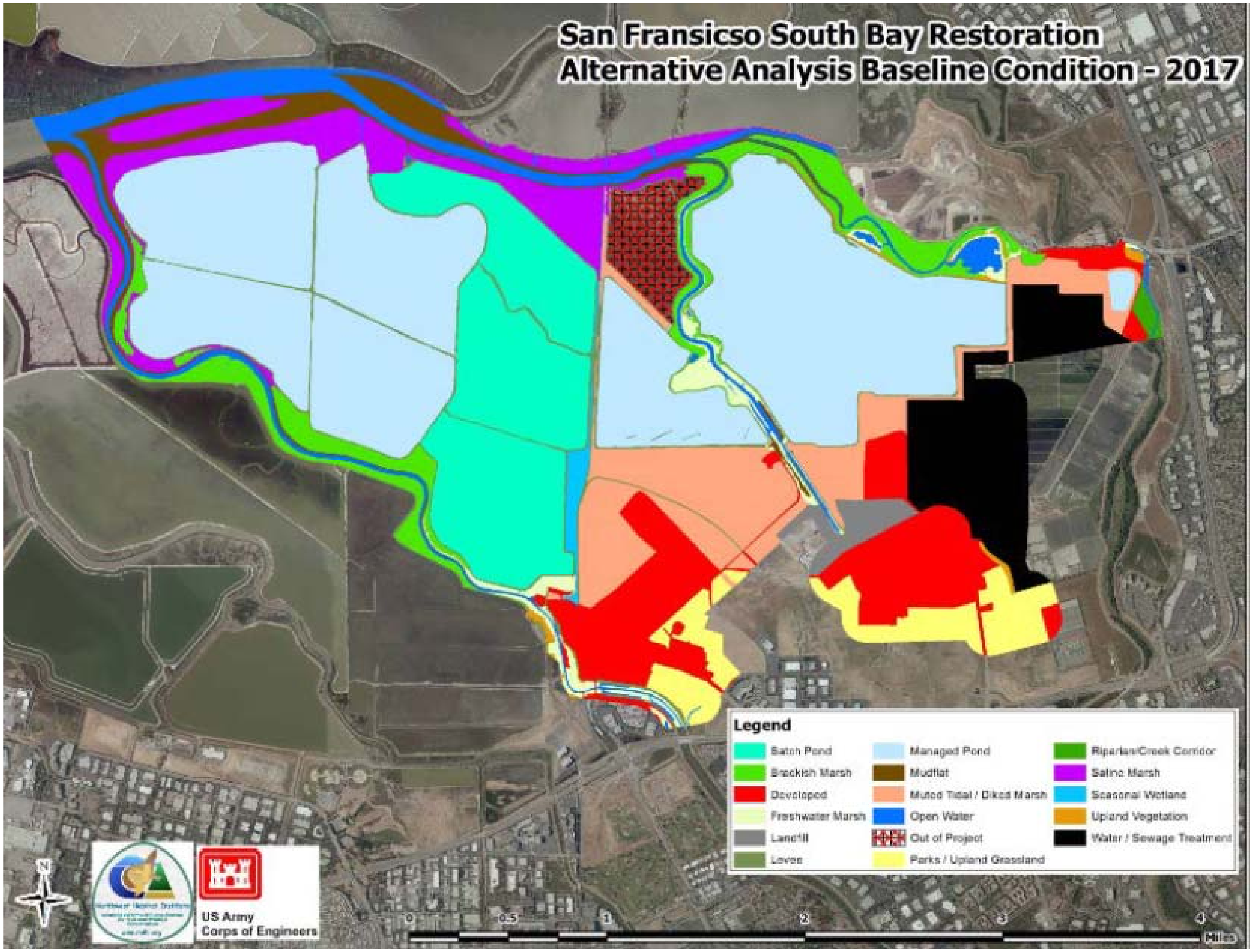
Note: Classes shown are the traditional taxonomic groupings for vertebrates that are most commonly used in planning and management of ecosystems. Evolutionarily unified (monophyletic) groups may differ from these categories.

2.5.1 Sediment Availability and Sea Level Rise

Areas already subject to tidal action would be affected by sea level rise (SLR). To evaluate this issue, consideration of the past behavior of the area as well as forecasts of future sediment dynamics should be taken into account. Due to the past construction of steep-sided levees and dikes along the shores of essentially all land areas in the study area, the transition from tidal to non-tidal areas within the study area is very abrupt. Therefore, significant encroachment of tidal waters and marshes onto currently non-tidal lands is not expected during the evaluation period.

During portions of the 20th Century, the study area experienced large amounts (2 to 6 feet in 33 years) of relative SLR due to land subsidence caused by overdraft of deep aquifers underlying the Santa Clara Valley and neighboring portions of San Francisco Bay. Due to relatively high suspended sediment concentrations in tidal waters within the study area, local tidal marshes were able to trap sufficient sediment to keep up with this relative SLR and even expand into mudflat areas (H.T. Harvey and Associates, 2012).

Figure 2: Habitat Types



Map credit: H.T. Harvey and Associates; Northwest Habitat Institute

Tidal wetlands in the San Francisco Estuary are generally accreting sediment fast enough to keep up with SLR (Callaway et al.,2012). In the immediate vicinity of the study area, Coyote Creek and Alviso Slough show much higher rates of accretion (Watson 2004, and Patrick and DeLaune 1990), which may be a response to past local subsidence coupled with the abundant fine sediment supply in the area (Patrick and DeLaune 1990). This past subsidence can be viewed as an analog for current eustatic SLR.

Projected net local SLR between the present time and the end of the evaluation period (56 years from the present) is at the low end of past relative SLR in the study area and would occur over a much longer period. Modeling of tidal marsh adaptation to SLR in San Francisco Bay suggests that the study area is expected to retain a relatively high ability to adapt to SLR over the next 60 years (Stralberg et al., 2011).

Therefore, it is reasonable to project that tidal marshes in the study area will be able to keep up with SLR through sediment capture for the duration of the evaluation period. Mudflats and subtidal habitats can be expected to evolve some during this period but no large net changes in their extent is expected. However, it should be noted that this situation may change in decades following the evaluation period, as the rate of SLR is expected to accelerate greatly later in the century.

2.5.2 Climate Change

Another factor that could affect habitat values is climate change. While most attention on this issue has focused on global forecasts, regional climate change is what would affect local conditions. However, regional forecasts contain considerable uncertainty, including that due to uncertainty over future emissions of greenhouse gases. These forecasts do agree that increasing average temperatures can be expected in California over the course of this period. However, it can reasonably be expected that sites within a short distance of tidal waters and downwind from those waters, such as those in the study area, can be expected to have relatively modest changes in average air temperatures due to the moderating effect of these waters.

The most likely means for future regional climate change to affect local habitat conditions would be through changes in moisture balance. Increased temperatures increase evapotranspiration even if precipitation stays the same. However, the Third National Climate Assessment (Melillo, et al., 2014) shows only modest (under five percent) projected reductions in soil moisture in the San Francisco Bay Area for the 2040-2071 period. This would primarily affect non-tidal habitat areas, though decreased moisture could have a modest effect on upper tidal marsh vegetation which receives relatively infrequent tidal water input.

With the exception of New Chicago Marsh which has some access to Bay water, non-tidal vegetated areas in the study area consist nearly entirely of degraded and invasive non-native vegetation types. Based on the ecological tolerances of these habitat types, they are not expected to experience substantial changes in habitat attributes and structure under the modest temperature increases and soil moisture deficits projected for the study period, and in any case it is not possible to quantify such changes with any degree of reliability at this time.

2.5.3 Invasive Species

Invasive species have continued to arrive in the study area and cause new ecological disruptions from time to time. The CHAP evaluation assumes this will continue to occur and adjusts future habitat values accordingly.

2.5.4 Site-Specific Factors

Site-specific factors that could affect habitat values in the study area consist of potential changes in land use and management. Relevant study assumptions for the without-project condition include:

•The managed ponds under study (A12-A15 and A18) would continue under similar management as present. Levee reinforcement efforts under current management would continue in the future. While pond breaches might occur sporadically, they would be repaired reasonably promptly and would not result in significant changes in habitat value in the long term. Pond A16 and A17 were not evaluated under this study as they have recently been restored or modified as part of a separate project.
•New Chicago Marsh would not change significantly. This assumes that the USFWS raises levees adequately over time to keep out regular tidal action. This would be needed for the USFWS to minimize liability for flooding of Alviso. This does not imply an adequate level of flood protection for developed areas, but rather the exclusion of tidal action under normal circumstances.
•The City of San José implements its master plan for the San José-Santa Clara Water Pollution Control Plant and surrounding lands it owns. This would include new development in some currently undeveloped areas.
•The City of San José would allow development to continue in the Alviso area as provided by existing plans. Over several decades all remaining developable private lands would become urbanized in this planning area. It is assumed that any subsequent abandonment of developed properties in the Alviso area due to increased flooding risk late in the evaluation period would not result in restoration of natural habitat values on these properties, due to the dominance of pavement and buildings on these sites which would largely prevent natural revegetation.
•Other non-tidal habitats would not be expected to change significantly.

2.6 Forecast of Future With-Project Habitat Conditions

All study alternatives include a phased approach to implementation of ecosystem restoration. Modeling of landscape evolution assumed that construction of the flood risk management levee would start in 2017 along with the restoration features within Pond A12. The pond would be breached in 2020, which would represent the start of the first phase of habitat development. Additional construction of restoration features, culminating in breaching of additional sets of ponds, would be accomplished in two successive phases to be completed in 2025 and 2030. See Section 2.7 for updates to this schedule. Following completion of each phase, the breached pond(s) would evolve naturally into mudflats and tidal marsh over time, potentially with assistance from the proposed adaptive management program.

Forecast of future habitat conditions started with the landscape evolution modeling performed by Environmental Sciences Associates/Philip Williams Associates. This modeling provided forecasts of substrate elevation in the breached ponds at discrete intervals for a period extending 50 years into the future from the expected start of construction. These forecasts provided a basis for projecting basic habitat types and acreages in the restored ponds at specific times in the future.

The next phase of forecasting was conducted by H.T. Harvey and Associates, and provided more detailed projections of habitat conditions in breached ponds to assist in the CRAM modeling. Projected habitat information available in GIS format was used by NHI to provide additional habitat details in restored ponds at specific points in the future. The result was a comprehensive set of maps of future habitat polygons. NHI then applied appropriate species, KECs, and KEFs to these polygons, based on their baseline work, to provide the basis for calculating CHAP outputs at specific points in the future under with-project conditions. Finally, with habitat units projected for specific times in the future, these units were averaged to produce average annual habitat units (AAHUs) which were the basis for comparing alternatives.

Forecast of future conditions was also needed for two sets of habitats not directly affected by the alternatives. First, marshes already subject to tidal action could be affected by SLR; this is addressed under the discussion of without-project conditions. Second, areas not subject to tidal action and not directly affected by an alternative might change in the future for other reasons. For these areas, future habitat conditions were generally determined to be the same as under the without-project condition except as otherwise noted.

2.7 Modeling and Evaluation Periods

Analyses performed for the South San Francisco Bay Shoreline Study used a 50-year economic evaluation period running from 2017 to 2067. After the modeling efforts were completed and the draft Integrated Report was circulated, the timing and phasing of construction including pond restoration was modified to address passage of time as well as public and agency concerns:

- Construction is now projected to start in 2018, which would move all following dates one year back.
- The first phase of construction would be complete in 2021, including breaching the first ponds.
- For USACE planning purposes, the evaluation period was changed to run from 2021 to 2071 to ensure consistency with USACE planning requirements.
- Ponds A12 and A18 are now proposed to be breached in the same year, after which further phases of breaching would be sequenced as originally planned, albeit delayed by one year. This would move up the breaching of Pond A18 by five years relative to other ponds, and would likely have a similar effect on subsequent habitat evolution in this pond.

Incorporating these changes into the CHAP study would have required redoing the landscape evolution and habitat evolution modeling before redoing the CHAP modeling itself, thereby causing substantial delays in the study. However, effects of these changes should be essentially identical across all four restoration alternatives due to their similarity. Since the NHI CHAP reports (Northwest Habitat Institute, 2015a; Northwest Habitat Institute, 2015b) use the earlier dates these will be retained for this report as well. Habitat changes beyond the end of this period are considered in evaluating the long-term sustainability and adaptability of study alternatives, but are not used for calculating ecosystem restoration or flood risk management benefits for these alternatives.

3.0 Alternatives and CHAP Results

3.1 Overview

FRM and ER measures (individual actions) were considered and combined into FRM and ER options (related actions that constitute building blocks for formulating complete alternatives). The bases for formulating these measures, for initial screening of them, and for the overall restoration design are described in the Integrated Report.

The options were assembled into combined FRM/ER alternatives for evaluation. ER options could not be evaluated on their own, as their success requires additional options to be implemented. For instance, the ecotone requires both an FRM levee option and a pond restoration option to be workable.

3.2 Ecosystem Restoration Options

A variety of ER and FRM measures were assessed for possible combination into ER options. ER options carried forward for detailed evaluation are listed below. The basic pond restoration, levee, and bench options were base action conditions (the minimum restoration actions required for a functioning alternative), and the other options represent additional expense and complexity incurred in pursuit of improved ER outputs.

- Basic pond restoration
- Accelerated pond restoration (additional ER measures in ponds)
- FRM levee with bench along the pond side
- 30:1 ecotone
- 100:1 ecotone

The minimal ER action would be basic pond restoration. The bench is an integral component of the several FRM levee alternatives considered and has incidental ER value. The 30:1 ecotone and 100:1 ecotone options represent increased investment in ecosystem restoration. An additional option for increased investment, accelerated pond restoration, could not be evaluated by CHAP due to data issues.

Various combinations of these options were considered in the plan formulation process. At the time of the initial CHAP alternatives modeling, two levee alignments with the three levels of ecotone (bench, 30:1, and 100:1 were included to obtain information on the cost-effectiveness of these options. Ponds were broken into four increments of restoration, based primarily on historic drainage patterns which are important to effective tidal marsh restoration.

3.3 Initial Round of CHAP Analysis, 2012

The initial CHAP analysis showed very similar outputs for the two alternatives evaluated. This is not surprising given that the pond habitat scored about as high as the tidal marsh habitat, and under both alternatives about the same acreage was allocated to the combined total of these two habitat categories. (The north alignment in Pond A18 under the early Alternative 2 resulted in portions of the pond being retained as pond rather than being restored to tidal action.)

This analysis showed fairly similar habitat benefits for restoration of each of the several pond groupings as shown in Table 3. Note that, as discussed in Section 2.2, these numbers are only tidal habitat outputs for areas undergoing restoration. Non-tidal habitat outputs are set to zero for purposes of evaluating tidal habitat outputs.

The highest output was from Pond A12 at 19.3 annualized habitat units per acre and the lowest (Ponds A13-A15) was 14.0 habitat units per acre. The differences are probably due primarily to the phasing of restoration, with ponds breached earlier having more time to develop complex tidal marsh features which provide better habitat value.

The transitional period between the breaching of ponds and the development of tidal marshes, during which the former ponds consisted of mudflats and subtidal aquatic habitat, showed slightly lower total habitat values than either the preceding ponds or the tidal marshes which followed. Breaching initially causes a reduction in habitat units per pond grouping of eleven to fifteen percent, followed by a slow climb up to very close to the pre-breaching number of habitat units with a net difference of one to three percent from the starting values. Both these habitat outputs and the habitat outputs for the managed ponds are similar under CHAP, so there is little net change in total CHAP outputs at the end of the evaluation period from implementing any of the final alternatives from this tradeoff.

The initial CHAP analysis showed no significant differences in outputs under the three ecotone fill options. This is because gains in marsh wildlife habitat value from additional fill were offset by losses in fish habitat from this fill. While the lower portion of the ecotone would be underwater much of the time, benefitting in turn both fish and marsh wildlife, the upper portion would nearly always or always be above water, benefitting only marsh and upland wildlife (some marsh species require adjacent upland with adequate vegetation so they can avoid predation during very high tides). This quantitative analysis does not take into account concerns over restoration of listed or otherwise rare species, as all species are weighted equally in CHAP.

Table 3: Comparison of Pond Groupings, Initial CHAP Analysis

Alternative 1 with bench	Breakpoints in Habitat Development							Annualized Outputs	Annualized Outputs per Acre
	2017	2020	2025	2030	2037	2047	2067		
Pond A9-A11	0	0	16,340	16,241	17,797	19,156	19,090	15,356	17.1
Pond A12	0	6,145	5,929	6,662	6,674	6,677	6,670	6,171	19.3
Ponds A13-A15	0	0	0	16,261	16,178	16,151	18,347	12,403	14.0
Pond A18	0	0	15,347	15,485	16,202	18,309	18,525	14,577	17.0
Total	0	6,145	37,617	54,649	58,851	60,293	62,631	48,508	

Alternative 2 (different levee alignment) had very similar outputs, as did either alternative with the 30:1 or 100:1 ecotone added. Impacts to habitats in areas which remain non-tidal, such as New Chicago Marsh, would be very small (about two percent for non-tidal habitats) compared to impacts in the pond areas to be opened to tidal action under the alternatives. The non-tidal impacts would not significantly affect the calculation of restoration benefits.

3.4 Evaluation of the Final Array of Alternatives, 2014-2015

Based in part on the results of the initial CHAP analysis, alternatives were reformulated and the final array of alternatives selected. These alternatives included four different levee alignments and two levels of ecotone: none (bench only) and 30:1. Details of the revised CHAP analysis are found in Northwest Habitat Institute (2015b).

Table 4 shows CHAP restoration outputs for the four final alternatives, within the areas where restoration measures would be implemented. Note that, as discussed in Section 2.2, these numbers are only tidal habitat outputs for areas undergoing restoration. Non-tidal habitat outputs are set to zero for purposes of evaluating tidal habitat outputs.

Differences between the alternatives were minimal because under all four alternatives, habitat conditions on the vast majority of the site would be the same at any one time during the period of habitat evaluation. As previously discussed, there would be modest differences between the output per acre of the several pond groupings.

Outputs shown are based on the original phasing of pond restoration where Pond A18 is not breached until the second phase of breaching. As discussed in Section 2.7, this phasing was later accelerated to address public and agency concerns but it was not practical to revise the results to reflect this. The effects of this acceleration should be nearly identical across the alternatives due to their great similarity in restoration actions.

Table 4: Comparison of CHAP Outputs, Final Array of Alternatives [1]								
	Breakpoints in Habitat Development [2]							Annualized Outputs
	2017	2020	2025	2030	2037	2047	2067	
Alternative 2 (NED/NER)								
Pond A9-A11	0	0	16,510	16,416	17,936	19,261	19,094	15,442
Pond A12	0	6,039	5,894	6,591	6,603	6,606	6,592	6,105
Ponds A13-A15	0	0	0	15,557	16,273	16,230	18,312	12,434
Pond A18 [3]	0	0	15,439	15,557	16,273	18,384	18,520	14,624
Total	0	6,039	37,843	54,878	57,054	60,481	62,518	48,606
Alternative 3								
Pond A9-A11	0	0	16,510	16,416	17,936	19,261	19,094	15,442
Pond A12	0	6,056	5,911	6,607	6,619	6,622	6,609	6,120
Ponds A13-A15	0	0	0	16,316	16,244	16,230	18,313	12,435
Pond A18 [3]	0	0	15,439	15,557	16,273	18,384	18,520	14,624
Total	0	6,056	37,859	54,895	57,072	60,498	62,535	48,622
Alternative 4 (LPP)								
Pond A9-A11	0	0	16,510	16,416	17,936	19,261	19,094	15,442
Pond A12	0	5,915	5,786	6,418	6,430	6,433	6,423	5,952
Ponds A13-A15	0	0	0	16,282	16,211	16,198	18,278	12,411
Pond A18 [3]	0	0	15,098	15,188	15,834	17,844	17,958	14,214
Total	0	5,915	37,393	54,304	56,412	59,737	61,753	48,019
Alternative 5								
Pond A9-A11	0	0	16,510	16,416	17,936	19,261	19,094	15,442
Pond A12	0	6,039	5,894	6,591	6,603	6,606	6,592	6,105
Ponds A13-A15	0	0	0	16,315	16,243	16,230	18,312	12,434
Pond A18 [3]	0	0	15,439	15,557	16,273	18,384	18,520	14,624
Total	0	6,039	37,843	54,878	57,054	60,481	62,518	48,606

1 Outputs are for tidal habitats in breached ponds only
2 Breakpoint dates are from the CHAP study and are expected to slip one year
3 Pond A18 is now planned to be breached in the same year as Pond A12

The ecotone was originally expected to show habitat benefits under CHAP. However, as in the first round of modeling, addition of the ecotone to the restoration plans very slightly reduced total tidal habitat benefits, with the reduction being about one percent. This difference is visible in Table 4 in comparing the NED/NER plan and the LPP. The specific reasons for this difference are discussed under subsection 3.3.

Models that tabulate site-specific habitat values (to arrive at an overall sum of habitat value for a defined area) typically are unable to assign a higher value to habitat tradeoffs which might very locally decrease total vertebrate diversity while increasing total landscape diversity, ecological function, and sustainability over a larger area. This is a common difficulty in ecosystem modeling when formulating and evaluating ecosystem restoration projects, and came into play with the evaluation of the ecotone.

Looking at all habitat units (tidal and non-tidal) combined, the 2012 and 2014-2015 analyses showed habitat units initially declining by up to eight percent after breaching of ponds as they became mudflats. Habitat units then increased over time as marshes developed in the former ponds. The final habitat values after fifty years were very close to the initial pond habitat values prior to breaching.

As a result, the restoration alternatives showed slightly lower AAHUs than the without-project condition (Northwest Habitat Institute, 2015b). This may seem to be counterintuitive, but it is not surprising considering the large bird populations which can exist in the ponds. As discussed earlier, the Shoreline Study considered conversion of one valuable habitat type to another to reverse historic losses of tidal marsh habitat value. Modeling alone cannot determine which habitat type should take precedence in a given situation, but can help inform such decisions.

The CHAP baseline and alternative reports from NHI were revised in July 2015 to provide additional information and to ensure all CHAP assumptions are consistent with study assumptions. This revision did not change the with-project habitat outputs or the zeroing out of non-tidal habitat outputs for purposes of ER formulation and evaluation.

4.0 Conclusions

The CHAP analysis provides a way of quantifying habitat values with and without a given project or alternative, by compiling animal species presence, species function, and habitat function data. In practice, it will tend to show a higher habitat value for areas with more vertebrate species and more diverse habitat features.

The CHAP analysis for the Shoreline Study showed similar values for managed ponds and tidal habitats, with slightly lower values for the initial period after breaching of ponds when little or no marsh would be present. It showed large increases in *tidal* habitat value after breaching of ponds, with tidal values continuing to increase over time to the end of the evaluation period. The analysis showed fairly similar habitat benefits per acre for restoration of the several pond groupings in the final array of alternatives. CHAP also showed slightly lower values for alternatives with an ecotone, but this was due to the method's tendency to give higher scores for areas with higher species diversity within a given evaluation polygon.

In summary, CHAP:

•Confirms the high habitat values of both managed ponds and tidal habitats in the study area.
•Shows large gains in tidal habitat value from the restoration actions under consideration.
•Shows fairly similar gains in tidal habitat value from restoration of each the several different pond groupings.
•Does not show additional gains from adding an ecotone to the restoration plan due to the nature of the CHAP analysis.

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Combined Habitat Assessment Protocols (CHAP)
Fish & Wildlife Habitat Assessment
Final Report

South San Francisco Bay Shoreline

South San Francisco Bay Shoreline Project Area

Baseline Conditions
U.S. Army Corps of Engineers
San Francisco District

Report and Analysis by
Northwest Habitat Institute

July14, 2015

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Wildlife Habitat Assessment of South San Francisco Bay Shoreline

Executive Summary

The wildlife habitat assessment of the South San Francisco Bay Shoreline study evaluated 173 polygons. Baseline conditions that consisted of 16 different habitat types were determined to describe the 6,674 acres (2,700 ha) site. The number of fish and wildlife species associated with the project totaled 253, of which 51 were fish, 165 birds, 30 terrestrial mammals, 6 reptiles, and 1 marine mammal. The baseline condition evaluation for the project area showed a total of 119,652 habitat units. Of these, about 60,000 habitat units are associated with Ponds A9 – A18. Breaking out the different habitat types revealed that there are 2,298 acres (930 ha) managed ponds within the study site. Of these, there are 826 acres (334 ha) batch ponds, 413 acres (167 ha) saline marsh ponds, 545 acres (221 ha) muted tidal or diked marsh ponds, and 119 acres (48 ha) freshwater marsh ponds. The average per-acre value of managed ponds overall is 22.1. By type, the values are 22.0 for batch ponds, 19.9 for saline marsh, 14.4 for muted tidal and diked marsh ponds, and 21.3 for freshwater marsh ponds. All habitat types' per-acre values fell within the range of 0 and 29.8.

To examine the future conditions that might exist if the proposed project does not occur, we began to put the project site into perspective by conducting a coarse evaluation of the amount of change in land use that has occurred from historic (ca. 1800) to modern times (ca. 2001) for the shoreline around the entire San Francisco Bay. To do this, the San Francisco Estuary Institute's Historic and Modern Bayland maps were used. This assessment showed an apparent loss in value that ranges from about 1.7 to 2.3 million habitat units for the area. To develop the future perspective for the next 50 years, additional steps were taken to obtain information on fish and wildlife species populations, invasive plant species, planned development, climate change influences and earthquake frequencies. Evaluating this information suggests that there will be a low turnover in species composition, salinity levels will still be controlling the spread of some of the invasive plants, future planned development will occur in already developed areas, sea rise due to climate change may periodically expand the bay's aquatic footprint for short periods in the Alviso area, and the design and engineering of the current levees and dikes are expected to withstand predictive earthquakes for the area. However, if this infrastructure failed, some flooding may occur though the surface water is expected to flow back in the San Francisco South Bay.

Introduction

Throughout the United States, there is a move towards assessing restoration and other conservation activities at the ecosystem level. Under current U.S. Army Corps of Engineers (Corps or USACE) authority, the objective of Civil Works ecosystem restoration is to restore significant ecosystem structure, function, and dynamic processes that have been degraded to a less degraded, more natural condition. Even partial restoration may provide significant and valuable improvements to degraded ecological resources.

Ecosystem restoration projects should examine the needs for improving or re-establishing both the structural components and the functions of the natural system. Restored ecosystems should mimic, as closely as possible, conditions that would occur in the area in the absence of human changes to the landscape and hydrology. Indicators of successful restoration would include the presence of a large variety of native plants and animals, the ability of the area to sustain larger numbers of certain indicator species or more biologically desirable species, and the ability of the restored area to continue to function and produce the desired outputs with a minimum of continuing human intervention. Those restoration opportunities that are associated with wetlands, riparian and other floodplain and aquatic systems are most appropriate for Corps involvement.

The information used in formulating, evaluating and selecting ecosystem restoration alternatives in Corps Civil Works projects includes both quantitative and qualitative information about outputs, costs, significance, acceptability, completeness, effectiveness, and reasonableness of costs. Within the USACE ecosystem restoration policy, *"An ecosystem restoration proposal must be justified on the basis of its contribution to restoring the structure or function, or both, of a degraded ecosystem, when considering the cost of the proposal. Ecosystem restoration projects are justified through a determination that the combined monetary and non-monetary benefits of the project are greater than its monetary and non-monetary costs. As such, plan selection is not based on economic justification in terms of a traditional monetary benefit to cost analysis, since the majority of benefits associated with the primary outputs of ecosystem restoration can rarely be quantified in dollars. Therefore, ecosystem restoration proposals need not have either a benefit-cost ratio greater than 1.0, or positive net economic benefits. However, any monetary incidental benefits which are anticipated from proposed ecosystem restoration projects, and relevant to the particular circumstances associated with the study, should be displayed to aide in decision making"* (USACE, EP 1165-2-502, 1999).

Instead of calculating economic benefits in monetary terms, Corps ecosystem restoration projects calculate the value and benefits of habitat using established habitat assessment methodologies. Evaluating habitat quality is the approach most often taken to compare ecosystem restoration alternatives because habitat is thought of as a surrogate for ecosystems; it is the setting where plants and animals live, interact, and reproduce. Habitat is frequently viewed in conjunction with species information to gain insight to various uses, structures, and functions existing within a landscape or site. Determining habitat structure and functional integrity of an area is supportive of an ecosystem management approach.

Habitat Units (HUs) are one of the currencies the Corps currently uses to rate and compare the value of one ecosystem restoration alternative to another. The concept of HUs is derived from the U.S. Fish and Wildlife Service's (USFWS) single-species habitat-assessment methodology known as Habitat Evaluation Procedures or HEP (1980), which the Corps has long used as a habitat evaluation tool.

The Combined Habitat Assessment Protocol (CHAP) is an accounting and appraisal methodology that utilizes an ecosystem-based habitat and biodiversity evaluation framework. CHAP generates an objective habitat-value score. This approach involves a triad assessment of habitat, species, and functions (O'Neil et al., 2005), and can provide assessments at multiple scales. The CHAP method integrates a habitat and biodiversity or HAB calculation that determines habitat units (HUs) based on an assessment of multiple species (all potential species at a site), habitat features, and functions by habitat type.

The overall goal of the South San Francisco Bay Shoreline Feasibility Study (Shoreline Study) ecosystem restoration project assessment was to evaluate baseline habitat conditions at a fine level of resolution within an ecosystem context. An ecosystem context is more holistic than assessing just a few individual species (Perkins, 2002), especially with federal or state-listed taxa. It calls for a multiple-species framework that includes an evaluation of ecological functions. Additionally, the Corps would like to assess alternative scenarios; hence a realistic depiction of actual habitat site conditions at a fine scale level was needed. The approach reported herein depicts the wildlife habitat baseline conditions at a fine resolution or site-level scale, uses multiple species and their habitat functions in its evaluation, and accounts for actual habitat types, structural conditions, and key environmental correlates within the Shoreline Study project assessment boundary based on input from knowledgeable field staff, inventories, and past studies of the area's habitat components.

Goal

The primary goal of this feasibility study is to determine the best solution under Corps criteria for provision of tidal flood risk management and/or ecosystem restoration in the study area, considering existing plans and projects such as the South Bay Salt Pond Restoration Project and the new recovery plans for listed species in the South Bay. Partners in this study include the U.S. Fish and Wildlife Service (USFWS), the State Coastal Conservancy (CSCC, a non-federal sponsor), and the Santa Clara Valley Water District (SCVWD, a non-federal sponsor).

Study Site

The Shoreline Study examines the feasibility of flood risk management and ecosystem restoration along a portion of the south shoreline of San Francisco Bay (http://www.southbayshoreline.org/. also see also Figure 1). In March 2011, the study was refocused on an area of about 6,800 acres (2,751 hectares) that cover the area between the Guadalupe River and Coyote Creek, also known as Economic Impact Area (EIA) 11. This area includes the community of Alviso, which is incorporated into San Jose, the San Jose-Santa Clara Water Pollution Control Plant (WPCP), and adjacent managed ponds formerly used as part of Cargill, Inc.'s salt production system.

The baseline condition assessment encompasses Ponds A9 through A16, Pond A18, and adjacent areas (see Figure 2). Pond A16 will be reconfigured by the Don Edwards San Francisco Bay National Wildlife Refuge (Refuge) but will still be a pond. Pond A17 will be breached for restoration of tidal habitats by the Refuge, but mapped habitat predictions are not available so this pond is excluded from the CHAP study. However, Pond A18 is being studied by the City of

San Jose as part of the reconfiguration of its wastewater treatment plant, and will also be considered by this study.

Background

The Alviso ponds were formerly part of the Cargill, Inc. solar salt production system, but were sold to the federal government in 2003. The Alviso ponds are now managed by the FWS as part of the Refuge. Current management of these ponds primarily favors various species of migratory shorebirds and waterfowl. The ponds are surrounded by sloughs and remnant tidal marshes which are habitat for listed species such as the Ridgeway's rail (formerly California Clapper rail) and the salt marsh harvest mouse. The ponds also provide other important ecological services, like retention and storage of water and filtering of water by wetland habitats.

The existing pond levees are not engineered structures. The lands behind them are low-lying and in some cases well below sea level. These lands include the community of Alviso, the New Chicago Marsh, and the San Jose/Santa Clara WPCP (Figure 2). These areas are vulnerable to tidal flooding if the perimeter pond levees fail.

The former salt ponds offer considerable potential for management of shorebirds and waterfowl populations, or for restoration to tidal habitats including marshes. Tidal marsh restoration is expected to be an important measure in assisting the recovery of several endangered species found in the study area such as the salt marsh harvest mouse and the California clapper rail. However, the ponds are currently valuable habitat for many species and hundreds of thousands of individual shorebirds, waterfowl, and other water birds.

Quantification of habitat restoration benefits will begin with the development of a baseline condition assessment and conclude with an assessment of the "no action" or without-project alternative with a 50- year projection horizon. These assessments will then be compared to various alternative scenarios to determine the overall cost-effectiveness of habitat restoration in a national context, and to determine optimum outcomes for restoration actions proposed for Ponds A9-A15 and Pond A18.

Evaluation of project benefits and impacts will be quantified for a period of 50 years from the start of construction, which is assumed to be 2017. Limited qualitative evaluation of projected effects after these 50 years will be conducted by others and is not part of this assessment.

Figure 1. Regional context for Shoreline study area location
(Source map: South Bay Salt Pond Restoration Project)

Figure 2. A local view of the Shoreline study area general project boundary delineation along with pond polygon identification numbers.

Methods for Determining Baseline Conditions

First, CHAP's habitat valuing system produces Habitat Units (HUs) for baseline and alternative future scenarios. When talking about HUs it is good to clarify (especially for non-ecologist) that CHAP's habitat values are not the same as those obtained using USFWS's Habitat Evaluation Procedures or HEP. CHAP assesses condition and function by incorporating multiple species, habitat components and functions into the analysis. When attempting to compare HUs between CHAP and HEP one would immediately see a magnitude of higher habitat values using CHAP because we do not normalize the values, evaluate only a few species, or use subjective values to determine habitat quality as HEP does.

So to begin the CHAP process, we start by developing a fish and wildlife species list for the project. The initial Habitat Evaluation Team meeting revealed that USFWS staff residing or working at the Refuge are a valuable source of wildlife information. The Habitat Evaluation Team suggested using the Refuge staff as the initial point of contact for pond and adjacent habitat information. Refuge staff in consultation with other knowledgeable people generated fish and wildlife species lists for the baseline habitat classifications and the conditions resulting from restoration scenarios and the no-action alternative. Additionally, the Northwest Habitat Institute (NHI) also generated an initial species list for the project by accessing the California Wildlife Habitat Relationships (CWHR) geographic information system (GIS) as a cross-reference. A query of the site's potential species was done by accessing the peer-reviewed wildlife-species range maps that overlapped with the project boundary. Refuge staff was also able to review the NHI-generated potential species list, as well as develop specific bird lists for each pond along with determining their presence during the four seasons. The species listed then needed to be associated with habitat types, which required a several step process.

First, it was necessary to develop a list of wildlife habitat types located within the South Shoreline project boundary by polygon. A number of habitat classifications have been used in past and ongoing studies. Additionally, there is a strong desire by the Habitat Evaluation Team to use this existing information for this project. NHI was able to work with the Refuge staff to determine two habitat classifications that would allow fish and wildlife species habitat associations to be created and used in the baseline condition report. One habitat classification was used for assessing baseline conditions (Table 1) and the other was used to evaluate without-project future conditions for the next 50-year period (see Table 9 in 50 Year Future without-project section).

Baseline Conditions
Batch Pond
Brackish Marsh
Developed
Freshwater Marsh
Landfill
Levee
Managed Pond
Tidal Flats/Mudflats
Muted Tidal / Diked Marsh
Open Water/Slough Channel
Parks / Upland Grassland
Riparian/Creek Corridor
Saline Marsh
Seasonal Wetland
Upland Vegetation
Water / Sewage Treatment

Table 1. Habitat classification used to determine baseline conditions effects.

Because there were a number of past projects that used more specific habitat classes to breakout portions of the San Francisco Bay, the partners wanted to use them. The above habitat types show the classification that was incorporated into the baseline evaluation. Specific vegetation types and associations were also noted when creating the crosswalk(s) [which is relating vegetation types and associations to habitat types] along with the number and extent of invasive species. Next, the Key Ecological Correlates (KECs) or fine-feature elements that may exist within each polygon were identified. Refuge staff developed a list of common KECs that would be found by habitat type that could be applied to the polygons within the project boundary.

Because CHAP is built around the triad concept of species-habitat-functions, the next step was to update the Northwest Habitat Institute's Integrated Biodiversity Information System (IBIS) data system[1] (Johnson and O'Neil, 2001) and establish the key ecological functions (KEFs) for each species. For 35 new species that were not already a part of IBIS, this required researching the species and identifying a list of KEFs for inclusion into IBIS.

To reiterate, KECs represent physical and biological habitat elements that are thought to most influence a species' distribution, abundance, fitness, and viability, while KEFs refer to the principal set of ecological roles performed by each species in its ecosystem. More specifically, KEFs refer to the main ways organisms use, influence, and alter their biotic and abiotic environments. The KECs and KEFs are crucial components in determining the wildlife habitat unit values.

An approach at the scale of the site is used to refine the habitat value calculations for the Shoreline project polygons. The CHAP approach involves four components: 1) preliminary mapping, 2) field inventory, 3) data compilation and analysis, and 4) GIS maps, spreadsheets and report.

1. <u>Preliminary mapping</u>: The Shoreline Study site is refined by identifying and delineating polygons with homogenous habitat types based on visual interpretation of photography or imagery. At the onset, the National Agriculture Imagery Program or NAIP imagery was used but this effort was later transferred to high-resolution imagery supplied by USACE.

2. <u>Field inventory</u>: This CHAP analysis used existing field inventory data generated by the project partners.

3. <u>Data compilation and analysis</u>: Data from the field inventory is used to generate a habitat value for each polygon within the study site. The species list developed for the project area was reviewed by the knowledgeable field staff. Additionally, the list of taxa is merged with the KEC and KEF fields within the IBIS data sets to allow the creation of two matrices for each polygon: species by functions and habitat by functions. These matrices are then summed and multiplied by the acreage of the polygon to calculate HUs for each polygon.

4. <u>GIS maps, spreadsheets, and report</u>: GIS maps are generated that depict the habitat values (HUs) of each polygon. Supporting maps illustrate: a) project or area boundaries; b) polygon numbering; c) corrected habitat value per acre; d) habitat

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[1] The IBIS data system is based on expert knowledge and peer reviews and contains current ecological information on more than 1,000 fish and wildlife species.

units; e) amounts of non-native plant species by polygon; f) wildlife habitat types by polygon; and g) structural conditions by polygon. Spreadsheets are developed that contain the polygon calculations of the species-functions and habitat-functions matrices, along with an overall site or area habitat value.

Determining the Habitat Unit Value

To establish a habitat unit value, two matrices are developed. The first matrix determines the species' mean functional redundancies (MFRI) based on the species list (Appendix A-1). This was developed and reviewed for the baseline condition of Shoreline Study by habitat class (Appendix A-2). Determining the MFRI is the first step in the computation to determine the baseline habitat condition values [see Appendix B - Matrix Relationships, Matrix 1]. A MFRI is created for each habitat type present within the study area.

The second matrix is usually generated by conducting field inventories by polygon. However, because of the number of knowledgeable field staff located at the site and the number of past studies conducted, it was determined that enough data existed to generate this information without further fieldwork. Using these resources, a list of Key Environmental Correlates (KECs[2]) was generated for each polygon. Once this was completed, a KEC function matrix by habitat type was created [see Appendix B - Matrix Relationships, Matrix 2]. This matrix represents the habitat components which characterize potential functions within each polygon at the site. Per-acre baseline values were then computed for each polygon by adding Matrices 1 and 2 together [species-functional redundancy (MFRI) value and the KEC-functional redundancy value] for each habitat type.

The per-acre value is a strong indicator of wildlife habitat quality because it represents the animal taxa, habitat characteristics, and biodiversity as determined by accounting for species, habitats, and their functions. It is also a stronger indicator because the influence of polygon size (acres) is removed from consideration. Thus, small polygon areas can be shown to have a high per-acre value, whereas large areas may show a low per acre value. Nevertheless, to determine a site's overall baseline HU value, each polygon's per-acre value is multiplied by its acreage and then these values are summed across all polygons. This generates an uncorrected HU value because no adjustments have been considered.

Site Location Adjustment Value

Because the South Shoreline project area is located near an urban setting, there are several ecosystem drivers and stressors that can affect the baseline condition and how it is currently managed. We identified invasive plant species as one major influence that can affect the habitat value potential in each habitat type. The CHAP protocol allows us to adjust polygon values based on the presence and abundance of invasive plant species, as documented during the field inventory from past projects or based on local knowledge (see Table 2). Additionally, the percent abundance of invasive species by polygon can also be spatially displayed to show their influence on the habitat value.

[2] See Appendix B – Matrix 2.

Subsequently, each polygon is assigned an invasive-plant value based on the occurrence of invasive species identified within the polygon. If a vegetation layer is not present, it is left blank and that layer does not contribute to the invasive factor calculation. Because invasive species generally negatively influence ecosystem function, the per-acre values were then discounted for the presence of invasive plants, using the values in Table 2; this allows us to arrive at a corrected per-acre value for each polygon.

The only locally invasive species of concern with the project area is peppergrass, also known as perennial pepperweed (*Lepidium latifolium*). Areas containing pepperweed were identified and delineated into GIS polygons by H.T. Harvey & Associates resulting during their 2010 Marsh Study. There were 10 vegetation classes within the Marsh Study that contained pepperweed as shown in Table 2 below. Based on conversations with H.T. Harvey & Associates staff about how the Marsh Study data collection methodology was designed and information collected, we were able to assign invasive plant adjustment factors that corresponded with CHAP protocols to each class. For instance, the "pickleweed/pepperweed" designation indicates that pickleweed is dominant with a pepperweed component between 15 and 49% of the total areal surface of the polygon. Conversely a "pepperweed/pickleweed" designation indicates that pepperweed is dominant with a pickleweed component between 15 and 49%. A polygon with only one species name in such as "pepperweed" indicates a composition of that species over 85% of the polygon. So, given these constructs by the Marsh Study the following adjustment factors by vegetation class are:

Adjustment Factor	Invasive Vegetation Class
0.3	Pepperweed
0.5	Pepperweed/Pickleweed
0.5	Pepperweed/Peripheral Halophytes
0.5	Pepperweed/Alkali Bulrush
0.5	Pepperweed/Upland vegetation
0.7	Pickleweed/Pepperweed
0.7	Peripheral Halophytes/Pepperweed
0.7	Alkali Bulrush/Pepperweed
0.7	Spearscale/Pepperweed
0.7	Alkali Heath/Pepperweed

Table 2. Invasive adjustment factor as identified by the 2010 Marsh study by vegetation class.

Refuge staff was also able to provide NHI with a list of adjustment factors for those polygons for which they had sufficient local knowledge to feel comfortable making recommendations. The remaining polygons were either intersected by the 2010 Marsh Study or were in the mostly upland or developed areas.

Next, the 2010 Marsh Study GIS data (Figure 3) was overlaid onto the baseline condition polygons to determine proportions of each polygon covered by invasive species. Once determined for each Marsh Study polygon with a pepperweed component, the invasive adjustment factor from Table 2 (above) was applied. The sum of the Invasive Adjustment Factors contained within the baseline condition polygon was then calculated. Finally, the proportional values were summed for each polygon and normalized (Table 3). For example, if a polygon's total invasive scored was 0.85, then the discount class in Table 3 would be 0.8. This would mean that 20% of the total polygon value would be reduced because of the amount of invasive species present within the polygon. For example, if a total baseline condition polygon score is 24 and has an adjustment factor of 0.8, it would yield a baseline condition corrected value of 19.2.

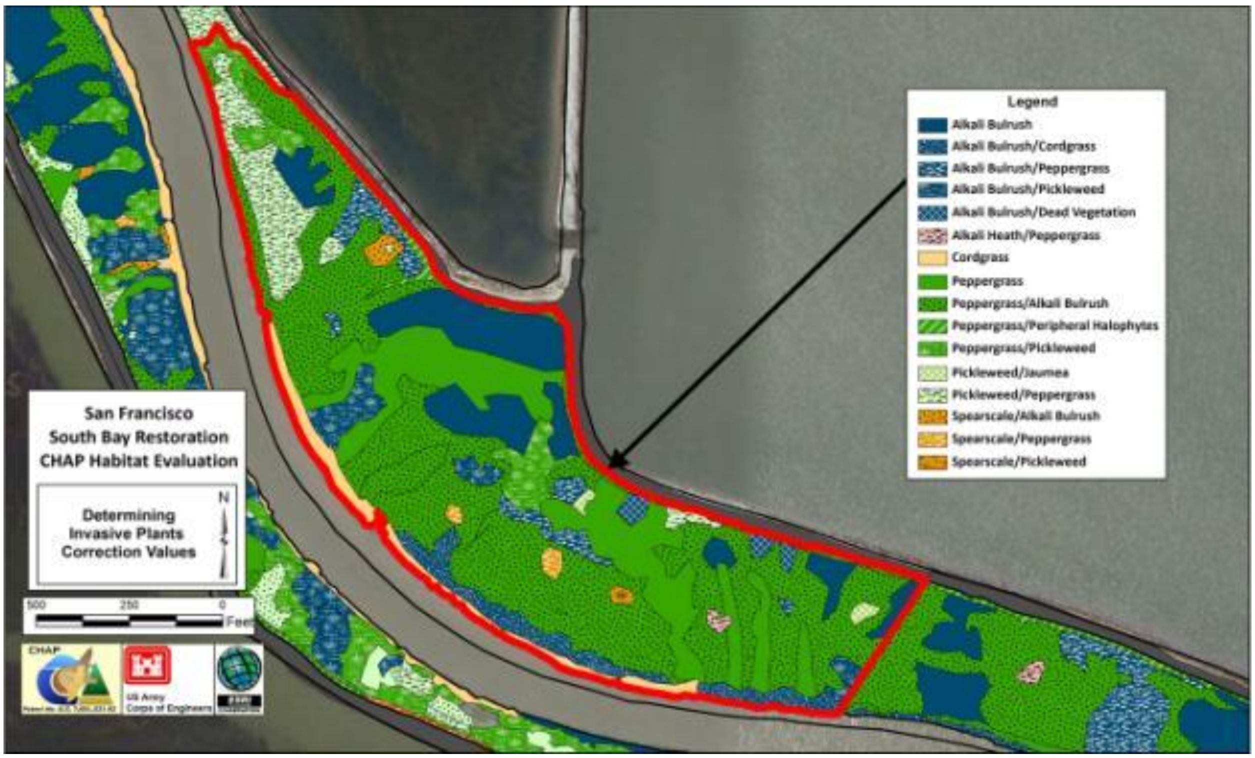

Figure 3. An example of the 2010 Marsh Study data depicting the various categories, spatial distribution and amounts of the various invasive species.

Determined Invasive Adjustment (based on area percent)	Discount Class
1 - 0.95	1
0.94 - 0.90	0.9
0.89 - 0.80	0.8
0.79 - 0.70	0.7
0.69 - 0.60	0.6
0.59 -0.50	0.5
0.49 - 0.40	0.4

Table 3. Normalizing table used to determine the appropriate discounting value for the presence and abundance of invasive species.

Areas within the study area that were not intersected by the 2010 Marsh Study or not commented on by Refuge staff did not have enough information available to allow us to apply an adjustment value. Forty-four polygons fell into the unknown category and are shown in black in Figure 5.

Results

Two hundred and fifty-three wildlife species were evaluated concurrently. The 173 polygons on the SF South Shoreline site were determined by delineating the various wildlife habitat types that occur within the project area. These include: batch pond, brackish marsh, developed area, freshwater marsh, landfill, levee, managed pond, mudflat, muted tidal/diked marsh, open water, park/upland grassland, riparian creek corridor, saline marsh, seasonal wetland, upland vegetation and water sewage treatment (see Table 4). In total these polygons account for about 6,674 acres or 2,700 ha. A complete breakout of the habitat units per polygon can be found in Table 5. The information in Table 5 illustrates by polygon that higher habitat unit scores have a higher habitat quality associated with them; conversely those with a low score would have lesser habitat quality.

Batch Pond	Brackish Marsh	Developed	Freshwater Marsh	Landfill	Levee	Managed Pond	Mudflat
825.74	328.37	573.65	119.49	67.32	197.55	2297.93	220.51
Muted Tidal / Diked Marsh	**Open Water**	**Parks / Upland Grassland**	**Riparian/ Creek Corridor**	**Saline Marsh**	**Seasonal Wetland**	**Upland Vegetation**	**Water / Sewage Treatment**
545.46	349.75	251.91	14.24	413.13	33.64	26.13	409.13

Table 4. Shoreline study areas breakout of acreage of habitat type.

Polygon ID	Acres	Habitat Type	Habitat Units
SB_001	1.58	Developed	8.33
SB_002	1.59	Levee	28.00
SB_003	6.95	Upland Vegetation	98.46
SB_004	4.87	Upland Vegetation	76.68
SB_005	2.79	Freshwater Marsh	59.52
SB_006	1.20	Upland Vegetation	18.86
SB_007	0.81	Open Water	24.10
SB_008	0.14	Open Water	3.86
SB_009	1.57	Levee	27.66
SB_010	0.58	Upland Vegetation	9.17
SB_011	0.68	Saline Marsh	6.15

Polygon ID	Acres	Habitat Type	Habitat Units
SB_012	0.77	Upland Vegetation	12.07
SB_013	0.90	Saline Marsh	10.16
SB_014	4.80	Levee	84.48
SB_015	8.64	Mudflat	161.72
SB_016	4.57	Mudflat	59.93
SB_017	2.03	Mudflat	37.91
SB_018	1.72	Mudflat	29.02
SB_019	0.42	Levee	7.43
SB_020	0.25	Levee	4.41
SB_021	0.17	Levee	3.02
SB_022	0.12	Levee	2.19

Polygon ID	Acres	Habitat Type	Habitat Units	Polygon ID	Acres	Habitat Type	Habitat Units
SB_023	13.79	Levee	242.86	SB_070	0.16	Upland Vegetation	2.47
SB_024	8.29	Developed	43.83	SB_071	0.03	Upland Vegetation	0.48
SB_025	3.41	Upland Vegetation	53.74	SB_072	0.07	Upland Vegetation	1.05
SB_026	1.07	Freshwater Marsh	22.87	SB_073	16.38	Muted Tidal / Diked Marsh	165.22
SB_027	12.09	Riparian/Creek Corridor	274.50	SB_074	0.24	Upland Vegetation	3.77
SB_028	2.14	Riparian/Creek Corridor	48.63	SB_075	0.29	Open Water	8.79
SB_029	14.65	Managed Pond	323.81	SB_076	41.87	Brackish Marsh	824.30
SB_030	6.07	Developed	32.09	SB_077	34.88	Brackish Marsh	600.87
SB_031	2.54	Seasonal Wetland	40.81	SB_078	0.35	Levee	6.11
SB_032	3.49	Open Water	104.16	SB_079	0.30	Open Water	8.91
SB_033	0.51	Open Water	15.21	SB_080	0.39	Upland Vegetation	6.11
SB_034	0.39	Open Water	11.69	SB_081	0.52	Freshwater Marsh	11.07
SB_035	0.26	Open Water	7.73	SB_082	1.65	Freshwater Marsh	35.28
SB_036	29.28	Seasonal Wetland	470.47	SB_083	11.16	Freshwater Marsh	214.28
SB_037	1.00	Muted Tidal / Diked Marsh	14.41	SB_084	0.19	Upland Vegetation	3.04
SB_038	0.66	Muted Tidal / Diked Marsh	9.58	SB_085	0.69	Upland Vegetation	10.84
SB_039	0.21	Levee	3.69	SB_086	27.64	Brackish Marsh	408.10
SB_040	85.39	Levee	1504.19	SB_087	4.04	Brackish Marsh	89.47
SB_041	62.73	Mudflat	1174.01	SB_088	3.98	Saline Marsh	89.96
SB_042	6.17	Mudflat	92.40	SB_089	19.26	Brackish Marsh	474.06
SB_043	3.82	Mudflat	71.57	SB_090	18.81	Saline Marsh	339.64
SB_044	0.76	Open Water	20.38	SB_091	0.23	Upland Vegetation	3.55
SB_045	1.83	Seasonal Wetland	29.36	SB_092	29.07	Brackish Marsh	500.69
SB_046	2.27	Levee	32.01	SB_093	3.99	Brackish Marsh	68.72
SB_047	22.88	Levee	403.07	SB_094	2.14	Brackish Marsh	47.39
SB_048	11.15	Levee	196.35	SB_095	10.88	Brackish Marsh	214.13
SB_049	0.54	Open Water	16.20	SB_096	19.39	Open Water	578.59
SB_050	0.95	Freshwater Marsh	20.23	SB_097	1.70	Brackish Marsh	41.95
SB_051	15.37	Saline Marsh	312.21	SB_098	30.55	Freshwater Marsh	651.78
SB_052	41.38	Saline Marsh	934.16	SB_099	45.99	Saline Marsh	1038.31
SB_053	11.40	Saline Marsh	205.88	SB_100	16.81	Saline Marsh	379.53
SB_054	8.39	Saline Marsh	170.44	SB_101	0.25	Upland Vegetation	3.86
SB_055	15.01	Saline Marsh	271.14	SB_102	3.49	Freshwater Marsh	74.48
SB_056	0.27	Saline Marsh	6.05	SB_103	9.72	Freshwater Marsh	207.45
SB_057	4.67	Saline Marsh	105.50	SB_104	15.62	Brackish Marsh	269.13
SB_058	0.20	Saline Marsh	4.44	SB_105	14.32	Freshwater Marsh	305.55
SB_059	59.18	Saline Marsh	1335.94	SB_106	0.32	Open Water	9.41
SB_060	1.23	Saline Marsh	27.87	SB_107	2.28	Freshwater Marsh	48.55
SB_061	7.12	Saline Marsh	160.77	SB_108	3.34	Developed	17.69
SB_062	2.17	Saline Marsh	48.97	SB_109	5.53	Levee	97.46
SB_063	7.08	Saline Marsh	159.80	SB_110	0.58	Open Water	17.16
SB_064	33.20	Saline Marsh	674.56	SB_111	6.80	Parks / Upland Grassland	80.55
SB_065	13.49	Saline Marsh	243.59	SB_112	13.95	Parks / Upland Grassland	165.38
SB_066	80.58	Saline Marsh	1637.25	SB_113	20.99	Parks / Upland Grassland	248.77
SB_067	14.75	Saline Marsh	299.74	SB_114	3.30	Parks / Upland Grassland	39.15
SB_068	0.34	Upland Vegetation	5.35	SB_115	27.51	Parks / Upland Grassland	326.04
SB_069	0.47	Upland Vegetation	7.37	SB_116	0.30	Freshwater Marsh	6.50

Polygon ID	Acres	Habitat Type	Habitat Units
SB_117	5.90	Open Water	176.16
SB_118	3.66	Freshwater Marsh	78.03
SB_119	2.84	Freshwater Marsh	60.49
SB_120	0.38	Freshwater Marsh	8.02
SB_121	2.29	Freshwater Marsh	48.88
SB_122	2.55	Levee	44.98
SB_123	9.45	Levee	166.48
SB_124	1.01	Freshwater Marsh	21.59
SB_125	27.87	Brackish Marsh	480.11
SB_126	13.45	Mudflat	251.73
SB_127	117.37	Mudflat	2196.72
SB_128	0.19	Open Water	5.75
SB_129	4.48	Saline Marsh	60.63
SB_130	5.99	Saline Marsh	108.27
SB_131	75.92	Brackish Marsh	1681.33
SB_132	33.49	Brackish Marsh	576.86
SB_133	17.50	Freshwater Marsh	373.25
SB_134	1.28	Muted Tidal / Diked Marsh	18.38
SB_135	315.87	Open Water	9423.89
SB_136	3.71	Levee	65.44
SB_137	6.63	Freshwater Marsh	141.33
SB_138	1.66	Developed	8.77
SB_139	0.44	Upland Vegetation	6.96
SB_140	58.81	Developed	311.07
SB_141	50.75	Muted Tidal / Diked Marsh	731.04
SB_142	28.76	Developed	152.12
SB_143	312.15	Water / Sewage Treatment	0.00
SB_144	72.97	Parks / Upland Grassland	864.87
SB_145	4.86	Upland Vegetation	76.55
SB_146	140.53	Muted Tidal / Diked Marsh	2024.28
SB_147	198.53	Muted Tidal / Diked Marsh	2859.77
SB_148	6.05	Muted Tidal / Diked Marsh	87.08
SB_149	11.37	Muted Tidal / Diked Marsh	163.79
SB_150	1.41	Muted Tidal / Diked Marsh	20.36
SB_151	15.15	Parks / Upland Grassland	179.59
SB_152	9.34	Parks / Upland Grassland	110.75
SB_153	211.03	Developed	1116.24
SB_154	4.36	Muted Tidal / Diked Marsh	62.78
SB_155	31.33	Levee	551.86
SB_156	6.38	Freshwater Marsh	122.41
SB_157	81.90	Parks / Upland Grassland	970.78
SB_158	174.24	Developed	921.65
SB_159	79.88	Developed	422.53
SB_160	68.12	Muted Tidal / Diked Marsh	981.24
SB_161	96.98	Water / Sewage Treatment	0.00
SB_162	67.32	Landfill	243.16
SB_163	20.89	Muted Tidal / Diked Marsh	300.92
SB_164	24.14	Muted Tidal / Diked Marsh	347.68
SB_A9	365.92	Managed Pond	8087.34
SB_A10	249.81	Managed Pond	5521.11
SB_A11	261.70	Managed Pond	5783.91
SB_A12	308.20	Batch Pond	6763.60
SB_A13	266.65	Batch Pond	5851.71
SB_A14	336.92	Managed Pond	7446.24
SB_A15	250.89	Batch Pond	5505.87
SB_A16	242.06	Managed Pond	5349.83
SB_A18	826.87	Managed Pond	18274.69

Table 5. Acreage and habitat value (HUs) for each of the CHAP habitat evaluation polygons.

Because Ponds A9 thru 15 are a focal point of the Shoreline Study, there was some interest expressed by Habitat Evaluation Team members to break out the ponds by seasonal use for just the bird species that are known to use them. Table 6 shows the habitat units by season for each pond. During different times of the year, the habitat value changes based on the diversity of 165 bird species; habitat value is not static throughout a year. This is the first time we are aware of that the year round seasons of use by a large diversity of bird can quantify habitat values throughout the year. Table 7 shows the per-acre value by season by pond based on the diversity of the bird species that use them. Figures 4 display the same information by season by pond. Interest was also expressed in how CHAP would address abundance of species using each pond. Utilizing a weighting scale is a possible way to handle this question. For example, based on the information recorded at each site by USGS Western Ecological Research Center staff, the number of birds could be grouped by increments of 1000 to determine a weighting scale. For instance, 1-1,000 would have a weighting of 1, 1001-2,000 a 2, 2,001-3,000 a 3, etc. Weighting has not been agreed to by the Habitat Evaluation Team; hence this information is only suggested as a possible solution to the question of considering the number of birds using each pond.

SITE_ID	Acres	Habitat Units		SITE_ID	Acres	Habitat Units
Spring				**Fall**		
SF_Pond A09	365.92	7,146.4		SF_Pond A09	365.92	7,678.3
SF_Pond A10	249.81	4,626.3		SF_Pond A10	249.81	4,948.0
SF_Pond A11	261.70	4,937.6		SF_Pond A11	261.70	4,766.6
SF_Pond A12	308.20	5,662.5		SF_Pond A12	308.20	5,757.0
SF_Pond A13	266.65	4,937.3		SF_Pond A13	266.65	5,334.2
SF_Pond A14	336.92	6,563.2		SF_Pond A14	336.92	6,635.9
SF_Pond A15	250.89	4,738.6		SF_Pond A15	250.89	4,963.1
SF_Pond A16	242.06	4,778.4		SF_Pond A16	242.06	4,555.4
SF_Pond A17*	130.88	2,583.0		SF_Pond A17*	130.88	2,731.0
SF_Pond A18	826.87	16,222.3		SF_Pond A18	826.87	16,002.5
Total	**3,240**	**62,195.7**		**Total**	**3,240**	**63,372.1**
SITE_ID	**Acres**	**Habitat Units**		**SITE_ID**	**Acres**	**Habitat Units**
Summer				**Winter**		
SF_Pond A09	365.92	6,359.4		SF_Pond A09	365.92	7,437.2
SF_Pond A10	249.81	4,196.7		SF_Pond A10	249.81	4,795.1
SF_Pond A11	261.70	4,321.4		SF_Pond A11	261.70	4,799.4
SF_Pond A12	308.20	5,123.7		SF_Pond A12	308.20	6,061.6
SF_Pond A13	266.65	4,219.3		SF_Pond A13	266.65	5,130.1
SF_Pond A14	336.92	5,756.5		SF_Pond A14	336.92	6,769.1
SF_Pond A15	250.89	4,455.5		SF_Pond A15	250.89	4,624.6
SF_Pond A16	242.06	4,587.8		SF_Pond A16	242.06	4,881.8
SF_Pond A17*	130.88	2,492.3		SF_Pond A17*	130.88	2,538.7
SF_Pond A18	826.87	14,127.7		SF_Pond A18	826.87	16,543.9
Total	**3,240**	**55,640.5**		**Total**	**3,240**	**63,581.6**

For a list of bird species associated with each pond by season, see Appendix 3. [*Note: Pond A17 is not part of this study and is shown only for informational purposes].

Table 6. Habitat unit value by pond; determined using the diversity of bird species and number of key environmental correlates associated with each pond by season

	Fall	Winter	Spring	Summer
Pond_A09	13.06	12.40	11.61	9.45
Pond_A10	11.88	11.27	10.59	8.88
Pond_A11	10.29	10.41	10.94	8.59
Pond_A12	9.47	10.46	9.16	7.41
Pond_A13	10.79	10.03	9.31	6.61
Pond_A14	11.77	12.17	11.56	9.16
Pond_A15	10.57	9.22	9.68	8.55
Pond_A16	10.89	12.24	11.82	11.03
Pond_A17	12.94	11.47	11.81	11.12
Pond_A18	11.43	12.08	11.69	9.16

Table 7. Baseline per-acre values by season by pond based on bird diversity.

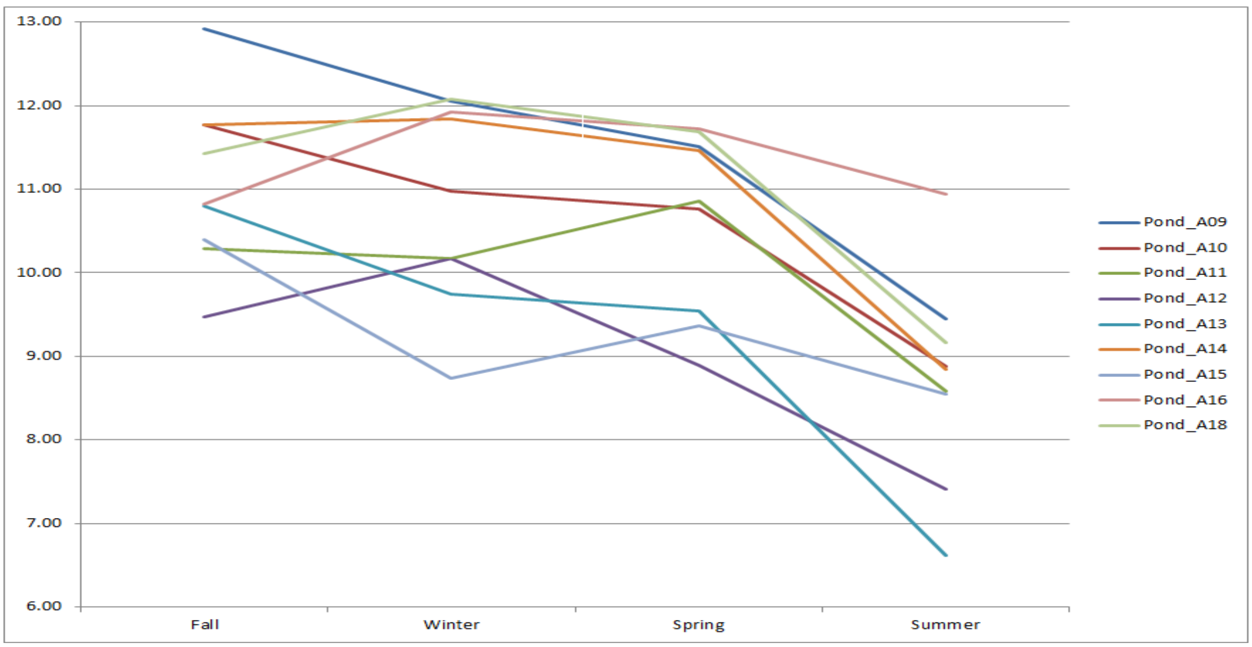

Figure 4. Baseline per-acre values by season by pond based on bird diversity.

Figures 5 & 6 further characterize the baseline conditions by showing the number of acres by habitat type and the average per-acre value for those habitat types, respectively. Figures 7 to 10 also inform baseline conditions by illustrating the spatial extent of the various habitat types (Figure 7), the amount and location of the invasive discounting (Figure 8), visual depiction of the per-acre habitat value from high to low scores (Figure 9), and finally an illustration showing the number of habitat units associated with each polygon (Figure 10).

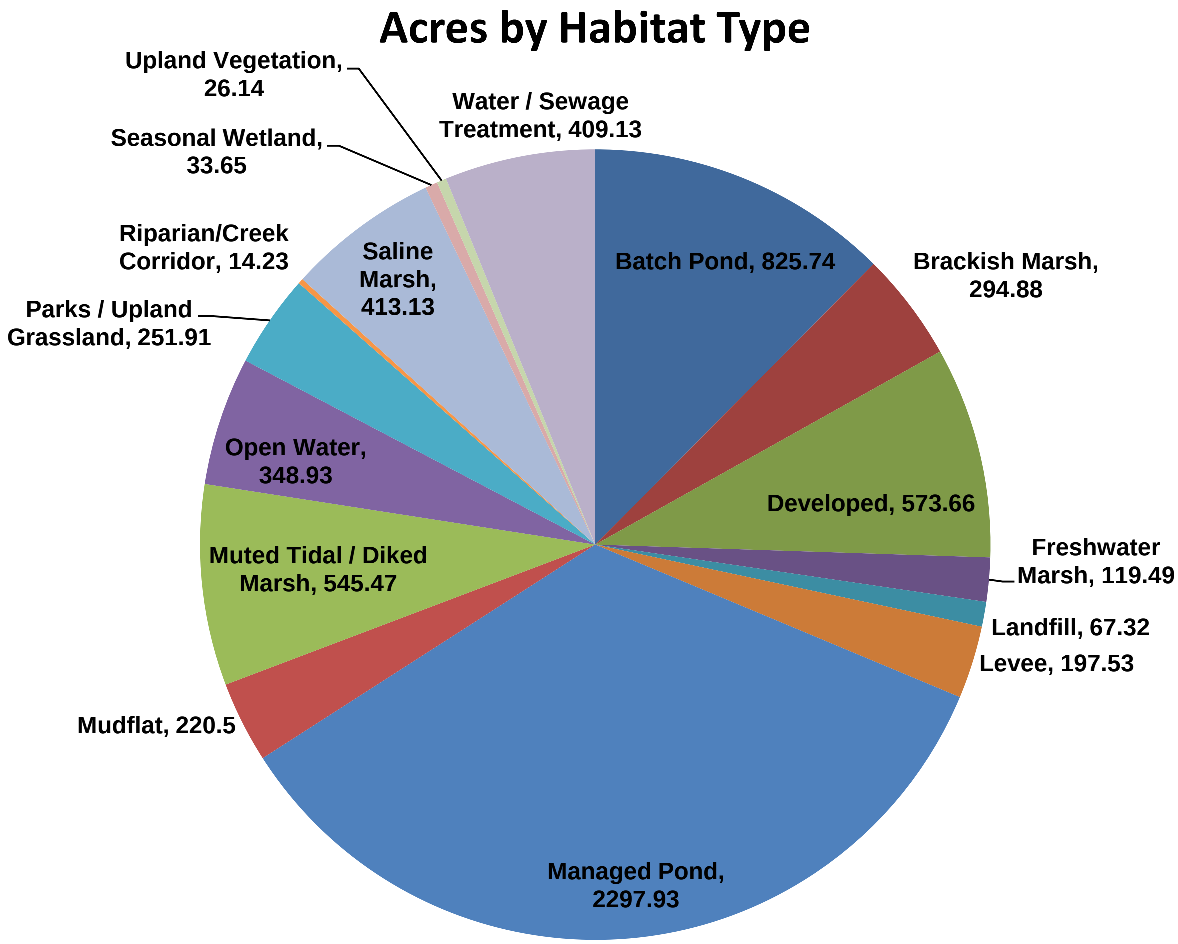

Figure 5. Breakout of baseline condition acreage by habitat type.

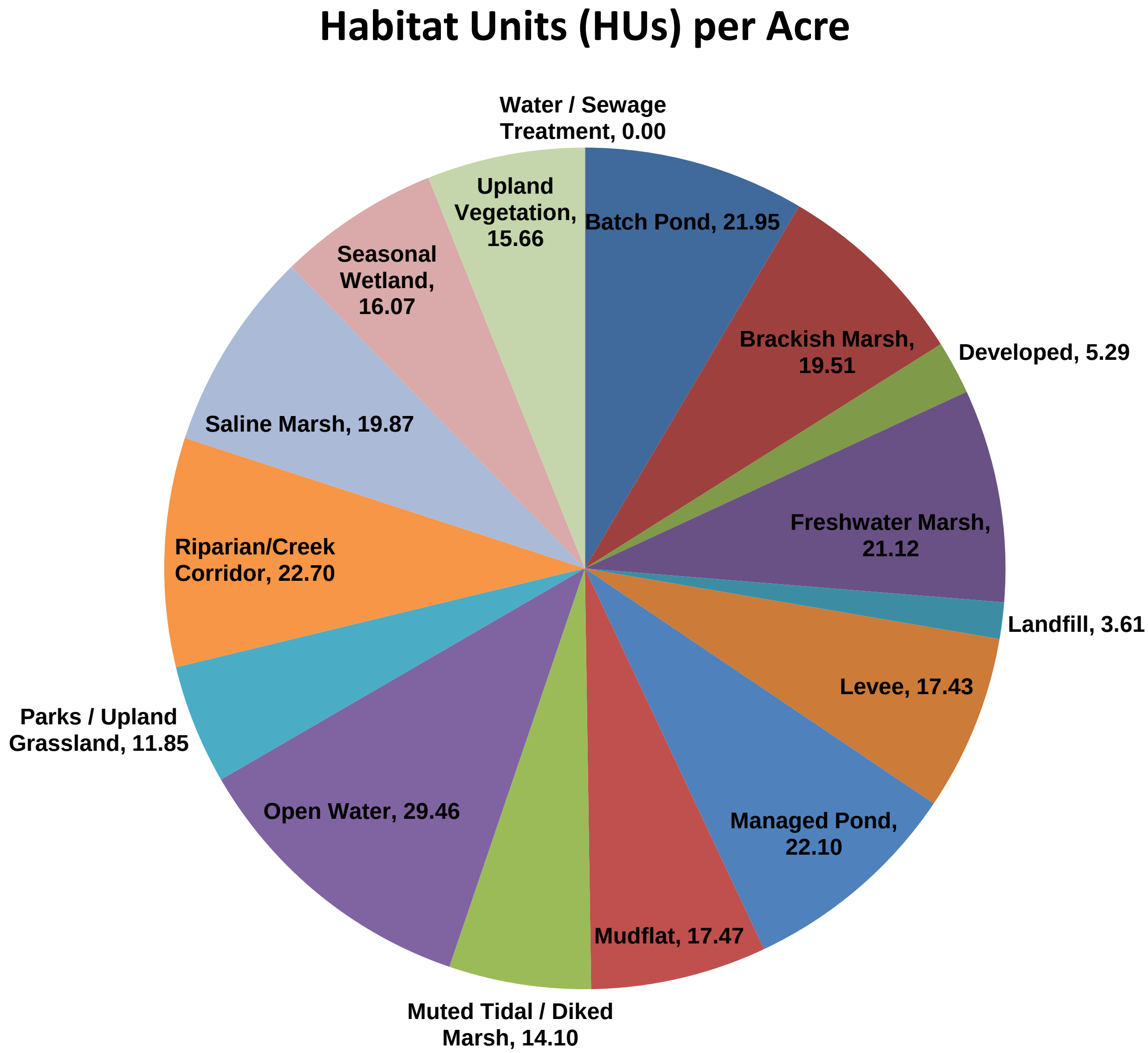

Figure 6. Breakout of the average baseline per-acre habitat value by habitat type.

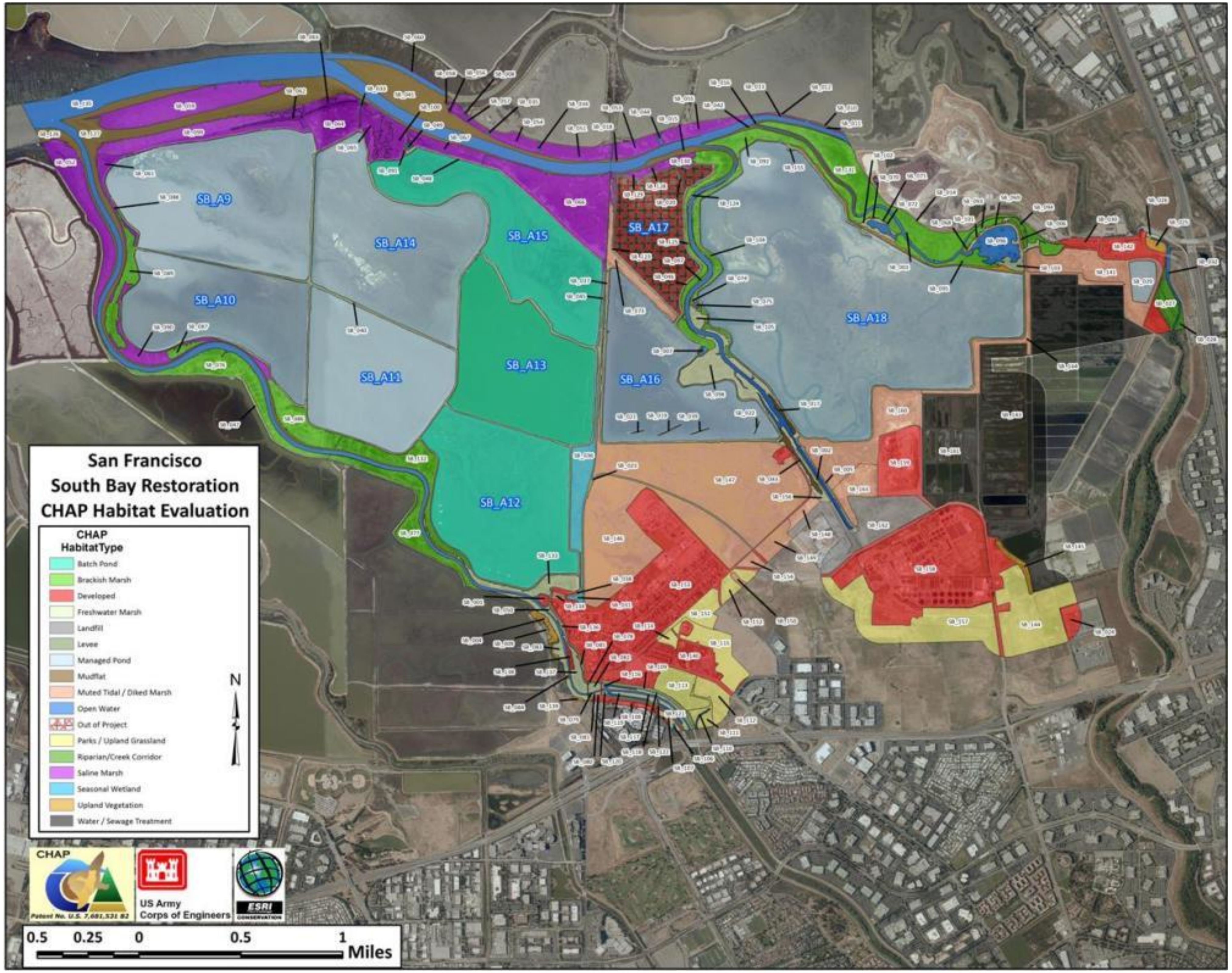

Figure 7. Shoreline study habitat assessment area showing the break out of polygons classified into the wildlife habitat types.

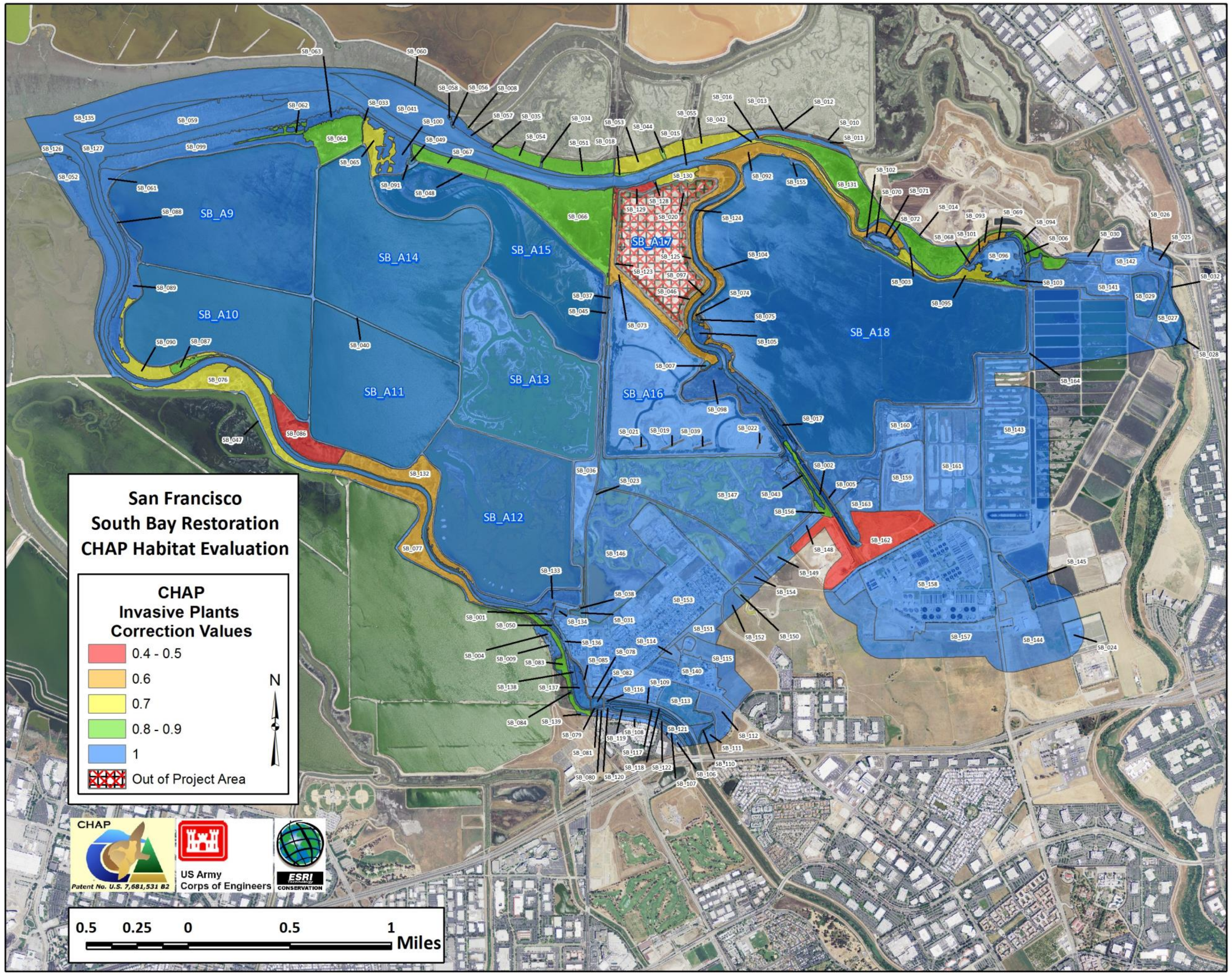

Figure 8. Depiction of the amount of invasive species as colored by their discounting value by polygon; these values were used in calculating overall habitat value within the Shoreline study project boundary.

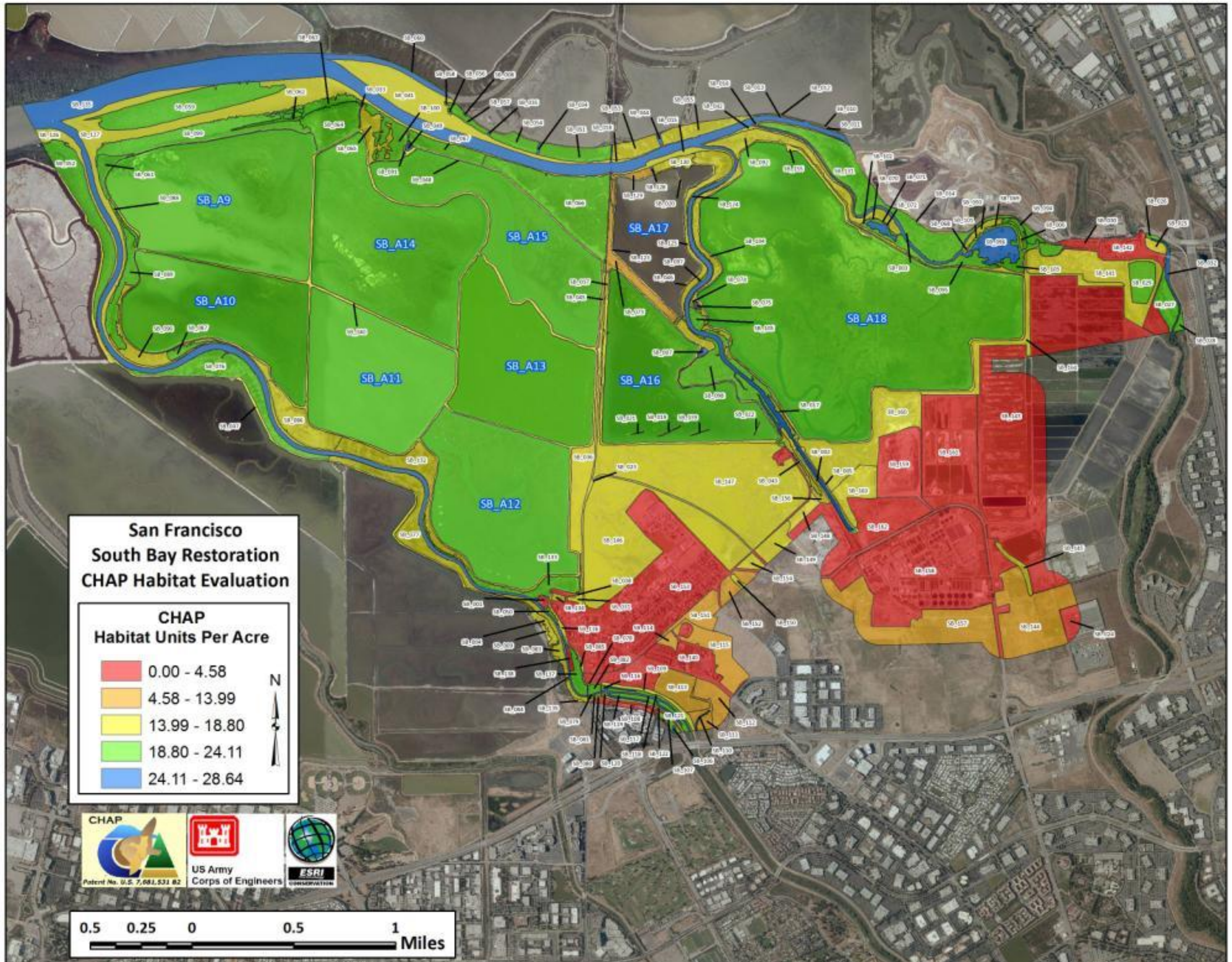

Figure 9. Illustrates the per-acre values for each polygon identified at Shoreline study project. [Note: Pond SB_A17 is not in this study. For zoom-in maps, see Appendix C]

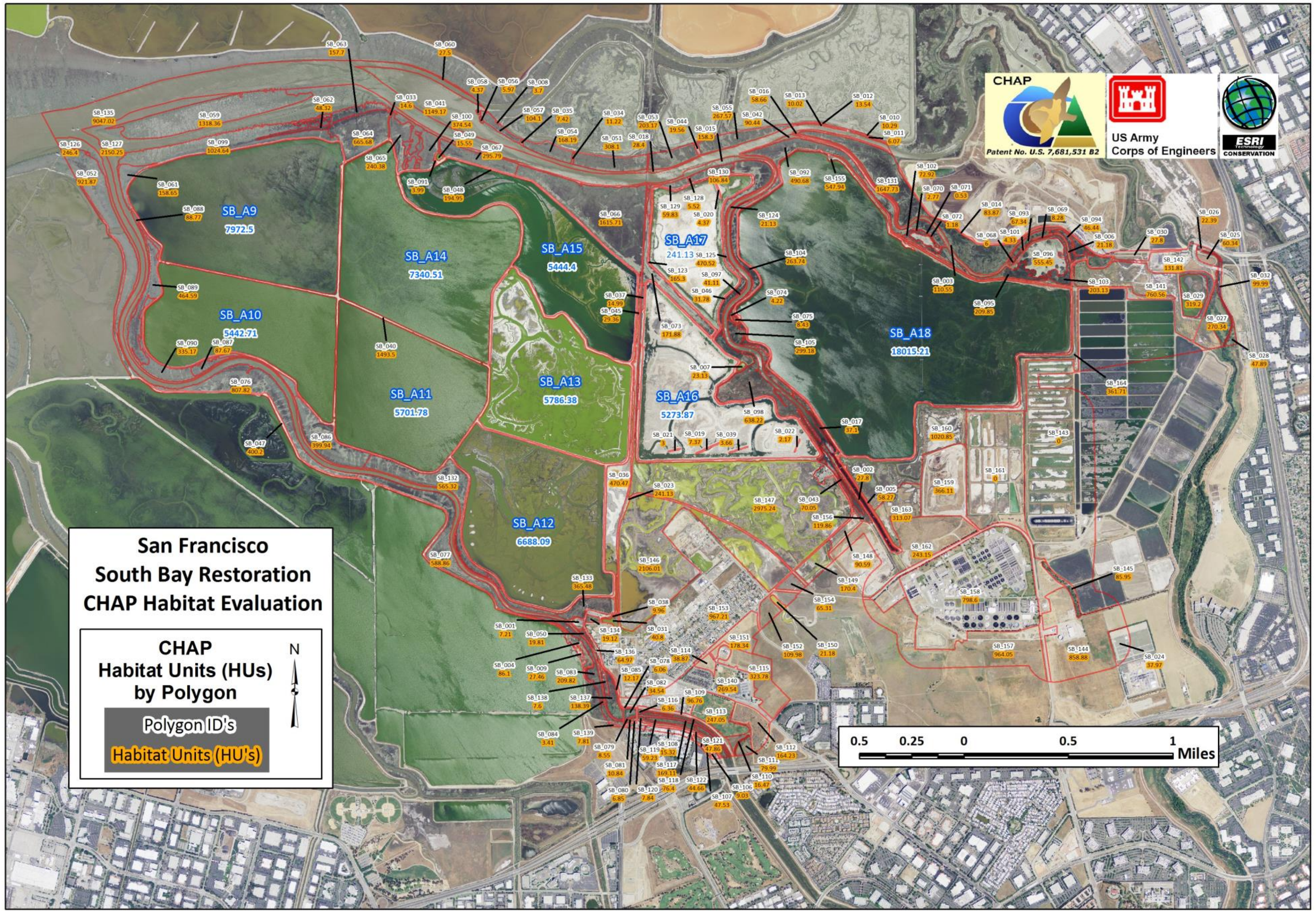

Figure 10. Shoreline study project showing the polygon number and associated habitat units (HUs). [Note: Pond SB_A17 is not in this study. For zoom-in maps, see Appendix D]

Validation

Species List - The development of the species list occurred in a series of steps. Refuge staff was able to generate a species list for both fish and wildlife by working with colleagues or based on their own knowledge of the Shoreline Study project area for baseline conditions, alternatives and without-project conditions. To help with quality control of these data, a potential species list was generated by accessing the California Wildlife Habitat Relationships (CWHR) geographic information system (GIS). A query of the site's potential species was done by accessing the peer-reviewed wildlife-species range maps that overlapped with the project boundary. Additionally, Refuge staff was also able to review the CWHR-generated species list. Refuge staff developed specific bird lists for each pond and determined their presence during the four seasons based on USGS Western Ecological Research Center. These data had been collected at the ponds and adjacent areas in 2011 by staff.. Lastly, the Refuge staff was also able to confirm the non-native species identified on the baseline condition species list can be found in Table 8.

ID	Common Name
10121	Striped bass
10149	Common carp
10177	Goldfish
10189	Western mosquito fish
10233	American shad
10234	Threadfin shad
10361	Cabezon
41190	Ring-necked Pheasant
42380	Rock Pigeon
43740	European Starling
44970	House Sparrow
50010	Virginia opossum
51070	Black rat
51080	Norway rat
51090	House mouse
51160	Red fox

Table 8. Non-native species evaluated as part of the baseline condition evaluation.

Habitat Findings – No separate vegetation transects were run to help verify the results from past habitat inventory for this project site. The data received was well attributed and based on maps that were developed and passed out for a prior review.

Conclusion

The wildlife habitat assessment of the Shoreline study evaluated 173 polygons to determine baseline conditions that consisted of 16 different habitat types to describe the 6,674 acres (or 2,700 ha) site. The number of fish and wildlife species associated with the project totaled 253, of which 51 were fish, 165 birds, 30 terrestrial mammals, 6 reptiles, and 1 marine mammal. The baseline condition evaluation for the Shoreline Study showed a total of 117,811 habitat units of which about 60,000 habitat units are associated with Ponds A9 – A18. Breaking out the different habitat types revealed that there are 2,298 managed ponds within the study site. Of these, there are 826 batch ponds, 413 saline marsh ponds, 545 muted tidal or diked marsh ponds, and 119 freshwater marsh ponds. The average per-acre value of managed ponds overall is 22.1. By type, the values are 22.0 for batch ponds, 19.9 for saline marsh, 14.4 for muted tidal and diked marsh ponds, and 21.3 for freshwater marsh ponds. All habitat types' per-acre values fell within the range of 0 and 29.8.

Year 50 Future Without-Project Condition

Introduction

CHAP habitat value utilizes species habitat functions to derive current habitat values. To determine a change in these values over time, projections are needed to alter either the species, habitat, or function parameters. Applying these changes over several time periods requires some conjecture to deduce the amount of influence that might be expected during each time period. To display the future condition outcomes and help visualize these changes in value over time, the habitat changes are applied to either a coarse or fine scale habitat map, while the species and function changes are applied to their respective data sets.

Originally, the baseline analysis of projected future conditions for the shoreline ecosystem restoration project was conducted at 25 and 50 years from the present as part of the project feasibility study. However, once the project moved onto the alternatives phase it was decided that there should be six breakpoints in time that would be studied. To keep consistent with the alternatives report, this portion of the without project analysis has been updated to reflect how this was done. The baseline year of analysis was 2017 with further analysis breakpoints occurring during 2020, 2025, 2030, 2037, 2047 and 2067. The assumptions NHI used for the without project analysis was that there would be permanent breaching of the ponds at various time intervals, which would lead to the managed ponds being restored to tidal action. This assumption has been revised to show that the managed ponds will be maintained as non-tidal in the without-project scenario throughout all six breakpoints. Breaches may occur due to heightened flood risk over time, but would be quickly repaired to avoid unacceptable risks to developed areas. The main assumption here is that because of the resilience of pond and marsh habitats in the South Bay, along with levee repairs as needed, there would be little change in habitat value over time.

Due to the uncertainties present and the high cost of developing accurate models to reflect these small changes in habitat value, it was decided that the baseline value would be used to represent the habitat value through the 2030 breakpoint. In the 2037 breakpoint onward the alternatives species list was used to re-calculate CHAP HU's for baseline to come up with an approximation of future conditions taking into account the species relationships developed for future conditions in the alternatives process. This yielded a slightly smaller total CHAP HU value for the project site in these later breakpoints.

Potential species decline

The habitat evaluation team discussed a reduction in the number of fish and wildlife taxa present within the project area over time. However, in this case, it was the consensus of the habitat evaluation team that most of the current landscape conditions in and around the project area would mostly prevail over time. Therefore, when reviewing the number of species that may decline over the 50 year period, several were discussed but the Refuge staff felt that given their current data, only 4 species might be identified as possibly declining within the project area (see Table 9). Thus, 2 species were randomly removed in the first 25 years interval and the remaining 2 species were removed in the later 25 years to reflect this potential decline over the 50 year period.

SPP ID	Common Name	Interval Species Removed
42510	Burrowing Owl	First 25 Year Period
41410	Western Snowy Plover	First 25 Year Period
41321	California Clapper Rail	Second 25 Year Period
40780	Redhead Duck	Second 25 Year Period

Table 9. Species that may decline over the next 50 year period

Because it is assumed that the remaining fish and wildlife species currently identified in the project would likely persist into the future, it was thought best to establish the current level of functional resiliency. This was done by comparing species functional redundancy between historic (343 species, Appendix A-5) and current baseline conditions (253 species, Appendix A-1). The top 20 functional categories in both time intervals are shown in Figures 11 & 12. Next, when these values are compared side-by-side, they show the potential resiliency levels for each functional category (Figure 13). A comparison of species that only perform a few functions was also done but there was little difference between the time periods. However, in a few categories in Figure 12, there is a higher level of functional resiliency occurring in the current baseline than the historic time period. This occurs in the categories of egg eaters, tertiary consumers and fish prey. This is the result of accounting for the non-native species (Table 8). These species are mostly generalists that did not occur in the past but are now common or widespread. Examples of functions each species may perform can be found in Appendix A-4.

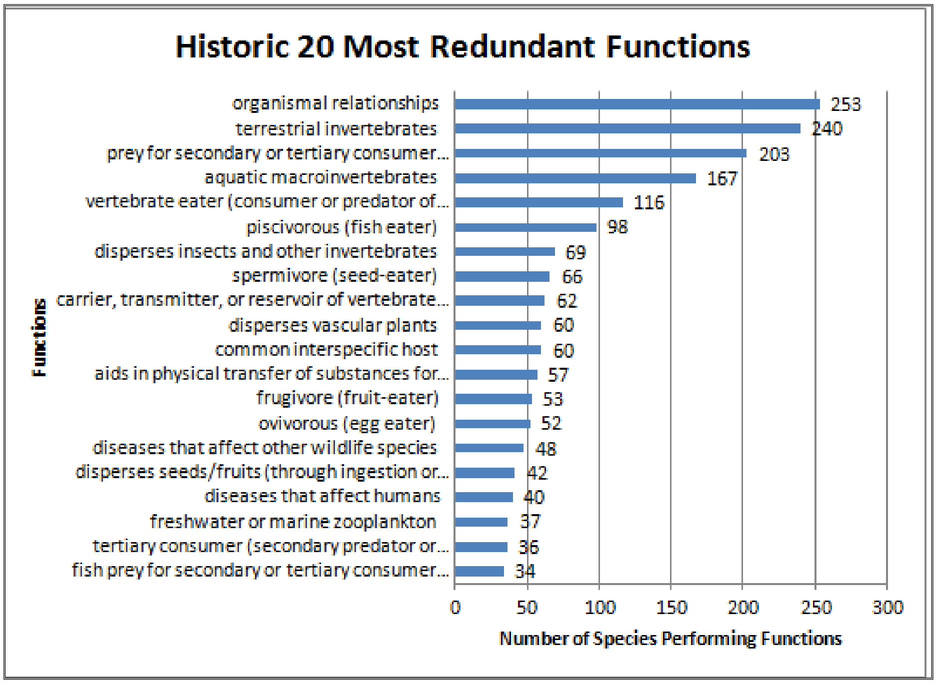

Figure 11. Top 20 key ecological functions for historic period.

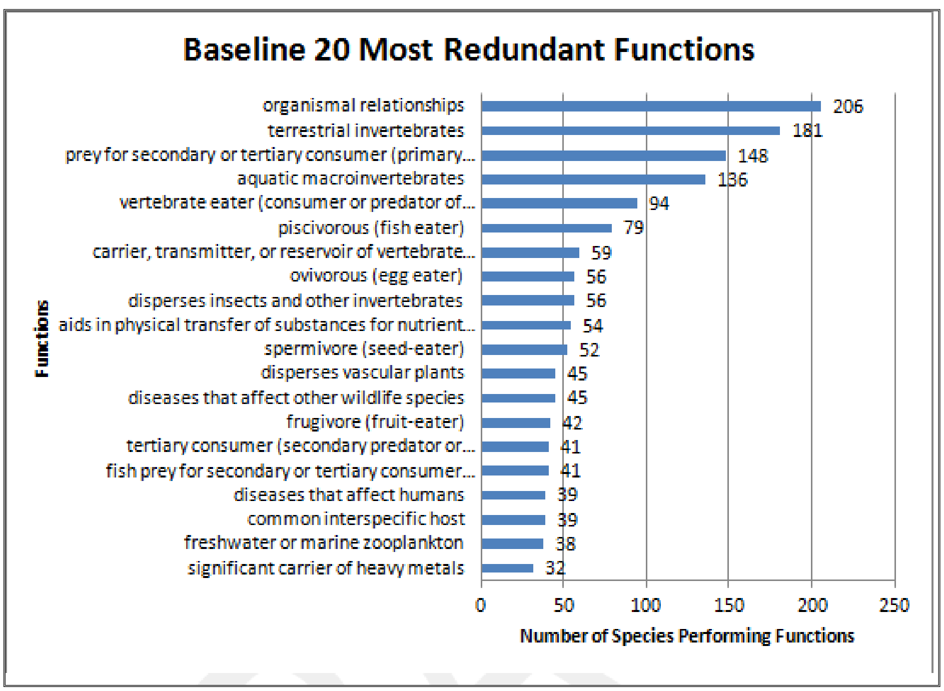

Figure 12. Top 20 key ecological functions for the current baseline.

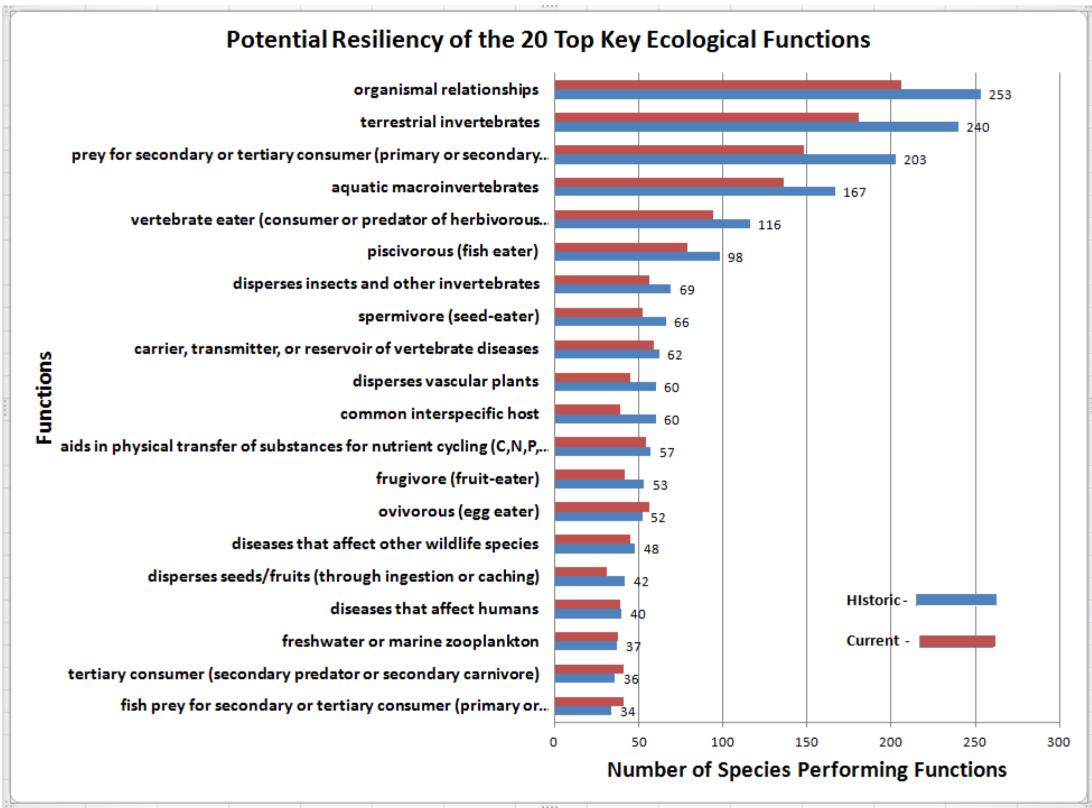

Figure 13. A comparison between historic and current baseline conditions for the Top 20 key ecological functions

Next, a quick coarse-level assessment of potential cumulative impacts can be shown by comparing San Francisco Bay habitats from historic to modern times (Figure 15). This allows a trajectory to be established that helps frame the current setting and give a general idea of how far we have come from a historical perspective. That is, a coarse-scale assessment from then to now will show approximately the change that has occurred in the San Francisco Bay area.

To determine the amount of change in habitat values, it is necessary to establish a species list for each habitat type that was mapped for both time periods. A map showing both historic and modern times can be found at the San Francisco Estuary Institute (SFEI) and is depicted in Figure 14. A species list and their habitat associations, which were determined by professional opinion (Refuge & NHI staff and IBIS data system) for the historic and modern time periods, can be found in Appendices A-5 and A-6 respectively. Table 10 shows the two separate habitat classifications (as mapped by SFEI) that were developed to allow the comparison from one time period to the other. In doing this exercise, there was a concern that the vast amount of tidal marsh shown in the historic map would receive an unrealistically high value. Hence, 2 historic species lists were generated; one consisting of 205 species and the other includes 171 species (see Appendix A-5). Table 10a shows the amount of change in habitat types from historic to modern times, while Table 10b depicts the range in habitat value change between those two time periods.

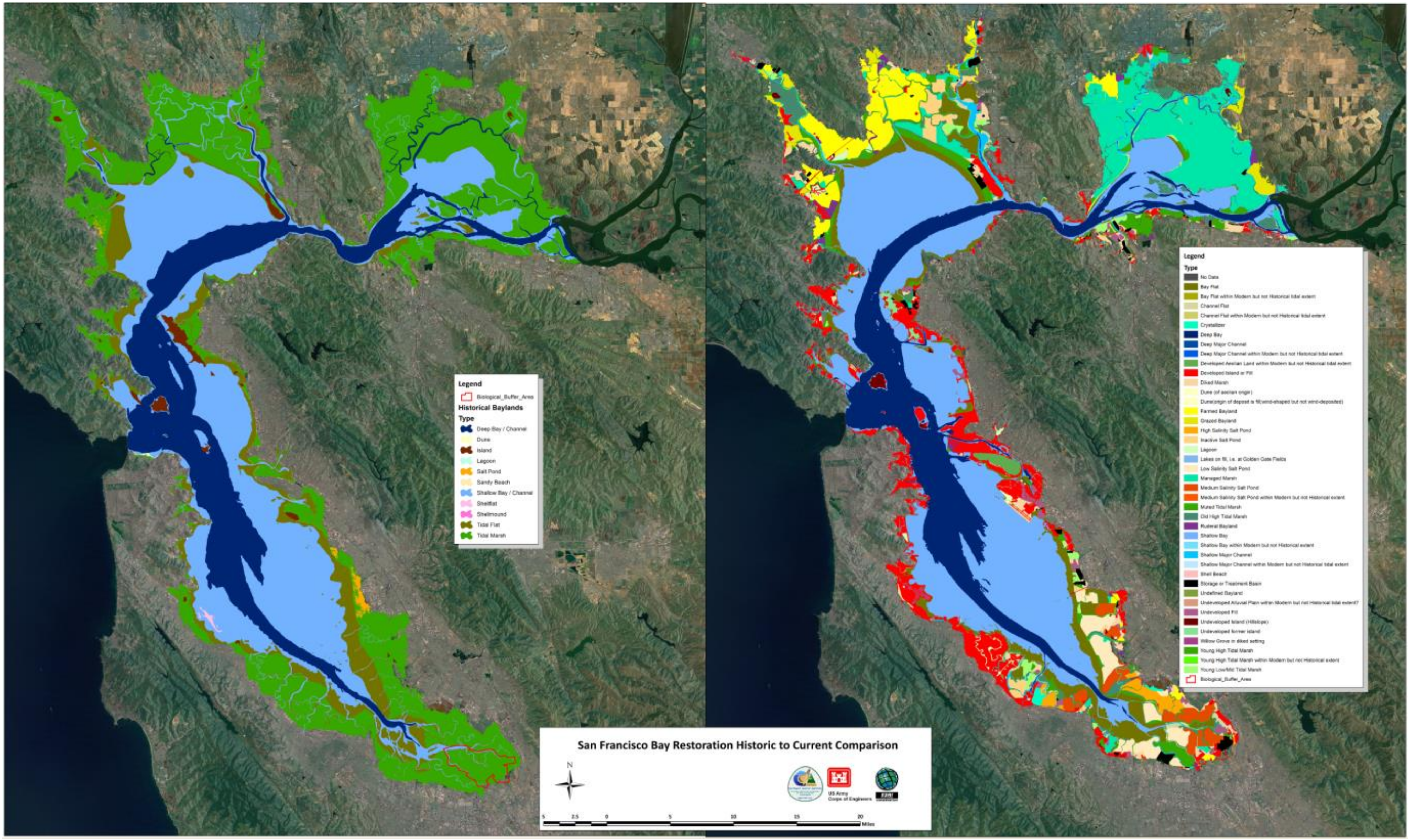

Figure 14. San Francisco Bay comparison between historic (ca. 1800) and modern times (ca. 2001) habitats (source: SFEI).

Historic Conditions San Francisco Bay	Modern Conditions San Francisco Bay
Deep Bay / Channel	Deep Bay / Channel
Dune	Dune
Island	Lagoon
Lagoon	Salt Pond
Natural Salt Pond	Shallow Bay / Channel
Sandy Beach	Tidal Flat
Shallow Bay / Channel	Tidal Marsh
Shellflat	Developed
Shell Mound	Agriculture
Tidal Flat	
Tidal Marsh	

Table 10. Habitat classifications used to compare historic (ca. 1800) to modern times (ca. 2001).

Historic Habitat Value Acreages and Proportions											
Habitats	Deep Bay / Channel	Dune	Lagoon	Salt Pond	Sandy Beach	Shallow Bay / Channel	Tidal Flat	Tidal Marsh	Island	Shellflat	Shell Mmound
Acres	99,527.68	54.75	84.17	1,594.53	199.33	174,440.54	50,054.73	189,985.90	4,823.86	395.34	12.01
Proportions	0.19	0.00	0.00	0.00	0.00	0.33	0.10	0.36	0.01	0.00	0.00
											Total Acres**
											521,172.83

Modern Habiat Value Acreages and Proportions											
Habitats	Deep Bay / Channel	Dune	Lagoon	Salt Pond	Shellflat	Shallow Bay / Channel	Tidal Flat	Tidal Marsh	Developed	Agriculture	No Correlation
Acres	82,530.76	2,254.80	2,325.53	29,738.39	12.41	171,838.91	35,313.67	103,501.19	50,341.78	31,738.89	13,789.87
Proportions	0.16	0.00	0.00	0.06	0.00	0.33	0.07	0.20	0.10	0.06	0.03
											Total Acres
**Note: there is a 2,213 acre discrepancy between Historic to Modern timeframe because of a gap not mapped in the Historic map											523,386.19

Table 10a. Acreage change in habitat types from historic (ca. 1800) to modern times (ca. 2001).

	Habitat Value	Difference Historic to Modern
Historic (High Range Habitat Value)	9,130,514	-2,343,419
Historic (Low Range Habitat Value)	8,516,173	-1,729,077
Modern Times Habitat Value	6,787,095	0

Table 10b. Overall habitat value change from historic (ca. 1800) to modern times (ca. 2001).

Invasive species would expand in area and abundance

Invasive plant species information for current conditions was originally collected from past studies or from knowledgeable staff on site. A value was determined and recorded for each polygon using the percent breakout in Table 11.The greater the adjustment value, the greater the discount applied.

Determined Invasive Adjustment (based on area percent)	Discount Class
1 - 0.95	1
0.94 - 0.90	0.9
0.89 - 0.80	0.8
0.79 - 0.70	0.7
0.69 - 0.60	0.6
0.59 -0.50	0.5
0.49 - 0.40	0.4

Table 11. Invasive plant species deduction factors

To determine the influence of invasive species for the without-project conditions, the habitat evaluation team expected that the presence and abundance of the invasive species would increase over time. Therefore, the percent invasive species for each polygon at the baseline condition should advance to the next highest percent level for the first 25 years, and to the next level beyond that for the next 25 years. In other words, if the current baseline condition of a polygon has .89-.80 invasive cover, then the condition at Year 25 would be assessed at .79-.70 invasive cover while the condition at Year 50 would be reflected as .69-.60 invasive cover. We recognize that these assumptions may not reflect real outcomes because salinity values within the ponds may check the spread of some invasive plants. Thus, increases in invasive plants may be more likely to occur in above-shoreline habitats.

Planned development

We used the city of San Jose Planning Services Division's future land use and transportation plan to determine future development in the project area. This document, known as *Envision San Jose 2040 General Plan* (http://www.sanjoseca.gov/planning/gp_update/default.asp) shows what the city planners envision over the next several decades. Below is their planning map for the Alviso area that would cover the project site (Figure 15). This information was overlaid onto the existing environment and shows that most of the anticipated change through 2040 will occur in the already developed area. The only significant development action proposed in Alviso aside from the Master Plan is a proposed height increase for Newby Island Landfill. Finally, there is also a recent San Jose/Santa Clara Water Pollution Control Plant Master Plan that was published in December 2011. This master plan updates the San Jose 2040 Plan. A further discussion of the Water Pollution Control Plant Master Plan can be found in the Climate Change section that follows.

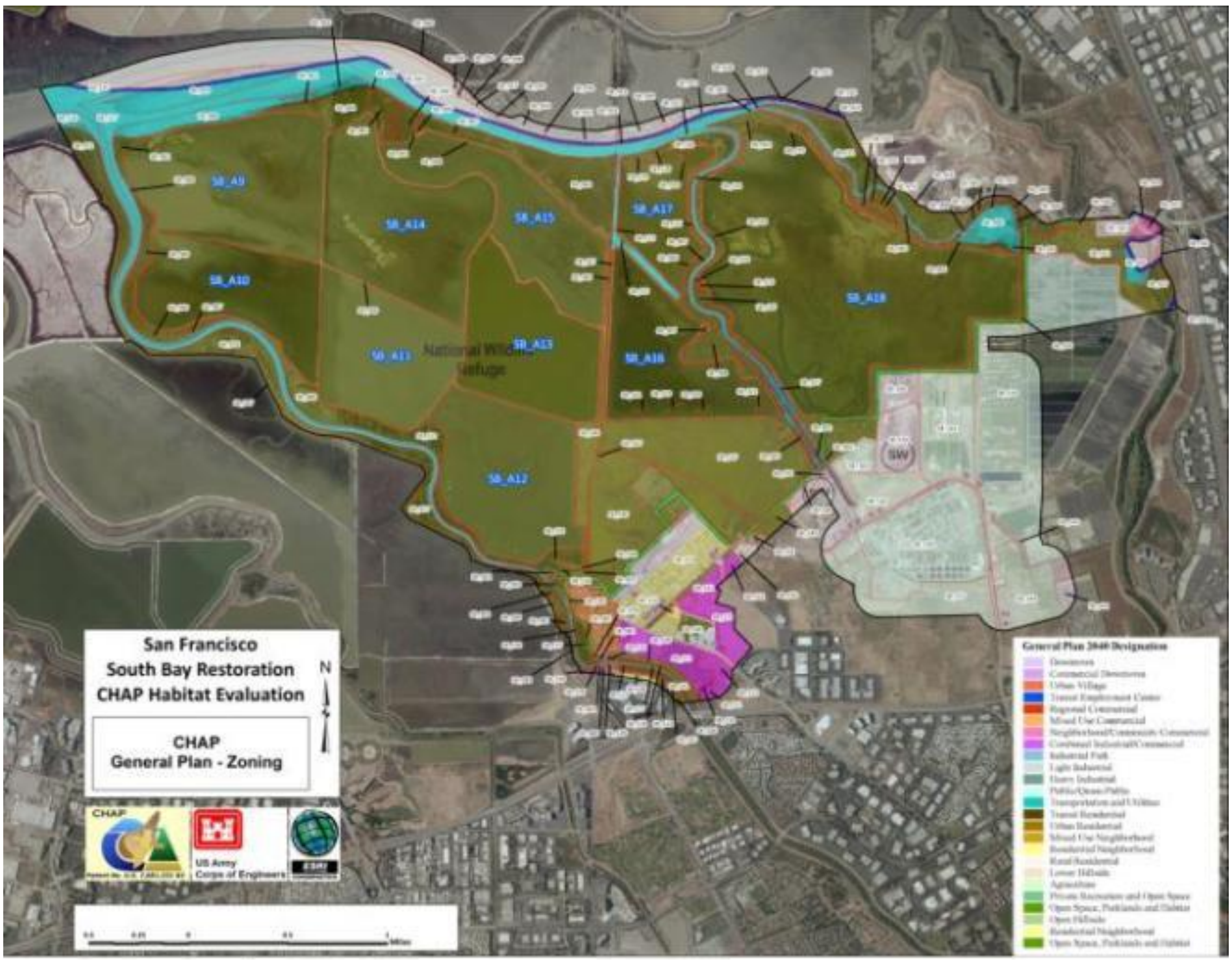

Figure 15. Alviso planning area until 2040. (Source: San Jose Services Planning Division - *Envision San Jose 2040 General Plan*).

Climate change increasing water level

The current distribution, abundance, and vitality of species and habitats are strongly dependent on climatic (and microclimatic) conditions. Climate change is expected to result in warmer temperatures year-round with most precipitation falling during winter from North Pacific storms. One of four climate model projects associated with *Cal-Adapt* shows slightly wetter winters, while others shows slightly drier winters with a 10 to 20 percent decrease in total annual precipitation. Nonetheless, even modest changes may have a significant impact to California ecosystems (http://cal-adapt.org/precip/decadal; last accessed 6-6-2012). Rising water level will significantly affect coastal wetlands because they are mostly within a few feet of sea level. As the sea level rises, these wetlands will move inland, or they will be lost if they abut development or high ground. Part of the current Climate Change Implementation Plan for Adaptation is a strategy to complete a statewide sea-level rise vulnerability assessment every five years. In 2006, the California Climate Change Center reported a historic sea-level rise of 7 inches in the last century and projected an additional rise of 4–35 inches by the end of this century. Their report uses the 20-55 inch projection, as it was the best available science at the time of the 2009 impacts assessment, but in so doing noted that future sea-level rise estimates will vary based on future greenhouse gas emissions (http://resources.ca.gov/climate_adaptation/docs/Statewide_Adaptation_Strategy_-_Chapter_6_-_Ocean_and_Coastal_Resources.pdf; last accessed 5-2-2012).

To assess the influence of the potential increase in sea level, the Shoreline Study used the National Research Council's (NRC) Curve III and the following comments apply only to the area south of Dumbarton Straits. This curve simulates a high rate or 1.5 meter rise in the water depth over the project area and adjacent lands (Figure 16), and we anticipated this event may likely occur once within the 50 year time period and any damage would be mitigated quickly. Under favorable sediment availability conditions, tidal marshes may be able to keep up with sea level rise; in addition, if a breach in a levee were to occur it would be quickly repaired. Thus there is a potential for an increase in aquatic habitats though the duration maybe short lived. By the end of the 50 years, it is thought that current without-project conditions might be roughly the same. This is based on past experience with relative sea level rise (due to ground subsidence) whereby tidal marshes were able to keep up with accumulating sediment fast enough; this process may be able to keep pace with the expected sea level rise over a 50-year period. However, this ability is not unlimited and that faster rates of sea level rise later in the century (after the 50-year period) may have different results for tidal marsh persistence. Additionally, USGS modeling of the non-vegetated tidal portions of the area south of the Dumbarton Bridge show it more or less has kept up with sea level rise over a 50-year period.

The City is working with the Shoreline Study to ensure that the Water Pollution Control Plant is protected from future sea-level rise, and hence are evaluating minimum and maximum levee build-out as well as other fortification options. The City is also evaluating 3 land use alternatives: Back to the Bay, Necklaces of Lakes, and Riparian Corridor (San Jose/Santa Clara Water Pollution Control Plant Master Plan, 2011). However, the City does not have funding to implement these plans. They will focus their funding on the plant makeover. Currently, habitat restoration will only occur on plant lands or in Pond A18 with the involvement of additional partners.

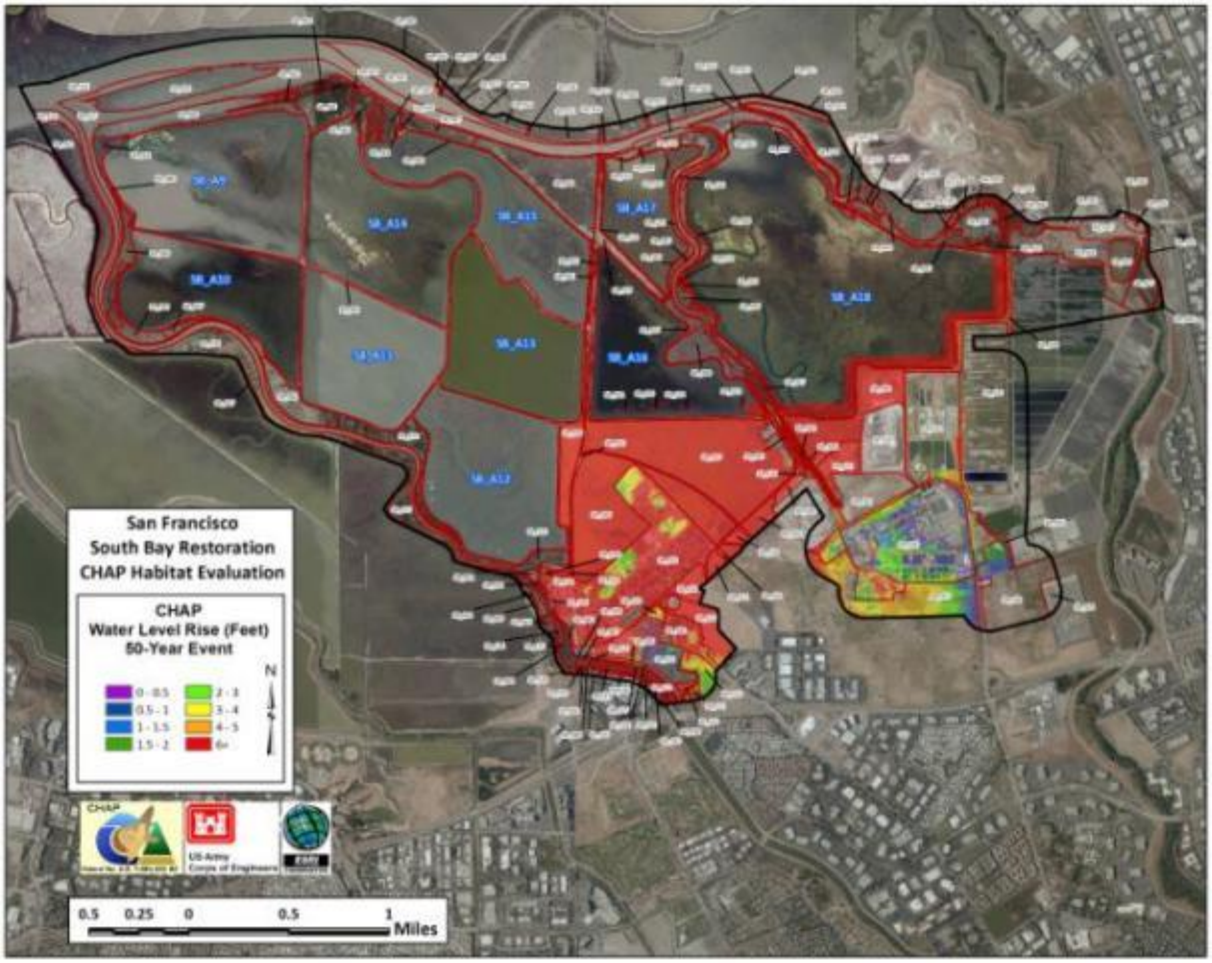

Figure 16. Depiction of the potential impact area from a 50 year flood event over the project area and adjacent lands.

Earthquakes

Earthquakes and their tremors are not uncommon in the San Francisco area. Figures 17a &17b depict the potential earthquake risk in and around the San Francisco area. If an earthquake occurred, the primary impact would be to infrastructure on the site. Salt pond levee/dikes are not engineered and might fail, but this risk is difficult to quantify and should be considered unquantifiable. That is, there is some risk of these structures failing, but during the 50-year evaluation period they are expected to be repaired after such an event even in the absence of a Corps project. Since the outermost levee is the highest one, this levee would be repaired to restore flood protection for urbanized areas and infrastructure, which would have the effect of maintaining non-tidal conditions for all the ponds. Also, liquefaction risk is high for current levees due to Bay mud that underlies the levees. Nonetheless, if this infrastructure failed, some flooding may occur and surface water is expected to flow back in the San Francisco South Bay.

The California Geological Survey has online a Probabilistic Seismic Hazards Mapping Ground Motion (Figure 17a). The USGS also indicated that the south segment of the Hayward Fault and the Peninsula segment of the San Andreas Fault are at high risk of a magnitude-7 quake in coming decades. Such an earthquake might shake the study area more strongly than the 1989 quake. For a reasonable map of shaking potential, see http://redirect.conservation.ca.gov/cgs/rghm/pshamap/psha12237.html (last accessed 06/ 08/2012). Lastly, the USGS also depicts the likelihood of a 6.7 or greater earthquake from 2007 to 2036.

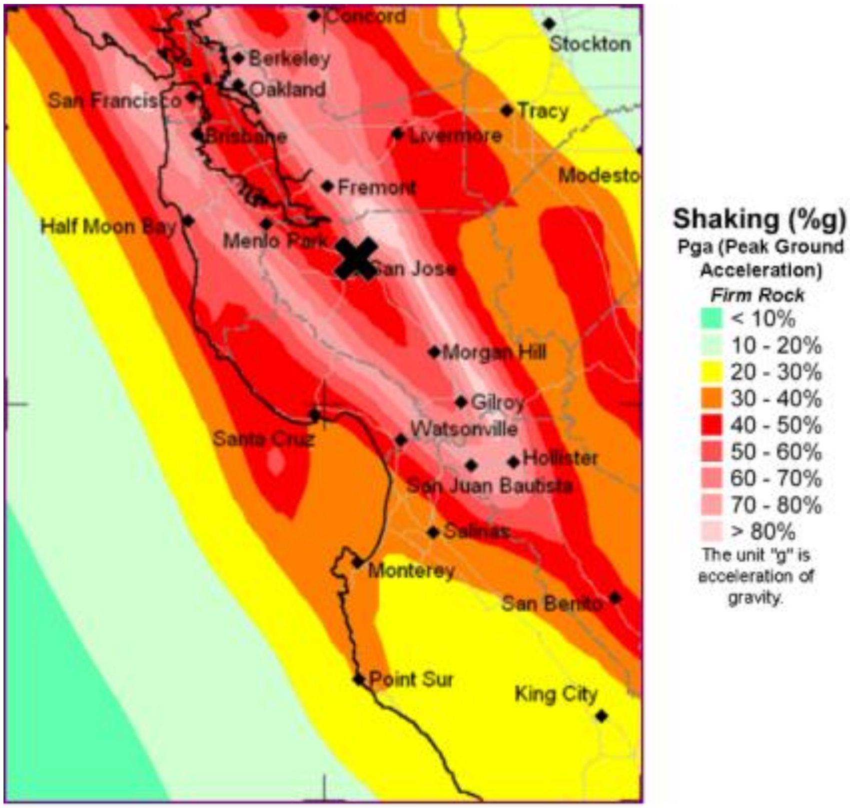

Figure 17a. Potential for ground motion within and near the project area as shown by California Geological Survey.
(Source: http://redirect.conservation.ca.gov/cgs/rghm/pshamap/psha12237.html; last accessed 06/ 08/2012).

Figure 17b. USGS map depicting the probability of a 6.7 or greater earthquake from 2007 to 2036 (Source: http://earthquake.usgs.gov/regional/nca/ucerf/images/2008probabilities-lrg.jpg; last accessed 6/15/2012).

Conclusion

To examine the future conditions that might exist without the proposed project, we began to put the project site into perspective by conducting a coarse evaluation of the amount of change in land use that has occurred from historic to modern times for the shoreline around the entire San Francisco Bay. To do this, the San Francisco Estuary Institute's Historic and Modern Bayland maps were used. This assessment showed an apparent loss in value that ranges from about 1.7 to 2.3 million habitat units for the area. To develop the future perspective for the next 50 years, additional steps were taken to obtain information on fish and wildlife species populations, invasive plant species, planned development, climate change influences and earthquake frequencies. Evaluating this information shows that there may be low turnover in species composition. Salinity levels will likely continue to control the spread of some of the invasive plants. Future planned development will occur in already developed areas. Sea level rise due to climate change may periodically expand the bay's aquatic footprint for short time periods in the Alviso area, and the design and engineering of the current levees and dikes are expected to withstand predictive earthquakes for the area.

However, if this infrastructure failed, some flooding may occur though the surface water is expected to flow back in the San Francisco South Bay.

Regarding uncertainty, any time we try to predict future conditions, whether for 10, 25 or 50 years from the present, there is a underlying degree of uncertainty associated with the above statements. Projections may change dramatically with further information in the future. In addition, information sources are not perfect. Planned development is closely associated with the economic conditions for an area;, although stated as a vision for 2040 we must remember that planning is dynamic and is also subject to change. For other outcomes that maybe affected by climate change, as mentioned 1 model out of 4 shows the potential for wetter conditions while that other 3 suggest drier conditions. Lastly, regarding prediction of potential catastrophic events such as earthquakes is extremely inexact and relies heavily on professional opinion; the likelihood of occurrence has a wide time interval associated with the predictions.

Citations

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Appendix A-1
Shoreline Study Project Species List for Baseline Conditions
[253 Fish and Wildlife Species]

SPP ID	Common Name	Scientific Name
10001	Pacific lamprey	*Lampetra tridentata*
10071	Sacramento sucker	*Catostomus occidentalis occidentalis*
10073	Threespine stickleback	*Gasterosteus aculeatus*
10081	Prickly sculpin	*Cottus asper*
10121	Striped bass	*Morone saxatilis*
10149	Common carp	*Cyprinus carpio*
10173	Starry flounder	*Platichthys stellatus*
10177	Goldfish	*Carassius auratus auratus*
10189	Western mosquito fish	*Gambusia affinis*
10221	Pacific staghorn sculpin	*Leptocottus armatus*
10233	American shad	*Alosa sapidissima*
10234	Threadfin shad	*Dorosma petenense*
10237	Shiner perch	*Cymatogaster aggregata*
10245	Longfin smelt	*Spirinchus thaleichthys*
10249	Green sturgeon	*Acipenser medirostris*
10295	Steelhead	*Oncorhynchus mykiss*
10325	Leopard shark	*Triakis semifasciata*
10326	Brown smoothhound	*Mustelus henlei*
10329	Soupfin shark	*Galeorhinus galeus*
10333	Spiny dogfish	*Squalus acanthias*
10337	Big skate	*Raja binoculata*
10341	California skate	*Raja inornata*
10361	Cabezon	*Scorpaenichthys marmoratus*
10405	Brown rockfish	*Sebastes auriculatus*
10537	English sole	*Parophrys vetulus*
10538	California tonguefish	*Symphurus atricaudus*
10539	Diamond turbot	*Hypsopsetta guttulata*
10545	Pacific sanddab	*Citharichthys sordidus*
10561	Sand sole	*Psettichthys melanostictus*
10585	Chinook salmon	*Oncorhynchus tshawytscha*
10589	Pink salmon	*Oncorhynchus gorbuscha*
10593	Chum salmon	*Oncorhynchus keta*
10628	Longjawed mudsucker	*Gillichthys mirabilis*

SPP ID	Common Name	Scientific Name
10629	Bay goby	*Lepidogobius lepidus*
10633	Arrow goby	*Clevelandia ios*
10634	Cheekspot goby	*Ilypnus gilberti*
10637	Speckled sanddab	*Citharichthys stigmaeus*
10641	Pacific herring	*Clupea pallasii*
10648	Barred surfperch	*Amphistichus argenteus*
10653	Surf Smelt	*Hypomesus pretiosus*
10657	Whitebait smelt	*Allosmerus elongatus*
10669	Bay pipefish	*Syngnathus leptorhynchus*
10686	Dwarf surfperch	*Micrometrus minimus*
10729	Plainfin midshipman	*Porichthys notatus*
10757	Topsmelt	*Atherinops affinis*
10758	Jack smelt	*Atherinopsis californiensis*
10765	Pacific sardine	*Sardinops sagax*
10808	Bat ray	*Myliobatis californica*
10817	Northern anchovy	*Engraulis mordax*
11113	White croaker	*Genyonemus lineatus*
11197	California halibut	*Paralichthys californicus*
30100	Southern alligator lizard	*Elgaria multicarinata*
30160	Western fence lizard	*Sceloporus occidentalis*
30290	Gopher snake	*Pituophis melanoleuca*
30320	Western terrestrial garter snake	*Thamnophis elegans*
30340	Common garter snake	*Thamnophis sirtalis*
30350	Western rattlesnake	Crotalus oreganus
40050	Pied-billed Grebe	*Podilymbus podiceps*
40060	Horned Grebe	*Podiceps auritus*
40070	Red-necked Grebe	*Podiceps grisegena*
40080	Eared Grebe	*Podiceps nigricollis*
40090	Western Grebe	*Aechmophorus occidentalis*
40100	Clark's Grebe	*Aechmophorus clarkii*
40320	American White Pelican	*Pelecanus erythrorhynchos*
40330	Brown Pelican	*Pelecanus occidentalis*
40350	Double-crested Cormorant	*Phalacrocorax auritus*
40380	American Bittern	*Botaurus lentiginosus*
40390	Least Bittern	*Ixobrychus exilis*
40400	Great Blue Heron	*Ardea herodias*

SPP ID	Common Name	Scientific Name
40410	Great Egret	*Ardea alba*
40420	Snowy Egret	*Egretta thula*
40450	Cattle Egret	*Bubulcus ibis*
40460	Green Heron	*Butorides virescens*
40470	Black-crowned Night-Heron	*Nycticorax nycticorax*
40500	Turkey Vulture	*Cathartes aura*
40530	Greater White-fronted Goose	*Anser albifrons*
40570	Canada Goose	*Branta canadensis*
40640	Gadwall	*Anas strepera*
40660	Eurasian Wigeon	*Anas penelope*
40670	American Wigeon	*Anas americana*
40690	Mallard	*Anas platyrhynchos*
40700	Blue-winged Teal	*Anas discors*
40710	Cinnamon Teal	*Anas cyanoptera*
40720	Northern Shoveler	*Anas clypeata*
40730	Northern Pintail	*Anas acuta*
40760	Green-winged Teal	*Anas crecca*
40770	Canvasback	*Aythya valisineria*
40780	Redhead	*Aythya americana*
40790	Ring-necked Duck	*Aythya collaris*
40810	Greater Scaup	*Aythya marila*
40820	Lesser Scaup	*Aythya affinis*
40860	Surf Scoter	*Melanitta perspicillata*
40870	White-winged Scoter	*Melanitta fusca*
40880	Black Scoter	*Melanitta nigra*
40890	Long-tailed Duck	*Clangula hyemalis*
40900	Bufflehead	*Bucephala albeola*
40910	Common Goldeneye	*Bucephala clangula*
40920	Barrow’s Goldeneye	*Bucephala islandica*
40940	Hooded Merganser	*Lophodytes cucullata*
40950	Common Merganser	*Mergus merganser*
40970	Ruddy Duck	*Oxyura jamaicensis*
40980	Osprey	*Pandion haliaetus*
40990	White-tailed Kite	*Elanus coeruleus*
41010	Northern Harrier	*Circus cyaneus*
41020	Sharp-shinned Hawk	*Accipiter striatus*

SPP ID	Common Name	Scientific Name
41030	Cooper's Hawk	*Accipiter cooperii*
41050	Red-shouldered Hawk	*Buteo lineatus*
41080	Red-tailed Hawk	*Buteo jamaicensis*
41090	Ferruginous Hawk	*Buteo regalis*
41110	Golden Eagle	*Aquila chrysaetos*
41120	American Kestrel	*Falco sparverius*
41130	Merlin	*Falco columbarius*
41150	Peregrine Falcon	*Falco peregrinus*
41190	Ring-necked Pheasant	*Phasianus colchicus*
41290	California Quail	*Callipepla californica*
41311	California Black Rail	*Laterallus jamaicensis coturniculus*
41320	Virginia Rail	*Rallus limicola*
41321	California Clapper rail	*Rallus longirostris obsoletus*
41330	Sora	*Porzana carolina*
41340	Common Moorhen	*Gallinula chloropus*
41350	American Coot	*Fulica americana*
41370	Black-bellied Plover	*Pluvialis squatarola*
41380	American Golden-Plover	*Pluvialis dominica*
41410	Western Snowy Plover	*Charadrius alexandrinus nivosus*
41420	Semipalmated Plover	*Charadrius semipalmata*
41440	Killdeer	*Charadrius vociferus*
41480	Black-necked Stilt	*Himantopus mexicanus*
41490	American Avocet	*Recurvirostra americana*
41500	Greater Yellowlegs	*Tringa melanoleuca*
41510	Lesser Yellowlegs	*Tringa flavipes*
41540	Willet	*Catoptrophorus semipalmatus*
41570	Spotted Sandpiper	*Actitis macularia*
41590	Whimbrel	*Numenius phaeopus*
41610	Long-billed Curlew	*Numenius americanus*
41640	Marbled Godwit	*Limosa fedoa*
41650	Ruddy Turnstone	*Arenaria interpres*
41700	Sanderling	*Calidris alba*
41710	Semipalmated Sandpiper	*Calidris pusilla*
41720	Western Sandpiper	*Calidris mauri*
41760	Least Sandpiper	*Calidris minutilla*
41820	Dunlin	*Calidris alpina*

SPP ID	Common Name	Scientific Name
41860	Ruff	*Philomachus pugnax*
41870	Short-billed Dowitcher	*Limnodromus griseus*
41880	Long-billed Dowitcher	*Limnodromus scolopaceus*
41900	Wilson’s Phalarope	*Phalaropus tricolor*
42010	Bonaparte’s Gull	*Larus Philadelphia*
42020	Heermann’s Gull	*Larus heermanni*
42030	Mew Gull	*Larus canus*
42040	Ring-billed Gull	*Larus delawarensis*
42050	California Gull	*Larus californicus*
42060	Herring Gull	*Larus argentatus*
42070	Thayer’s Gull	*Larus thayeri*
42100	Western Gull	*Larus occidentalis*
42110	Glaucous-winged Gull	*Larus glaucescens*
42120	Glaucous Gull	*Larus hyperboreus*
42130	Sabine’s Gull	*Xena sabini*
42180	Caspian Tern	*Sterna caspia*
42201	Black Skimmer	*Rynchops niger*
42220	Forster’s Tern	*Sterna forsteri*
42230	California Least Tern	*Sterna antillarum browni*
42380	Rock Pigeon	*Columba livia*
42390	Band-tailed Pigeon	*Columba fasciata*
42410	Mourning Dove	*Zenaida macroura*
42440	Barn Owl	*Tyto alba*
42470	Great Horned Owl	*Bubo virginianus*
42510	Burrowing Owl	*Athene cunicularia*
42560	Short-eared Owl	*Asio flammeus*
42650	Anna’s Hummingbird	*Calypte anna*
42700	Allen’s Hummingbird	*Selasphorus sasin*
42710	Belted Kingfisher	*Ceryle alcyon*
42840	Northern Flicker	*Colaptes auratus*
42940	Pacific-slope Flycatcher	*Empidonax difficilis*
42960	Black Phoebe	*Sayornis nigricans*
42980	Say’s Phoebe	*Sayornis saya*
43060	Loggerhead Shrike	*Lanius ludovicianus*
43200	Western Scrub-Jay	*Aphelocoma californica*
43240	American Crow	*Corvus brachyrhynchos*

SPP ID	Common Name	Scientific Name
43260	Common Raven	*Corvus corax*
43280	Horned Lark	*Eremophila alpestris*
43300	Tree Swallow	*Tachycineta bicolor*
43310	Violet-green Swallow	*Tachycineta thalassina*
43320	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
43330	Bank Swallow	*Riparia riparia*
43340	Cliff Swallow	*Petrochelidon pyrrhonota*
43350	Barn Swallow	*Hirundo rustica*
43380	Chestnut-backed Chickadee	*Poecile rufescens*
43400	Oak Titmouse	Baeolophus inornatus
43420	Bushtit	*Psaltriparus minimus*
43490	Bewick’s Wren	*Thryomanes bewickii*
43500	House Wren	*Troglodytes aedon*
43520	Marsh Wren	*Cistothorus palustris*
43550	Ruby-crowned Kinglet	*Regulus calendula*
43640	Hermit Thrush	*Catharus guttatus*
43660	American Robin	*Turdus migratorius*
43700	Northern Mockingbird	*Mimus polyglottos*
43740	European Starling	*Sturnus vulgaris*
43820	Cedar Waxwing	*Bombycilla cedrorum*
43970	Yellow-rumped Warbler	*Dendroica coronata*
44000	Townsend’s Warbler	*Dendroica townsendi*
44180	Common Yellowthroat	*Geothlypis trichas*
44180	San Francisco Common Yellowthroat	*Geothlypis trichas sinuosa*
44270	Spotted Towhee	*Pipilo maculatus*
44280	California Towhee	*Pipilo crissalis*
44390	Bryant's savannah sparrow	*Passerculus sandwichensis alaudinus*
44430	Fox Sparrow	*Passerella iliaca*
44440	Alameda song sparrow	*Melospiza melodia pusillula*
44440	Song sparrow	*Melospiza melodia*
44490	White-crowned Sparrow	*Zonotrichia atricapilla*
44500	Golden-crowned Sparrow	*Zonotrichia atricapilla*
44510	Dark-eyed Junco	*Junco hyemalis*
44590	Black-headed Grosbeak	*Pheucticus melanocephalus*
44660	Red-winged Blackbird	*Agelaius phoeniceus*

SPP ID	Common Name	Scientific Name
44670	Tricolored Blackbird	*Agelaius tricolor*
44680	Western Meadowlark	*Sturnella neglecta*
44710	Brewer’s Blackbird	*Euphagus cyanocephalus*
44740	Brown-headed Cowbird	*Molothrus ater*
44760	Hooded Oriole	*Icterus cucullatus*
44790	Bullock’s Oriole	*Icterus bullockii*
44870	House Finch	*Carpodacus mexicanus*
44930	Lesser Goldfinch	*Carduelis psaltria*
44950	American Goldfinch	*Carduelis tristis*
44970	House Sparrow	*Passer domesticus*
50010	Virginia opossum	Didelphis virginiana
50035	Ornate Shrew	Sorex ornatus
50040	Salt marsh wandering shrew	*Sorex vagrans halicoetes*
50110	Trowbridge's Shrew	Sorex trowbridgii
50200	Yuma myotis	*Myotis yumanensis*
50285	Western red bat	*Lasirurs blossevillii*
50290	Hoary bat	*Lasiurus cinereus*
50330	Mexican free-tailed bat	*Tadarida brasiliensis*
50360	Brush rabbit	*Sylvilagus bachmani*
50381	Audubon's cottontail	*Sylvilagus audubonii*
50420	Black-tailed jackrabbit	*Lepus californicus*
50610	California ground squirrel	*Spermophilus beecheyi*
50730	Botta's pocket gopher	*Thomomys bottae*
50820	Western harvest mouse	*Reithrodontomys megalotis*
50821	Salt marsh harvest mouse	*Reithrodontomys raviventris raviventris*
50830	Deer mouse	*Peromyscus maniculatus*
50990	California vole	*Microtus californicus*
51050	Common muskrat	*Ondatra zibethicus*
51070	Black rat	*Rattus rattus*
51080	Norway rat	*Rattus norvegicus*
51090	House mouse	*Mus musculus*
51140	Coyote	*Canis latrans*
51160	Red fox	*Vulpes vulpes*
51180	Gray fox	*Urocyon cinereoargenteus*
51220	Raccoon	*Procyon lotor*

SPP ID	Common Name	Scientific Name
51260	Long-tailed weasel	*Mustela frenata*
51300	Western spotted skunk	*Spilogale gracilis*
51310	Striped skunk	*Mephitis mephitis*
51330	Mountain lion	*Felis concolor*
51405	Mule Deer	*Odocoileus hemionus*
60040	Pacific harbor seal	*Phoca vitulina richardsi*

Appendix A-2

Species and Habitat Associations for Baseline Conditions

[253 Fish and Wildlife Species]

Common Name	Batch Pond	Brackish Marsh	Developed	Freshwater Marsh	Landfill	Levee	Managed Pond	Tidal Flats/ Mudflat	Muted Tidal / Diked Marsh	Open Water /Slough Channel	Parks / Upland Grassland	Riparian/Creek Corridor	Saline Marsh	Seasonal Wetland	Upland Vegetation
Pacific lamprey		1								1					
Sacramento sucker										1					
Threespine stickleback	1	1		1			1	1		1			1		
Prickly sculpin		1		1				1		1					
Striped bass		1		1				1		1			1		
Common carp		1		1						1					
Starry flounder		1		1						1			1		
Goldfish				1						1					
Western mosquito fish		1		1						1					
Pacific staghorn sculpin	1	1					1	1		1			1		
American shad		1		1				1		1					
Threadfin shad		1		1				1		1					
Shiner perch	1	1					1	1		1			1		
Longfin smelt		1						1		1					
Green sturgeon				1						1					
Steelhead				1						1					
Leopard shark	1						1	1		1			1		
Brown smoothhound	1						1			1					

Common Name	Batch Pond	Brackish Marsh	Developed	Freshwater Marsh	Landfill	Levee	Managed Pond	Tidal Flats/ Mudflat	Muted Tidal / Diked Marsh	Open Water /Slough Channel	Parks / Upland Grassland	Riparian/Creek Corridor	Saline Marsh	Seasonal Wetland	Upland Vegetation
Soupfin shark										1					
Spiny dogfish										1					
Big skate										1					
California skate										1					
Cabezon										1					
Brown rockfish								1		1					
English sole										1			1		
California tonguefish										1					
Diamond turbot	1						1			1					
Pacific sanddab										1					
Sand sole										1					
Chinook salmon		1		1						1			1		
Pink salmon		1		1						1					
Chum salmon		1		1						1					
Longjawed mudsucker	1	1					1	1		1					
Bay goby	1							1		1					
Arrow goby	1							1		1			1		
Cheekspot goby										1					
Speckled sanddab							1			1					
Pacific herring	1	1						1		1			1		
Barred surfperch	1						1	1		1			1		
Surf Smelt		1								1					

Common Name	Batch Pond	Brackish Marsh	Developed	Freshwater Marsh	Landfill	Levee	Managed Pond	Tidal Flats/ Mudflat	Muted Tidal / Diked Marsh	Open Water /Slough Channel	Parks / Upland Grassland	Riparian/Creek Corridor	Saline Marsh	Seasonal Wetland	Upland Vegetation
Whitebait smelt										1					
Bay pipefish		1					1			1			1		
Dwarf surfperch										1					
Plainfin midshipman	1							1		1					
Topsmelt	1	1					1	1		1			1		
Jack smelt	1	1						1		1			1		
Pacific sardine										1					
Bat ray	1	1					1	1		1			1		
Northern anchovy	1	1					1	1		1			1		
White croaker										1					
California halibut										1					
Southern alligator lizard					1						1				1
Western fence lizard					1						1				1
Gopher snake					1						1	1			1
Western terrestrial garter snake					1						1	1			1
Common garter snake					1						1	1			1
Western rattlesnakes					1						1				1
Pied-billed Grebe	1			1			1			1		1	1		
Horned Grebe	1			1			1			1		1	1		
Red-necked Grebe	1			1			1								
Eared Grebe	1						1			1			1	1	
Western Grebe	1			1			1			1					

Common Name	Batch Pond	Brackish Marsh	Developed	Freshwater Marsh	Landfill	Levee	Managed Pond	Tidal Flats/ Mudflat	Muted Tidal / Diked Marsh	Open Water /Slough Channel	Parks / Upland Grassland	Riparian/Creek Corridor	Saline Marsh	Seasonal Wetland	Upland Vegetation
Clark's Grebe	1			1			1			1					
American White Pelican	1					1	1			1					
Brown Pelican	1					1	1								
Double-crested Cormorant	1					1	1			1					
American Bittern		1		1								1	1		
Least Bittern		1		1					1			1	1		
Great Blue Heron	1	1		1	1	1	1	1	1			1	1	1	
Great Egret		1		1		1	1	1	1			1	1	1	
Snowy Egret	1	1		1		1	1	1				1	1		
Cattle Egret		1		1		1						1			
Green Heron		1		1								1			
Black-crowned Night-Heron		1		1	1							1			
Turkey Vulture	1				1	1			1						1
Greater White-fronted Goose						1	1		1		1				
Canada Goose		1	1	1		1	1		1	1	1		1	1	1
Gadwall	1	1		1		1	1			1		1	1	1	
Eurasian Wigeon							1		1	1					
American Wigeon				1					1	1			1	1	
Mallard	1	1		1		1	1		1	1	1	1	1	1	
Blue-winged Teal		1		1					1	1		1	1		
Cinnamon Teal		1		1					1	1		1	1	1	
Northern Shoveler	1	1		1		1	1		1	1			1	1	

Common Name	Batch Pond	Brackish Marsh	Developed	Freshwater Marsh	Landfill	Levee	Managed Pond	Tidal Flats/ Mudflat	Muted Tidal / Diked Marsh	Open Water /Slough Channel	Parks / Upland Grassland	Riparian/Creek Corridor	Saline Marsh	Seasonal Wetland	Upland Vegetation
Northern Pintail	1			1					1	1			1	1	
Green-winged Teal	1	1		1			1		1	1			1	1	
Canvasback		1		1			1			1					
Redhead				1			1			1				1	
Ring-necked Duck							1			1					
Greater Scaup	1						1								
Lesser Scaup	1	1					1								
Surf Scoter							1								
White-winged Scoter							1								
Black Scoter							1								
Long-tailed Duck							1								
Bufflehead	1			1			1			1					
Common Goldeneye							1			1					
Barrow's Goldeneye							1								
Hooded Merganser				1			1			1		1			
Common Merganser				1			1			1		1			
Ruddy Duck	1			1		1	1			1				1	
Osprey										1		1			1
White-tailed Kite		1							1			1			1
Northern Harrier		1		1									1		1
Sharp-shinned Hawk												1			1
Cooper's Hawk					1							1			1

Common Name	Batch Pond	Brackish Marsh	Developed	Freshwater Marsh	Landfill	Levee	Managed Pond	Tidal Flats/ Mudflat	Muted Tidal / Diked Marsh	Open Water /Slough Channel	Parks / Upland Grassland	Riparian/Creek Corridor	Saline Marsh	Seasonal Wetland	Upland Vegetation
Red-shouldered Hawk					1							1			1
Red-tailed Hawk					1							1			1
Ferruginous Hawk					1							1			1
Golden Eagle					1										1
American Kestrel													1		1
Merlin															1
Peregrine Falcon					1								1		1
Ring-necked Pheasant					1						1	1			1
California Quail											1	1			1
California Black Rail									1				1		
Virginia Rail		1		1					1				1		
California Clapper rail													1		
Sora		1		1									1		
Common Moorhen		1		1					1			1	1		
American Coot	1	1		1			1	1		1	1	1	1	1	1
Black-bellied Plover	1					1	1	1						1	
American Golden-Plover						1	1	1							
Western Snowy Plover						1	1	1							
Semipalmated Plover						1	1	1					1	1	
Killdeer	1		1			1	1	1	1					1	1
Black-necked Stilt	1					1	1	1	1				1	1	
American Avocet	1	1				1	1	1	1				1	1	

Common Name	Batch Pond	Brackish Marsh	Developed	Freshwater Marsh	Landfill	Levee	Managed Pond	Tidal Flats/ Mudflat	Muted Tidal / Diked Marsh	Open Water /Slough Channel	Parks / Upland Grassland	Riparian/Creek Corridor	Saline Marsh	Seasonal Wetland	Upland Vegetation
Greater Yellowlegs	1					1	1	1	1				1	1	
Lesser Yellowlegs	1					1	1	1					1	1	
Willet	1					1	1	1	1				1	1	
Spotted Sandpiper								1					1		
Whimbrel	1					1	1	1	1						
Long-billed Curlew	1					1	1	1	1				1	1	
Marbled Godwit	1					1	1	1					1	1	
Ruddy Turnstone						1	1	1							
Sanderling	1						1	1							
Semipalmated Sandpiper						1	1	1							
Western Sandpiper						1	1	1					1	1	
Least Sandpiper	1					1	1	1					1	1	
Dunlin	1					1	1	1	1				1	1	
Ruff	1							1							
Short-billed Dowitcher	1					1	1	1						1	
Long-billed Dowitcher	1					1	1	1						1	
Wilson’s Phalarope	1			1			1							1	
Bonaparte’s Gull	1					1	1							1	
Heermann’s Gull						1	1								
Mew Gull	1					1	1							1	
Ring-billed Gull	1		1		1	1	1		1	1	1		1	1	
California Gull	1		1		1	1	1			1	1		1	1	

Common Name	Batch Pond	Brackish Marsh	Developed	Freshwater Marsh	Landfill	Levee	Managed Pond	Tidal Flats/ Mudflat	Muted Tidal / Diked Marsh	Open Water /Slough Channel	Parks / Upland Grassland	Riparian/Creek Corridor	Saline Marsh	Seasonal Wetland	Upland Vegetation
Herring Gull	1				1	1	1			1			1	1	
Thayer’s Gull	1				1	1	1			1				1	
Western Gull	1		1		1	1	1			1	1		1		
Glaucous-winged Gull					1	1	1			1	1				
Glaucous Gull					1	1	1								
Sabine’s Gull						1	1								
Caspian Tern	1			1		1	1			1					
Black Skimmer						1	1			1					
Forster’s Tern	1			1		1	1			1					
California Least Tern						1	1			1					
Rock Pigeon			1		1						1				1
Band-tailed Pigeon			1								1				1
Mourning Dove			1		1						1				1
Barn Owl											1	1			1
Great Horned Owl									1		1	1			1
Burrowing Owl					1						1				1
Short-eared Owl															1
Anna’s Hummingbird											1	1			1
Allen’s Hummingbird											1	1			1
Belted Kingfisher		1		1								1			
Northern Flicker											1	1			1
Pacific-slope Flycatcher									1			1			1

Common Name	Batch Pond	Brackish Marsh	Developed	Freshwater Marsh	Landfill	Levee	Managed Pond	Tidal Flats/ Mudflat	Muted Tidal / Diked Marsh	Open Water /Slough Channel	Parks / Upland Grassland	Riparian/Creek Corridor	Saline Marsh	Seasonal Wetland	Upland Vegetation
Black Phoebe			1								1	1	1		1
Say’s Phoebe											1	1			1
Loggerhead Shrike											1	1			1
Western Scrub-Jay			1		1						1	1			1
American Crow			1		1						1	1			1
Common Raven	1		1		1						1	1			1
Horned Lark					1										1
Tree Swallow				1						1		1	1		1
Violet-green Swallow				1						1		1	1		1
Northern Rough-winged Swallow				1						1		1	1		1
Bank Swallow				1						1		1	1		1
Cliff Swallow				1						1		1	1		1
Barn Swallow				1						1		1	1		1
Chestnut-backed Chickadee											1	1			1
Oak Titmouse											1	1			1
Bushtit											1	1			1
Bewick’s Wren												1			1
House Wren			1						1		1	1			1
Marsh Wren				1								1	1		
Ruby-crowned Kinglet											1	1			1
Hermit Thrush											1	1			1
American Robin			1								1	1			1

Common Name	Batch Pond	Brackish Marsh	Developed	Freshwater Marsh	Landfill	Levee	Managed Pond	Tidal Flats/ Mudflat	Muted Tidal / Diked Marsh	Open Water /Slough Channel	Parks / Upland Grassland	Riparian/Creek Corridor	Saline Marsh	Seasonal Wetland	Upland Vegetation
Northern Mockingbird			1		1						1	1			1
European Starling			1		1						1	1			1
Cedar Wa1wing											1	1			1
Yellow-rumped Warbler											1	1			1
Townsend's Warbler									1		1	1			1
Common Yellowthroat		1		1					1		1	1			1
San Francisco common yellowthroat		1		1								1			
Spotted Towhee											1	1			1
California Towhee											1	1			1
Bryant's savannah sparrow											1	1		1	1
Fox Sparrow									1		1	1			1
Alameda song sparrow		1		1								1	1		1
Song sparrow		1		1					1		1	1	1		
White-crowned Sparrow		1							1		1	1			1
Golden-crowned Sparrow		1									1	1			1
Dark-eyed Junco											1	1			1
Black-headed Grosbeak											1	1			1
Red-winged Blackbird		1		1								1	1	1	1
Tricolored Blackbird		1		1								1			1
Western Meadowlark		1		1							1	1			1
Brewer's Blackbird			1		1						1	1			1
Brown-headed Cowbird											1	1			1

Common Name	Batch Pond	Brackish Marsh	Developed	Freshwater Marsh	Landfill	Levee	Managed Pond	Tidal Flats/ Mudflat	Muted Tidal / Diked Marsh	Open Water /Slough Channel	Parks / Upland Grassland	Riparian/Creek Corridor	Saline Marsh	Seasonal Wetland	Upland Vegetation
Hooded Oriole											1	1			1
Bullock’s Oriole											1	1			1
House Finch			1								1	1			1
Lesser Goldfinch											1	1			1
American Goldfinch											1	1			1
House Sparrow			1		1						1	1			1
Virginia opossum			1		1				1		1	1			1
Ornate Shrew		1							1				1		1
Salt marsh wandering shrew		1											1		1
Trowbridge's Shrew															1
Yuma myotis				1							1	1	1		1
Western red bat											1	1	1		1
Hoary bat				1							1	1	1		1
Mexican free-tailed bat				1							1	1	1		1
Brush rabbit											1	1			1
Audubon's cottontail											1	1			1
Black-tailed jackrabbit					1							1			1
California ground squirrel					1						1				1
Botta's pocket gopher					1				1		1				1
Western harvest mouse		1							1				1	1	
Salt marsh harvest mouse		1							1				1	1	
Deer mouse				1					1				1		1

Common Name	Batch Pond	Brackish Marsh	Developed	Freshwater Marsh	Landfill	Levee	Managed Pond	Tidal Flats/ Mudflat	Muted Tidal / Diked Marsh	Open Water /Slough Channel	Parks / Upland Grassland	Riparian/Creek Corridor	Saline Marsh	Seasonal Wetland	Upland Vegetation
California vole		1			1				1		1	1	1		1
Common muskrat		1		1						1		1	1		1
Black rat			1		1				1			1			1
Norway rat			1		1				1				1	1	1
House mouse			1		1								1	1	1
Coyote											1	1			1
Red fox												1			1
Gray fox												1			1
Raccoon			1	1	1						1	1	1		1
Long-tailed weasel												1			1
Western spotted skunk												1			1
Striped skunk			1	1	1							1			1
Mountain lion												1			1
Mule Deer											1	1			1
Pacific harbor seal								1		1			1		

Appendix A-3

Pond Species by Season (present=1, not present=0)

SPPID	Common Name	Season	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18
40050	Pied-billed Grebe	Fall	1	1	1	1	1	1	1	1	1	1
40060	Horned Grebe	Fall	1	1	1	0	1	1	1	1	1	1
40080	Eared Grebe	Fall	1	1	1	1	1	1	1	1	1	1
40090	Western Grebe	Fall	1	1	1	1	1	1	1	1	1	1
40100	Clark's Grebe	Fall	1	1	1	1	1	1	1	1	1	1
40320	American White Pelican	Fall	1	1	1	1	1	1	1	1	1	1
40330	Brown Pelican	Fall	1	1	1	1	1	1	0	1	1	1
40350	Double-crested Cormorant	Fall	1	1	1	1	1	1	1	1	1	1
40400	Great Blue Heron	Fall	1	1	1	1	1	1	1	1	1	1
40410	Great Egret	Fall	1	1	1	1	1	1	1	1	1	1
40420	Snowy Egret	Fall	1	1	1	1	1	1	1	1	1	1
40470	Black-crowned Night-Heron	Fall	1	0	0	0	0	1	0	1	1	1
40500	Turkey Vulture	Fall	1	1	1	1	1	1	1	1	1	1
40571	Canada Goose	Fall	1	1	0	0	0	0	0	1	1	0
40640	Gadwall	Fall	1	1	1	0	1	1	1	1	1	1
40660	Eurasian Wigeon	Fall	1	0	0	0	0	0	0	0	1	0
40670	American Wigeon	Fall	1	1	1	1	0	1	0	1	1	1
40690	Mallard	Fall	1	1	1	1	1	1	1	1	1	1
40700	Blue-winged Teal	Fall	1	0	0	0	0	0	0	1	1	0
40710	Cinnamon Teal	Fall	1	1	0	0	0	0	0	0	1	0
40720	Northern Shoveler	Fall	1	1	1	1	1	1	1	1	1	1
40730	Northern Pintail	Fall	1	1	1	0	1	1	0	1	1	1
40760	American Green-winged Teal	Fall	1	1	0	0	0	0	1	1	1	0
40770	Canvasback	Fall	1	1	1	0	1	1	0	0	1	1
40780	Redhead	Fall	1	1	1	0	0	1	0	1	0	1
40810	Greater scaup	Fall	1	1	1	0	1	1	1	1	1	1
40820	Lesser scaup	Fall	1	1	1	0	1	1	1	1	1	0

SPPID	Common Name	Season	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18
40860	Surf Scoter	Fall	1	1	1	0	0	0	0	0	0	0
40870	White-winged scoter	Fall	0	0	1	0	0	0	0	0	0	0
40900	Bufflehead	Fall	1	1	1	0	0	9	1	1	1	1
40910	Common Goldeneye	Fall	1	1	1	0	0	1	1	1	1	1
40940	Hooded Merganser	Fall	0	1	0	0	0	0	0	0	0	0
40950	Common Merganser	Fall	0	1	0	0	0	1	0	0	0	1
40960	Red-breasted Merganser	Fall	1	1	1	1	1	1	0	0	1	1
40970	Ruddy Duck	Fall	1	1	1	1	1	1	1	1	1	1
40990	White-tailed Kite	Fall	1	0	0	0	0	0	0	0	0	0
41010	Northern Harrier	Fall	1	0	0	0	1	1	1	2	1	1
41080	Red-tailed Hawk	Fall	1	1	1	1	1	1	1	0	0	1
41130	Merlin	Fall	0	0	0	0	0	0	0	0	0	0
41150	Peregrine Falcon	Fall	1	1	0	1	1	1	1	0	1	1
41350	American Coot	Fall	1	1	1	1	1	1	1	1	1	1
41370	Black-bellied Plover	Fall	1	0	1	1	1	1	1	1	1	1
41420	Semipalmated Plover	Fall	1	0	0	1	0	0	0	1	1	0
41440	Killdeer	Fall	0	0	0	1	0	0	1	1	1	0
41480	Black-necked Stilt	Fall	1	0	0	1	1	1	1	1	1	1
41490	American Avocet	Fall	1	1	1	1	1	1	1	1	1	1
41500	Greater Yellowlegs	Fall	1	1	1	1	1	1	1	1	1	1
41510	Lesser Yellowlegs	Fall	1	0	0	1	1	1	1	1	1	1
41540	Willet	Fall	1	1	1	1	1	1	1	1	1	1
41590	Whimbrel	Fall	1	1	0	0	0	0	1	0	0	0
41610	Long-billed Curlew	Fall	1	1	0	0	0	1	1	0	1	1
41640	Marbled Godwit	Fall	1	1	1	0	1	1	1	1	1	1
41700	Sanderling	Fall	0	0	0	1	0	0	1	0	0	0
41720	Western Sandpiper	Fall	1	1	1	1	1	1	1	1	1	1
41760	Least Sandpiper	Fall	1	1	1	1	1	1	1	1	1	1
41790	Pectoral Sandpiper	Fall	0	0	0	0	0	0	0	1	0	0
41820	Dunlin	Fall	1	0	1	1	0	1	1	1	0	1

SPPID	Common Name	Season	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18
41860	Ruff	Fall	0	0	0	0	1	0	0	0	0	0
41870	Short-billed Dowitcher	Fall	1	0	0	0	1	1	1	1	1	1
41880	Long-billed Dowitcher	Fall	1	0	0	0	1	1	1	1	1	0
41910	Red-necked Phalarope	Fall	0	0	0	1	1	1	1	0	0	1
42010	Bonaparte's Gull	Fall	1	1	1	1	1	1	1	1	1	1
42030	Mew Gull	Fall	0	0	1	0	1	0	1	1	0	0
42040	Ring-billed Gull	Fall	1	1	1	1	1	1	1	1	1	1
42050	California Gull	Fall	1	1	1	1	1	1	1	1	1	1
42060	Herring Gull	Fall	1	1	1	1	1	1	1	1	1	1
42070	Thayer's Gull	Fall	0	0	0	0	1	0	0	0	1	0
42100	Western Gull	Fall	1	1	1	1	1	1	1	1	1	1
42110	Glaucous-winged Gull	Fall	0	0	1	0	0	0	0	0	0	0
42180	Caspian Tern	Fall	1	1	1	1	1	1	1	0	1	1
42190	Elegant Tern	Fall	1	1	1	0	1	0	1	1	1	0
42201	Black Skimmer	Fall	0	0	0	0	0	0	0	1	0	0
42220	Forster's Tern	Fall	1	1	1	1	1	1	1	1	1	1
42230	Least Tern	Fall	0	1	0	0	0	0	0	0	0	0
42240	Black Tern	Fall	0	0	1	0	0	0	0	1	0	0
43240	American Crow	Fall	0	0	0	0	0	0	0	0	1	0
43260	Common Raven	Fall	1	1	1	1	1	1	1	1	1	1
40020	Pacific Loon	Winter	0	0	1	0	0	0	0	0	0	0
40050	Pied-billed Grebe	Winter	1	1	1	1	1	1	1	1	1	1
40060	Horned Grebe	Winter	1	1	1	0	1	0	1	1	0	0
40080	Eared Grebe	Winter	1	1	1	1	1	1	1	1	1	1
40090	Western Grebe	Winter	1	1	1	1	1	1	1	1	1	1
40100	Clark's Grebe	Winter	1	1	1	1	1	1	0	1	0	1
40320	American White Pelican	Winter	1	1	1	0	1	1	0	1	1	1
40330	Brown Pelican	Winter	0	1	1	1	1	1	0	1	1	1
40350	Double-crested Cormorant	Winter	1	1	1	1	1	1	1	1	1	1
40400	Great Blue Heron	Winter	1	1	1	1	1	1	1	1	1	1

SPPID	Common Name	Season	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18
40410	Great Egret	Winter	1	1	1	1	1	1	1	1	1	1
40420	Snowy Egret	Winter	1	1	1	1	1	1	0	1	1	1
40470	Black-crowned Night-Heron	Winter	1	0	1	0	0	0	0	1	0	0
40500	Turkey Vulture	Winter	1	1	1	1	1	1	1	1	1	1
40550	Snow Goose	Winter	1	0	0	0	0	0	0	0	0	0
40571	Canada Goose	Winter	1	1	1	1	1	1	1	1	1	1
40640	Gadwall	Winter	1	1	1	1	1	1	1	1	1	1
40660	Eurasian Wigeon	Winter	1	1	0	0	0	1	0	1	1	0
40670	American Wigeon	Winter	1	1	1	1	1	1	0	1	1	1
40690	Mallard	Winter	1	1	1	1	0	1	1	1	1	1
40700	Blue-winged Teal	Winter	0	0	0	0	0	0	0	0	1	0
40710	Cinnamon Teal	Winter	1	1	0	0	0	0	0	1	1	0
40720	Northern Shoveler	Winter	1	1	1	1	1	1	1	1	1	1
40730	Northern Pintail	Winter	1	1	1	1	1	1	0	1	1	1
40760	American Green-winged Teal	Winter	1	1	1	0	1	1	0	1	1	1
40770	Canvasback	Winter	1	1	1	1	0	1	0	0	0	1
40780	Redhead	Winter	1	1	1	0	0	1	1	1	1	1
40810	Greater scaup	Winter	1	1	1	1	1	1	1	1	1	1
40820	Lesser scaup	Winter	1	1	1	1	1	1	1	1	1	1
40860	Surf Scoter	Winter	0	1	1	0	0	1	0	1	1	1
40870	White-winged scoter	Winter	0	1	1	0	0	1	0	0	0	1
40900	Bufflehead	Winter	1	1	1	1	1	1	1	1	1	1
40910	Common Goldeneye	Winter	1	1	1	1	1	1	1	1	1	1
40950	Common Merganser	Winter	0	1	0	1	0	1	0	0	0	1
40960	Red-breasted Merganser	Winter	1	1	1	1	1	1	1	1	1	1
40970	Ruddy Duck	Winter	1	1	1	1	1	1	1	1	1	1
40990	White-tailed Kite	Winter	0	0	1	0	0	1	0	0	0	1
41010	Northern Harrier	Winter	1	1	1	0	0	1	2	1	3	1
41080	Red-tailed Hawk	Winter	1	1	1	0	1	1	1	1	1	1
41120	American Kestrel	Winter	0	0	0	0	0	1	0	0	0	1

SPPID	Common Name	Season	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18
41130	Merlin	Winter	1	1	0	0	0	0	0	0	0	0
41150	Peregrine Falcon	Winter	0	1	1	1	1	1	1	0	1	1
41350	American Coot	Winter	1	1	1	1	1	1	0	1	1	1
41370	Black-bellied Plover	Winter	1	1	1	1	0	1	1	1	0	1
41420	Semipalmated Plover	Winter	1	0	0	0	0	1	1	1	0	1
41440	Killdeer	Winter	0	0	0	1	0	0	0	1	0	0
41480	Black-necked Stilt	Winter	1	1	0	1	1	1	1	1	1	1
41490	American Avocet	Winter	1	1	1	1	1	1	1	1	1	1
41500	Greater Yellowlegs	Winter	1	0	1	1	1	1	1	1	1	1
41510	Lesser Yellowlegs	Winter	1	1	0	1	0	1	0	1	1	1
41540	Willet	Winter	1	1	1	1	1	1	1	1	1	1
41590	Whimbrel	Winter	1	0	0	0	0	1	1	0	0	1
41610	Long-billed Curlew	Winter	1	0	0	0	0	1	1	1	1	1
41640	Marbled Godwit	Winter	1	1	0	0	0	1	1	1	1	1
41700	Sanderling	Winter	1	0	0	1	1	1	1	1	0	1
41720	Western Sandpiper	Winter	1	1	1	1	1	1	1	1	1	1
41760	Least Sandpiper	Winter	1	1	1	1	1	1	1	1	1	1
41820	Dunlin	Winter	1	0	0	1	1	1	1	1	1	1
41870	Short-billed Dowitcher	Winter	1	0	0	1	0	1	1	1	1	1
41880	Long-billed Dowitcher	Winter	1	0	0	1	0	1	1	1	1	1
41910	Red-necked Phalarope	Winter	0	0	1	0	0	0	0	0	0	0
42010	Bonaparte's Gull	Winter	0	0	1	1	1	1	1	1	1	1
42030	Mew Gull	Winter	0	1	1	1	1	1	1	1	1	1
42040	Ring-billed Gull	Winter	1	1	1	1	1	1	1	1	1	1
42050	California Gull	Winter	1	1	1	1	1	1	1	1	1	1
42060	Herring Gull	Winter	1	1	1	1	1	1	1	1	1	1
42070	Thayer's Gull	Winter	1	0	0	1	1	0	1	1	1	0
42100	Western Gull	Winter	1	1	1	1	1	1	1	1	1	1
42110	Glaucous-winged Gull	Winter	0	1	1	0	1	1	0	1	1	1
42220	Forster's Tern	Winter	1	1	1	1	1	1	1	1	1	1

SPPID	Common Name	Season	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18
42230	Least Tern	Winter	1	0	0	0	0	0	0	0	0	0
42710	Belted Kingfisher	Winter	0	0	1	0	0	0	0	0	0	0
43240	American Crow	Winter	1	1	1	0	0	0	1	1	0	0
43260	Common Raven	Winter	1	1	1	1	1	1	1	1	1	1
40030	Common Loon	Spring	0	1	0	0	0	0	0	0	0	0
40050	Pied-billed Grebe	Spring	1	1	1	1	0	1	1	1	1	1
40060	Horned Grebe	Spring	0	1	1	0	0	0	1	0	1	0
40080	Eared Grebe	Spring	1	1	1	1	1	1	1	1	1	1
40090	Western Grebe	Spring	1	1	1	1	1	1	1	1	1	1
40100	Clark's Grebe	Spring	1	1	1	1	1	1	0	1	1	1
40320	American White Pelican	Spring	1	1	1	0	1	1	0	1	1	1
40330	Brown Pelican	Spring	0	1	1	0	0	0	0	1	1	0
40350	Double-crested Cormorant	Spring	1	1	1	1	1	1	1	1	1	1
40400	Great Blue Heron	Spring	1	1	1	1	1	1	0	1	1	1
40410	Great Egret	Spring	1	1	1	1	1	1	1	1	1	1
40420	Snowy Egret	Spring	1	1	1	1	1	1	1	1	1	1
40470	Black-crowned Night-Heron	Spring	1	1	0	0	0	1	0	1	1	1
40500	Turkey Vulture	Spring	1	1	1	0	0	0	0	1	0	0
40571	Canada Goose	Spring	1	1	1	1	1	1	1	1	1	1
40640	Gadwall	Spring	1	1	1	1	1	1	1	1	1	1
40660	Eurasian Wigeon	Spring	0	0	0	0	0	1	0	1	1	1
40670	American Wigeon	Spring	1	1	1	0	1	1	0	1	1	1
40690	Mallard	Spring	1	1	1	1	1	1	1	1	1	1
40710	Cinnamon Teal	Spring	1	0	1	0	0	0	0	1	1	0
40720	Northern Shoveler	Spring	1	1	1	0	1	1	1	1	1	1
40730	Northern Pintail	Spring	1	1	1	0	0	1	0	1	1	1
40760	American Green-winged Teal	Spring	1	1	1	0	0	1	0	0	1	1
40770	Canvasback	Spring	1	1	1	0	0	1	0	1	1	1
40780	Redhead	Spring	1	1	1	1	0	0	0	1	1	0
40810	Greater scaup	Spring	1	1	1	1	1	1	1	1	1	1

SPPID	Common Name	Season	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18
40820	Lesser scaup	Spring	1	1	1	1	1	1	1	1	1	1
40860	Surf Scoter	Spring	0	1	1	1	0	0	0	0	1	0
40870	White-winged scoter	Spring	0	1	1	0	0	0	0	0	0	0
40900	Bufflehead	Spring	1	1	1	1	1	1	1	1	1	1
40910	Common Goldeneye	Spring	1	1	1	1	0	1	1	1	1	1
40950	Common Merganser	Spring	1	1	0	0	0	0	0	0	0	0
40960	Red-breasted Merganser	Spring	1	1	1	1	1	1	1	1	1	1
40970	Ruddy Duck	Spring	1	1	1	1	1	1	1	1	1	1
40990	White-tailed Kite	Spring	0	0	0	0	0	0	1	0	0	0
41010	Northern Harrier	Spring	1	1	1	1	0	1	1	1	1	1
41080	Red-tailed Hawk	Spring	0	1	0	0	0	0	1	1	1	0
41150	Peregrine Falcon	Spring	1	1	0	0	1	1	1	0	0	1
41350	American Coot	Spring	1	1	1	1	0	1	0	1	1	1
41370	Black-bellied Plover	Spring	1	0	1	1	1	1	0	1	0	1
41410	Snowy Plover	Spring	0	0	0	0	1	0	0	0	0	1
41420	Semipalmated Plover	Spring	0	0	0	1	0	0	0	0	0	0
41440	Killdeer	Spring	0	0	0	0	0	0	1	1	0	0
41480	Black-necked Stilt	Spring	0	0	0	1	1	0	1	1	1	0
41490	American Avocet	Spring	1	0	0	1	1	1	1	1	1	1
41500	Greater Yellowlegs	Spring	1	0	1	1	1	1	1	0	1	1
41510	Lesser Yellowlegs	Spring	1	0	0	1	1	0	1	0	1	0
41540	Willet	Spring	1	0	0	1	1	1	1	1	1	1
41590	Whimbrel	Spring	1	0	0	0	0	1	0	0	0	1
41610	Long-billed Curlew	Spring	1	0	0	0	0	1	1	0	0	1
41640	Marbled Godwit	Spring	1	0	0	0	0	1	0	0	1	1
41690	Red Knot	Spring	0	0	0	0	0	1	0	0	0	1
41700	Sanderling	Spring	0	0	0	0	1	1	0	0	0	1
41720	Western Sandpiper	Spring	1	1	1	1	1	1	1	1	1	1
41760	Least Sandpiper	Spring	1	1	1	1	1	1	1	1	1	1
41820	Dunlin	Spring	1	1	0	1	1	1	1	1	1	1

SPPID	Common Name	Season	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18
41870	Short-billed Dowitcher	Spring	1	0	0	1	1	1	1	1	1	1
41880	Long-billed Dowitcher	Spring	1	0	0	1	1	1	1	1	1	1
41910	Red-necked Phalarope	Spring	1	0	0	1	1	1	1	1	1	1
41980	Franklin's Gull	Spring	0	0	0	0	0	0	0	1	0	0
42010	Bonaparte's Gull	Spring	1	0	1	1	1	1	1	1	1	1
42030	Mew Gull	Spring	1	1	0	1	1	1	1	1	0	1
42040	Ring-billed Gull	Spring	1	1	1	1	1	1	1	1	1	1
42050	California Gull	Spring	1	1	1	1	1	1	1	1	1	1
42060	Herring Gull	Spring	1	1	1	1	1	1	1	1	1	1
42070	Thayer's Gull	Spring	0	1	1	0	1	0	0	1	0	0
42100	Western Gull	Spring	1	1	1	1	1	1	1	1	1	1
42110	Glaucous-winged Gull	Spring	1	0	1	0	1	1	1	1	1	1
42120	Glaucous Gull	Spring	0	0	0	0	0	1	0	0	0	1
42180	Caspian Tern	Spring	1	1	1	1	1	1	0	1	1	1
42201	Black Skimmer	Spring	0	0	0	0	0	0	0	1	0	0
42220	Forster's Tern	Spring	1	1	1	1	1	1	1	1	1	1
42240	Black Tern	Spring	0	0	0	0	0	0	0	0	1	0
43240	American Crow	Spring	1	1	1	1	0	0	1	1	0	0
43260	Common Raven	Spring	1	1	1	1	1	1	1	1	1	1
40050	Pied-billed Grebe	Summer	1	1	1	1	0	1	1	1	1	1
40080	Eared Grebe	Summer	1	1	1	1	1	0	1	1	1	0
40090	Western Grebe	Summer	0	1	1	1	0	1	0	1	0	1
40100	Clark's Grebe	Summer	1	1	1	1	0	1	0	1	1	1
40320	American White Pelican	Summer	1	1	1	1	1	1	1	1	1	1
40330	Brown Pelican	Summer	1	1	1	1	1	1	0	1	1	1
40350	Double-crested Cormorant	Summer	1	1	1	1	1	1	1	1	1	1
40400	Great Blue Heron	Summer	1	1	1	1	1	1	1	1	1	1
40410	Great Egret	Summer	1	1	1	1	1	1	1	1	1	1
40420	Snowy Egret	Summer	1	1	1	1	1	1	1	1	1	1
40430	Little Blue Heron	Summer	0	1	0	0	0	0	0	0	0	0

SPPID	Common Name	Season	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18
40470	Black-crowned Night-Heron	Summer	1	1	1	0	0	1	1	1	1	1
40500	Turkey Vulture	Summer	1	0	0	0	1	1	0	1	1	1
40571	Canada Goose	Summer	0	0	0	0	0	1	0	1	1	1
40640	Gadwall	Summer	1	1	1	1	1	1	1	1	1	1
40670	American Wigeon	Summer	0	0	0	0	0	0	0	1	1	0
40690	Mallard	Summer	1	1	1	1	0	1	1	1	1	1
40710	Cinnamon Teal	Summer	0	0	0	0	0	0	0	1	1	0
40720	Northern Shoveler	Summer	1	0	0	0	0	1	0	1	1	1
40730	Northern Pintail	Summer	1	0	0	0	0	0	1	1	1	0
40760	American Green-winged Teal	Summer	0	0	0	0	0	0	0	0	1	0
40770	Canvasback	Summer	0	0	1	0	0	0	0	1	0	0
40810	Greater scaup	Summer	1	1	1	0	0	0	0	1	1	0
40820	Lesser scaup	Summer	1	1	1	0	0	0	0	1	1	0
40860	Surf Scoter	Summer	0	1	0	0	0	0	0	0	0	0
40870	White-winged scoter	Summer	0	1	0	0	0	0	0	0	0	0
40900	Bufflehead	Summer	1	0	0	0	0	0	0	0	0	0
40910	Common Goldeneye	Summer	0	0	0	0	0	0	0	0	1	0
40970	Ruddy Duck	Summer	1	1	1	0	0	1	0	1	1	1
41010	Northern Harrier	Summer	1	1	0	1	0	0	0	0	1	0
41150	Peregrine Falcon	Summer	0	1	0	0	0	0	1	0	0	0
41350	American Coot	Summer	1	1	1	0	0	0	0	1	1	0
41370	Black-bellied Plover	Summer	1	0	1	1	1	1	1	0	1	1
41410	Snowy Plover	Summer	0	0	1	1	0	0	0	0	0	0
41420	Semipalmated Plover	Summer	1	0	0	1	0	1	1	1	1	1
41440	Killdeer	Summer	0	0	0	0	1	0	1	1	1	0
41480	Black-necked Stilt	Summer	1	1	1	1	1	1	1	1	1	1
41490	American Avocet	Summer	1	1	1	1	1	1	1	1	1	1
41500	Greater Yellowlegs	Summer	1	1	0	0	0	1	1	1	1	1
41510	Lesser Yellowlegs	Summer	1	1	0	0	0	1	0	1	1	1
41540	Willet	Summer	1	1	1	1	1	1	1	1	1	1

SPPID	Common Name	Season	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18
41590	Whimbrel	Summer	0	0	0	0	0	1	1	1	1	1
41610	Long-billed Curlew	Summer	1	1	1	0	0	1	1	0	1	1
41640	Marbled Godwit	Summer	1	1	1	0	0	1	1	1	1	1
41650	Ruddy Turnstone	Summer	0	0	0	1	0	0	0	0	0	0
41690	Red Knot	Summer	0	0	0	0	1	0	0	0	0	0
41720	Western Sandpiper	Summer	1	1	1	1	1	1	1	1	1	1
41760	Least Sandpiper	Summer	1	1	0	1	1	1	1	1	1	1
41820	Dunlin	Summer	1	0	0	1	1	1	1	0	0	1
41870	Short-billed Dowitcher	Summer	1	0	1	0	1	1	1	1	1	1
41880	Long-billed Dowitcher	Summer	1	0	1	0	1	1	1	1	1	1
41900	Wilson's Phalarope	Summer	0	0	0	1	1	1	1	1	1	1
41910	Red-necked Phalarope	Summer	0	1	1	1	1	1	1	1	1	1
41980	Franklin's Gull	Summer	0	0	0	0	0	0	0	0	0	0
42010	Bonaparte's Gull	Summer	0	1	1	0	0	0	1	1	1	0
42040	Ring-billed Gull	Summer	1	0	0	1	1	1	1	1	1	1
42050	California Gull	Summer	1	1	1	1	1	1	1	1	1	1
42060	Herring Gull	Summer	0	0	0	0	0	1	0	1	1	1
42100	Western Gull	Summer	1	1	1	1	0	1	1	1	1	1
42180	Caspian Tern	Summer	1	1	1	0	1	1	1	1	0	1
42201	Black Skimmer	Summer	0	0	0	0	0	0	0	1	1	0
42220	Forster's Tern	Summer	1	1	1	1	1	1	1	1	1	1
42230	Least Tern	Summer	0	1	0	0	0	0	0	0	0	0
42240	Black Tern	Summer	0	0	1	0	0	0	0	1	0	0
43240	American Crow	Summer	1	0	0	0	1	0	0	0	0	0
43260	Common Raven	Summer	1	1	1	0	1	1	1	1	1	1

Data Source: USGS Western Ecological Research Center and a review by USFWS Refuge staff.

Appendix A-4
Example Species Performing Functions for Select Key Ecological Functions (KEFs)

SppID	Common Name	KEFCode	KEFDescription
40640	Gadwall	1.1.1.2	spermivore (seed-eater)
40670	American Wigeon	1.1.1.2	spermivore (seed-eater)
40690	Mallard	1.1.1.2	spermivore (seed-eater)
40700	Blue-winged Teal	1.1.1.2	spermivore (seed-eater)
40710	Cinnamon Teal	1.1.1.2	spermivore (seed-eater)
40730	Northern Pintail	1.1.1.2	spermivore (seed-eater)
40760	Green-winged Teal	1.1.1.2	spermivore (seed-eater)
41260	Wild Turkey	1.1.1.2	spermivore (seed-eater)
41290	California Quail	1.1.1.2	spermivore (seed-eater)
41330	Sora	1.1.1.2	spermivore (seed-eater)
41360	Sandhill Crane	1.1.1.2	spermivore (seed-eater)
41390	Pacific Golden-Plover	1.1.1.2	spermivore (seed-eater)
41670	Surfbird	1.1.1.2	spermivore (seed-eater)
41690	Red Knot	1.1.1.2	spermivore (seed-eater)
41850	Buff-breasted Sandpiper	1.1.1.2	spermivore (seed-eater)
41860	Ruff	1.1.1.2	spermivore (seed-eater)
41900	Wilson’s Phalarope	1.1.1.2	spermivore (seed-eater)
42030	Mew Gull	1.1.1.2	spermivore (seed-eater)
42390	Band-tailed Pigeon	1.1.1.2	spermivore (seed-eater)
42410	Mourning Dove	1.1.1.2	spermivore (seed-eater)
42700	Allen’s Hummingbird	1.1.1.2	spermivore (seed-eater)
42730	Acorn Woodpecker	1.1.1.2	spermivore (seed-eater)
42770	Red-breasted Sapsucker	1.1.1.2	spermivore (seed-eater)
42900	Least Flycatcher	1.1.1.2	spermivore (seed-eater)
42940	Pacific-slope Flycatcher	1.1.1.2	spermivore (seed-eater)
43200	Western Scrub-Jay	1.1.1.2	spermivore (seed-eater)

SppID	Common Name	KEFCode	KEFDescription
43240	American Crow	1.1.1.2	spermivore (seed-eater)
43280	Horned Lark	1.1.1.2	spermivore (seed-eater)
43380	Chestnut-backed Chickadee	1.1.1.2	spermivore (seed-eater)
43550	Ruby-crowned Kinglet	1.1.1.2	spermivore (seed-eater)
43670	Varied Thrush	1.1.1.2	spermivore (seed-eater)
43880	Nashville Warbler	1.1.1.2	spermivore (seed-eater)
44270	Spotted Towhee	1.1.1.2	spermivore (seed-eater)
44280	California Towhee	1.1.1.2	spermivore (seed-eater)
44300	Chipping Sparrow	1.1.1.2	spermivore (seed-eater)
44310	Clay-colored Sparrow	1.1.1.2	spermivore (seed-eater)
44320	Brewer’s Sparrow	1.1.1.2	spermivore (seed-eater)
44340	Vesper Sparrow	1.1.1.2	spermivore (seed-eater)
44350	Lark Sparrow	1.1.1.2	spermivore (seed-eater)
44370	Sage Sparrow	1.1.1.2	spermivore (seed-eater)
44390	Bryant's savannah sparrow	1.1.1.2	spermivore (seed-eater)
44430	Fox Sparrow	1.1.1.2	spermivore (seed-eater)
44440	Alameda song sparrow	1.1.1.2	spermivore (seed-eater)
44450	Lincoln’s Sparrow	1.1.1.2	spermivore (seed-eater)
44460	Swamp Sparrow	1.1.1.2	spermivore (seed-eater)
44470	White-throated Sparrow	1.1.1.2	spermivore (seed-eater)
44490	White-crowned Sparrow	1.1.1.2	spermivore (seed-eater)
44500	Golden-crowned Sparrow	1.1.1.2	spermivore (seed-eater)
44510	Dark-eyed Junco	1.1.1.2	spermivore (seed-eater)
44590	Black-headed Grosbeak	1.1.1.2	spermivore (seed-eater)
44610	Lazuli Bunting	1.1.1.2	spermivore (seed-eater)
44660	Red-winged Blackbird	1.1.1.2	spermivore (seed-eater)
44670	Tricolored Blackbird	1.1.1.2	spermivore (seed-eater)
44680	Western Meadowlark	1.1.1.2	spermivore (seed-eater)
44710	Brewer’s Blackbird	1.1.1.2	spermivore (seed-eater)
44740	Brown-headed Cowbird	1.1.1.2	spermivore (seed-eater)

SppID	Common Name	KEFCode	KEFDescription
44870	House Finch	1.1.1.2	spermivore (seed-eater)
44920	Pine Siskin	1.1.1.2	spermivore (seed-eater)
44930	Lesser Goldfinch	1.1.1.2	spermivore (seed-eater)
44950	American Goldfinch	1.1.1.2	spermivore (seed-eater)
50610	California ground squirrel	1.1.1.2	spermivore (seed-eater)
50820	Western harvest mouse	1.1.1.2	spermivore (seed-eater)
50821	Salt marsh harvest mouse	1.1.1.2	spermivore (seed-eater)
50830	Deer mouse	1.1.1.2	spermivore (seed-eater)
50890	Dusky-footed woodrat	1.1.1.2	spermivore (seed-eater)
51220	Raccoon	1.1.1.2	spermivore (seed-eater)
40530	Greater White-fronted Goose	1.1.1.4	grazer (grass, forb eater)
40550	Snow Goose	1.1.1.4	grazer (grass, forb eater)
40570	Canada Goose	1.1.1.4	grazer (grass, forb eater)
40670	American Wigeon	1.1.1.4	grazer (grass, forb eater)
41360	Sandhill Crane	1.1.1.4	grazer (grass, forb eater)
41390	Pacific Golden-Plover	1.1.1.4	grazer (grass, forb eater)
50360	Brush rabbit	1.1.1.4	grazer (grass, forb eater)
50420	Black-tailed jackrabbit	1.1.1.4	grazer (grass, forb eater)
50610	California ground squirrel	1.1.1.4	grazer (grass, forb eater)
50730	Botta's pocket gopher	1.1.1.4	grazer (grass, forb eater)
50890	Dusky-footed woodrat	1.1.1.4	grazer (grass, forb eater)
41260	Wild Turkey	1.1.1.5	frugivore (fruit-eater)
41290	California Quail	1.1.1.5	frugivore (fruit-eater)
41360	Sandhill Crane	1.1.1.5	frugivore (fruit-eater)
41590	Whimbrel	1.1.1.5	frugivore (fruit-eater)
42390	Band-tailed Pigeon	1.1.1.5	frugivore (fruit-eater)
42730	Acorn Woodpecker	1.1.1.5	frugivore (fruit-eater)
42770	Red-breasted Sapsucker	1.1.1.5	frugivore (fruit-eater)
42890	Willow Flycatcher	1.1.1.5	frugivore (fruit-eater)
42900	Least Flycatcher	1.1.1.5	frugivore (fruit-eater)

SppID	Common Name	KEFCode	KEFDescription
42940	Pacific-slope Flycatcher	1.1.1.5	frugivore (fruit-eater)
42980	Say’s Phoebe	1.1.1.5	frugivore (fruit-eater)
43000	Ash-throated Flycatcher	1.1.1.5	frugivore (fruit-eater)
43020	Western Kingbird	1.1.1.5	frugivore (fruit-eater)
43120	Cassin's Vireo	1.1.1.5	frugivore (fruit-eater)
43130	Hutton’s Vireo	1.1.1.5	frugivore (fruit-eater)
43140	Warbling Vireo	1.1.1.5	frugivore (fruit-eater)
43200	Western Scrub-Jay	1.1.1.5	frugivore (fruit-eater)
43240	American Crow	1.1.1.5	frugivore (fruit-eater)
43260	Common Raven	1.1.1.5	frugivore (fruit-eater)
43380	Chestnut-backed Chickadee	1.1.1.5	frugivore (fruit-eater)
43420	Bushtit	1.1.1.5	frugivore (fruit-eater)
43540	Golden-crowned Kinglet	1.1.1.5	frugivore (fruit-eater)
43550	Ruby-crowned Kinglet	1.1.1.5	frugivore (fruit-eater)
43630	Swainson’s Thrush	1.1.1.5	frugivore (fruit-eater)
43640	Hermit Thrush	1.1.1.5	frugivore (fruit-eater)
43660	American Robin	1.1.1.5	frugivore (fruit-eater)
43670	Varied Thrush	1.1.1.5	frugivore (fruit-eater)
43680	Wrentit	1.1.1.5	frugivore (fruit-eater)
43700	Northern Mockingbird	1.1.1.5	frugivore (fruit-eater)
43710	Sage Thrasher	1.1.1.5	frugivore (fruit-eater)
43800	American Pipit	1.1.1.5	frugivore (fruit-eater)
43820	Cedar Waxwing	1.1.1.5	frugivore (fruit-eater)
43870	Orange-crowned Warbler	1.1.1.5	frugivore (fruit-eater)
43970	Yellow-rumped Warbler	1.1.1.5	frugivore (fruit-eater)
44250	Western Tanager	1.1.1.5	frugivore (fruit-eater)
44270	Spotted Towhee	1.1.1.5	frugivore (fruit-eater)
44280	California Towhee	1.1.1.5	frugivore (fruit-eater)
44390	Bryant's savannah sparrow	1.1.1.5	frugivore (fruit-eater)
44430	Fox Sparrow	1.1.1.5	frugivore (fruit-eater)

SppID	Common Name	KEFCode	KEFDescription
44440	Alameda song sparrow	1.1.1.5	frugivore (fruit-eater)
44470	White-throated Sparrow	1.1.1.5	frugivore (fruit-eater)
44490	White-crowned Sparrow	1.1.1.5	frugivore (fruit-eater)
44500	Golden-crowned Sparrow	1.1.1.5	frugivore (fruit-eater)
44590	Black-headed Grosbeak	1.1.1.5	frugivore (fruit-eater)
44710	Brewer's Blackbird	1.1.1.5	frugivore (fruit-eater)
44790	Bullock's Oriole	1.1.1.5	frugivore (fruit-eater)
44870	House Finch	1.1.1.5	frugivore (fruit-eater)
44930	Lesser Goldfinch	1.1.1.5	frugivore (fruit-eater)
44950	American Goldfinch	1.1.1.5	frugivore (fruit-eater)
50820	Western harvest mouse	1.1.1.5	frugivore (fruit-eater)
50821	Salt marsh harvest mouse	1.1.1.5	frugivore (fruit-eater)
50830	Deer mouse	1.1.1.5	frugivore (fruit-eater)
51220	Raccoon	1.1.1.5	frugivore (fruit-eater)
10073	Threespine stickleback	1.1.2.3	ovivorous (egg eater)
10081	Prickly sculpin	1.1.2.3	ovivorous (egg eater)
10221	Pacific staghorn sculpin	1.1.2.3	ovivorous (egg eater)
10237	Shiner perch	1.1.2.3	ovivorous (egg eater)
10238	Tule perch	1.1.2.3	ovivorous (egg eater)
10249	Green sturgeon	1.1.2.3	ovivorous (egg eater)
10405	Brown rockfish	1.1.2.3	ovivorous (egg eater)
10537	English sole	1.1.2.3	ovivorous (egg eater)
10538	California tonguefish	1.1.2.3	ovivorous (egg eater)
10539	Diamond turbot	1.1.2.3	ovivorous (egg eater)
10561	Sand sole	1.1.2.3	ovivorous (egg eater)
10628	Longjawed mudsucker	1.1.2.3	ovivorous (egg eater)
10629	Bay goby	1.1.2.3	ovivorous (egg eater)
10633	Arrow goby	1.1.2.3	ovivorous (egg eater)
10634	Cheekspot goby	1.1.2.3	ovivorous (egg eater)
10637	Speckled sanddab	1.1.2.3	ovivorous (egg eater)

SppID	Common Name	KEFCode	KEFDescription
10641	Pacific herring	1.1.2.3	ovivorous (egg eater)
10648	Barred surfperch	1.1.2.3	ovivorous (egg eater)
10653	Surf Smelt	1.1.2.3	ovivorous (egg eater)
10686	Dwarf surfperch	1.1.2.3	ovivorous (egg eater)
10729	Plainfin midshipman	1.1.2.3	ovivorous (egg eater)
10757	Topsmelt	1.1.2.3	ovivorous (egg eater)
10758	Jack smelt	1.1.2.3	ovivorous (egg eater)
10808	Bat ray	1.1.2.3	ovivorous (egg eater)
10817	Northern anchovy	1.1.2.3	ovivorous (egg eater)
11113	White croaker	1.1.2.3	ovivorous (egg eater)
30100	Southern alligator lizard	1.1.2.3	ovivorous (egg eater)
30290	Gopher snake	1.1.2.3	ovivorous (egg eater)
30350	Western rattlesnakes	1.1.2.3	ovivorous (egg eater)
40470	Black-crowned Night-Heron	1.1.2.3	ovivorous (egg eater)
41000	Bald Eagle	1.1.2.3	ovivorous (egg eater)
41350	American Coot	1.1.2.3	ovivorous (egg eater)
41360	Sandhill Crane	1.1.2.3	ovivorous (egg eater)
41610	Long-billed Curlew	1.1.2.3	ovivorous (egg eater)
41650	Ruddy Turnstone	1.1.2.3	ovivorous (egg eater)
41950	Parasitic Jaeger	1.1.2.3	ovivorous (egg eater)
42020	Heermann's Gull	1.1.2.3	ovivorous (egg eater)
42040	Ring-billed Gull	1.1.2.3	ovivorous (egg eater)
42050	California Gull	1.1.2.3	ovivorous (egg eater)
42060	Herring Gull	1.1.2.3	ovivorous (egg eater)
42070	Thayer's Gull	1.1.2.3	ovivorous (egg eater)
42100	Western Gull	1.1.2.3	ovivorous (egg eater)
42110	Glaucous-winged Gull	1.1.2.3	ovivorous (egg eater)
42120	Glaucous Gull	1.1.2.3	ovivorous (egg eater)
43200	Western Scrub-Jay	1.1.2.3	ovivorous (egg eater)
43240	American Crow	1.1.2.3	ovivorous (egg eater)

SppID	Common Name	KEFCode	KEFDescription
43260	Common Raven	1.1.2.3	ovivorous (egg eater)
50610	California ground squirrel	1.1.2.3	ovivorous (egg eater)
51180	Gray fox	1.1.2.3	ovivorous (egg eater)
51220	Raccoon	1.1.2.3	ovivorous (egg eater)
51300	western spotted skunk	1.1.2.3	ovivorous (egg eater)
51310	Striped skunk	1.1.2.3	ovivorous (egg eater)

Appendix A-5

Shoreline Study Project Without Project Conditions Species List

[343 Fish and Wildlife Species used for Historic Functional Redundancy & Resiliency]

SPP ID	Common Name	Scientific Name	Classification
10001	Pacific lamprey	*Lampetra tridentata*	native
10071	Sacramento sucker	*Catostomus occidentalis occidentalis*	native
10073	Threespine stickleback	*Gasterosteus aculeatus*	native
10081	Prickly sculpin	*Cottus asper*	native
10173	Starry flounder	*Platichthys stellatus*	native
10221	Pacific staghorn sculpin	*Leptocottus armatus*	native
10237	Shiner perch	*Cymatogaster aggregata*	native
10238	Tule perch	*Hysterocarpus traski*	native
10245	Longfin smelt	*Spirinchus thaleichthys*	native
10249	Green sturgeon	*Acipenser medirostris*	native
10295	Steelhead	*Oncorhynchus mykiss*	native
10325	Leopard shark	*Triakis semifasciata*	native
10326	Brown smoothhound	*Mustelus henlei*	native
10329	Soupfin shark	*Galeorhinus galeus*	native
10333	Spiny dogfish	*Squalus acanthias*	native
10337	Big skate	*Raja binoculata*	native
10341	California skate	*Raja inornata*	native
10405	Brown rockfish	*Sebastes auriculatus*	native
10537	English sole	*Parophrys vetulus*	native
10538	California tonguefish	*Symphurus atricaudus*	native
10539	Diamond turbot	*Hypsopsetta guttulata*	native
10545	Pacific sanddab	*Citharichthys sordidus*	native
10561	Sand sole	*Psettichthys melanostictus*	native
10585	Chinook salmon	*Oncorhynchus tshawytscha*	native
10589	Pink salmon	*Oncorhynchus gorbuscha*	native
10593	Chum salmon	*Oncorhynchus keta*	native
10628	Longjawed mudsucker	*Gillichthys mirabilis*	native

SPP ID	Common Name	Scientific Name	Classification
10629	Bay goby	*Lepidogobius lepidus*	native
10633	Arrow goby	*Clevelandia ios*	native
10634	Cheekspot goby	*Ilypnus gilberti*	native
10637	Speckled sanddab	*Citharichthys stigmaeus*	native
10641	Pacific herring	*Clupea pallasii*	native
10648	Barred surfperch	*Amphistichus argenteus*	native
10653	Surf Smelt	*Hypomesus pretiosus*	native
10657	Whitebait smelt	*Allosmerus elongatus*	native
10669	Bay pipefish	*Syngnathus leptorhynchus*	native
10686	Dwarf surfperch	*Micrometrus minimus*	native
10729	Plainfin midshipman	*Porichthys notatus*	native
10757	Topsmelt	*Atherinops affinis*	native
10758	Jack smelt	*Atherinopsis californiensis*	native
10765	Pacific sardine	*Sardinops sagax*	native
10808	Bat ray	*Myliobatis californica*	native
10817	Northern anchovy	*Engraulis mordax*	native
11113	White croaker	*Genyonemus lineatus*	native
11197	California halibut	*Paralichthys californicus*	native
20010	California tiger salamander	*Ambystoma californiense*	native
20210	California slender salamander	*Batrachoseps attenuatus*	native
20217	Arboreal salamander	*Aneides lugubris*	native
20260	Pacific tree frog	*Pseudacris regilla*	native
30030	Western pond turtle	*Clemmys marmorata*	native
30100	Southern alligator lizard	*Elgaria multicarinata*	native
30160	Western fence lizard	*Sceloporus occidentalis*	native
30180	Western skink	*Eumeces skiltonianus*	native
30290	Gopher snake	*Pituophis melanoleuca*	native
30320	Western terrestrial garter snake	*Thamnophis elegans*	native
30340	Common garter snake	*Thamnophis sirtalis*	native
30350	Western rattlesnakes	*Crotalus oreganus*	native

SPP ID	Common Name	Scientific Name	Classification
40010	Red-throated Loon	*Gavia stellata*	native
40020	Pacific Loon	*Gavia pacifica*	native
40030	Common Loon	*Gavia immer*	native
40050	Pied-billed Grebe	*Podilymbus podiceps*	native
40060	Horned Grebe	*Podiceps auritus*	native
40070	Red-necked Grebe	*Podiceps grisegena*	native
40080	Eared Grebe	*Podiceps nigricollis*	native
40090	Western Grebe	*Aechmophorus occidentalis*	native
40100	Clark's Grebe	*Aechmophorus clarkii*	native
40300	Brown Booby	*Sula leucogaster*	native
40320	American White Pelican	*Pelecanus erythrorhynchos*	native
40330	Brown Pelican	*Pelecanus occidentalis*	native
40340	Brandt's Cormorant	*Phalacrocorax penicillatus*	native
40350	Double-crested Cormorant	*Phalacrocorax auritus*	native
40360	Pelagic Cormorant	*Phalacrocorax pelagicus*	native
40370	Magnificent Frigatebird	*Fregata magnificens*	native
40380	American Bittern	*Botaurus lentiginosus*	native
40390	Least Bittern	*Ixobrychus exilis*	native
40400	Great Blue Heron	*Ardea herodias*	native
40410	Great Egret	*Ardea alba*	native
40420	Snowy Egret	*Egretta thula*	native
40430	Little Blue Heron	*Egretta caerulea*	native
40450	Cattle Egret	*Bubulcus ibis*	native
40460	Green Heron	*Butorides virescens*	native
40470	Black-crowned Night-Heron	*Nycticorax nycticorax*	native
40490	White-faced Ibis	*Plegadis chihi*	native
40490	Glossy Ibis	*Plegadis falcinellus*	native
40500	Turkey Vulture	*Cathartes aura*	native
40530	Greater White-fronted Goose	*Anser albifrons*	native
40550	Snow Goose	*Chen hyperborea*	native

SPP ID	Common Name	Scientific Name	Classification
40560	Ross's Goose	*Chen rossii*	native
40570	Canada Goose	*Branta canadensis*	native
40575	Cackling Goose	*Branta hutchinsii*	native
40580	Brant	*Branta bernicla*	native
40610	Tundra Swan	*Cygnus columbianus*	native
40640	Gadwall	*Anas strepera*	native
40660	Eurasian Wigeon	*Anas penelope*	native
40670	American Wigeon	*Anas americana*	native
40690	Mallard	*Anas platyrhynchos*	native
40700	Blue-winged Teal	*Anas discors*	native
40710	Cinnamon Teal	*Anas cyanoptera*	native
40720	Northern Shoveler	*Anas clypeata*	native
40730	Northern Pintail	*Anas acuta*	native
40760	Green-winged Teal	*Anas crecca*	native
40770	Canvasback	*Aythya valisineria*	native
40780	Redhead	*Aythya americana*	native
40790	Ring-necked Duck	*Aythya collaris*	native
40810	Greater Scaup	*Aythya marila*	native
40820	Lesser Scaup	*Aythya affinis*	native
40860	Surf Scoter	*Melanitta perspicillata*	native
40870	White-winged Scoter	*Melanitta fusca*	native
40880	Black Scoter	*Melanitta nigra*	native
40890	Long-tailed Duck	*Clangula hyemalis*	native
40900	Bufflehead	*Bucephala albeola*	native
40910	Common Goldeneye	*Bucephala clangula*	native
40940	Hooded Merganser	*Lophodytes cucullata*	native
40950	Common Merganser	*Mergus merganser*	native
40960	Red-breasted Merganser	*Mergus serrator*	native
40970	Ruddy Duck	*Oxyura jamaicensis*	native
40980	Osprey	*Pandion haliaetus*	native

SPP ID	Common Name	Scientific Name	Classification
40990	White-tailed Kite	*Elanus coeruleus*	native
41000	Bald Eagle	*Haliaeetus leucocephalus*	native
41010	Northern Harrier	*Circus cyaneus*	native
41020	Sharp-shinned Hawk	*Accipiter striatus*	native
41030	Cooper's Hawk	*Accipiter cooperii*	native
41050	Red-shouldered Hawk	*Buteo lineatus*	native
41080	Red-tailed Hawk	*Buteo jamaicensis*	native
41090	Ferruginous Hawk	*Buteo regalis*	native
41100	Rough-legged Hawk	*Buteo lagopus*	native
41110	Golden Eagle	*Aquila chrysaetos*	native
41120	American Kestrel	*Falco sparverius*	native
41130	Merlin	*Falco columbarius*	native
41150	Peregrine Falcon	*Falco peregrinus*	native
41160	Prairie Falcon	*Falco mexicanus*	native
41260	Wild Turkey	*Meleagris gallopavo*	native
41290	California Quail	*Callipepla californica*	native
41311	California Black Rail	*Rallus longirostris obsoletus*	native
41320	Virginia Rail	*Laterallus jamaicensis coturniculus*	native
41321	California Clapper Rail	*Rallus limicola*	native
41330	Sora	*Porzana carolina*	native
41340	Common Moorhen	*Gallinula chloropus*	native
41350	American Coot	*Fulica americana*	native
41360	Sandhill Crane	*Grus canadensis*	native
41370	Black-bellied Plover	*Pluvialis squatarola*	native
41380	American Golden-Plover	*Pluvialis dominica*	native
41390	Pacific Golden-Plover	*Pluvialis fulva*	native
41410	Western Snowy Plover	*Charadrius alexandrinus nivosus*	native
41420	Semipalmated Plover	*Charadrius semipalmata*	native
41440	Killdeer	*Charadrius vociferus*	native
41470	Black Oystercatcher	*Haematopus bachmani*	native

SPP ID	Common Name	Scientific Name	Classification
41480	Black-necked Stilt	*Himantopus mexicanus*	native
41490	American Avocet	*Recurvirostra americana*	native
41500	Greater Yellowlegs	*Tringa melanoleuca*	native
41510	Lesser Yellowlegs	*Tringa flavipes*	native
41530	Solitary Sandpiper	*Tringa solitaria*	native
41540	Willet	*Catoptrophorus semipalmatus*	native
41550	Wandering Tattler	*Heteroscelus incanus*	native
41570	Spotted Sandpiper	*Actitis macularia*	native
41590	Whimbrel	*Numenius phaeopus*	native
41610	Long-billed Curlew	*Numenius americanus*	native
41620	Hudsonian Godwit	*Limosa haemastica*	native
41630	Bar-tailed Godwit	*Limosa lapponica*	native
41640	Marbled Godwit	*Limosa fedoa*	native
41650	Ruddy Turnstone	*Arenaria interpres*	native
41660	Black Turnstone	*Arenaria melanocephala*	native
41670	Surfbird	*Aphriza virgata*	native
41690	Red Knot	*Calidris canutus*	native
41700	Sanderling	*Calidris alba*	native
41710	Semipalmated Sandpiper	*Calidris pusilla*	native
41720	Western Sandpiper	*Calidris mauri*	native
41740	Little Stint	*Calidris minuta*	native
41760	Least Sandpiper	*Calidris minutilla*	native
41780	Baird’s Sandpiper	*Calidris bairdii*	native
41790	Pectoral Sandpiper	*Calidris melanotos*	native
41800	Sharp-tailed Sandpiper	*Calidris acuminata*	native
41820	Dunlin	*Calidris alpina*	native
41830	Curlew Sandpiper	*Calidris ferruginea*	native
41840	Stilt Sandpiper	*Calidris himantopus*	native
41850	Buff-breasted Sandpiper	*Tryngites subruficollis*	native
41860	Ruff	*Philomachus pugnax*	native

SPP ID	Common Name	Scientific Name	Classification
41870	Short-billed Dowitcher	*Limnodromus griseus*	native
41880	Long-billed Dowitcher	*Limnodromus scolopaceus*	native
41890	Wilson’s Snipe	*Gallinago delicata*	native
41900	Wilson’s Phalarope	*Phalaropus tricolor*	native
41910	Red-necked Phalarope	*Phalaropus lobatus*	native
41920	Red Phalarope	*Phalaropus fulicaria*	native
41950	Parasitic Jaeger	*Stercorarius parasiticus*	native
41980	Franklin’s Gull	*Larus pipixcan*	native
41990	Little Gull	*Larus minutus*	native
42000	Black-headed Gull	*Larus ridibundus*	native
42010	Bonaparte’s Gull	*Larus Philadelphia*	native
42020	Heermann’s Gull	*Larus heermanni*	native
42030	Mew Gull	*Larus canus*	native
42040	Ring-billed Gull	*Larus delawarensis*	native
42050	California Gull	*Larus californicus*	native
42060	Herring Gull	*Larus argentatus*	native
42070	Thayer’s Gull	*Larus thayeri*	native
42090	Slaty-backed Gull	*Larus schistisagus*	native
42100	Western Gull	*Larus occidentalis*	native
42110	Glaucous-winged Gull	*Larus glaucescens*	native
42120	Glaucous Gull	*Larus hyperboreus*	native
42130	Sabine’s Gull	*Xena sabini*	native
42180	Caspian Tern	*Sterna caspia*	native
42190	Elegant Tern	*Sterna elegans*	native
42200	Common Tern	*Sterna hirundo*	native
42201	Black Skimmer	*Rynchops niger*	native
42210	Arctic Tern	*Sterna paradisaea*	native
42220	Forster’s Tern	*Sterna forsteri*	native
42230	California Least Tern	*Sterna antillarum browni*	native
42240	Black Tern	*Chlidonias niger*	native

SPP ID	Common Name	Scientific Name	Classification
42250	Common Murre	*Uria aalge*	native
42270	Pigeon Guillemot	*Cepphus columba*	native
42320	Ancient Murrelet	*Synthliboramphus antiquus*	native
42390	Band-tailed Pigeon	*Columba fasciata*	native
42410	Mourning Dove	*Zenaida macroura*	native
42440	Barn Owl	*Tyto alba*	native
42470	Great Horned Owl	*Bubo virginianus*	native
42510	Burrowing Owl	*Athene cunicularia*	native
42560	Short-eared Owl	*Asio flammeus*	native
42620	Vaux's Swift	*Chaetura vauxi*	native
42630	White-throated Swift	*Aeronautes saxatalis*	native
42640	Black-chinned Hummingbird	*Archilochus alexandri*	native
42650	Anna's Hummingbird	*Calypte anna*	native
42690	Rufous Hummingbird	*Selasphorus rufus*	native
42700	Allen's Hummingbird	*Selasphorus sasin*	native
42710	Belted Kingfisher	*Ceryle alcyon*	native
42730	Acorn Woodpecker	*Melanerpes formicivorus*	native
42770	Red-breasted Sapsucker	*Sphyrapicus ruber*	native
42780	Nuttall's Woodpecker	*Picoides nuttallii*	native
42790	Downy Woodpecker	*Picoides pubescens*	native
42840	Northern Flicker	*Colaptes auratus*	native
42870	Western Wood-Pewee	*Contopus sordidulus*	native
42890	Willow Flycatcher	*Empidonax traillii*	native
42900	Least Flycatcher	*Empidonax minimus*	native
42910	Hammond's Flycatcher	*Empidonax hammondii*	native
42930	Dusky Flycatcher	*Empidonax oberholseri*	native
42940	Pacific-slope Flycatcher	*Empidonax difficilis*	native
42960	Black Phoebe	*Sayornis nigricans*	native
42980	Say's Phoebe	*Sayornis saya*	native
43000	Ash-throated Flycatcher	*Myiarchus cinerascens*	native

SPP ID	Common Name	Scientific Name	Classification
43010	Tropical Kingbird	*Tyrannus melancholicus*	native
43020	Western Kingbird	*Tyrannus verticalis*	native
43060	Loggerhead Shrike	*Lanius ludovicianus*	native
43120	Cassin's Vireo	*Vireo cassinii*	native
43130	Hutton’s Vireo	*Vireo huttoni*	native
43140	Warbling Vireo	*Vireo gilvus*	native
43200	Western Scrub-Jay	*Aphelocoma californica*	native
43240	American Crow	*Corvus brachyrhynchos*	native
43260	Common Raven	*Corvus corax*	native
43280	Horned Lark	*Eremophila alpestris*	native
43290	Purple Martin	*Progne subis*	native
43300	Tree Swallow	*Tachycineta bicolor*	native
43310	Violet-green Swallow	*Tachycineta thalassina*	native
43320	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	native
43330	Bank Swallow	*Riparia riparia*	native
43340	Cliff Swallow	*Petrochelidon pyrrhonota*	native
43350	Barn Swallow	*Hirundo rustica*	native
43380	Chestnut-backed Chickadee	*Poecile rufescens*	native
43420	Bushtit	*Psaltriparus minimus*	native
43470	Rock Wren	*Salpinctes obsoletus*	native
43490	Bewick’s Wren	*Thryomanes bewickii*	native
43500	House Wren	*Troglodytes aedon*	native
43520	Marsh Wren	*Cistothorus palustris*	native
43540	Golden-crowned Kinglet	*Regulus satrapa*	native
43530	American Dipper	*Cinclus mexicanus*	native
43550	Ruby-crowned Kinglet	*Regulus calendula*	native
43560	Blue-gray Gnatcatcher	*Polioptila caerulea*	native
43630	Swainson’s Thrush	*Catharus ustulatus*	native
43640	Hermit Thrush	*Catharus guttatus*	native
43660	American Robin	*Turdus migratorius*	native

SPP ID	Common Name	Scientific Name	Classification
43670	Varied Thrush	*Ixoreus naevius*	native
43680	Wrentit	*Chamaea fasciata*	native
43700	Northern Mockingbird	*Mimus polyglottos*	native
43710	Sage Thrasher	*Oreoscoptes montanus*	native
43770	White Wagtail	*Motacilla alba*	native
43800	American Pipit	*Anthus rubescens*	native
43820	Cedar Waxwing	*Bombycilla cedrorum*	native
43870	Orange-crowned Warbler	*Vermivora celata*	native
43880	Nashville Warbler	*Vermivora ruficapilla*	native
43920	Yellow Warbler	*Dendroica petechia*	native
43940	Magnolia Warbler	*Dendroica magnolia*	native
43970	Yellow-rumped Warbler	*Dendroica coronata*	native
44000	Townsend's Warbler	*Dendroica townsendi*	native
44060	Palm Warbler	*Dendroica palmarum*	native
44080	Blackpoll Warbler	*Dendroica striata*	native
44100	American Redstart	*Setophaga ruticilla*	native
44140	Northern Waterthrush	*Seiurus noveboracensis*	native
44180	San Francisco common yellowthroat	*Geothlypis trichas sinuosa*	native
44200	Wilson's Warbler	*Wilsonia pusilla*	native
44220	Yellow-breasted Chat	*Icteria virens*	native
44250	Western Tanager	*Piranga ludoviciana*	native
44270	Spotted Towhee	*Pipilo maculatus*	native
44280	California Towhee	*Pipilo crissalis*	native
44300	Chipping Sparrow	*Spizella passerina*	native
44310	Clay-colored Sparrow	*Spizella pallida*	native
44320	Brewer's Sparrow	*Spizella breweri*	native
44340	Vesper Sparrow	*Pooecetes gramineus*	native
44350	Lark Sparrow	*Chondestes grammacus*	native
44370	Sage Sparrow	*Amphispiza belli*	native

SPP ID	Common Name	Scientific Name	Classification
44390	Bryant's savannah sparrow	*Passerculus sandwichensis alaudinus*	native
44420	Nelson’s Sharp-tailed Sparrow	*Ammodramus nelsoni*	native
44430	Fox Sparrow	*Passerella iliaca*	native
44440	Alameda song sparrow	*Melospiza melodia pusillula*	native
44450	Lincoln’s Sparrow	*Melospiza lincolnii*	native
44460	Swamp Sparrow	*Melospiza georgiana*	native
44470	White-throated Sparrow	*Zonotrichia leucophrys*	native
44490	White-crowned Sparrow	*Zonotrichia atricapilla*	native
44500	Golden-crowned Sparrow	*Zonotrichia atricapilla*	native
44510	Dark-eyed Junco	*Junco hyemalis*	native
44540	Chestnut-collared Longspur	*Calcarius ornatus*	native
44590	Black-headed Grosbeak	*Pheucticus melanocephalus*	native
44610	Lazuli Bunting	*Passerina amoena*	native
44660	Red-winged Blackbird	*Agelaius phoeniceus*	native
44670	Tricolored Blackbird	*Agelaius tricolor*	native
44680	Western Meadowlark	*Sturnella neglecta*	native
44710	Brewer’s Blackbird	*Euphagus cyanocephalus*	native
44740	Brown-headed Cowbird	*Molothrus ater*	native
44760	Hooded Oriole	*Icterus cucullatus*	native
44790	Bullock’s Oriole	*Icterus bullockii*	native
44870	House Finch	*Carpodacus mexicanus*	native
44920	Pine Siskin	*Spinus pinus*	native
44930	Lesser Goldfinch	*Carduelis psaltria*	native
44950	American Goldfinch	*Carduelis tristis*	native
50040	Salt marsh wandering shrew	*Sorex vagrans halicoetes*	native
50180	California myotis	*Myotis californicus*	native
50200	Yuma myotis	*Myotis yumanensis*	native
50220	Long-legged myotis	*Myotis volans*	native
50250	Long-eared myotis	*Myotis septentrionalis*	native
50280	Big brown bat	*Eptesicus fuscus*	native

SPP ID	Common Name	Scientific Name	Classification
50285	Western red bat	*Lasirurs blossevillii*	native
50290	Hoary bat	*Lasiurus cinereus*	native
50310	Townsend's big-eared bat	*Corynorhinus townsendii*	native
50320	Northern river otter	*Lontra canadensis*	native
50330	Mexican free-tailed bat	*Tadarida brasiliensis*	native
50360	Brush rabbit	*Sylvilagus bachmani*	native
50381	Desert cottontail	*Sylvilagus audubonii*	native
50420	Black-tailed jackrabbit	*Lepus californicus*	native
50610	California ground squirrel	*Spermophilus beecheyi*	native
50730	Botta's pocket gopher	*Thomomys bottae*	native
50820	Western harvest mouse	*Reithrodontomys megalotis*	native
50821	Salt marsh harvest mouse	*Reithrodontomys raviventris raviventris*	native
50830	Deer mouse	*Peromyscus maniculatus*	native
50890	Dusky-footed woodrat	*Neotoma fuscipes*	native
50990	California vole	*Microtus californicus*	native
51050	Muskrat	*Ondatra zibethicus*	native
51180	Gray fox	*Urocyon cinereoargenteus*	native
51220	Raccoon	*Procyon lotor*	native
51260	Long-tailed weasel	*Mustela frenata*	native
51300	Western spotted skunk	*Spilogale gracilis*	native
51310	Striped skunk	*Mephitis mephitis*	native
51330	Mountain lion	*Felis concolor*	native
60030	California sea lion	Zalophus californianus	native
60040	Pacific harbor seal	*Phoca vitulina richardsi*	native

Appendix A-6
Species Associations with Historic Habitats for Without Project Assessment

[Total species listed 205 used to determine higher habitat value level // 171 species used to determine the lower habitat value level (indicates which species were removed)]

Spp ID	Common Name	Deep Bay / Channel (subtidal)	Dune	Island	Lagoon	Salt Pond	Sandy Beach	Shallow Bay / Channel (intertidal)	Shellflat	Tidal Flat	Tidal Marsh	Shell Mounds
10001	Pacific lamprey	1				1		1	1	1	1	
10071	Sacramento sucker					1					1	
10073	Threespine stickleback	1				1		1	1	1	1	
10081	Prickly sculpin	1				1		1	1	1	1	
10173	Starry flounder	1				1			1	1	1	
10221	Pacific staghorn sculpin	1			1	1	1	1	1	1	1	
10237	Shiner perch	1			1	1		1	1	1	1	
10238	Tule perch	1			1	1		1	1	1	1	
10245	Longfin smelt	1				1		1	1	1	1	
10249	Green sturgeon	1						1	1	1	1	
10295	Steelhead	1						1	1	1	1	
10325	Leopard shark	1						1	1	1	1	
10326	Brown smoothhound	1						1	1	1	1	
10329	Soupfin shark								1	1	1	
10333	Spiny dogfish	1						1	1	1	1	
10337	Big skate	1						1	1	1	1	
10341	California skate	1						1	1	1	1	
10405	Brown rockfish	1			1			1	1	1	1	
10537	English sole	1						1	1	1	1	
10538	California tonguefish	1						1	1	1	1	
10539	Diamond turbot	1						1	1	1	1	
10545	Pacific sanddab								1	1	1	

Spp ID	Common Name	Deep Bay / Channel (subtidal)	Dune	Island	Lagoon	Salt Pond	Sandy Beach	Shallow Bay / Channel (intertidal)	Shellflat	Tidal Flat	Tidal Marsh	Shell Mounds
10561	Sand sole	1						1	1	1	1	
10585	Chinook salmon	1				1		1	1	1	1	
10589	Pink salmon	1				1		1	1	1	1	
10593	Chum salmon	1				1		1	1	1	1	
10628	Longjawed mudsucker	1				1		1			1	
10629	Bay goby	1						1			1	
10633	Arrow goby	1						1			1	
10634	Cheekspot goby	1						1			1	
10637	Speckled sanddab				1				1	1	1	
10641	Pacific herring				1	1			1	1	1	
10648	Barred surfperch	1			1			1	1	1	1	
10653	Surf Smelt					1			1	1	1	
10657	Whitebait smelt	1						1	1	1	1	
10669	Bay pipefish	1				1		1	1	1	1	
10686	Dwarf surfperch	1			1			1	1	1	1	
10729	Plainfin midshipman	1						1	1	1	1	
10757	Topsmelt	1				1		1	1	1	1	
10758	Jack smelt	1				1		1	1	1	1	
10765	Pacific sardine	1						1	1	1	1	
10808	Bat ray	1				1			1	1	1	
10817	Northern anchovy	1				1		1	1	1	1	
11113	White croaker	1						1	1	1	1	
11197	California halibut	1						1	1	1	1	
30100	Southern alligator lizard											1
30160	Western fence lizard											1
30290	Gopher snake										1	1
30320	Western terrestrial garter snake							1			1	1

Spp ID	Common Name	Deep Bay / Channel (subtidal)	Dune	Island	Lagoon	Salt Pond	Sandy Beach	Shallow Bay / Channel (intertidal)	Shellflat	Tidal Flat	Tidal Marsh	Shell Mounds
30340	Common garter snake										1	1
30350	Western rattlesnakes											1
40010	Red-throated Loon	1							1			
40020	Pacific Loon	1							1			
40030	Common Loon	1							1			
40050	Pied-billed Grebe	1			1	1		1	1		1	
40060	Horned Grebe	1				1			1		1	
40070	Red-necked Grebe	1							1			
40080	Eared Grebe	1				1		1	1		1	
40090	Western Grebe	1							1		1	
40100	Clark's Grebe	1							1		1	
40320	American White Pelican			1	1	1			1		1	
40330	Brown Pelican	1			1	1	1		1			
40350	Double-crested Cormorant	1		1		1		1	1	1	1	
40380	American Bittern				1						1	
40390	Least Bittern				1						1	
40400	Great Blue Heron			1	1	1				1	1	1
40410	Great Egret			1	1	1				1	1	
40420	Snowy Egret			1	1	1					1	
40460	Green Heron				1						1	
40470	Black-crowned Night-Heron			1							1	1
40500	Turkey Vulture											1
40530	Greater White-fronted Goose							1			1	
40570	Canada Goose			1	1	1		1			1	
40640	Gadwall				1	1		1			1	
40660	Eurasian Wigeon				1	1		1	1		1	

Spp ID	Common Name	Deep Bay / Channel (subtidal)	Dune	Island	Lagoon	Salt Pond	Sandy Beach	Shallow Bay / Channel (intertidal)	Shellflat	Tidal Flat	Tidal Marsh	Shell Mounds
40670	American Wigeon				1	1		1	1		1	
40690	Mallard			1	1	1		1			1	
40700	Blue-winged Teal				1			1			1	
40710	Cinnamon Teal				1			1			1	
40720	Northern Shoveler				1	1		1			1	
40730	Northern Pintail				1	1		1	1		1	
40760	Green-winged Teal				1	1		1	1		1	
40770	Canvasback	1			1	1		1	1	1	1	
40780	Redhead	1			1	1		1	1	1	1	
40790	Ring-necked Duck	1			1	1		1	1	1	1	
40810	Greater Scaup	1			1	1			1	1	1	
40820	Lesser Scaup	1			1	1			1	1	1	
40860	Surf Scoter	1							1	1	1	
40870	White-winged Scoter	1							1	1	1	
40880	Black Scoter	1							1	1	1	
40890	Long-tailed Duck	1							1	1	1	
40900	Bufflehead	1			1	1			1	1	1	
40910	Common Goldeneye	1			1	1			1	1	1	
40920	Barrow's Goldeneye					1					1	
40940	Hooded Merganser				1				1	1	1	
40950	Common Merganser	1			1				1	1	1	
40960	Red-breasted Merganser				1						1	
40970	Ruddy Duck	1			1	1			1	1	1	
40980	Osprey	1							1	1	1	
40990	White-tailed Kite										1	
41000	Bald Eagle	1		1	1		1				1	1
41010	Northern Harrier					1					1	
41030	Cooper’s Hawk										1	1

Spp ID	Common Name	Deep Bay / Channel (subtidal)	Dune	Island	Lagoon	Salt Pond	Sandy Beach	Shallow Bay / Channel (intertidal)	Shellflat	Tidal Flat	Tidal Marsh	Shell Mounds
41050	Red-shouldered Hawk										1	1
41080	Red-tailed Hawk										1	1
41090	Ferruginous Hawk										1	1
41110	Golden Eagle										1	1
41120	American Kestrel										1	
41130	Merlin										1	
41150	Peregrine Falcon				1		1	1			1	1
41311	California Black Rail										1	
41320	Virginia Rail										1	
41321	California Clapper Rail										1	
41330	Sora				1						1	
41340	Common Moorhen				1						1	
41350	American Coot				1	1		1		1	1	
41370	Black-bellied Plover				1	1	1		1	1		
41380	American Golden-Plover		1		1	1	1		1	1		
41390	Pacific Golden-Plover		1		1	1	1		1	1		
41410	Western Snowy Plover				1	1	1		1	1		
41420	Semipalmated Plover		1	1	1	1	1		1	1		
41440	Killdeer		1	1	1	1	1		1	1	1	
41470	Black Oystercatcher					1	1		1	1		
41480	Black-necked Stilt			1	1	1			1	1	1	
41490	American Avocet			1	1	1			1	1	1	
41500	Greater Yellowlegs		1	1	1	1			1	1	1	
41510	Lesser Yellowlegs		1	1	1	1			1	1	1	
41540	Willet			1	1	1	1		1	1	1	
41550	Wandering Tattler					1	1		1	1		
41570	Spotted Sandpiper			1	1	1			1	1	1	
41590	Whimbrel				1	1			1	1	1	

Spp ID	Common Name	Deep Bay / Channel (subtidal)	Dune	Island	Lagoon	Salt Pond	Sandy Beach	Shallow Bay / Channel (intertidal)	Shellflat	Tidal Flat	Tidal Marsh	Shell Mounds
41610	Long-billed Curlew			1		1	1		1	1	1	
41640	Marbled Godwit				1	1	1		1	1	1	
41650	Ruddy Turnstone		1		1	1	1		1	1	1	
41660	Black Turnstone				1	1	1		1	1	1	
41670	Surfbird					1			1	1	1	
41690	Red Knot				1	1	1		1	1	1	
41700	Sanderling		1			1	1		1	1	1	
41710	Semipalmated Sandpiper			1	1	1	1		1	1		
41720	Western Sandpiper			1	1	1	1		1	1	1	
41760	Least Sandpiper		1		1	1	1		1	1	1	
41780	Baird’s Sandpiper		1	1	1	1	1		1	1	1	
41790	Pectoral Sandpiper			1	1	1			1	1	1	
41800	Sharp-tailed Sandpiper			1	1	1			1	1		
41820	Dunlin			1	1	1	1		1	1	1	
41840	Stilt Sandpiper			1		1			1	1		
41850	Buff-breasted Sandpiper					1	1		1	1		
41860	Ruff				1	1			1	1		
41870	Short-billed Dowitcher			1	1	1	1		1	1	1	
41880	Long-billed Dowitcher			1	1	1	1		1	1	1	
41890	Wilson’s Snipe			1					1		1	
41900	Wilson’s Phalarope	1		1		1		1				
41910	Red-necked Phalarope			1	1	1		1			1	
41980	Franklin’s Gull			1			1					
42010	Bonaparte’s Gull	1	1	1	1		1	1	1	1	1	1
42020	Heermann’s Gull		1		1		1		1	1		
42030	Mew Gull	1		1	1		1	1			1	1
42040	Ring-billed Gull	1		1	1		1	1			1	1
42050	California Gull	1		1	1		1	1			1	1

Spp ID	Common Name	Deep Bay / Channel (subtidal)	Dune	Island	Lagoon	Salt Pond	Sandy Beach	Shallow Bay / Channel (intertidal)	Shellflat	Tidal Flat	Tidal Marsh	Shell Mounds
42060	Herring Gull	1		1	1		1	1			1	1
42070	Thayer's Gull	1	1	1	1		1	1			1	1
42100	Western Gull	1	1	1	1		1	1	1	1	1	1
42110	Glaucous-winged Gull	1	1	1	1		1	1	1	1	1	1
42120	Glaucous Gull		1	1	1		1		1	1	1	1
42180	Caspian Tern	1		1	1		1	1	1	1	1	
42190	Elegant Tern						1					
42200	Common Tern	1						1			1	
42210	Arctic Tern						1					
42220	Forster's Tern			1	1			1	1	1	1	
42230	California Least Tern								1	1		
42390	Band-tailed Pigeon						1				1	
42410	Mourning Dove										1	1
42440	Barn Owl					1					1	
42560	Short-eared Owl		1								1	
42710	Belted Kingfisher				1						1	
43200	Western Scrub-Jay										1	1
43280	Horned Lark		1				1					
43300	Tree Swallow										1	
43310	Violet-Green Swallow										1	
43320	Northern Rough-winged Swallow										1	
43350	Barn Swallow		1		1						1	
43520	Marsh Wren										1	
43700	Northern Mockingbird											1
43800	American Pipit										1	
44180	San Francisco common yellowthroat					1					1	

Spp ID	Common Name	Deep Bay / Channel (subtidal)	Dune	Island	Lagoon	Salt Pond	Sandy Beach	Shallow Bay / Channel (intertidal)	Shellflat	Tidal Flat	Tidal Marsh	Shell Mounds
44390	Savannah Sparrow										1	
44440	Alameda song sparrow										1	
44490	White-crowned Sparrow										1	
44660	Red-winged Blackbird										1	
44680	Western Meadowlark										1	
44710	Brewer's Blackbird											1
50040	Salt marsh wandering shrew										1	
50200	Yuma myotis				1	1		1			1	
50285	Western red bat				1	1						
50290	Hoary Bat					1					1	
50820	Western harvest mouse										1	
50821	Salt marsh harvest mouse										1	
50830	Deer mouse										1	1
50990	California vole										1	1
51050	Muskrat					1					1	
51220	Raccoon		1	1		1	1				1	1
51260	Long-tailed weasel					1					1	
51310	Striped skunk					1					1	1
60030	California sea Lion	1						1				
60040	Pacific harbor seal	1					1	1		1	1	

Appendix A-7
Species Associations with Modern Habitats for Without Project Assessment [240 species]

SPP ID	Common Name	Deep Bay / Channel (subtidal)	Dune	Lagoon	Salt Pond	Shallow Bay / Channel (intertidal)	Tidal Flat	Tidal Marsh	Developed	Agriculture
10001	Pacific lamprey	1				1				
10071	Sacramento sucker									
10073	Threespine stickleback	1			1	1	1	1		
10081	Prickly sculpin	1			1	1	1	1		
10121	Striped bass	1			1	1	1	1		
10149	Common carp				1					
10173	Starry flounder	1						1		
10177	Goldfish				1					
10189	Western mosquito fish				1					
10221	Pacific staghorn sculpin	1		1	1	1	1	1		
10233	American shad	1				1	1			
10234	Threadfin shad	1				1	1			
10237	Shiner perch	1		1	1	1	1	1		
10238	Tule perch	1		1		1	1	1		
10245	Longfin smelt	1				1	1			
10249	Green sturgeon	1				1				
10295	Steelhead	1				1				
10325	Leopard shark	1			1	1	1	1		
10326	Brown smoothhound	1			1	1				
10329	Soupfin shark	1								
10333	Spiny dogfish	1				1				
10337	Big skate	1				1				
10341	California skate	1				1				
10361	Cabezon	1				1				
10405	Brown rockfish	1		1		1	1			

SPP ID	Common Name	Deep Bay / Channel (subtidal)	Dune	Lagoon	Salt Pond	Shallow Bay / Channel (intertidal)	Tidal Flat	Tidal Marsh	Developed	Agriculture
10537	English sole	1				1		1		
10538	California tonguefish	1				1				
10539	Diamond turbot	1			1	1				
10545	Pacific sanddab	1								
10561	Sand sole	1				1				
10585	Chinook salmon	1				1		1		
10589	Pink salmon	1				1				
10593	Chum salmon	1				1				
10628	Longjawed mudsucker				1	1	1	1		
10629	Bay goby					1	1			
10633	Arrow goby					1	1	1		
10634	Cheekspot goby					1				
10637	Speckled sanddab	1		1	1					
10641	Pacific herring	1		1			1	1		
10648	Barred surfperch	1		1	1	1	1	1		
10653	Surf Smelt	1								
10657	Whitebait smelt	1				1				
10669	Bay pipefish	1			1	1		1		
10686	Dwarf surfperch	1		1		1				
10729	Plainfin midshipman	1				1	1			
10757	Topsmelt	1			1	1	1	1		
10758	Jack smelt	1				1	1	1		
10765	Pacific sardine	1				1				
10808	Bat ray	1			1		1	1		
10817	Northern anchovy	1			1	1	1	1		
11113	White croaker	1				1				
11197	California halibut	1				1				
30100	Southern alligator lizard									1

SPP ID	Common Name	Deep Bay / Channel (subtidal)	Dune	Lagoon	Salt Pond	Shallow Bay / Channel (intertidal)	Tidal Flat	Tidal Marsh	Developed	Agriculture
30160	Western fence lizard							1		1
30290	Gopher snake									1
30320	Western terrestrial garter snake							1		1
30340	Common garter snake									1
40010	Red-throated Loon	1								
40020	Pacific Loon	1								
40030	Common Loon	1								
40050	Pied-billed Grebe	1		1	1			1		
40060	Horned Grebe	1			1			1		
40080	Eared Grebe	1			1			1		
40090	Western Grebe	1			1			1		
40100	Clark's Grebe	1			1			1		
40320	American White Pelican	1		1	1			1		
40330	Brown Pelican	1		1	1					
40350	Double-crested Cormorant	1			1			1		
40380	American Bittern					1		1		
40390	Least Bittern					1		1		
40400	Great Blue Heron			1	1	1	1	1		1
40410	Great Egret			1	1	1	1	1		1
40420	Snowy Egret				1	1	1	1		1
40450	Cattle Egret							1		1
40460	Green Heron			1				1		
40470	Black-crowned Night-Heron							1	1	1
40500	Turkey Vulture									1
40530	Greater White-fronted Goose					1		1		1
40570	Canada Goose			1	1	1		1	1	1

SPP ID	Common Name	Deep Bay / Channel (subtidal)	Dune	Lagoon	Salt Pond	Shallow Bay / Channel (intertidal)	Tidal Flat	Tidal Marsh	Developed	Agriculture
40640	Gadwall			1	1	1		1		1
40660	Eurasian Wigeon			1	1	1		1		
40670	American Wigeon			1	1	1		1		1
40690	Mallard			1	1	1		1		1
40700	Blue-winged Teal			1		1		1		1
40710	Cinnamon Teal			1		1		1		
40720	Northern Shoveler			1	1	1		1		
40730	Northern Pintail			1	1	1		1		
40760	Green-winged Teal			1	1	1		1		
40770	Canvasback	1		1	1	1		1		
40780	Redhead	1		1	1			1		
40790	Ring-necked Duck	1			1			1		
40810	Greater Scaup	1			1					
40820	Lesser Scaup	1		1	1					
40860	Surf Scoter	1			1					
40870	White-winged Scoter	1			1					
40880	Black Scoter	1			1					
40890	Long-tailed Duck	1			1					
40900	Bufflehead	1		1	1					
40910	Common Goldeneye	1		1	1					
40920	Barrow's Goldeneye	1			1					
40940	Hooded Merganser	1		1	1			1		
40950	Common Merganser	1		1	1			1		
40970	Ruddy Duck	1		1	1			1		
40980	Osprey	1						1		
40990	White-tailed Kite							1		
41010	Northern Harrier				1			1		1
41020	Sharp-shinned Hawk								1	

SPP ID	Common Name	Deep Bay / Channel (subtidal)	Dune	Lagoon	Salt Pond	Shallow Bay / Channel (intertidal)	Tidal Flat	Tidal Marsh	Developed	Agriculture
41030	Cooper's Hawk								1	
41050	Red-shouldered Hawk									1
41080	Red-tailed Hawk									1
41090	Ferruginous Hawk									1
41110	Golden Eagle									1
41120	American Kestrel									1
41130	Merlin									1
41150	Peregrine Falcon			1	1	1		1	1	1
41190	Ring-necked Pheasant									1
41290	California Quail									1
41311	California Black Rail							1		
41320	Virginia Rail							1		
41321	California Clapper rail							1		
41330	Sora			1				1		
41340	Common Moorhen			1				1		
41350	American Coot			1	1	1	1	1		
41370	Black-bellied Plover			1	1		1	1		
41380	American Golden-Plover		1	1	1		1	1		
41410	Western Snowy Plover			1	1		1	1		
41420	Semipalmated Plover		1	1	1		1	1		
41440	Killdeer			1	1		1	1	1	1
41480	Black-necked Stilt			1	1		1	1		
41490	American Avocet			1	1		1	1		
41500	Greater Yellowlegs		1	1	1		1	1		
41510	Lesser Yellowlegs		1	1	1		1	1		
41540	Willet			1	1		1	1		
41570	Spotted Sandpiper			1			1	1		
41590	Whimbrel			1	1		1			

SPP ID	Common Name	Deep Bay / Channel (subtidal)	Dune	Lagoon	Salt Pond	Shallow Bay / Channel (intertidal)	Tidal Flat	Tidal Marsh	Developed	Agriculture
41610	Long-billed Curlew			1	1		1	1		1
41640	Marbled Godwit			1	1		1	1		
41650	Ruddy Turnstone		1	1	1		1	1		
41700	Sanderling		1		1		1			
41710	Semipalmated Sandpiper			1	1		1			
41720	Western Sandpiper			1	1		1	1		
41760	Least Sandpiper		1	1	1		1	1		
41820	Dunlin			1	1		1	1		
41860	Ruff						1	1		
41870	Short-billed Dowitcher			1	1		1	1		
41880	Long-billed Dowitcher			1	1		1	1		
41900	Wilson’s Phalarope	1			1	1				
41910	Red-necked Phalarope	1			1	1				
42010	Bonaparte’s Gull	1	1	1	1			1		
42020	Heermann’s Gull	1	1	1	1			1		
42030	Mew Gull			1	1			1		
42040	Ring-billed Gull			1	1	1		1	1	
42050	California Gull			1	1	1		1	1	
42060	Herring Gull			1	1	1		1		
42070	Thayer’s Gull		1	1	1	1		1		
42100	Western Gull	1	1	1	1	1		1	1	
42110	Glaucous-winged Gull	1	1	1	1			1		
42120	Glaucous Gull	1	1	1	1			1		
42130	Sabine’s Gull				1			1		
42180	Caspian Tern	1			1	1		1		
42201	Black Skimmer	1			1					
42220	Forster’s Tern	1		1	1	1		1		
42230	California Least Tern	1			1	1				

SPP ID	Common Name	Deep Bay / Channel (subtidal)	Dune	Lagoon	Salt Pond	Shallow Bay / Channel (intertidal)	Tidal Flat	Tidal Marsh	Developed	Agriculture
42380	Rock Pigeon								1	1
42390	Band-tailed Pigeon								1	
42410	Mourning Dove								1	1
42440	Barn Owl				1			1		1
42470	Great Horned Owl				1			1		1
42510	Burrowing Owl				1			1		
42560	Short-eared Owl							1		1
42650	Anna’s Hummingbird								1	
42700	Allen’s Hummingbird								1	
42710	Belted Kingfisher							1		
42840	Northern Flicker								1	
42960	Black Phoebe							1	1	
43060	Loggerhead Shrike									1
43200	Western Scrub-Jay								1	
43240	American Crow								1	1
43260	Common Raven								1	1
43280	Horned Lark		1							1
43300	Tree Swallow							1		
43310	Violet-green Swallow							1		
43320	Northern Rough-winged Swallow							1		
43330	Bank Swallow							1		
43340	Cliff Swallow							1		
43350	Barn Swallow		1	1				1		1
43380	Chestnut-backed Chickadee								1	
43420	Bushtit								1	
43490	Bewick’s Wren							1		
43500	House Wren								1	

SPP ID	Common Name	Deep Bay / Channel (subtidal)	Dune	Lagoon	Salt Pond	Shallow Bay / Channel (intertidal)	Tidal Flat	Tidal Marsh	Developed	Agriculture
43520	Marsh Wren							1		
43550	Ruby-crowned Kinglet								1	
43660	American Robin								1	1
43700	Northern Mockingbird								1	
43740	European Starling								1	1
43820	Cedar Waxwing								1	
43970	Yellow-rumped Warbler								1	
44000	Townsend's Warbler								1	
44180	San Francisco common yellowthroat							1		
44270	Spotted Towhee								1	
44280	California Towhee							1	1	
44390	Bryant's savannah sparrow							1		1
44440	Alameda song sparrow							1		
44490	White-crowned Sparrow							1	1	
44500	Golden-crowned Sparrow							1	1	
44510	Dark-eyed Junco								1	
44660	Red-winged Blackbird							1		1
44670	Tricolored Blackbird							1		1
44680	Western Meadowlark							1		1
44710	Brewer's Blackbird								1	1
44740	Brown-headed Cowbird									1
44790	Bullock's Oriole								1	
44870	House Finch								1	1
44970	House Sparrow								1	1
50010	Virginia opossum				1			1	1	1
50035	Ornate Shrew							1		
50040	Salt marsh wandering shrew							1		

SPP ID	Common Name	Deep Bay / Channel (subtidal)	Dune	Lagoon	Salt Pond	Shallow Bay / Channel (intertidal)	Tidal Flat	Tidal Marsh	Developed	Agriculture
50110	Trowbridge's Shrew							1		
50200	Yuma myotis			1	1					
50285	Western red bat			1	1					1
50290	Hoary bat				1					
50330	Mexican free-tailed bat				1					
50420	Black-tailed jackrabbit				1					
50610	California ground squirrel				1					1
50730	Botta's pocket gopher									1
50820	Western harvest mouse							1		1
50821	Salt marsh harvest mouse							1		
50830	Deer mouse									1
50990	California vole							1		1
51050	Common muskrat				1			1		
51070	Black rat								1	
51080	Norway rat				1			1	1	1
51090	House mouse							1	1	1
51160	Red fox				1			1		1
51180	Gray fox				1			1		1
51220	Raccoon		1		1			1	1	1
51260	Long-tailed weasel				1					
51310	Striped skunk				1			1	1	1
60040	Pacific harbor seal	1				1	1	1		

Relationship Matrix Descriptions

MATRIX 1: Potential Species by Function Matrix

The potential species list generated by IBIS (see Appendix A) is aligned with Key Ecological Functions (KEFs) that could potentially be performed in the habitat type and structural condition represented by the polygon. For example, if the polygon represents a "shrub-steppe" habitat type, the KEFs thought to be performed in that habitat type by the potential species are included in the relationship matrix. This information is generated from IBIS. The result of this matrix is the number of potential species performing key functions in that habitat type. Example follows:

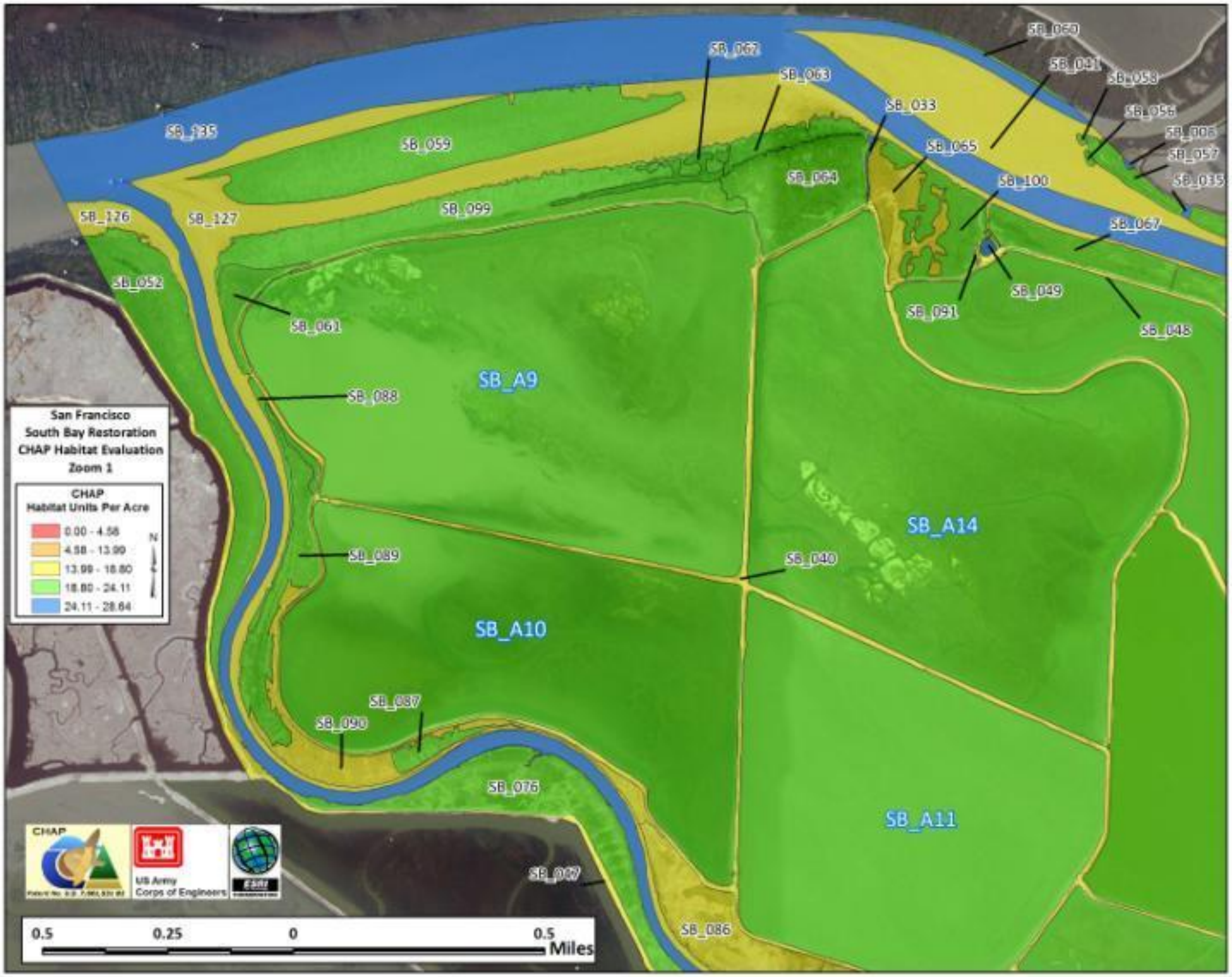
Lowland Mixed Conifer Habitat Type *Species Value (Potential)*	**Function 1** ***Secondary Consumer***	**Function 2** ***Breaks up Down Wood***	**Function 3** ***Primary Excavator***	**Function 4** ***Eats Terrestrial Insects***
Downey Woodpecker	**0**	**1**	**1 (tree)**	**1**
Bobcat	**1**	**0**	**0**	**0**
Belted Kingfisher	**1**	**0**	**1 (burrows)**	**1**
Great Blue Heron	**1**	**0**	**0**	**1**

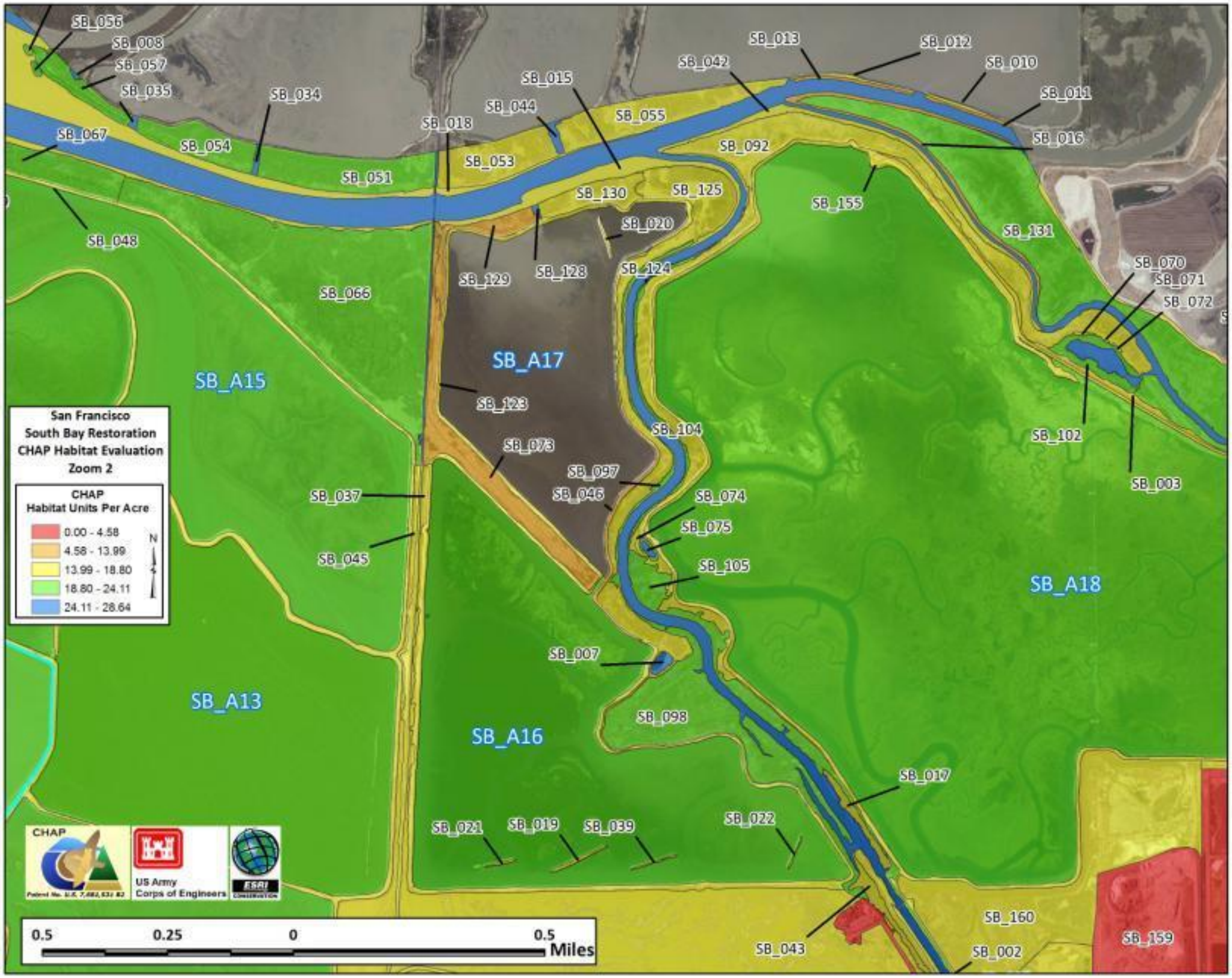
MATRIX 2: Actual KEC by Function Matrix

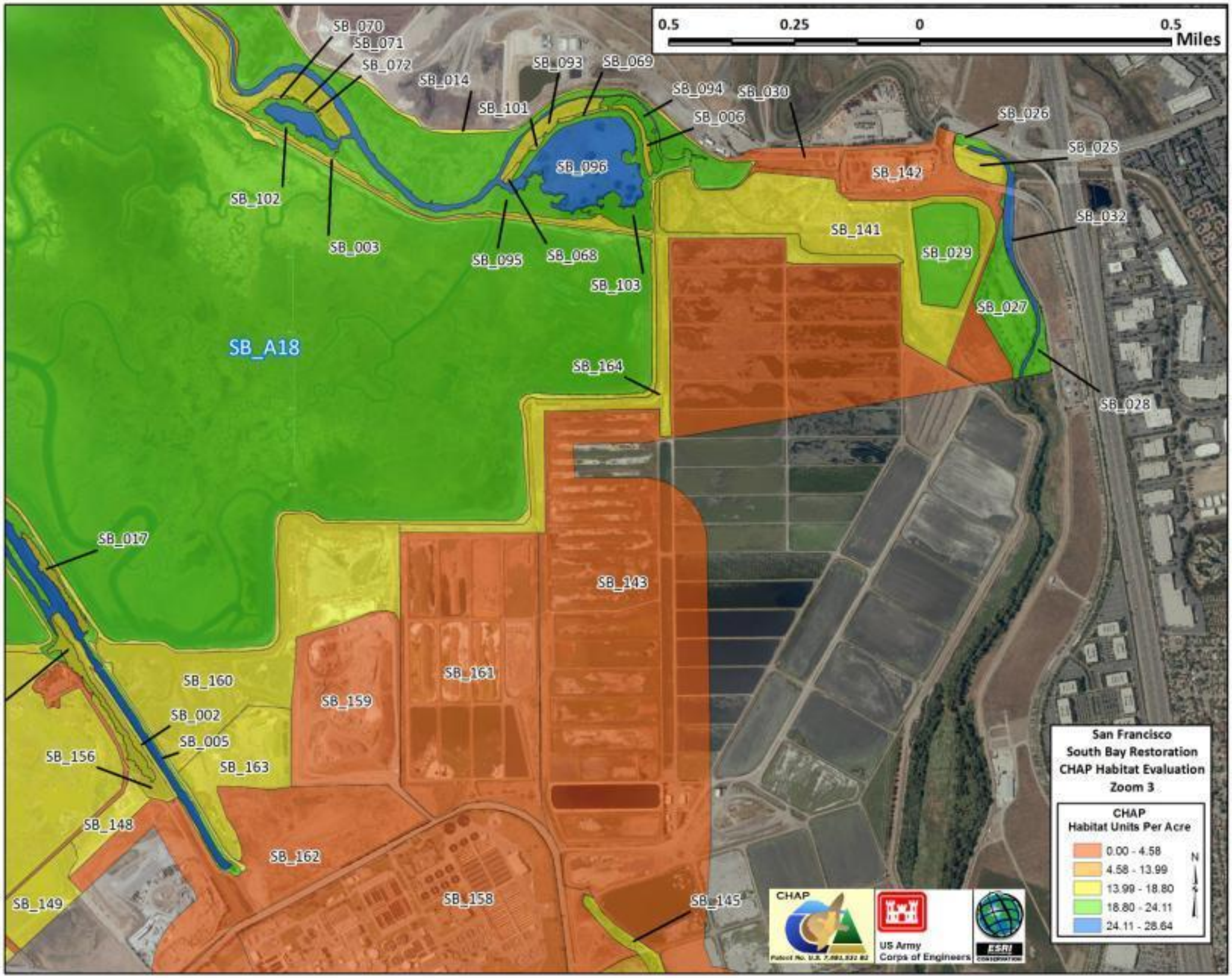
In this matrix, the functions, or KEFs, are again related to Key Environmental Correlates (KECs), but this time the KECs are actually present at the site (based on field data inventory). Because this is an actual account, those KEFs not correlated to an actual KEC are then removed. The result of this matrix is the number of KEFs characterized by KECs specific to that polygon. Example follows:

Lowland Mixed Conifer <u>Habitat Type</u> *KEC Value (Potential)*	**Function 1** ***Creates Snags***	**Function 2** ***Breaks up Down Wood***	**Function 3** ***Primary Excavator***	**Function 4** ***Eats Terrestrial Insects***	**Function 5** ***Eats Aquatic MacroInvertebrates***
KEC 1 down wood	**0**	**1**	**0**	**1**	**0**
KEC 2 snags	**1**	**0**	**1**	**1**	**0**
KEC 3 tree cavities	**1**	**1**	**1**	**1**	**0**
KEC 4 intertidal	**0**	**0**	**0**	**1**	**1**
KEC 5 Aquatic substrate cobble	**0**	**0**	**0**	**0**	**1**

Appendix C
Zoom-in maps of corrected per-acre values by polygon




San Francisco
South Bay Restoration
CHAP Habitat Evaluation
Zoom 2
CHAP
Habitat Units Per Acre
0.00 - 4.58
4.58 - 13.99
13.99 - 18.80
18.80 - 24.11
24.11 - 28.64
N
SB_A15
SB_A17
SB_A13
SB_A16
SB_A18
SB_056
SB_008
SB_057
SB_035
SB_034
SB_067
SB_054
SB_051
SB_048
SB_066
SB_018
SB_044
SB_015
SB_053
SB_055
SB_042
SB_013
SB_012
SB_010
SB_011
SB_016
SB_092
SB_130
SB_125
SB_020
SB_155
SB_131
SB_129
SB_128
SB_124
SB_070
SB_071
SB_072
SB_123
SB_104
SB_102
SB_003
SB_073
SB_097
SB_046
SB_074
SB_075
SB_037
SB_045
SB_105
SB_007
SB_098
SB_017
SB_021
SB_019
SB_039
SB_022
SB_160
SB_159
SB_043
SB_002
US Army
Corps of Engineers
0.5
0.25
0
0.5
Miles


0.5
0.25
0
0.5
Miles
SB_070
SB_071
SB_072
SB_014
SB_093
SB_069
SB_094
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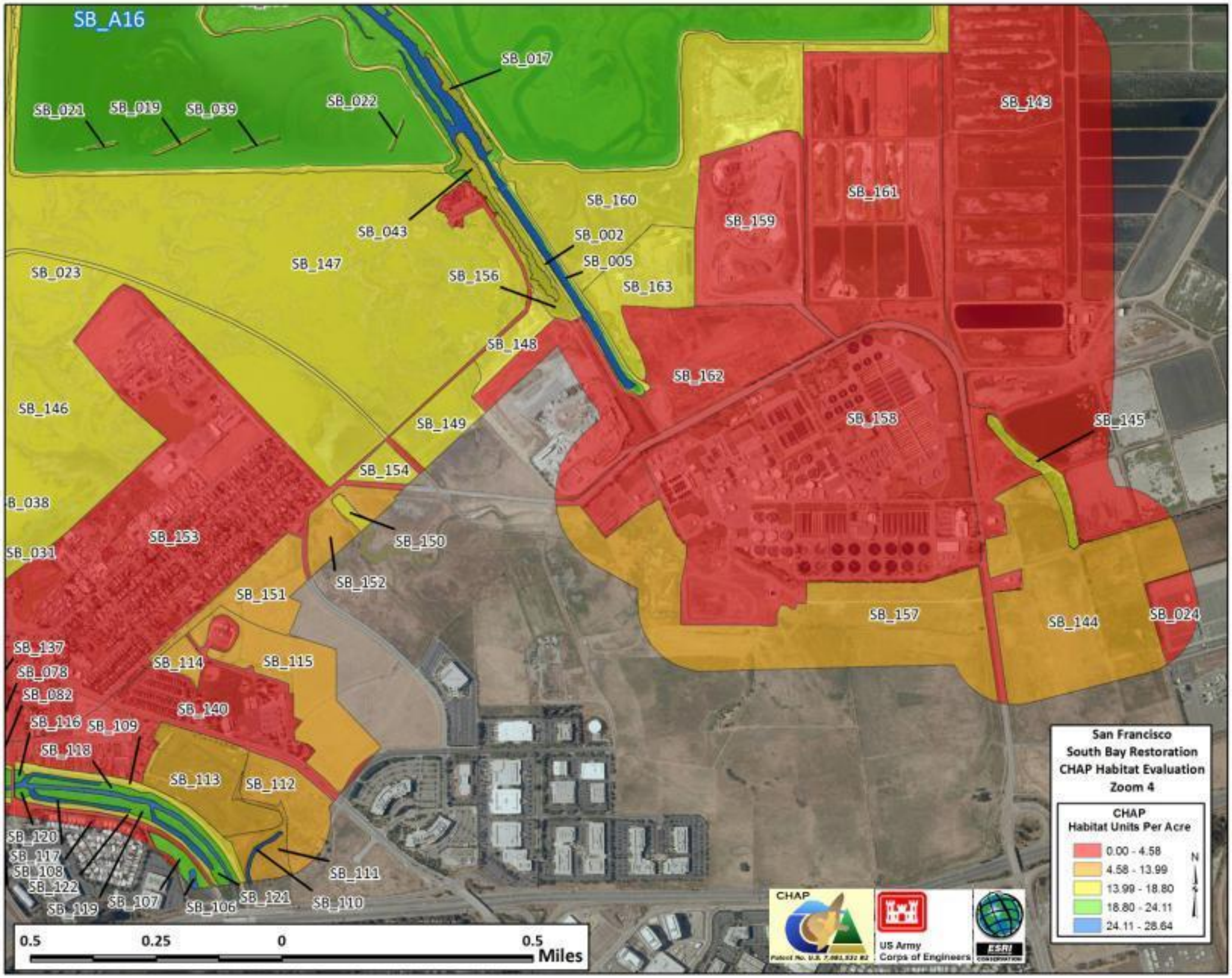
SB_101
SB_006
SB_026
SB_025
SB_096
SB_142
SB_102
SB_003
SB_095
SB_068
SB_103
SB_141
SB_029
SB_032
SB_027
SB_A18
SB_164
SB_028
SB_017
SB_143
SB_160
SB_161
SB_159
SB_002
SB_005
SB_156
SB_163
SB_148
SB_162
SB_149
SB_158
SB_145
San Francisco
South Bay Restoration
CHAP Habitat Evaluation
Zoom 3
CHAP
Habitat Units Per Acre
0.00 - 4.58
4.58 - 13.99
13.99 - 18.80
18.80 - 24.11
24.11 - 28.64
N
US Army
Corps of Engineers
ESRI


SB_A16
SB_017
SB_021
SB_019
SB_039
SB_022
SB_143
SB_161
SB_160
SB_159
SB_043
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SB_005
SB_023
SB_156
SB_163
SB_148
SB_162
SB_146
SB_149
SB_158
SB_145
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SB_038
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SB_150
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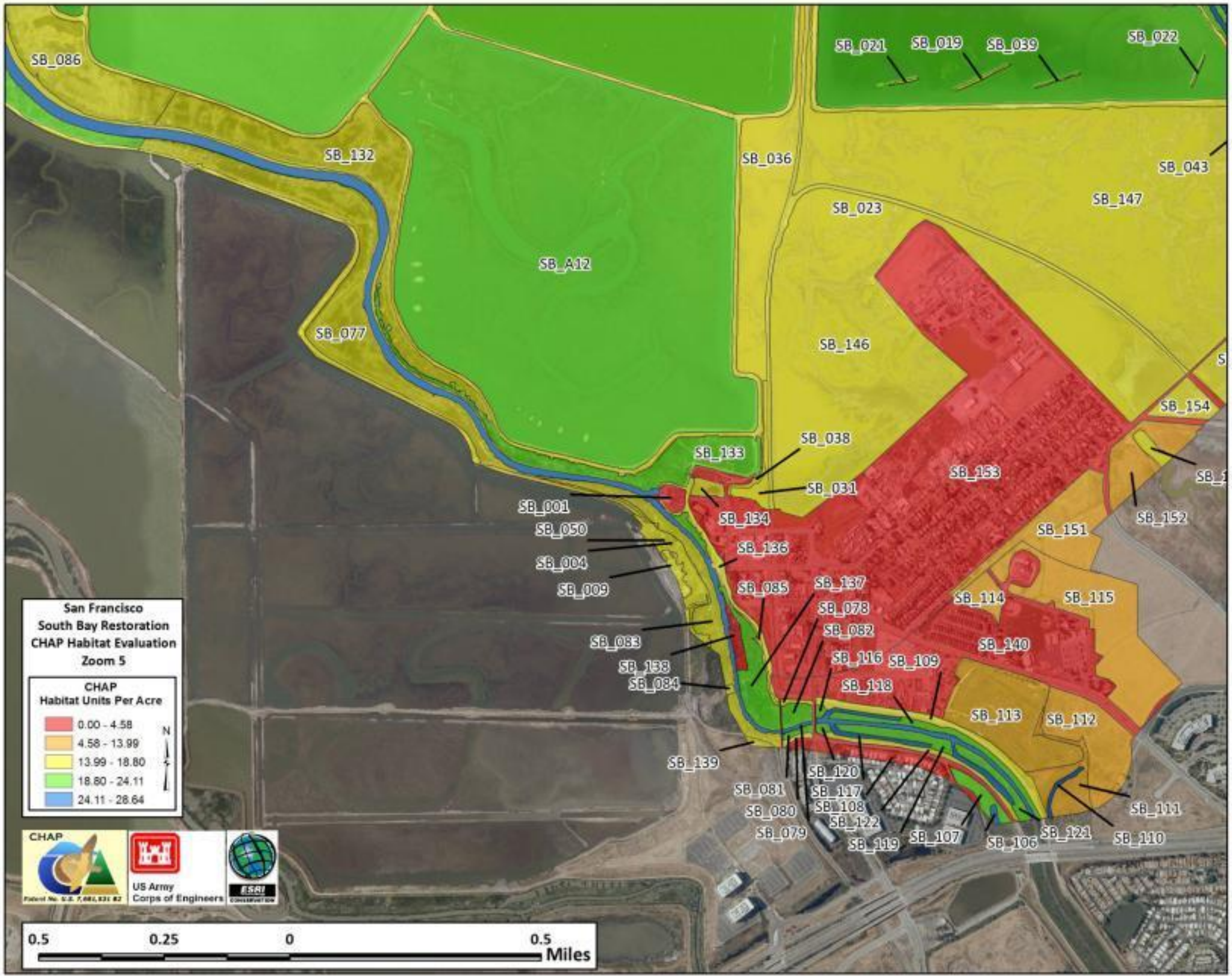
SB_024
SB_137
SB_114
SB_115
SB_078
SB_082
SB_140
SB_116
SB_109
SB_118
SB_113
SB_112
SB_120
SB_117
SB_111
SB_108
SB_122
SB_119
SB_107
SB_106
SB_121
SB_110
0.5
0.25
0
0.5
Miles
CHAP
US Army Corps of Engineers
ESRI
San Francisco
South Bay Restoration
CHAP Habitat Evaluation
Zoom 4
CHAP
Habitat Units Per Acre
0.00 - 4.58
4.58 - 13.99
13.99 - 18.80
18.80 - 24.11
24.11 - 28.64
N



San Francisco
South Bay Restoration
CHAP Habitat Evaluation
Zoom 5
CHAP
Habitat Units Per Acre
0.00 - 4.58
4.58 - 13.99
13.99 - 18.80
18.80 - 24.11
24.11 - 28.64
N
US Army
Corps of Engineers
0.5
0.25
0
0.5
Miles
SB_086
SB_132
SB_077
SB_A12
SB_036
SB_023
SB_146
SB_147
SB_043
SB_021
SB_019
SB_039
SB_022
SB_154
SB_153
SB_038
SB_133
SB_031
SB_001
SB_050
SB_004
SB_009
SB_134
SB_136
SB_085
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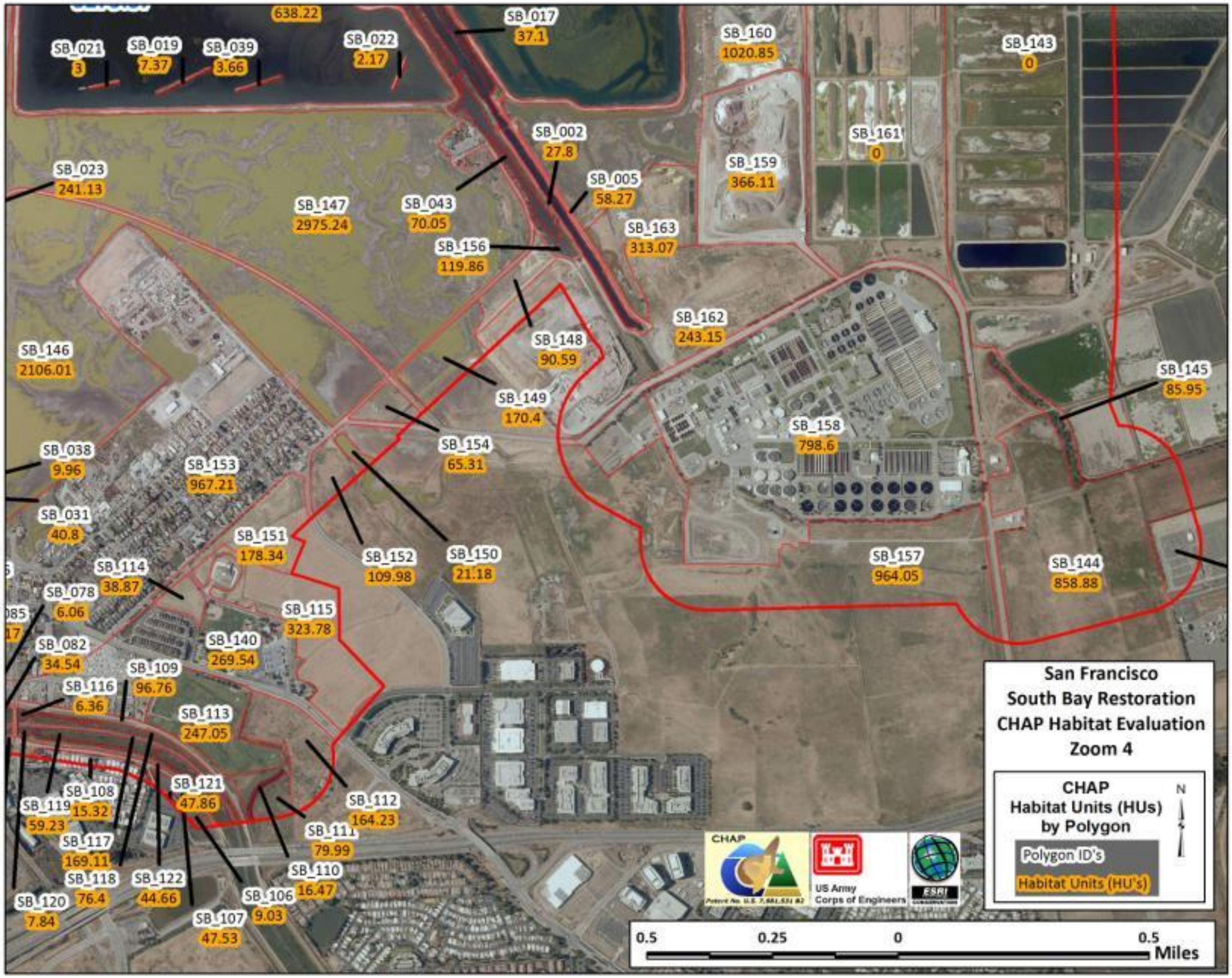
SB_113
SB_112
SB_111
SB_110
SB_121
SB_106
SB_107
SB_119
SB_122
SB_108
SB_117
SB_120
SB_081
SB_080
SB_079

Appendix D
Zoom-in maps of habitat unit values by polygon


San Francisco
South Bay Restoration
CHAP Habitat Evaluation
Zoom 2
CHAP
Habitat Units (HUs)
by Polygon
Polygon ID's
Habitat Units (HU's)
N
0.5
0.25
0
Miles
US Army
Corps of Engineers
SB_A15
5444.4
SB_A17
241.13
SB_A13
5786.38
SB_A16
5273.87
SB_A18
18015.21
SB_066
1615.71
SB_048
194.95
SB_092
490.68
SB_155
547.94
SB_131
1647.73
SB_098
638.22
SB_104
263.74
SB_105
299.18
SB_073
171.88
SB_123
165.3
SB_125
470.52
SB_100
374.54
SB_067
295.79
SB_051
308.1
SB_055
267.57
SB_053
203.17
SB_054
168.19
SB_015
158.3
SB_130
106.84


0.5
0.25
0
0.5
Miles
San Francisco
South Bay Restoration
CHAP Habitat Evaluation
Zoom 3
CHAP
Habitat Units (HUs)
by Polygon
Polygon ID's
Habitat Units (HU's)
SB_A18
18015.21
SB_155
547.94
SB_131
1647.73
SB_070
2.77
SB_071
0.53
SB_072
1.18
SB_014
83.87
SB_093
67.34
SB_069
8.28
SB_094
46.44
SB_006
21.18
SB_068
6
SB_101
4.33
SB_096
555.45
SB_030
27.8
SB_026
22.39
SB_025
60.34
SB_142
131.81
SB_104
263.74
SB_003
110.55
SB_103
203.13
SB_141
760.56
SB_029
319.2
SB_032
99.99
SB_095
209.85
SB_075
8.43
SB_027
270.34
SB_105
299.18
SB_028
47.89
SB_164
361.71
SB_017
37.1
SB_160
1020.85
SB_143
0
SB_002
27.8
SB_161
0
SB_159
366.11
SB_005
58.27
SB_043
70.05
SB_163
313.07
SB_156
119.86
SB_162
243.15
SB_148
90.59
SB_145
490.68
US Army
Corps of Engineers


San Francisco
South Bay Restoration
CHAP Habitat Evaluation
Zoom 4
CHAP
Habitat Units (HUs)
by Polygon
Polygon ID's
Habitat Units (HU's)
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0.5
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Miles
US Army
Corps of Engineers
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3
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9.03
SB_120
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SB_107
47.53


San Francisco
South Bay Restoration
CHAP Habitat Evaluation
Zoom 5
CHAP
Habitat Units (HUs)
by Polygon
Polygon ID's
Habitat Units (HU's)
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US Army
Corps of Engineers
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Miles
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Appendix B3

Flood Risk Management Coordination with the USFWS

United States Department of the Interior

FISH AND WILDLIFE SERVICE
San Francisco Bay National Wildlife Refuge Complex
1 Marshlands Road
Fremont, California 94555

September 10, 2015

LTC John Morrow, District Commander
Attn: Caleb Conn, Project Manager U.S. Army Corps of Engineers
San Francisco District
1455 Market Street, 17th Floor
San Francisco, California 94103

Dear LTC Morrow,

The purpose of this letter is to clarify what is intended by our Compatibility Determination (CD) for the South San Francisco Bay Shoreline Phase I Study, dated September 4, 2015. First and foremost, nothing in the CD is intended to be inconsistent with the roles and responsibilities outlined in the recommended plan set out in the Final Integrated Document (Final Interim Feasibility Study With Environmental Impact Statement/Environmental Impact Report) and in the Draft Memorandum of Understanding (MOU) between the United States Fish and Wildlife Service (FWS), the Santa Clara Valley Water District (SCVWD), and the California State Coastal Conservancy (SCC).

As such, it is understood that the flood risk management, ecosystem restoration and recreational features in the recommended plan, to be constructed by the Corps, will be operated, maintained, repaired, replaced and rehabilitated by the SCVWD and SCC, the non-Federal Sponsors (NFS) for the South San Francisco Bay Shoreline Phase I Study Project, under sections 103(i) and 103(j) of the Water Resources Development Act of 1986, 33 U.S.C. § 2213(i)(j), and USACE regulations and policies. Please refer to Chapter 9 of the Integrated Document and paragraphs 2 and 3.B. of the draft MOU, attached, that discusses the operations, maintenance, repair, replacement and rehabilitation of the project .

The FWS recognizes that the subsequent restoration activities, i.e., the conversion of Refuge Ponds A9-15 to tidal marsh habitat and the enhancement of recreational features (replacing trails and interpretive signs along levee), that will follow the levee construction are Refuge Management Activities and therefore from our perspective do not require a CD.

The term "Refuge Management Activities" is from our own policy and is not a reference to the specific activities of the Shoreline project but rather refers to a category of "refuge uses." A "Refuge Management Activity" is a specific term defined by our policy as: "An activity conducted by the Service or a Service-authorized agent to fulfill one or more purposes of the national wildlife refuge, or the National Wildlife Refuge System mission. Service-authorized agents include contractors, cooperating agencies, cooperating associations, refuge support groups, and volunteers." Even though USACE and the sponsors are funding the ecosystem restoration and recreation features and have control over the project features, including mitigation, monitoring, and adaptive management activities, those activities fulfill one or more purposes of the refuge; therefore, we consider those to be "Refuge Management Activities." Fortunately for all involved, those "general" (not specific) uses have already been evaluated in prior planning documents and have been determined to be compatible.

Also note that although the "Description of Use" section of the CD refers to USACE being responsible for levee construction and the NFS as being responsible for levee operation and maintenance, it was not intended to limit any other responsibilities or authorities in any manner, shape or form. The other components of the South San Francisco Bay Shoreline Phase I Study Project, i.e., ecosystem restoration and recreation, have already been deemed to be compatible and thus were not included in the CD. As described in the MOU, access for the design and construction of the levee, ecosystem restoration, and recreation features will be granted to USACE through issuance of a Special Use Permit and access for operation and maintenance of the features will be granted to the NFS in the form of a Right of Way without term limitations.

To ensure that there is no doubt of the FWS intentions, we will ensure that our Record of Decision is sufficiently robust to include all three major project elements of flood control, ecosystem restoration, and recreation. Additionally, we will discuss the OMRR&R responsibilities of the NFSs. Should you have any further questions, please do not hesitate to contact me by telephone on (510) 792-0222 extension 123 or by email at anne_morkill@fws.gov.

Sincerely,

Anne E. Morkill

Anne E. Morkill
Refuge Complex Manager

United States Department of the Interior

FISH AND WILDLIFE SERVICE
San Francisco Bay National Wildlife Refuge Complex
1 Marshlands Road
Fremont, California 94555

Compatibility Determination
for the South San Francisco Bay Shoreline Phase I Study,
Don Edwards San Francisco Bay National Wildlife Refuge, California

Use: Issuance of a Special Use Permit to the U.S. Corps of Engineers and a Right of Way to the Santa Clara Valley Water District for the construction and operation of an engineered flood risk management levee as a component of the South San Francisco Bay Shoreline Phase I Study.

Refuge Name: Don Edwards San Francisco Bay National Wildlife Refuge, Alameda, Santa Clara and San Mateo Counties, California (see Figure 1).

Date Established: June 30, 1972

Establishing and Acquisition Authorities: 86 Stat. 399, dated June 30, 1972, An Act Authorizing the Transfer of Certain Real Property for Wildlife, or other purposes (16 U.S.C. 667b); Endangered Species Act of 1973 (16 U.S.C. 1534); Fish and Wildlife Act of 1956 (16 U.S.C. 742f)

Refuge Purpose(s):

"...for the preservation and enhancement of highly significant wildlife habitat...for the protection of migratory waterfowl and other wildlife, including species known to be threatened with extinction, and to provide an opportunity for wildlife-oriented recreation and nature study..." (86 Stat. 399, dated June 30, 1972).

"...particular value in carrying out the national migratory bird management program" 16 U.S.C. 667b (An Act Authorizing the Transfer of Certain Real Property for Wildlife, or other purposes).

"...to conserve (A) fish or wildlife which are listed as endangered species or threatened species....or (B) plants ..." 16 U.S.C. 1534 (Endangered Species Act of 1973).

"...for the development, advancement, management, conservation, and protection of fish and wildlife resources ..." 16 U.S.C. 742f(a)(4) "...for the benefit of the United States Fish and Wildlife Service, in performing its activities and services. Such acceptance may be subject to the terms of any restrictive or affirmative covenant, or condition of servitude ..." 16 U.S.C. 742f (b)(1) (Fish and Wildlife Act of 1956).

National Wildlife Refuge System Mission: The mission of the National Wildlife Refuge System is "to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife and plant resources and their habitats within the United States for the benefit of present and future generations of Americans." (National Wildlife Refuge System Administration Act of 1966, as amended [16 U.S.C. 668dd- 668ee]).

Description of Use: The proposed use is the issuance of permits to grant access for the construction and operation of an engineered flood risk management levee on the Don Edwards San Francisco Bay NWR, including pre-construction engineering and design activities, geotechnical and hydrological analyses, equipment staging, construction of project features, and the long-term operations, maintenance, repair, replacement, and rehabilitation of the levee. The levee is part of the South San Francisco Bay Shoreline Study (Study), a multi-purpose flood risk management, ecosystem restoration, and recreation enhancement project led by the U.S. Corps of Engineers (USACE) in coordination with California State Coastal Conservancy (SCC), Santa Clara Valley Water District (SCVWD), U.S. Fish and Wildlife Service (USFWS), and City of San Jose. Access for the proposed use would be granted through issuance of a Special Use Permit to the USACE (levee design and construction) and a Right Of Way to the SCVWD (levee operation and maintenance).

The engineered levee would be constructed on an existing pond dike alignment along the eastern border of Refuge Ponds A12-13 and the southern border of Refuge Pond A16 and cross Artesian Slough onto city property where it would continue along the southern border of the city's Pond A18. The engineered levee would be built to 15.2 feet high (approximately 6-8 feet higher than existing pond dikes) to provide protection against a 100- year storm event, meet local requirements for flood risk management within Santa Clara County, and allow for continued Federal Emergency Management Agency (FEMA) accreditation at the end of the Study's period of analysis (the year 2067). The proposed use also includes construction of a 30:1 (1 foot of elevation rise for each 30 feet of horizontal distance) broad-sloping ecotone along the levee alignment adjacent to Refuge Ponds A12-13 (Figure 2).

The subsequent restoration activities (conversion of Refuge Ponds A9-15 to tidal marsh habitat) and enhancement of recreational features (replacing trails and interpretive signs along levee) that will follow the levee construction are Refuge Management Activities, and therefore do not require a compatibility determination.

Availability of Resources:

Adequacy of existing resources: Existing resources are adequate to administer the special use permit and the right of way. The primary staff responsible is the Refuge Manager (and other staff as appropriate) of the Don Edwards San Francisco Bay NWR, with support as necessary from the Project Leader for the San Francisco Bay National Wildlife Refuge Complex, headquartered in Fremont, California.

Needed resources: No additional fiscal resources are needed to manage this use. The Refuge Manager will be using regular base allocations for the long-term operations and maintenance of the ecosystem restoration features and associated recreational features on Refuge lands (Ponds A9- 16). Operations and maintenance costs will be reduced significantly once Ponds A9-15 are restored to tidal marsh, negating the need to maintain the system of earthen dikes and water control structures that currently exist. Further, the USFWS will no longer be responsible for maintaining the levee along Refuge Ponds A12-13 and A16 as they will be placed under a right-of-way permit for the SCVWD to operate and maintain once it is re-constructed to the proposed engineered flood risk management levee height of 15.2 feet.

Anticipated Impacts of the Use:

Water Quality: Negative short-term impacts from temporary increase in salinity in sloughs and remobilization of mercury in ponds and sloughs. Potential positive long-term benefits to surface water and sediment quality. Restoration of the ponds would reduce turbidity of waters flowing into the bay, provide energy dissipation that will reduce erosion and flooding, provide higher levels of dissolved oxygen in some ponds in the short term, and sequester water pollutants in the South San Francisco Bay.

Air Quality/Greenhouse Gases: Moderate but short-term negative construction-related impacts.

Subtidal Marsh and Mudflat Habitat Values: Minor negative construction-related impacts; potential positive long-term effects. Proposed use would not have a substantial adverse effect on or cause a substantial decrease in the abundance or distribution of steelhead, Chinook salmon, green sturgeon, longfin smelt, estuarine species, or bay shrimp populations, nor result in the substantial loss or degradation of designated essential fish habitat. The proposed use would not interfere substantially with the movement of any native or migratory fish or impede the use of aquatic nursery sites.

Tidal Marsh Habitat Value: Substantial positive mid- and long-term effects; additional ecotone provides for early evolution of marsh communities in former ponds and provides high-tide refugia for marsh-dependent species during high tide events, storm events, and accelerating rates of sea level rise.

Upland Habitat Value: Minor negative temporary construction-related impacts. Minor permanent increases from levee construction.

Threatened and Endangered Species: Substantial positive mid- and long-term effects; potential for minor and temporary negative effects during construction. Restoration of the ponds, which will be facilitated by the construction of the flood risk management levee, and the additional ecotone will provide for early evolution of marsh communities in former ponds and provide high-tide refugia for marsh-dependent listed species during high tide events, storm events, and accelerating rates of sea level rise.

Cultural Resources: No documented sites in the project area. Potential disturbance to unknown sites; however, any previously unknown sites that are discovered during construction activities will be handled in compliance with cultural resources consultation process.

Aesthetics: Minor negative temporary construction-related impacts. The expanded ecotone would provide shallow slopes along certain segments bayside of the levee, would include vegetation on these slopes, and would soften the contrast in form in contrast to a more traditional sharp-sloped concrete or rocked sterile-like engineered levee. The project could also result in long-term impacts to the viewshed from the Refuge's Environmental Education Center; but those impacts would be ameliorated by the addition of new trails leading up to and along the crest of the levee to provide new opportunities for views.

Land Use: Project would benefit adjacent land use by providing high level of flood risk management. There is potential for temporary construction nuisance impacts— such as noise, dust, and visual impacts—on Refuge visitors, Alviso residents, and the use of the Alviso County Marina. Construction activities may require temporary closure of public trails and the Refuge's Environmental Education Center.

Recreation: The ecosystem restoration component will result in a net loss of approximately 2.2 miles of Refuge trails once levees are breached to facilitate tidal marsh restoration, but would still support a useful Refuge trail system and a connection to other regional trails such as the San Francisco Bay Trail system. The project would result in long-term enhancements for Refuge visitors by providing providing benches, interpretive displays, and observation platforms, and facilitating connections to other trail systems with the addition of new pedestrian crossings of Artesian Slough and the Union Pacific Railroad tracks.

Public Review and Comment:

Public review and comment was solicited on the draft CD for 30 days. The draft CD was available to the public for review during June 8-July 10, 2015 while posted on the Refuge website and as hard copy at the Refuge headquarters on 1 Marshlands Road, Fremont, California. No public comment was received on the draft CD.

For additional consideration, public comment received on the Draft EIS was also evaluated. The USACE and USFWS are acting as the co–lead agencies under the National Environmental Policy Act (NEPA), and the SCVWD is acting as the lead agency under the California Environmental Quality Act (CEQA). Additionally, the SCC serves as a non-Federal cost-share partner and CEQA responsible agency for this project. The interagency project team commenced the South San Francisco Bay Shoreline Study's Phase 1 Interim Feasibility Study and Environmental Impact Statement/Environmental Impact Report (EIS/EIR) process in January 2006. The public involvement program for the project included a formal pubic scoping meeting on January 25, 2006 in Milpitas, CA, as well as ongoing stakeholder coordination and opportunities to comment on the scope and content of the proposed project through a stakeholder forum originally convened for the South Bay Salt Pond Restoration Project (SBSPRP). Forum meetings occurred once a year and were open to the public. The Draft Interim Feasibility Study and EIS/EIR (Integrated Document) was released for public review and comment from December 19, 2014 through February 2, 2015. A public meeting on the Draft Integrated Document was held on January 14, 2015 in Alviso, CA. The comment period was subsequently extended until February 23, 2015. A total of 40 comment letters were received, including 9 letters requesting a time extension for the public comment period. The comments represented a variety of stakeholder groups as follows: Fed/State/County/City Agencies – 17, for-profit business – 2 (PG&E, Cargill), non-profit business – 12, private citizens - 9. A full description of the previous public review and comment process can be found in Chapter 6.0, Public Involvement, Review, and Consultation in the Draft Integrated Document (December 2014); and the response to comments will be included in the Final Integrated Document (December 21015).

Determination:

___ Use is Not Compatible

XX Use is Compatible with Following Stipulations

Stipulations Necessary to Ensure Compatibility:

The general conservation measures that will be implemented during project activities to avoid and minimize adverse effects on sensitive species and habitats are listed in the South San Francisco Bay Shoreline Study's Draft Interim Feasibility Study and Environmental Impact Statement/Environmental Impact Report (December 18, 2014) and Intra-Service Section 7 Endangered Species Act Final Biological Opinion/Conference Opinion (April 27, 2015), and incorporated herein by reference.

Justification:

With the acquisition of some 11,000 acres for former commercial solar salt ponds (including new fee title and salt-making rights on existing fee title) from Cargill, Inc. in 2003, the Don Edwards San Francisco Bay NWR gained responsibility for more than 70 miles of non- engineered dikes (earthen berms) and associated water control structures that were originally designed and constructed for commercial salt ponds. The dikes, which were created as early as the 1920s, were generally maintained to protect the salt pond production from tidal flooding, but were not meant to prevent flooding of adjacent communities. To date, the USFWS has received insufficient funds to adequately maintain the non-engineered dike system, resulting in an extremely degraded condition of many of the dikes with capability of only periodic spot-repairs as needed. Currently, much of the land south of the ponds is urbanized, including the residential and historic community of Alviso (within the limits of the City of San Jose), Silicon Valley tech business parks, transportation corridors, landfills, the City of San Jose's wastewater treatment plant, and other critical infrastructure. Much of this area has subsided as much as 13 feet below sea level due to extensive groundwater withdrawal for agricultural uses. There is considerable risk for tidal flooding caused by having large areas of low-lying terrain that are bordered by severely degraded non-engineered dikes, which are inadequate to provide reliable flood risk management for the urbanized areas south of the ponds. Sea level rise will further exacerbate risks from tidal flooding caused by higher waters stressing the dikes. Flood benefits (damages reduced) from the project will be fully realized simply as a function of levee height and engineered design features, replacing the non-engineered dikes that currently exist.

Addressing flood risk in the Alviso area would also allow for the restoration of some 3,000 acres of former salt-production ponds to tidal marsh habitats along with associated ecological functions and habitat for threatened and endangered species. San Francisco Bay is one of the most extensive wetland ecosystems along the Pacific Coast, providing habitat for millions of migratory waterfowl and shorebirds along the Pacific Flyway as well as resident fish and wildlife. Since the area was settled in the 1880s, more than 85% of the tidal marshes have been filled, diked, or drained to support development, agricultural, and commercial solar salt-making. Since the 1960s, the trend shifted towards protection and restoration of the estuary, including the establishment of the Don Edwards San Francisco Bay NWR for the purposes of conserving and restoring tidal marsh habitats and supporting the recovery of endangered species, including the salt marsh harvest mouse (*Reithrodontomys r. raviventris*) and California Ridgway's rail (*Rallus obsoletus*, formerly *Rallus longirostris obsoletus*). The USFWS is consequently an active partner in the South Bay Salt Pond Restoration Project, the largest wetland restoration program on the West Coast that seeks to restore and enhance a mix of wetland habitats, provide wildlife-oriented public access and recreation, and provide for flood risk management in the South Bay. The proposed use described herein meets all of these goals in addition to the goals and objectives of the Don Edwards San Francisco Bay NWR Comprehensive Conservation Plan (2012) and the USFWS's Recovery Plan for Tidal Marsh Ecosystems in Northern and Central California (2014).

Reevaluation Date: In accordance with Compatibility Policy (603 FW 2.11 H), we will reevaluate compatibility when the conditions under which the special use permit or right of way permit are authorized change significantly, if there is significant new information regarding the effects of the use, and/or upon extension or termination of the permits. In addition, we will periodically monitor and review for compliance with permit terms and conditions.

NEPA Compliance for Refuge Use Decision:

____ Categorical Exclusion without Environmental Action Statement

_____ Categorical Exclusion and Environmental Action Statement

_____ Environmental Assessment and Finding of No Significant Impact

__X__ Environmental Impact Statement and Record of Decision

Refuge Determination

Prepared by:

Sept 3, 2015

Project Leader (Signature) (Date)

Concurrence:

9/4/2015

Refuge Supervisor (Signature) (Date)

9.4.2015

Assistant Regional Director, Refuges (Signature) (Date)

Figure 1. Don Edwards San Francisco Bay National Wildlife Refuge (location of proposed use indicated by yellow arrow)

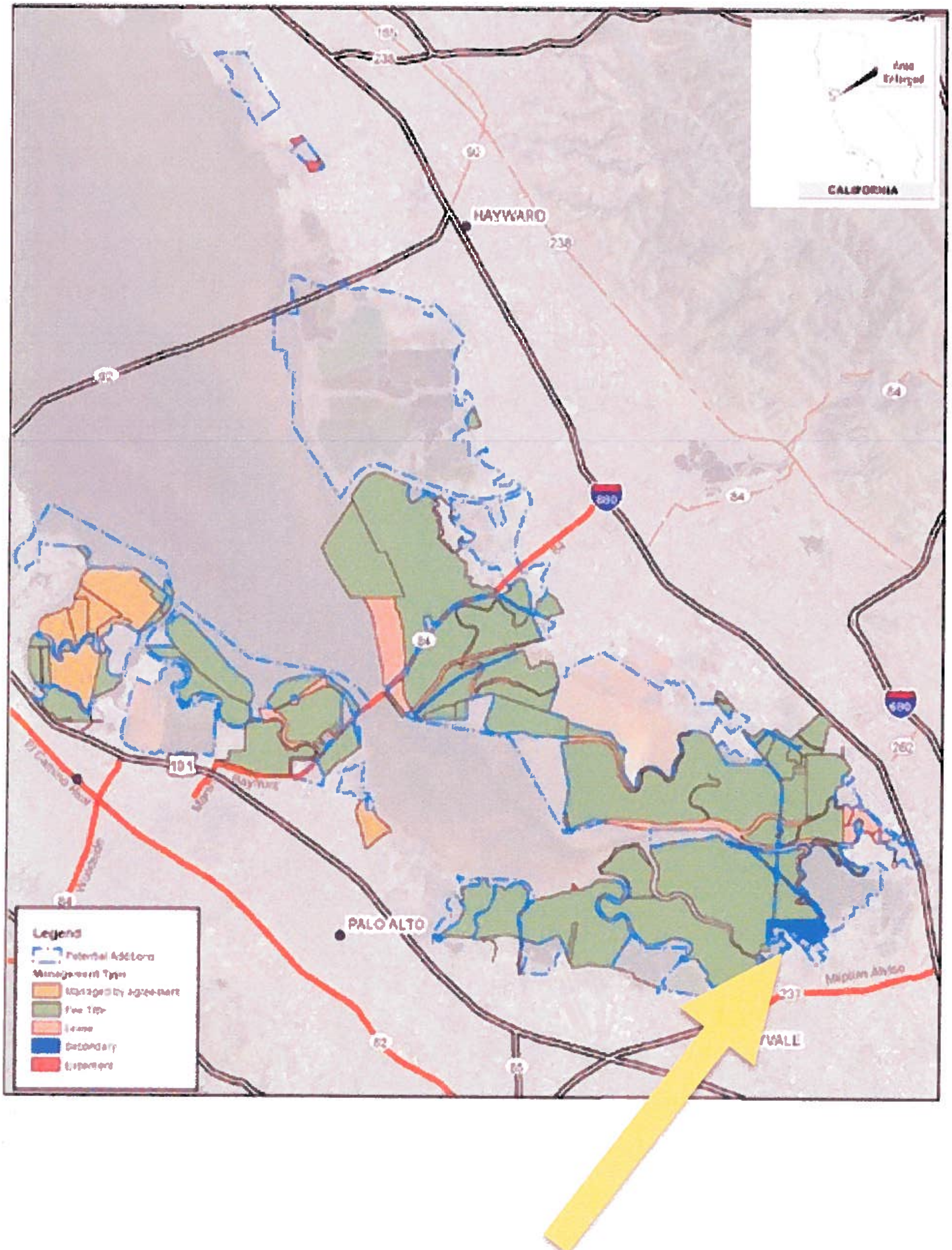

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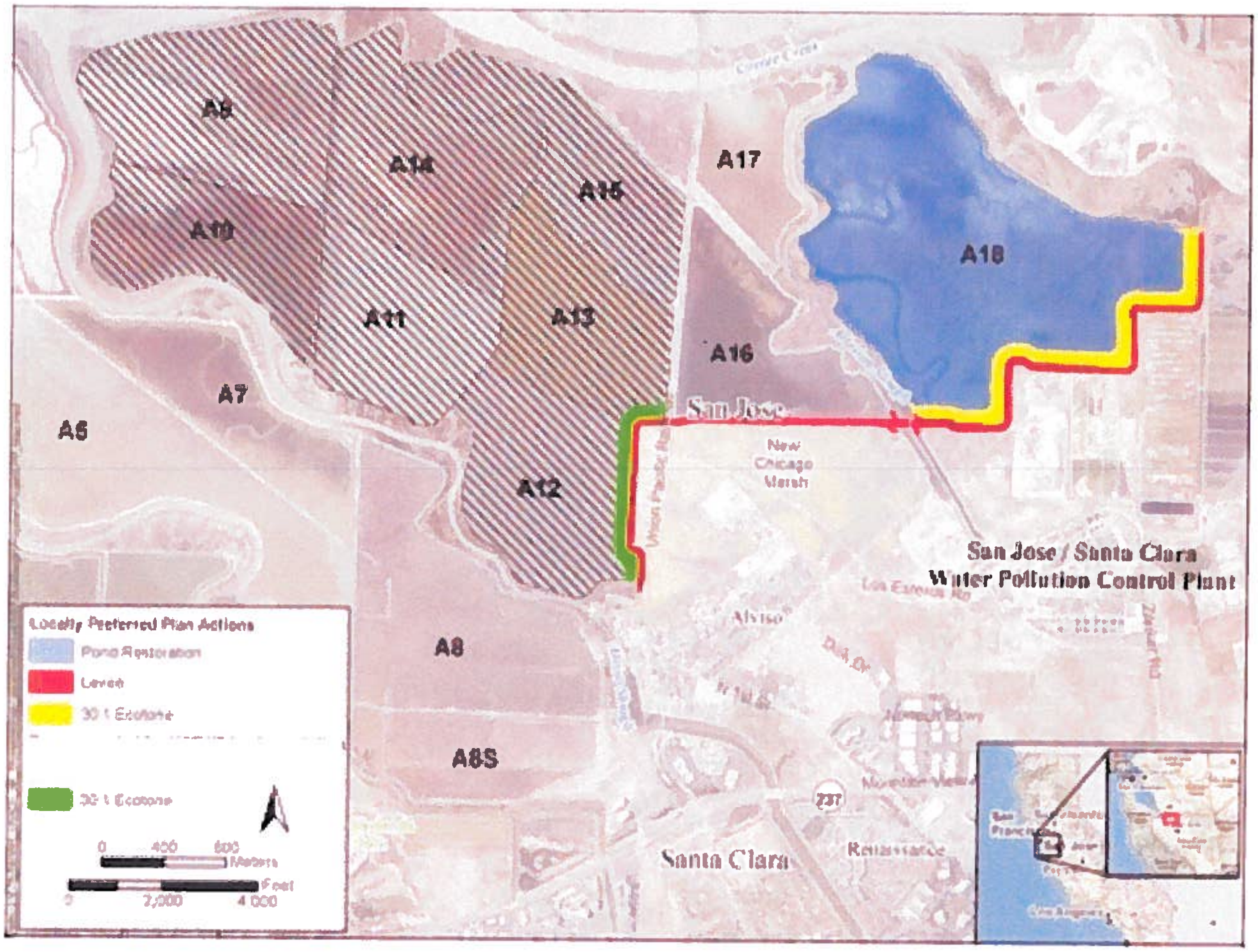
Figure 2. Proposed alignment for engineered flood risk management levee and associated ecosystem restoration features (Tentatively Selected Plan/Locally Preferred Plan for South San Francisco Bay Shoreline Study). The levee alignment and associated ecotone along Ponds A12-13 and A-16 are on Service property. The remaining levee alignment and ecotone along Pond A-18 ares on city property.



United States Department of the Interior

FISH AND WILDLIFE SERVICE
Bay Delta Fish and Wildlife Office
650 Capitol Mall 8th floor 8-300
Sacramento, California 95814

In Reply Refer to:
08ESMF00-
2013-CPA-0002

MAR 31 2015

Lt. Col. John C. Morrow
Commander
Attn: William DeJager
U.S. Army Corps of Engineers
San Francisco District
1455 Market Street
San Francisco, California 94103-1398

Dear Lt. Colonel Morrow:

This letter revises and supersedes the U.S. Fish and Wildlife Service's (Service) letter dated October 21, 2014, which described the Service's position and recommendations regarding the U.S. Army Corps of Engineers' (Corps) South San Francisco Bay Shoreline Phase I Study.

The Service has participated in planning efforts associated with the South San Francisco Bay Shoreline Phase I study for a number of years. The Service has also participated as a federal co-lead agency on this study pursuant to the National Environmental Policy Act since the project is proposed to occur on a portion of Don Edwards San Francisco Bay National Wildlife Refuge (Refuge). In addition, the Service's Sacramento and Bay Delta Fish and Wildlife Offices provide guidance and support regarding federally listed species pursuant to the Endangered Species Act and on proposed water resource development projects pursuant to the Fish and Wildlife Coordination Act (FWCA).

The Service's efforts under FWCA are supported by transfer funding from the Corps. Transfer funding to date has been inadequate to support the type of detailed evaluation and develop recommendations such as would be in a Coordination Act Report (CAR) for a project of this scope. The Corps recently informed us that such funds will soon be provided for continued coordination including development of a CAR. Up to the time of our October 21, 2014, letter, we used the limited funds available for initial document review and informal coordination. Since our October 21, 2014, letter, we have had further opportunity to coordinate with Refuge and Corps staff and to review the alternative levee alignments and other information discussed in the Corps' December 2014 draft interim Feasibility Study/Environmental Impact Statement (FS/EIS) (Corps 2014). Based on this review, we have developed the following revised comments and recommendations. The content of this letter is still to be considered preliminary and subject to confirmation or further revision as needed pending the completion of a CAR.

Comments and recommendations

In our October 21, 2014, letter, we expressed concern that the Alviso North levee alignment, now a component of the Corps' tentatively selected plan and proposed project (FS/EIS Alternative 3), would permanently isolate New Chicago Marsh (NCM) from the San Francisco Bay, limiting the extent to which the project could restore full tidal marsh. At that time, we supported a project similar to that shown in FS/EIS Alternative 4 involving the more southerly Alviso Railroad Spur alignment for levee improvements to the west, which would expose part of NCM to tidal action, in combination with the Water Pollution Control Plant (WPCP) south alignment to the east. Among other reasons, we believed then that this alternative would result in a more comprehensive restoration and would incur reduced long term management costs. Our recommendations also differed from the earlier locally-preferred alternative that included a WPCP north alignment which would have reduced the extent of tidal restoration. These recommendations were previously discussed in our earlier letter of December 26, 2012, which is included in the FS/EIS (Appendix H *in* Corps 2014). We acknowledge that the WPCP North levee alignment has since been eliminated from the proposed project and locally preferred alternative and was not included in the final alternatives analysis in the FS/EIS.

Like many parts of the study area, NCM has experienced significant subsidence. Based on reasonable estimates of suspended sediment concentration, modeling of areas adjacent to NCM indicate that it would take several decades or more after initial exposure to tidal action for accretion to raise elevations to the point where vegetation could colonize the surface (ESA PWA 2012). This modeling indicates that the interior, more deeply subsided areas such as pond A12, would need to be restored first in order to maximize the rate of sediment accretion in these locations; otherwise, they would remain subtidal habitat. The NCM was not included in the area modeled by ESA PWA (2012) and is not under consideration for any of the alternatives. Nevertheless, it is reasonable to suggest that if tidal restoration of NCM were modeled, it would probably indicate a need for treatment sequence and marsh plain evolution similar to pond A12 (i.e., early breaching; decades needed for restoration). Inclusion of NCM, while maximizing the overall extent of tidal restoration, could affect or delay restoration of other areas.

Additionally, we have reconsidered the effect of retaining NCM versus opening it to full tidal action on fish and wildlife resources. Currently, NCM is a muted tidal marsh with water control structures that limit the amount of Bay water that enters and exits the marsh. Because of the reduction in tidal level and range, muted tidal marsh of this type generally has a lower diversity of vegetation and habitat types than full tidal marsh. Nevertheless, NCM in its present form constitutes one of the largest intact blocks of tidal marsh vegetation in the project vicinity and provides habitat that supports a number of rare species, including the federally listed salt marsh harvest mouse and western snowy plover, and others such as Forster's tern, black-necked stilt, and American avocet (Appendix Q *in* Corps 2014). If NCM were to be exposed to full tidal action under the levee configuration we had recommended, it would become open water at the expense of the marsh vegetation and the populations of these important wildlife species and would likely remain open water for a considerable time (decades).

Conversely, if NCM were retained in its present form or enhanced, it would provide continued habitat for these species. The populations in NCM, if preserved and protected, could then serve as a nearby source to expand onto the tidally restored habitat as it becomes available. Although the majority of the tidal restoration would occur over the long term, the proposed project does include a significant component of 30:1 ecotone created by gently sloping fill placed on the outboard side of significant portions of the levee. We expect this ecotone to be rapidly colonized once exposed to full tidal action and provide more immediate additional tidal marsh and upland habitat adjacent to NCM. The proposed project, while perpetuating the muted tidal condition of NCM, provides protection from flood risks (including sea level rise) to that habitat which does not exist currently. Finally, the proposed project (also the locally preferred project) now includes the WPCP south alignment, which would maximize tidal restoration of pond A18. Both the ecotone and WPCP south components of the proposed project remain consistent with our October 21, 2014, recommendations regarding those elements.

The Service is sensitive to the need to adequately inspect and maintain the proposed levee improvements, which would also protect habitat in NCM and incorporate habitat enhancement in the form of the ecotone element in this case. Based on recent information provided by the Corps (February 20, 2015 email from Bill DeJager, San Francisco District), we now understand that most of the 30:1 ecotone element, to be composed of non-engineered fill, would be allowed to have maintenance-free marsh vegetation for nearly its entire length. As described to us, only the first 15 feet of that fill from the point it meets the levee would be maintained as a vegetation-free zone under current Corps policy (Engineering Technical Letter 1110-2-583). We expect this allowance to preserve most of the potential value of the ecotone as transitional habitat. We anticipate further coordination with the Corps and Service Refuge staff to understand and make further recommendations on maintenance needs as well as to formulate measures to minimize the effect of maintenance on listed species.

As we discussed initially in our October 21, 2014, letter, there are inherent difficulties in the application and interpretation of the Combined Habitat Assessment Protocol (CHAP) habitat evaluation methodology for this project. In principle, CHAP is based on biodiversity and places a higher value on those habitats which support greater species numbers and functions. This principle may not be appropriate to this project. Additionally, the CHAP study as provided in the FS/EIS appears to be incomplete and inadequate for present evaluation. Specifically, the FS/EIS includes only a baseline condition report and not evaluation of the alternatives (Appendix J *in* Corps 2014). Elsewhere, the FS/EIS (e.g., main report p. 3-39 and Appendix D pp. 4-5 *in* Corps 2014) makes inferences regarding evaluation of the alternatives, but the documentation of this alternative evaluation does not appear to be included in the FS/EIS. The Service would need full documentation as well as additional time and transfer funding to better evaluate the results of the CHAP effort. However, independent of the habitat evaluation, we believe that the project as proposed will result in near term protection of existing habitat on NCM from flood risks, an increment of additional enhanced habitat in the intermediate term on the ecotone, and a much more significant amount of habitat over the long term as the restored areas attain elevations needed for vegetation establishment.

Based on all of these considerations, it is the Service's preliminary finding to withdraw our previous support of the Alviso Railroad Spur and WPCP south alignment, and instead recommend Alternative 3 with its Alviso Slough North and WPCP south alignment, the Corps' tentatively selected plan and locally-preferred alternative. We now believe that Alternative 3 represents a reasonable and supportable combination of tidal restoration for the majority of the study area together with maintenance and protection of current habitat within NCM.

If you have any further questions on the Service's revised position and recommendations regarding the South San Francisco Bay Shoreline Phase I Study as described in this letter, please contact Steven Schoenberg of my staff at (916) 414-6564.

Sincerely,

Larry Rabin

Acting Field Supervisor

cc:
Joseph Terry, Sacramento Fish and Wildlife Office, Sacramento, California
Melisa Amato, Refuge Manager, Don Edwards NWR, Fremont, California
William DeJager, San Francisco Corps of Engineers, San Francisco, California
Judy McCrea, San Francisco Corps of Engineers, San Francisco, California
Brenda Buxton, California Coastal Conservancy, Oakland, California

REFERENCES

ESA PWA. 2012. Shoreline Study Preliminary Alternatives and Landscape Evolution. Memorandum prepared for the U.S. Army Corps of Engineers San Francisco District. ESA PWA. San Francisco, California. February 10, 2012. 16 pp + appendix + figures.

U.S. Army Corps of Engineers (Corps). 2014. Draft Interim Feasibility Study and Environmental Impact Statement/Report. South San Francisco Bay Shoreline Study Phase 1 Project. Santa Clara County, CA. December, 2014. U.S. Army Corps of Engineers San Francisco District.

DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT, U.S. ARMY CORPS OF ENGINEERS
1455 MARKET STREET
SAN FRANCISCO, CALIFORNIA 94103-1398

CESPN-ET-P 14 March 2014

Memorandum for Record: South San Francisco Bay Shoreline Study Supplemental Analyses on Sea Level Change and Flood Risk Associated with U.S. Fish & Wildlife Service's (USFWS) Refuge Lands

ISSUE: The recently completed supplemental analyses for the South San Francisco Bay Shoreline Study suggest greater flood risks to the community of Alviso, fronted by USFWS's dikes, than previously determined under this study.
The USFWS's San Francisco Bay National Wildlife Refuge Complex includes a former Cargill, Incorporated salt harvesting operation that includes a series of ponds and dikes to manage water levels primarily for wildlife benefits, but which historically have also peripherally reduced the risk of tidal flooding to the community of Alviso. USFWS has assumed maintenance responsibilities nominally to the same level as those once practiced by Cargill, Incorporated and is committed to continuing this practice. Increasing sea level and associated storm events will increase tidal flooding risk to Alviso, which sits behind these unengineered dikes. Recent analysis of the flood risk has identified that the risk of some tidal flooding to Alviso, even at project year zero (2017, prior to significant sea level rise), may be as high as 1 in 3 (0.33 annual chance exceedance). While this is not a surprising finding relative to the National Flood Insurance Rate Map program mapping that currently attributes no flood protection to these dikes, this nonetheless could be an alarming message to residents and certainly one that USFWS is considering when budgeting for management of their complex. USFWS's limited capacities on dike maintenance are a fundamental aspect of the future without-project conditions assumed for the South San Francisco Bay Shoreline Study and needed to be confirmed following the results of the supplemental analyses.

ASSESSMENT: On 4 March 2014, a meeting was held with Anne Morkill, San Francisco Bay National Wildlife Refuge Complex Manager, Eric Mruz, Refuge Manager for the Don Edwards San Francisco Bay National Wildlife Refuge, Craig Conner, CESPN Flood Risk Program Manager, Caleb Conn, CESPN Project Manager, and the undersigned to discuss the flood risk findings and the USFWS's response.

The USFWS is aware of the results of the new analysis, which shows the higher likelihood of inner dike failure and an associated increased chance (over previous analyses) of flood waters reaching Alviso (perhaps as high as a 0.33 annual chance in 2017). These analyses do recognize that USFWS has assumed the maintenance responsibilities once practiced by Cargill, Incorporated; however, USFWS efforts to perform maintenance are to the best of their abilities and within their means. This situation has meant prioritizing work on the outboard dikes and de-prioritizing the inner ones. The USFWS does not propose to take on a major flood risk management investment in levee upgrades in the foreseeable future, only to perform continued maintenance consistent with the current regime.

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Given the potential sensitivities of this message, and as part of the ongoing study partnership and in their co-lead role for Environmental Impact Statement (EIS), the USFWS will review the Draft EIS as well as talking points for any public meeting where flood risks to Alviso are discussed for the South San Francisco Bay Shoreline Study.

CONCLUSION: The USFWS is not planning to change their maintenance actions based on any perception of increased liability stemming from the flood risk analyses. The USACE's geotechnical assumptions (or "fragility curves") used for the dikes in the current and future without-project condition are therefore consistent with the current and proposed maintenance practices by the USFWS. A "risk communication strategy" on USFWS dike maintenance should be prepared and vetted with USFWS.

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DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=KENDALL.THOMAS.R.1231850356
Date: 2014.04.22 18:56:18 -07'00'

Thomas R. Kendall, P.E.
Chief of Planning
San Francisco District, U.S. Army Corps of Engineers

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825-1846

In Reply Refer To:
08ESMF00-2013-CPA-0002

DEC 26 2012

Lt. Col. John K. Baker P.E.,
Commander,
U.S. Army Corps of Engineers, San Francisco District
1455 Market Street
San Francisco, California 94103-1398

Dear Colonel Baker:

This letter is in response to a request received via email from Bill DeJager of your office on December 11, 2012, for the U.S. Fish and Wildlife Service (Service) to document our position regarding the selection of levee alignment alternatives to be studied by the San Francisco Bay Shoreline Study.

On June 5, 2012, the Service participated in a meeting attended by the Corps of Engineers (Corps) and California Coastal Conservancy, in which several levee alignment alternatives were discussed. During the course of the meeting, two alternatives were proposed to be dropped from further consideration by the Corps as they were not supported by the local sponsors. These two alternatives were the Alviso Railroad Spur and WPCP South, which borders Pond A18 and the San Jose Waste Water Treatment Plant (see Attachment 1). The Service did not support removing these two alternatives from further consideration as proposed by the Corps and local sponsors. We continue to recommend that the Alviso Railroad Spur and WPCP South levee alignments remain part of the ongoing NEPA/CEQA process. It is our position that the implementation of these two alternatives would have less impact on fish and wildlife resources, including endangered species, and would allow for a more sustainable restoration project.

The Service recommended retaining the Alviso Railroad Spur alignment in the EIS/EIR in order to minimize effects to New Chicago Marsh and to evaluate a full range of alternatives pursuant to NEPA. Based on the Service's current understanding of the New Chicago Marsh, implementation of the Alviso Railroad Spur alignment would potentially minimize impacts to fish and wildlife resources, including federally listed species protected under the Endangered Species Act. In contrast the construction of the Alviso North levee alignment would continue to isolate the remaining portion of New Chicago Marsh from the San Francisco Bay, limit the ability to restore the area to a fully functioning tidal marsh, and result in a largely fresh water or brackish marsh.

Based on our review of materials presently available, the Service is concerned that the WPCP North levee alignment would have potentially unacceptable effects to listed species. The WPCP

South alignment would have less impact on existing habitat functions and would potentially result in a more comprehensive restoration of Pond A18. The WPCP South alignment may also better support the long-term management of the pond as fish and wildlife habitat by reducing management costs and minimizing human disturbance as a result of creating a larger intact habitat area. Furthermore, the WPCP South alignment has been identified in the Service's draft Tidal Marsh Recovery Plan as providing habitat functions (i.e., high marsh refugia) which would help contribute to the recovery of salt marsh harvest mouse, California clapper rail, and snowy plover.

If you have any further questions please contact Mark Littlefield, Chief, Watershed Planning Branch, at (916) 414-6520.

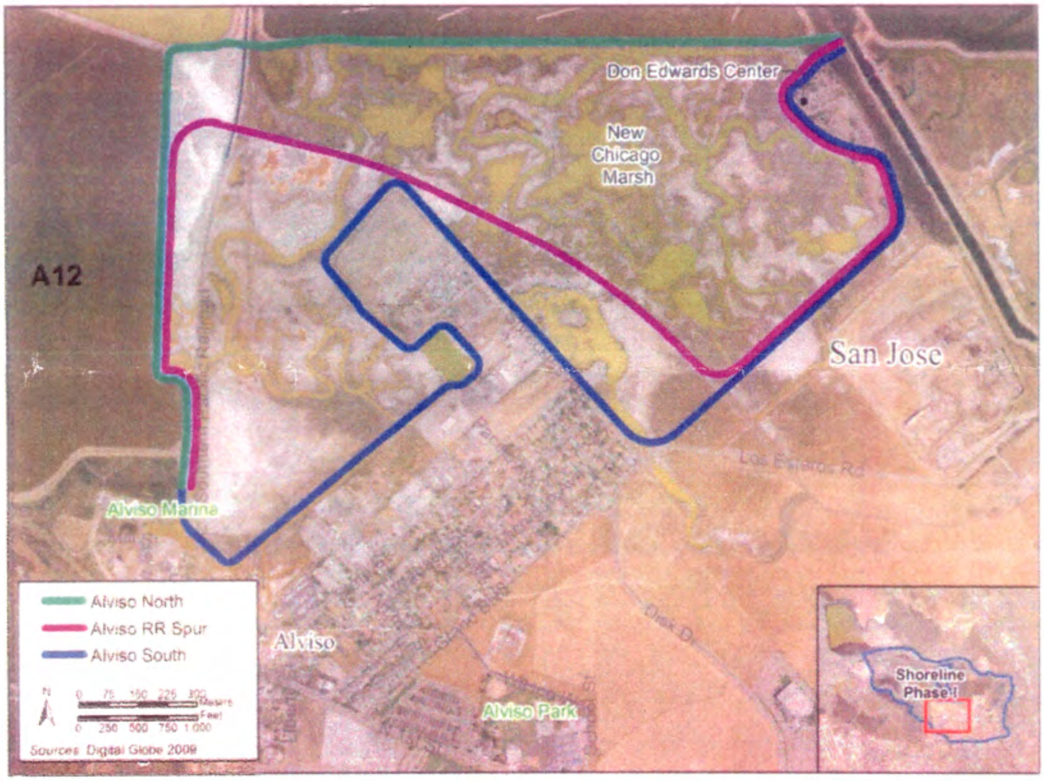
Sincerely

Daniel Welsh
Assistant Field Supervisor

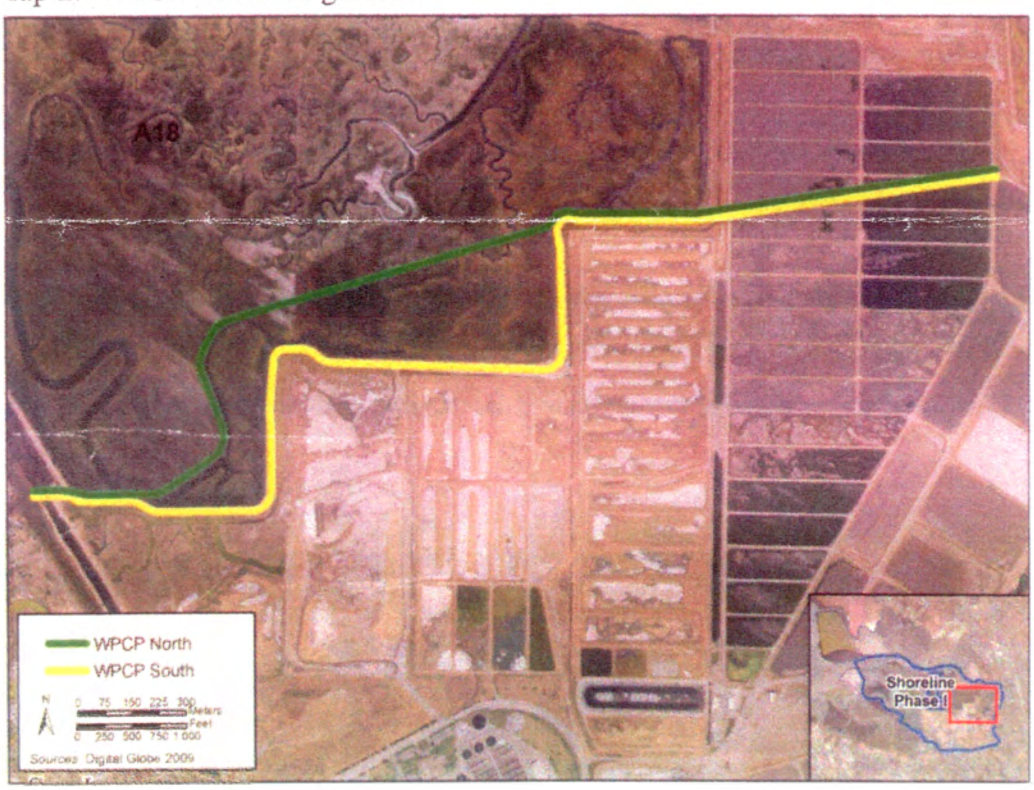
cc:
Joseph Terry, Sacramento Fish and Wildlife Office, Sacramento, California
Eric Mruz, Refuge Manager, Don Edwards NWR, Fremont, California
William DeJager, San Francisco Corps of Engineers, San Francisco, California
Judy Sheen, San Francisco Corps of Engineers, San Francisco, California
Brenda Buxton, California Coastal Conservancy, Oakland, California

ATTACHMENT 1

Map 1. Alviso Levee Alignments



Map 2. WPCP Levee Alignments



Appendix B4

Draft Memorandum Regarding Shoreline Study Ecosystem Restoration Phasing Alternatives (Ponds A9–A15)

South Bay Salt Pond Restoration Project
Restoring the Wild Heart of the South Bay

Memorandum

To: Shoreline Study planning team

From: South Bay Salt Pond planning team

Date: 17 November 2011

Re: Shoreline Study Ecosystem Restoration Phasing Alternatives (Ponds A9-15)
(*Draft*)

Below is the consensus preferred approach for the phasing of Ponds A9-A15 as they relate to the Shoreline Study planning. All of these alternatives assume that the project will be able to proceed beyond the 50:50 scenario based on the adaptive management plan, particularly regarding the issues of waterbird use and mercury.

Preferred Phasing Alternative

The different starting times for each breach event (phase) place the restored ponds on a different part of the sea level rise curve. This means that without substantial suspended sediment, if delayed, Ponds A12-15 will end up at lower elevations because they have fewer years to accrete sediment and their restoration begins on a steeper part of the sea level rise curve.

Therefore, the preferred alternative phasing sequence would be to expedite the restoration of Pond A12 (the most deeply subsided pond). This will help scour out Alviso Slough and will also provide an area to construct upland ecotone areas from the beginning of the project. Subsequent phases may then include Ponds A9-A11, and finally A13-A15. Upland refugia areas would be designed into each phase, with the upland ecotone areas located on the landward side of restored ponds that are adjacent to flood protection levees.

The ecosystem features proposed under the "less fill" to "more fill" scenarios still apply to this Alternative.

Issues to be addressed under Adaptive Management

If the adaptive management plan indicates that we are not ready to open Pond A12 due to waterbird and/or mercury concerns, options for capturing sediment in A12 include:

- Installing a new water control structure in Pond A12 to begin capturing sediment.
- Importing clean fill to raise the pond bottom to accelerate marsh evolution (as was done with Inner Bair Island).

The potential import of fill could be done in advance, after, or simultaneously with breaching other ponds in the A9-15 complex. The filling of A12 (and possibly the other deeply subsided Ponds A13 and A15) may reduce scour in Alviso Slough, bury any in situ mercury, and reduce the material volumes needed for future construction of a broad upland ecotone area.

If concerns about Pond A12 persist, the project could then proceed with breaching Ponds A9-A10. The division between the restored and managed ponds includes the realignment of the internal berm between Pond A9 and A11 to more accurately reflect the historic marsh drainage patterns. Subsequent phases may include restoration of Ponds A11-A15.

Upland refugia areas would be designed into the original phase. If the first phase (A9 and A10) alone remains the ultimate configuration of the restoration in these ponds, then a broad upland ecotone area can be added to the realigned internal berm described above. If further phases of tidal restoration are constructed, then the upland ecotone areas would be located on the landward side of all restored ponds as described above.

Proposed Timing

For purposes of habitat evolution modeling, we propose the following timing for the preferred alternative:
Pond A12: breached in 2017
Ponds A9-A11: breached in 2022
Ponds A13-A15: breached in 2030

ESA-PWA will be providing updated habitat maps of this scenario.

New Chicago Marsh

New Chicago Marsh (NCM) will not be analyzed as part of the ecosystem benefits for the proposed project. However, the Refuge has spelled out below their long term vision for NCM to assist the team in understanding the rationale behind some of the proposed levee alignments.

For the foreseeable future (next 10 to 20 years), the ecological goal for NCM will be to maintain or improve the quality of the existing managed marsh for the salt marsh harvest mouse (SMHM) and nesting bird species in NCM and A16. This goal is unlikely to change until sufficient replacement habitat for the SMHM and breeding birds has been created in the adjacent areas. However, in the longer term, once there is high-quality marsh habitat in the project area to support SMHM populations and nesting birds, the Refuge could change the management or configuration of NCM. These future changes would need to be defined through an adaptive management process and are not proposed to be part of the Shoreline Study alternatives. Rather this alternative acknowledges that the future management options for NCM greatly depend on the alignment of the flood protection levee build by the Shoreline Study. By constructing a levee alignment “behind” NCM (Alignments 2 and 3) the Shoreline Study would avoid impacts to NCM and allow for future habitat enhancement by allowing the Refuge to:

1. Continue existing management for the SMHM and maintain the connection between the nesting islands in Pond A16 and forage/cover for chicks in NCM; or
2. Connect NCM to the tides and create a deep water pond; or
3. Connect NCM to the tides and manage flows with a water control structure to accumulate sediment and raise existing elevation to marsh plain.

If the levee is constructed on the existing pond berm alignment (Alignment 1), the Refuge's future options will be constrained to the existing management régime with the additional impact of degraded connectivity between Pond A16 and NCM.

Appendix B5

Biological Resources: Species Scientific Names, CNDDB Report, and CRPR Report

Appendix B5. Scientific Names of Plants, Fish, and Wildlife Mentioned in the Integrated Document

Common Name	Latin Name
Plants	
Alkali bulrush	*Schoenoplectus robustus* (former *Scirpus robustus)*
Alkali heath	*Frankenia salina*
Annual pickleweed (slender pickleweed, glasswort)	*Salicornia europaea*
Atlantic cordgrass	*Spartina alterniflora*
Black mustard	*Brassica nigra*
Brass buttons	*Cotula coronopifolia*
Bristly ox-tongue	*Picris echioides*
Broad-leaved cattail	*Typha latifolia*
Bull thistle	*Cirsium vulgare*
California blackberry	*Rubus sp.*
California bulrush	*Schoenoplectus californicus* (former *Scirpus californicus)*
California cordgrass	*Spartina foliosa*
Chilean cordgrass	*Spartina densiflora*
Cocklebur	*Xanthim strumarium*
Common sow thistle	*Sonchus oleraceus*
Congdon's tarplant	*Centromadia parryi ssp. Congdonii*
Cordgrass species	*Spartina spp.*
Coyote brush	*Baccharis pilularis*
Curly dock	*Rumex crispus*
Elderberry	*Sambucus mexicana*
English cordgrass	*Spartina anglica*
Fremont cottonwood	*Populus fremontii*
French broom	*Genista monspessulana*
Giant reed	*Arundo donax*
Hall's bush-mallow	*Malacothamnus halli*
Hardstem bulrush	*Schoenoplectus acutus* (former *Scirpus acutus)*
Hyssop loosestrife	*Lythrum hyssopifolium*
Italian ryegrass	*Lolium multiflorum*
Italian thistle	*Carduus pycnocephalus*
Marsh gumplant	*Grindelia stricta var. angustifolia*
Mediterranean barley	*Hordeum marinum ssp. gussoneanum*
Pampas grass	*Cortaderia sp.*
Perennial pepperweed	*Lepidium latifoium*
Perennial pickleweed	*Sarcocornia pacifica (*former *Salicornia virginica)*
Purple star-thistle	*Centaurea calcitrapa*
Rabbits foot grass	*Polypogon monspeliensis*

Common Name	Latin Name
Ripgut brome	*Bromus diandrus*
Saltmarsh bulrush	*Bolboschoenus maritimus* (former *Scirpus maritimus)*
Saltmeadow cordgrass	*Spartina patens*
Scotch broom	*Cytisus scoparius*
Sweet fennel	*Foeniculum vulgare*
Wild oats	*Avena fatua*
Wild radish	*Raphanus sativus*
Wild rose	*Rosa californica*
Willow	*Salix sp.*
Yellow star-thistle	*Centaurea solstitialis*
********	*Eliocharis *****
Fishes	
American shad	*Alosa sapidissima*
Arrow goby	*Clevelandia ios*
Bay goby	*Lepidogobius lepidus*
Bay pipefish	*Syngnathus leptorhynchus*
Black bullhead	*Ameiurus melas*
Black crappie	*Pomoxis nigromaculatus*
Bluegill	*Lepomis macrochirus*
Brown bullhead	*Ictalurus nebulosus*
California bat ray	*Myliobatis californica*
California central coast DPS steelhead	*Oncorhynchus mykiss irideus*
California halibut	*Paralichthys californicus*
California roach	*Lavinia symmetricus*
California skate	*Raja inornata*
Carp	*Cyprinus carpio*
Chameleon goby	*Tridentiger trigonocephalus*
Channel catfish	*Ictalurus punctatus*
Chinook salmon (Central Valley)	*Oncorhynchus tshawytscha*
Coho salmon	*Oncorhynchus kisutch*
English sole	*Parophrys vetulus*
Fathead minnow	*Pimephales promelas*
Golden shiner	*Notemigonus crysoleucas*
Goldfish	*Carassius auratus*
Green sturgeon	*Acipenser medirostris*
Green sunfish	*Lepomis cyanellus*
Hitch	*Lavinia exilicauda*
Inland silverside	*Menidia beryllina*
Jack mackerel	*Trachurus symmetricus*
Jacksmelt	*Atherinopsis californiensis*

Common Name	Latin Name
Largemouth bass	*Micropterus salmoides*
Leopard shark	*Trikakis semifasciata*
Longfin smelt	*Spirinchus thaleichthys*
Longjaw mudsucker	*Gillichthys mirabilis*
Mississippi silverside	*Menidia audens*
Mosquitofish	*Gambusia affinis*
Northern anchovy	*Engraulis mordax*
Pacific herring	*Clupea pallasii*
Pacific lamprey	*Lampetra tridentata*
Pacific sardine	*Sardinops sagax*
Pacific staghorn sculpin	*Leptocottus armatus*
Plainfin midshipman	*Porichthys notatus*
Prickly sculpin	*Cottus asper*
Rainwater killifish	*Lucania parva*
Red shiner	*Notropis lutrensis*
Redear sunfish	*Lepomis microlophus*
Riffle sculpin	*Cottus gulosus*
Sacramento blackfish	*Orthodon microlepidotus*
Sacramento perch	*Archoplites interruptus*
Sacramento pikeminnow	*Ptychocheilus grandis*
Sacramento sucker	*Catostomus occidentalis occidentalis*
Shimofuri goby	*Tridentiger bifasciatus*
Shiner surfperch	*Cymatogaster aggregata*
Shokahaze goby	*Tridentiger barbatus*
Speckled dace	*Rhinichthys osculus*
Speckled sanddab	*Citharichthys stigmaeus*
Splittail	*Pogonichthys macrolepidotus*
Starry flounder	*Platichthys stellatus*
Striped bass	*Morone saxatilis*
Surf smelt	*Hypomesus pretiosus*
Thicktail chub	*Gila crassicauda*
Threadfin shad	*Dorosma petenense*
Three-spined stickleback	*Gasterosteus aculeatus*
Topsmelt	*Atherinops affinis*
Tule perch	*Hysterocarpus traski*
White crappie	*Pomoxis annularis*
White sturgeon	*Acipenser transmontanus*
Yellow bullhead	*Ameiurus natakis*
Yellowfin goby	*Acanthogobius flavimanus*

Common Name	Latin Name
Invertebrates	
(Amphipod)	*Grandidierella japonica*
(Amphipod)	*Corophium sp.*
(Amphipod)	*Ampelisca abdita*
Asian clam	*Corbula amurensis*
Asian cumacean	*Nippoleucon hinumensis*
Asian mussel	*Musculista sp.*
Atlantic clam	*Gemma sp.*
Atlantic ribbed marsh mussel	*Arcuatula demissa*
Baltic clam	*Macoma petalum*
Blackspotted bay shrimp	*Crangon nigromaculata*
Blacktrail bay shrimp	*Crangon nigricauda*
Brine flies	Family Ephydridae
Brine shrimp	*Artemia* sp.
Brine shrimp	*Artemia franciscana*
California bay shrimp	*Crangdon franciscorum*
Capet shell, littleneck clam	*Venerupis sp.*
Chinese mitten crab	*Eriocheir sinensis*
European green crab	*Carcinus maenas*
Miniature spinyhead	*Mesocrangon munitella*
Mud snail	*Illyanassa obsoleta*
New Zealand burrowing isopod	*Sphaeroma quoyanum*
Opossum shrimp	*Mysida sp.*
Oriental shrimp	*Palaemon macrodactylus*
Reticulate water boatmen	*Trichocorixa reticulate*
Ribbed mussel	*Ischadium demissum*
Ridgetail prawn	*Exopalaemon carinicauda*
Soft-shell clam	*Mya arenaria*
Stout coastal shrimp	*Heptacarpus brevirostris*
Visored shrimp	*Betasus longidactylus*
Yellow shore crab	*Hemigrapsus oregonensis*
Reptiles and Amphibians	
Arboreal salamander	*Aneides lugubris*
Bullfrog	*Rana catesbeiana*
California slender salamander	*Batrachoseps attenuatus*
California tiger salamander	*Ambystoma californiense*
Garter snake	*Thamnophis couchi, T. elegans,* and *T. sirtalis*
Gopher snake	*Pituophis melanoleucus*
Pacific treefrog	*Hyla regilla*
Southern alligator lizard	*Elgaria multicaranata*

Common Name	Latin Name
Western fence lizard	*Sceloporus occidentialis*
Western pond turtle	*Emys marmorata*
Western toad	*Bufo boreas*
Mammals	
Audubon's cottontail	*Sylvilagus audubonii*
Black rat	*Rattus rattus*
Black-tailed jack rabbit	*Lepus californicus*
Botta's (valley) pocket gopher	*Thomomys bottae*
Brush rabbit	*Sylvilagus bachmani*
California ground squirrel	*Spermophilus beecheyi*
California vole	*Microtus californicus*
Common muskrat	*Ondatra zibethicus*
Deer mouse	*Peromyscus maniculatus*
Feral cat	*Felis catus*
Hoary bat	*Lasiurus cinereus*
House mouse	*Mus musculus*
Long-tailed weasel	*Mustela frenata*
Mexican free-tailed bat	*Tadarida brasiliensis*
Norway rat	*Rattus norvegicus*
Pacific harbor seal	*Phoca vitulina richardsi*
Raccoon	*Procyon lotor*
Red fox	*Vulpes vulpes regalis*
Salt marsh harvest mouse	*Reithrodontomys raviventris raviventris*
Salt marsh wandering shrew	*Sorex vagrans halicoetes*
Shrew	*Sorex sp.*
Striped skunk	*Mephitis mephitis*
Virginia opossum	*Didelphis virginiana*
Western harvest mouse	*Reithrodontomys megalotis*
Western red bat	*Lasirurs blossevillii*
Yuma myotis	*Myotis yumanensis*
Birds	
Alameda song sparrow	*Melospiza melodia pusillula*
American avocet	*Recurvirostra americana*
American coot	*Fulica americana*
American crow	*Corvus brachyrhynchos*
American goldfinch	*Carduelis tristis*
American kestrel	*Falco sparverius*
American pipit	*Anthus rubescens*
American white pelican	*Pelecanus erythrorhynchos*
American wigeon	*Anas americana*

Common Name	Latin Name
Anna's hummingbird	*Calypte anna*
Barn swallow	*Hirundo rustica*
Belted kingfisher	*Ceryle alcyon*
Black phoebe	*Sayornis nigricans*
Black skimmer	*Rynchops niger*
Black-bellied plover	*Pluvialis squatarola*
Black-chinned hummingbird	*Archilochus alexandri*
Black-crowned night-heron	*Nycticorax nycticorax*
Black-necked stilt	*Himantopus mexicanus*
Bonaparte's gull	*Chroicocephalus philadelphia*
Brown pelican	*Pelecanus occidentalis*
Bufflehead	*Bucephala albeola*
Burrowing owl (western burrowing owl)	*Athene cunicularia*
Bushtit	*Psaltriparus minimus*
California black rail	*Laterallus jamaicensis coturniculus*
California clapper rail	*Rallus longirostris obsoletus*
California gull	*Larus californicus*
California least tern	*Sterna antillarum browni*
California yellow warbler	*Dendroica petechia brewsteri*
Canada goose	*Branta canadensis*
Canvasback	*Aythya valisineria*
Caspian tern	*Hydroprogne caspia*
Chestnut-backed chickadee	*Poecile rufescens*
Cinnamon teal	*Anas cyanoptera*
Clark's grebe	*Aechmophorus clarkii*
Cliff swallow	*Petrochelidon pyrrhonota*
Common goldeneye	*Bucephala clangula*
Common loon	*Gavia immer*
Common moorhen	*Gallinula chloropus*
Common raven	*Corvus corax*
Common tern	*Sterna hirundo*
Cooper's hawk	*Accipiter cooperii*
Double-crested cormorant	*Phalacrocorax auritus*
Downy woodpecker	*Picoides pubescens*
Dunlin	*Calidris alpina*
Eared grebe	*Podiceps nigricollis*
Elegant tern	*Sterna elegans*
European starling	*Sturnus vulgaris*
Forster's tern	*Sterna forsteri*
Fox sparrow	*Passerella iliaca*

Common Name	Latin Name
Gadwall	*Anas strepera*
Glaucous-winged gull	*Larus glaucescens*
Golden-crowned sparrow	*Zonotrichia atricapilla*
Great blue heron	*Ardea herodias*
Great egret	*Ardea alba*
Greater scaup	*Aythya marila*
Greater yellowlegs	*Tringa melanoleuca*
Green heron	*Butorides virescens*
Herring gull	*Larus argentatus*
Horned lark	*Eremophila alpestris actia*
House finch	*Haemorhous mexicanus*
House sparrow	*Passer domesticus*
Killdeer	*Charadrius vociferus*
Least sandpiper	*Calidris minutilla*
Lesser goldfinch	*Carduelis psaltria*
Lesser scaup	*Aythya affinis*
Lincoln's sparrow	*Melospiza lincolnii*
Little blue heron	*Egretta caerulea*
Loggerhead shrike	*Lanius ludovicianus*
Long-billed curlew	*Numenius americanus*
Long-billed dowitcher	*Limnodromus scolopaceus*
Mallard	*Anas platyrhynchos*
Marbled godwit	*Limosa fedoa*
Marsh wren	*Cistothorus palustris*
Merlin	*Falco columbarius*
Mew gull	*Larus canus*
Mourning dove	*Zenaida macroura*
Northern harrier	*Circus cyaneus*
Northern pintail	*Anas acuta*
Northern shoveler	*Anas clypeata*
Orange-crowned warbler	*Oreothlypis celata*
Pacific-slope flycatcher	*Empidonax difficilis*
Peregrine falcon (American peregrone falcon)	*Falco peregrinus*
Pied-billed grebe	*Podilymbus podiceps*
Red knot	*Calidris canutus*
Red-breasted merganser	*Mergus serrator*
Red-shouldered hawk	*Buteo lineatus*
Red-tailed hawk	*Buteo jamaicensis*
Ring-billed gull	*Larus delawarensis*
Rock pigeon	*Columba livia*

Common Name	Latin Name
Ruddy duck	*Oxyura jamaicensis*
Saltmarsh common yellowthroat	*Geothlypis trichas sinuosa*
Savannah sparrow	*Passerculus sandwichensis*
Semipalmated plover	*Charadrius semipalmatus*
Short-billed dowitcher	*Limnodromus griseus*
Short-eared owl	*Asio flammeus*
Snowy egret	*Egretta thula*
Song sparrow	*Melospiza melodia*
Sora	*Porzana carolina*
Surf scoter	*Melanitta perspicillata*
Swainson’s thrush	*Catharus ustulatus*
Thayer’s gull	*Larus thayeri*
Tricolored blackbird	*Agelaius tricolor*
Virginia rail	*Rallus limicola*
Warbling vireo	*Vireo gilvus*
Western grebe	*Aechmophorus occidentalis*
Western gull	*Larus occidentalis*
Western meadowlark	*Sturnella neglecta*
Western sandpiper	*Calidris mauri*
Western snowy plover	*Charadrius alexandrinus nivosus*
Whimbrel	*Numenius phaeopus*
White-crowned sparrow	*Zonotrichia leucophrys*
White-faced ibis	*Plegadis chihi*
White-tailed kite	*Elanus leucurus*
Willet	*Tringa semipalmata*
Wilson’s warbler	*Wilsonia pusilla*

Appendix B6

South San Francisco Bay Shoreline Study
Existing Biological Conditions Report

H. T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

SOUTH SAN FRANCISCO BAY SHORELINE STUDY
EXISTING BIOLOGICAL CONDITIONS REPORT

DRAFT

Prepared for:

U.S. ARMY CORPS OF ENGINEERS
CALIFORNIA STATE COASTAL CONSERVANCY

Prepared by:

H. T. HARVEY & ASSOCIATES

05 November 2007 Project No. 2606-01

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ACRONYMS AND ABBREVIATIONS

CDFG	California Department of Fish and Game
CIR	Color infrared
ESU	Evolutionary Significant Unit
GIS	Geographic Information Systems
ISP	Interim Stewardship Plan
PG&E	Pacific Gas & Electric
PRBO	PRBO Conservation Science
SBSP	South Bay Salt Ponds
SCVWD	Santa Clara Valley Water District
MHW	Mean High Water
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
SFBBO	San Francisco Bay Bird Observatory
SFBNWR	Don Edwards San Francisco Bay National Wildlife Refuge
USACOE	U.S. Army Corp of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WPCP	Water Pollution Control Plant

1. EXECUTIVE SUMMARY

The San Francisco Estuary is an extremely productive, diverse ecosystem. Despite the loss of more than 90% of historic tidal wetlands in the Bay Area to diking, draining, and filling (Goals Project 1999), wildlife diversity is high, with more than 250 species of birds, 120 species of fish, 81 species of mammals, 30 species of reptiles, and 14 species of amphibians regularly occurring in the estuary (Siegel and Bachand 2002). More importantly, the San Francisco Bay supports populations of a number of species of regional, hemispheric, or even global importance. Numerous endemic, endangered, threatened, and rare wildlife species or subspecies reside in the San Francisco Bay Area.

The South San Francisco Bay (South Bay) is a vital component of the larger estuary. The South Bay supports some of the most important habitat remaining in the entire Bay Area for a number of wildlife species, in spite of the surrounding areas being highly urbanized and the Bay itself having been dramatically altered by the diking and filling of wetlands for salt production and urban development (Goals Project 1999).

This report characterizes the existing biological conditions related to the Shoreline Study which focuses on ecosystem restoration and flood damage reduction for the entire Study Area. The principal biological components of concern are the vegetation and habitats, and the wildlife. This report outlines the current state of understanding of these resources in the South Bay. The description of existing biological conditions is an important step in the early stages of planning as this description provides a foundation from which to evaluate and contrast a wide range of flood control and restoration alternatives, will serve to help inform the selection of the preferred alternative, and will provide baseline data for monitoring and adaptive management.

Habitats and Vegetation. The Shoreline Study Area (approximately 44,624 total acres) encompasses a variety of habitat types due to its land use history, its hydrologic placement within the landscape, and the extreme range of abiotic soil variables present within the area. Habitats vary from urbanized areas lined with concrete culverts to riparian fluvial drainages to freshwater, brackish, and salt marsh habitat. The dominant habitats that occur in the Study Area include approximately:

- 14,480 acres of developed area;
- 7498 acres of intertidal mudflat habitat (at –0.9 ft Mean Lower Low Water);
- 7135 acres of former and current salt production ponds;
- 3679 acres of wetland and riparian areas; and
- 2664 acres of open water/bay habitat.

Numerous occurrences of six special-status plant species, including Point Reyes bird’s-beak, Hoover’s button-celery, Congdon’s tarplant, alkali milk-vetch, Contra Costa goldfields, and San Joaquin spearscale, have been documented in the immediate vicinity of the Study Area; the latter five species are known from the Study Area primarily from the Warm Springs Unit of the Don Edwards San Francisco Bay National Wildlife Refuge (SFBNWR) and the adjacent Pacific Commons Preserve in Fremont. Historical (likely extirpated) populations of alkali milk-vetch and Point Reyes bird's-beak are documented in the vicinity of Alviso.

Wildlife Resources. This report includes discussions of the species composition and structure of invertebrate, fish, reptile, amphibian, mammal, bird, and plant communities in the South Bay. These species' life histories (as they pertain to their use of the South Bay), habitat requirements and habitat use in the South Bay, and the spatial and temporal variation in these species' presence/distribution in the region are summarized, as are the occurrence and use of the South Bay by special-status plant and wildlife species.

In summary, the ecology of South Bay wildlife communities is characterized by:

- High productivity of tidal marshes, with export of organic matter from tidal marshes to tidal sloughs, channels, and mudflats, and to the Bay, supporting high abundance of invertebrates, fish, and birds.
- High productivity of salt ponds and former salt ponds, supporting an abundance of invertebrates (particularly in higher-salinity ponds) and high numbers of fish in lower-salinity ponds, but with virtually no export of organic matter to other habitats aside from variable (and at times, very heavy) use of the salt ponds by birds.
- A heavily invaded aquatic invertebrate community dominated by non-native species, particularly in the estuarine and salt pond habitats.
- Heavy use of South Bay habitats by waterbirds, including significant proportions of Pacific Coast migratory shorebird populations.
- Highly dynamic bird and fish communities, with use of different areas varying several times a day with tide height, and with abundance and community composition varying seasonally depending on migration, precipitation, temperature, salinity, and other factors. In particular, large numbers of shorebirds forage on intertidal mudflats at low tide and use salt ponds and other alternative habitats (e.g., water treatment plant ponds) for roosting and/or foraging, particularly at high tide, and steelhead use bay habitats during their migrations as adults to spawn in tributaries and as juveniles moving from tributaries to the sea .
- The presence of rare San Francisco Bay endemics, including the California clapper rail and salt marsh harvest mouse, in remnant tidal marsh habitat.
- The presence of rare vernal pool-associated species, including the vernal pool tadpole shrimp and California tiger salamander, in vernal pools within the Warm Springs unit of the SFBNWR.
- The presence of several freshwater streams flowing into the South Bay; woody riparian habitat is limited to narrow corridors, or is highly degraded or even absent, along these streams, although moderately high-quality riparian habitat is present along lower Coyote Creek, and riparian habitats in the Study Area support very high densities of birds.

2. INTRODUCTION

This document describes the existing biological conditions of the South San Francisco Bay Shoreline (Shoreline Study) Study Area. The purposes of the Shoreline Study are to investigate the feasibility of a federally cost-shared project to meet the objectives of flood damage reduction, ecosystem restoration, and related purposes such as public access, and, if a potential project can be justified through existing Corps policy, to recommend such a project for Congressional authorization. An understanding of the existing natural landscape is necessary to accomplish these goals.

Other existing documents that are relevant to this report include the South Bay Salt Ponds (SBSP) Initial Stewardship Plan (ISP) (Life Science 2003), SBSP Biology and Habitats Existing Conditions Report (H. T. Harvey & Associates 2005), and the SBSP Draft Programmatic Environmental Impact Statement/Environmental Impact Report (PWA 2007).

To help guide the ecosystem restoration and flood protection aspects of the planning effort, the Shoreline Study will incorporate findings from the SBSP Restoration Project, a California Coastal Conservancy-led effort to restore historical wetlands on 15,100 acres of former salt-harvesting ponds in the South Bay. The U.S. Army Corps of Engineers (USACOE) and the Santa Clara Valley Water District (SCVWD) are active project management team members of the SBSP Restoration Project. Extensive coordination has occurred, and will continue to occur, between the Shoreline Study and SBSP projects.

This existing conditions report documents the current conditions within the Shoreline Study Area, including portions of this area that have not already been investigated for the SBSP Restoration Project. Therefore, in preparing this report, existing conditions information for the relevant portions of the SBSP project area were augmented by compiling information for the baylands area outside of the SBSP project area, but within the Alviso Ponds and Santa Clara County Interim Feasibility Study area, at the same level of detail as for the SBSP Restoration Project.

The existing biological conditions described in this document include habitat type, plant species composition, and potential wildlife use within the Shoreline Study Area at the onset of planning. This report contains the following sections:

Section 3. Habitats and Vegetation. Here, the existing conditions for habitats and vegetation in the Shoreline Study Area are presented, including an overall habitat assessment, the presence of non-native plant species, and the occurrence and potential for reintroduction of special-status plant species along with associated maps.

Section 4. Wildlife Resources. In this section, the existing conditions for wildlife in the Shoreline Study Area are documented. Included here are discussions of the composition and structure of invertebrate, fish, reptile, amphibian, mammal, and bird communities in the Study Area. Details of these species' life histories (as they pertain to their use of the South Bay), habitat requirements and use, and the spatial and temporal variation in these species' distributions in the region are also included. Further, the occurrence and use of the Shoreline Study Area by special-status wildlife species is summarized.

2.1 Regional Setting

The San Francisco Estuary is an extremely productive, diverse ecosystem. Despite the loss of more than 90% of historic tidal wetlands in the Bay Area to diking, draining, and filling (Goals Project 1999), wildlife diversity is high, with more than 250 species of birds, 120 species of fish, 81 species of mammals, 30 species of reptiles, and 14 species of amphibians regularly occurring in the estuary (Siegel and Bachand 2002). More importantly, the San Francisco Bay supports populations of a number of species of regional, hemispheric, or even global importance. Numerous endemic, endangered, threatened, and rare wildlife species or subspecies reside in the San Francisco Bay Area.

The South San Francisco Bay (South Bay) is a vital component of the larger estuary. The South Bay supports some of the most important habitat remaining in the entire Bay Area for a number of wildlife species, in spite of the surrounding areas being highly urbanized and the Bay itself having been dramatically altered by the diking and filling of wetlands for salt production and urban development (Goals Project 1999).

The term "South Bay" is typically used to refer to the portion of the San Francisco Bay south of Coyote Point on the western shore of the Bay and San Leandro Marina on the eastern shore of the Bay (Goals Project 1999). This region differs in several physical and ecological aspects from the Central Bay, North Bay, San Pablo and Suisun Bays, and the Delta portions of the San Francisco Estuary. The Shoreline Study Area, for this existing conditions document, includes the open waters of the Bay up to the upper reaches of tidal action, the tidal and nontidal wetlands adjacent to the Bay, the former salt evaporation ponds adjacent to the Bay, the upland areas adjacent to and surrounding these features, developed areas, and the fluvial riparian inputs into the South Bay (Figure 1). This Study Area is bordered by the open waters of the South Bay to the northwest and by urban development on all other sides. While this Study Area is likely larger than what would be included in an actual Shoreline Study project, this landscape-level description of potentially impacted areas will be integral to the consideration of feasible restoration options and the concomitant benefits and impacts of those options.

2.2 Study Area

Broadly, the Study Area includes the Palo Alto/Mountain View area (south of San Francisquito Creek); Moffet Field, and the Alviso Ponds (and the areas inland to them) owned by the USFWS, SCVWD (Pond A4), and the City of San Jose (Pond A18) (Figure 1). It includes all of the Shoreline Study geographic area in Santa Clara County, as well as a small area in Alameda County that is part of the Coyote Creek/Mud Slough drainage from Santa Clara County. For aquatic Bay habitats, the Dumbarton Bridge is used as the northern boundary of the Study Area.

The Shoreline Study will focus on ecosystem restoration and flood damage reduction for the entire Study Area, though ecosystem restoration will most likely occur within the Alviso Ponds. The drainages in this

Study Area all flow through Santa Clara County and include: Coyote Creek/Mud Slough, Artesian Slough, Guadalupe River/Alviso Slough, Guadalupe Slough/Moffett Channel/Sunnyvale East and West Channels, Stevens Creek, Permanente Creek/Mountain View Slough, Charleston Slough/Barron Creek/Adobe Creek, and Matadero Creek/Mayfield Slough. The Study Are also includes the lower reaches of Laguna Creek and its watershed in Alameda County. The Alviso ponds occur at the base of several watersheds formed by the following drainages: Coyote watershed, Guadalupe watershed, San Tomas/Calabazas watersheds, Sunnyvale East/West watersheds, Permanente/Stevens watersheds, Adobe/Matedero watersheds and the San Francisquito watershed**.** Flood protection for San Francisquito Creek is being studied under separate authorization. San Francisquito Creek serves as the northern edge of the Study area, dividing the Santa Clara County and Alviso Ponds from San Mateo County and the Ravenswood Ponds.

3. HABITATS AND VEGETATION

3.1 Introduction

The Shoreline Study, which serves to identify and recommend for Federal funding one or more projects for flood damage reduction, ecosystem restoration and public access, serves as a complementary effort to the SBSP Restoration Project, a programmatic plan for habitat restoration, flood management and wildlife-oriented public access within former salt ponds of the South Bay. The physical boundaries of these two efforts overlap at the Alviso ponds and the open water/mudflats extending north to the Dumbarton Bridge, with the Shoreline Study Area reaching beyond the Alviso ponds into adjacent uplands. To describe existing conditions for habitats and vegetation in the Shoreline Study Area, an analysis of surrounding habitat types (Figure 1) was performed utilizing aerial mapping and site visits. This included a general habitat assessment, along with considerations for the potential occurrence and/or reintroduction of special-status plant species. The assessment of historical habitats in the Shoreline Study Area was also used to provide a baseline for the existing conditions of the ecological communities.

3.2 Methods

3.2.1 Base Imagery

All habitat mapping was rendered on IKONOS satellite imagery. The City of San Jose acquired the IKONOS imagery from a satellite pass that occurred at noon on 8 May 2004. The tidal elevation at this time was –0.9 feet Mean Lower Low Water (MLLW) near the mouth of Coyote Creek in the Alviso complex. The City of San Jose purchased the satellite images and subsequently donated them for use in the SBSP restoration planning. The 1-meter Multispectral (four-bands) CIR & True Color IKONOS satellite imagery is projected in UTM NAD83 (meters) Zone 10 North. Habitat mapping was based upon the imagery obtained and completed at a 1:2400 (1 inch = 200 feet) scale using the IKONOS imagery as a base layer.

3.2.2 Habitat Mapping and Area Calculations

Habitat mapping was completed using laptop computers (Panasonic Toughbook 18) equipped with GIS software (ArcView 9). The computers and software allow the IKONOS imagery to be used for mapping in the field or office.

Initial habitat boundaries and classifications using the IKONOS imagery were identified based on the signatures of the photographic imagery. Topographic features, marsh boundaries, and tentative habitat types (based on photographic signatures) were mapped in the office prior to field visits.

During the site visits in January 2007, extensive ground-truthing of those areas in the Shoreline Study Area that were not included in the original SBSP mapping was conducted. Marshes and riparian corridors were observed primarily from levee trails, unimproved salt pond levees, and Pacific Gas and Electric

(PG&E) walkways. The GIS database was downloaded and backed up weekly, and the digitized boundaries of habitat areas were reviewed for consistency and quality. Habitat acreages and color-coded figures for the entire Study Area were generated in GIS (ArcView 9.0).

3.3 Habitats and Vegetation

The Shoreline Study Area encompasses a variety of habitat types due to its land use history, its hydrologic placement within the landscape, and the extreme range of abiotic soil variables present within the area. Habitats vary from urbanized areas lined with concrete culverts to riparian fluvial drainages to freshwater, brackish, and salt marsh habitat. The Shoreline Study serves to analyze the unique demands placed upon this area of the Bay to balance urban demands for flood protection with restoration efforts and the needs of special-status plant and animal species.

3.3.1 Historical Habitats

The assessment of habitats that historically occurred along the South Bay provides a context in which to examine the existing conditions of South San Francisco Bay. Historical ecological communities of the South Bay are described in detail in the South Bay Salt Ponds Biology and Habitats Existing Conditions Report (H. T. Harvey & Associates 2005), Collins and Grossinger (2004), and Grossinger et al. (2006). Historically, the margins of San Francisco Bay were surrounded by a mosaic of wetland habitats, dominated by tidal salt marsh with large expanses of upland ecotones, intramarsh ponds, salt pannes, sinuous channel networks, beaches, lagoons, and sausals (Collins and Grossinger 2004).

Collins and Grossinger (2004) describe three major historical South Bay landscapes: saline tidal marsh, riparian tidal marsh, and salt pond. The South Bay saline tidal marsh landscape once consisted of marshlands with high channel density, abundant marsh pannes and salinas, moist grasslands along the backshore, large sausals, and extensive tidal flats. The South Bay riparian tidal marsh landscape existed along a salinity gradient from fresh to saline or brackish waters, influenced by perennial creeks such as Coyote Creek and the Guadalupe River. These areas had large marsh pannes and a less dense channel network in the vicinity of major freshwater sources. The South Bay salt pond landscape comprised tidal marshlands dominated by salt ponds. Native Americans developed these early ponds from salinas and marsh pannes by using low berms and weirs to control their hydroperiod. Tidal marsh and salt ponds were roughly equal in area, with minimal tidal channel network development. Small salinas and marsh pannes were adjacent to the salt ponds, with moist grasslands occurring along the backshore. Saltgrass-alkali meadow habitat existed in the complex transition zone between the tidal marsh and the wet meadows of the bottomlands of the South Bay. Unusually high concentrations of salt in alluvial soils created favorable conditions for unique plant communities with characteristics of high tidal marsh, alkali flats, and vernal pools (Grossinger et al. 2006).

Most of these historical communities have been greatly reduced in size due to land use changes in the South Bay, including residential development, agricultural use, salt production, and flood protection. More recently, South Bay marshes were significantly modified via diking to retain and concentrate Bay water for salt production. Beginning in the mid- to late 1800's through the 1940's, levee construction led to the direct loss of tens of thousands of acres of tidal marsh in the South Bay (Collins and Grossinger 2004). Apart from these direct impacts, this construction led to dramatic changes in the physical processes influencing marsh development. By diking off these large expanses of marsh habitat, the tidal prism (volume of water that moves in and out of an area during a tidal cycle) was drastically reduced. The results of this decrease in tidal prism are still being observed in the South Bay, particularly in the Alviso pond complex (H. T. Harvey & Associates 2006).

3.3.2 Current Habitat Mapping Results

To generally assess existing conditions, broad-scale mapping for the Shoreline Study area included the Alviso pond complex, Moffett Field and the Palo Alto/Mountain View area south of San Francisquito Creek in Santa Clara County. In addition, a small area in Alameda County that is part of the Coyote Creek/Mud Slough drainage from Santa Clara County was also included in the Shoreline Study area. All habitats within the Shoreline Study Area were mapped at the scale shown in Figure 1.

During the mapping of the Shoreline Study Area, 25 different habitat categories were utilized. These habitat types included open water, mudflat, salt marsh, brackish marsh, freshwater marsh, riparian/creek corridor, muted tidal/diked marsh, active salt ponds, restored tidal salt ponds (under ISP Management) [1], seasonal ponds (under ISP Management), high salinity ponds (under ISP Management), system ponds (under ISP Management), seasonal ponds/high salinity ponds (under ISP Management), related projects (ponds), vernal pools, peripheral halophytes, landfill, water/sewage treatment, golf course, upland vegetation, parks/upland grassland, levee, airport, unvegetated, and developed (Figure 1). Each of these habitats is briefly described below, with survey results, and the locations of each habitat type are shown in Figure 1. It is important to note that small inclusions of differing habitat types may occur within a mapped section; however, these inclusions do not change the overall value or use of the habitat as described. For example, golf courses and/or airports probably contain areas of annual grassland or other such habitat types. Summary tables including all habitat types follow at the end of this section (Tables 1 and 2).

Open Water. Approximately 2664 acres of open water are found in the Study Area (Figure 1). The open waters of South San Francisco Bay, to the north of the Study Area, extend from a maximum depth of 25+ feet in the channel between the San Mateo and Dumbarton Bridges up to the MLLW elevation. However, water depth across the majority of the South Bay, particularly in the area southeast of the Dumbarton Bridge in the Study Area, is six to12 feet deep or less. Open water exists along Mountain View Slough, Charleston Slough, Stevens Creek, Alviso Slough, Artesian Slough, Guadalupe Slough, and in Coyote Creek and extends into their corresponding drainages. The open water category includes a variety of habitat types, including subtidal Bay waters, tidal sloughs and channels, and areas of standing or flowing

[1] The Initial Stewardship Plan (ISP)(Life Sciences 2003) describes the operation and maintenance of the ponds prior to the long-term restoration plan and, as such the ISP represents the existing condition. Since the ISP implementation began in July 2004 and will continue to be implemented through 2007, assumptions have been made regarding biological functions and values that will be present once the ISP is fully operational, but prior to the implementation of the SBSP Restoration plan. The ISP will continue beyond 2007 for many ponds, until tidal restoration or managed pond condition is "implemented" in phases of the SBSP Restoration Project.

waters within all of the salt ponds as well as within tidal marshes. Despite lacking terrestrial or emergent vegetation, deep bays and channels support large aquatic invertebrates, fishes, waterbirds, and marine mammals and, in a few areas within the upper reaches of shallow bays, eelgrass (*Zostera pacifica*), an important submerged plant species.

Open water habitat that was mapped in detail occurs within the low-flow channel of adjacent creeks and slough channels that drain to the Bay, within the borrow ditches and former tidal meanders found within the salt ponds throughout the Study Area, and within the interior marsh ponds. The tidal sloughs and channels that carry water between and through salt ponds and marsh remnants provide important habitat for large numbers of benthic and pelagic invertebrates and fish. These detritus-rich channels serve as important nurseries and feeding areas for estuarine resident fish as well as migratory species such as the migratory life stages (adult, juveniles) of Central California Coast steelhead (*Oncorhynchus mykiss*), Chinook salmon (*Oncorhynchus tshawytscha*), and green sturgeon (*Acipenser medirostris*). Shorebirds, waterfowl, and other waterbirds utilize the channels and marsh ponds while the open waters of the Bay support a high diversity of benthic and pelagic macroinvertebrates. Piscivorous (fish-eating) birds such as the Forster's tern (*Sterna forsteri*), California least tern (*Sterna antillarum browni*), and double-crested cormorant (*Phalacrocorax auritus*) fly over open water in search of fish, while diving ducks such as greater scaup (*Aythya marila*), lesser scaup (*Aythya affinis*), canvasbacks (*Aythya valisineria*), and surf scoters (*Melanitta perspicillata*) dive in shallower water for bivalves, crustaceans, and other invertebrates. Only birds that can forage from the air (e.g., terns) or that are able to swim can exploit subtidal areas of the Bay, resulting in low bird diversity in the open waters. However, large densities of diving ducks occur in some areas where appropriate depths and concentrations of benthic invertebrates, particularly bivalves, provide a rich food source. Some wildlife species, such as gulls, also roost on the Bay, especially at night.

Mudflats. Approximately 7498 acres of intertidal mudflat habitat (based on the satellite imagery obtained during a –0.9 feet MLLW tide condition) are found in the Study Area (Figure 1). Mudflat habitat occurs in intertidal areas from below MLLW to Mean Tide Level (MTL) just beyond the edge of wetlands along the Bay and between the low-flow channel and edge of wetlands within the tidal reaches of slough and creek channels that drain to the Bay. Intertidal mudflats are expanses of unvegetated mud lying between MLLW and the lower marsh zone. These flats are generally covered by shallow water during high tide, but are uncovered at low tide. Narrow mudflats occur along the edges of the tidal sloughs and channels and on the outboard side of some salt pond levees, while much more extensive flats are present at the mouths of the major sloughs and along the edge of the Bay. Mudflats are dynamic depositional features, changing in extent and location depending on the nature of erosion and deposition of sediments.

Large expanses of newly formed mudflat habitat exist downstream of the Island Ponds (A19, A20, and A21), including a large, newly formed mudflat island at the mouth of Alviso Slough adjacent to Pond A9. Mudflat habitat also occurs at the mouth of Guadalupe Slough and along Charleston Slough and accreting mudflat occurs adjacent to Calaveras Point, the mouth of Mountain View Slough, and the mouth of Stevens Creek adjacent to Ponds A1 and A2W. Small areas of mudflat surrounded by open water are adjacent to Pond A12. Additional small areas of mudflat are surrounded by freshwater marsh at the upper end of the reach of Coyote Slough to the south of the Island Ponds.

Mudflats are located on the bayside of ponds and provide important habitat for resident and migratory bird populations in the South Bay as well as foraging habitat for Bay fishes and invertebrates. Shorebirds, gulls, terns, American white pelicans (*Pelecanus erythrorhynchos*), and ducks often use exposed mudflats as roosting or loafing areas when they are available, as will Pacific harbor seals (*Phoca vitulina richardsi*).

This habitat typically supports less than 10% cover of vascular emergent vegetation, typically in the form of cordgrass (*Spartina* spp.) and annual pickleweed (*Salicornia europaea*) that is too sparse to map as distinct salt marsh habitat. The mudflat substrate comprises primarily fine-grained silts and clays that support an extensive community of diatoms, worms, shellfish, and algal flora. Inundated mudflats provide foraging habitat for many species of fish, and, during low tides, these mudflats additionally provide a primary food source for shorebirds.

High productivity of benthic invertebrates on mudflats is a result of nutrient availability resulting from detritus from tidal marshes, phytoplankton that settle in the water column, algae, and diatoms growing on the intertidal mudflats (Life Science 2003; Warwick and Price 1975). Crustaceans, polychaete worms, mollusks, and other invertebrates live on or just below the surface of the mud. During daily high tides, fish school over mudflats to feed on these invertebrates. As the tide recedes and the flats emerge, the fish retreat to subtidal areas while large numbers of birds, primarily shorebirds, leave their high-tide roosts to feed on the flats. These mudflats are primarily what make the San Francisco Bay Area important to West Coast shorebird populations; an average of 67% of all the shorebirds on the West Coast of the U.S. use San Francisco Bay wetlands (Page et al. 1999). Gulls and some dabbling ducks forage on the exposed mudflats as well. Because benthic invertebrates often recede deeper into the mud as the tidal elevation drops, especially large concentrations of foraging birds usually occur at the edge of the receding or rising tideline. Although the largest numbers of shorebirds forage on the broad flats along the edge of the Bay at low tide, some shorebirds, gulls, and large waders (e.g., herons and egrets) feed on the exposed flats along sloughs and channels. The smaller channels in the brackish and salt marshes are the favored foraging areas for the state and federally endangered California clapper rail (*Rallus longirostris obsoletus*).

Tidal Wetlands. For purposes of this study, tidal wetlands were divided into salt marsh, brackish marsh, and freshwater marsh. Although not fully tidal, muted tidal and diked marsh habitat is also discussed in this section. These habitats collectively account for the greatest acreage of vegetated habitat adjacent to the ponds, occupying 3419 acres of the surrounding habitat (Figure 1). Each of these distinct types of tidal wetland habitat is described in further detail, below. The tidal wetlands are mainly located in narrow strips between the mudflats and the Cargill and salt pond levees.

Salt Marsh. Approximately 725 acres of tidal salt marsh occurs on the outboard levees of the Study Area. Areas of tidal salt marsh in the South Bay are characterized by interstitial soil salinities greater than approximately 27 ppt, on average (H. T. Harvey & Associates 2002b). Salt marsh habitat occurs primarily along the outboard (tidal) side of existing levees separating the salt ponds from the Bay. Salt marshes typically consist of three zones in the Bay: low marsh dominated by cordgrass, middle marsh dominated by pickleweed, and high marsh with a mixture of pickleweed and other moderately halophytic species that can tolerate occasional high tides.

The salt marsh habitat in the South Bay consists primarily of low and middle marsh and is dominated by pickleweed (*Sarcocornia pacifica*, formerly known as *Salicornia virginica*) and cordgrass. Pickleweed and cordgrass salt marsh habitats are separated by elevation; cordgrass typically occurs below the MHW mark and pickleweed occurs above the MHW, often extending up levee banks. Differences in pickleweed and cordgrass salt marsh habitat types also affect wildlife use and sedimentation in the slough and channels draining into the Bay.

There are two species of dominant cordgrass in the South Bay, the native Pacific cordgrass (*Spartina foliosa*) and smooth cordgrass (*S. alterniflora*), a non-native species from the east coast of North America. Smooth cordgrass can easily hybridize with the native cordgrass, causing widespread distribution of the hybridized species within a short amount of time. Smooth cordgrass and its hybrids are the predominant invasive plant species found in the tidal marshes south of the San Francisco Bay Bridge. In the Palo Alto Baylands, a survey conducted by the Coastal Conservancy's San Francisco Estuary Invasive Spartina Project from 2003 to 2006 showed an increase in the size of infestation from 0.61 acres spread over 49 patches in 2005, to 0.94 acres spread over 46 patches in 2006, a 54% increase (Porcella 2007). Total infestation of invasive cordgrass, based on both the SCVWD and Invasive Spartina Project's 2006 survey efforts, is estimated to be 18.9 acres spread amongst 286 patches. This is a 117% increase in acreage from 2005 to 2006 (Porcella 2007). Research has found that these infestations not only affect the foodweb, but that the smooth cordgrass and its hybrids grow lower into channels than the native cordgrass, which can reduce the extent of mudflat edge and possibly result in the loss of channels to vegetation encroachment and subsequent sedimentation (PWA and H.T. Harvey & Associates 2006). Current research and management programs on smooth cordgrass and its hybrids can provide guidance for salt pond restoration work (California State Coastal Conservancy and U.S. Fish and Wildlife Service 2003).

Other halophytic plant species commonly found in salt marsh habitat located within the South Bay include alkali heath (*Frankenia salina*), saltgrass (*Distichlis spicata*), saltmarsh dodder (*Cuscuta salina*), fleshy jaumea (*Jaumea carnosa*), spearscale (*Atriplex triangularis*), sea lavender (*Limonium californicum*), marsh gumplant (*Grindelia stricta* var. *angustifolia*), and the invasive perennial pepperweed (*Lepidium latifolium*). These species typically occur above the MHW mark in the high marsh zone, up to the ecotone between salt marsh and upland habitats. While these species usually occur in areas dominated by pickleweed, species such as marsh gumplant and perennial pepperweed sometimes occur in dense patches with less than 50% aerial coverage of pickleweed--areas assigned the *other salt marsh* classification. Areas with greater than 50% coverage of pickleweed, among any combination of other prevalent species, were classified as pickleweed salt marsh habitat.

Brackish Marsh. Approximately 955 acres of brackish marsh occur throughout the Study Area (Figure 1). This habitat covers the marsh plain in the transition from salt to brackish marsh along Coyote Creek, and also dominates the outboard levees near the junction of Mud Slough and Coyote Creek. Brackish marsh replaces salt marsh moving upstream along Guadalupe Slough, Alviso Slough, Mountain View Slough, and Stevens Creek.

Brackish marsh habitat typically occurs in the low-to-mid intertidal reaches of sloughs and creeks draining into the Bay where vegetation is subject to tidal inundation diluted by freshwater flows from upstream. As such, the average interstitial soil salinity of tidal brackish marsh is lower than in salt marshes, ranging from 15 to 20 ppt in the South Bay (H. T. Harvey & Associates 2002b). The water-surface elevation within reaches of brackish marsh in the Study Area (primarily located in the upper reaches of the Study Area) can vary by as much as ten feet, depending on daily tidal activity, seasonal freshwater flows from upstream, and their location within this estuary system.

The vegetation in brackish marsh habitat is dominated by emergent, vascular plant species adapted to intermediate (brackish) interstitial soil salinities including short bulrushes such as alkali bulrush (*Schoenoplectus robustus*, formerly known as *Scirpus robustus*) and saltmarsh bulrush (*Bolboschoenus maritimus,* formerly known as *Scirpus maritimus*). These species dominate lower brackish marsh habitat where sediment deposits have formed terraced floodplains between the low-flow channels and levees. The middle reaches of these channels are also dominated by shorter bulrushes, but in addition may have dense stands of tall bulrushes such as California bulrush (*Schoenoplectus californicus,* formerly known as *Scirpus californicus*) and hard-stem bulrush (*Schoenoplectus acutus*, formerly known as *Scirpus acutus*) adjacent to the low-flow channel of creeks and sloughs. Large, dense patches of invasive perennial pepperweed may also occur within terraced areas in middle reaches otherwise exclusively dominated by alkali bulrush. Other plants that can occur in brackish marshes include alkali heath, spearscale, and, along the high marsh/upland ecotone, pickleweed. Higher-order slough channels and upper-creek reaches dominated by these species may also be considered brackish marsh, depending on the extent of intrusion of fresher water in these areas.

Muted Tidal/Diked Marsh. There are a number of muted tidal/diked marsh areas occupying approximately 1250 acres in total in the vicinity of the Study Area, including New Chicago Marsh, the Palo Alto Flood Basin, and several smaller, adjacent areas (Figure 1). Muted tidal/diked marshes have limited tidal exchange due to the presence of levees around the perimeter of Bay waters/salt ponds. Water exchange is limited, so that the range in water level in the muted tidal marsh is small (usually a few inches) compared to the range of tidal change in other marsh areas (several feet). Muted tidal marshes exhibit many of the same features as fully tidal marshes, but they often have lower plant diversity due to the limited range in tidal action. The muted tidal and diked marshes in the Study Area represent the gradient from fresh to brackish to saline marsh habitat. For example, New Chicago Marsh is dominated by salt marsh, while the Palo Alto Flood Basin ranges from freshwater marsh habitat in the south to salt marsh habitat in the north.

<u>Freshwater Marsh.</u> Approximately 489 acres of freshwater marsh habitat occur throughout the Study Area (Figure 1). The majority of this habitat type is tidal freshwater marsh found in the upper reaches of Coyote Creek, Artesian Slough, Alviso Slough, and Guadalupe Slough where it transitions from brackish marsh. Freshwater marsh vegetation then extends from the upper reaches of Alviso Slough into the Guadalupe River and from the upper reaches of Guadalupe Slough into San Tomas Aquino and Calabazas Creeks. Freshwater marsh habitat typically occurs in the upper reaches of sloughs and creeks draining into the Bay. While these reaches may be subject to occasional tidal influence associated with high (usually spring) tides, and/or have somewhat saline historical sediments, these reaches are otherwise flushed with fresh water on a daily basis and therefore support mostly freshwater emergent vegetation. The water-surface elevation within reaches of freshwater marsh may also vary by as much as ten feet depending on daily tidal activity and seasonal, freshwater flows from upstream. Other non-tidal freshwater marshes are also present in the Study Area, including the Emily Renzel wetlands in Palo Alto.

Broad-leaf cattail (*Typha latifolia*) and taller bulrushes, including California bulrush and hard-stem bulrush, typically dominate the freshwater marsh habitat. Due to regular inundation, these species often form dense stands covering entire floodplain terraces along channels. Patches of perennial pepperweed and thickets of California blackberry (*Rubus ursinus*) also occur in regions of freshwater marsh.

Tidal marshes in the South Bay are remnants of their former extent, but support high densities of several wildlife species, including several San Francisco Bay endemic wildlife species. The state and federally endangered salt marsh harvest mouse (*Reithrodontomys raviventris*) and the salt marsh wandering shrew (*Sorex vagrans halicoetes*) occur in the salt marshes of the South Bay, particularly where pickleweed is present. The California vole (*Microtus californicus*) occurs here as well and is often the most common small mammal in tidal marshes. California clapper rails nest in cordgrass, denser stands of pickleweed, and marsh gumplant, particularly in the lower marsh zone where numerous small tidal channels are present, in both salt and brackish tidal marshes. The Alameda song sparrow (*Melospiza melodia pusillula*), endemic to the Central and South San Francisco Bay, nests in dense herbaceous vegetation in salt and brackish marshes as well, while the savannah sparrow (*Passerculus sandwichensis*) nests in pickleweed and peripheral halophytes in the upper marsh and upland transitional zones. The saltmarsh common yellowthroat (*Geothlypis trichas sinuosa*) nests in tidal and nontidal brackish and freshwater marshes, and possibly in low densities in salt marsh habitat as well (Ray 1919; Steve Rottenborn, pers. obs.), in the South Bay. Several species of ducks, and in a few locations herons and egrets, also nest in the tidal marshes of the South Bay (Gill 1977), and California black rails (*Laterallus jamaicensis coturniculus*) winter in small numbers in these marshes. Non-breeding birds, including larger shorebirds, swallows, blackbirds, and other species roost, occasionally in large numbers, in the tidal marsh, and tidal marshes (and mudflats) in several South Bay areas are used as haul-outs and pupping sites by harbor seals.

Riparian/Creek Corridor. Approximately 260 acres of fluvial riparian habitat and urban creek corridors are found throughout the Study Area (Figure 1). Riparian habitat is found along the upstream portions of the majority of the drainages within the Study Area. Riparian habitat includes vegetation that occurs adjacent to freshwater streams, creek, and rivers. The historical riparian landscape found in the South Bay was characterized by perennial creeks that intersect the intertidal zone, producing brackish marsh at the interface with the saline landscape. Currently in the South Bay, riparian habitats that include large, mature riparian trees are limited to select portions of Coyote Creek and the Guadalupe River. Dominant canopy species in the South Bay include willow (*Salix* sp.) and Fremont cottonwood (*Populus fremontii*) while common understory species include elderberry (*Sambucus mexicana*) and wild rose (*Rosa californica*). Many of the creek corridors however, are concrete-lined channels with little to no woody vegetation and are confined by flood control levees.

Salt Ponds (Active and Inactive). Approximately 7612 acres of the Study Area are occupied by active and inactive salt ponds. Approximately 235 acres of Cargill-managed active salt ponds occur within the Study Area (Figure 1) represented by the southeast portions of salt ponds M4 and M5 which border the northern extent of the bayland boundary of the Study Area. The vast majority of salt ponds within the Study Area, referred to as the "Alviso salt ponds" and numbered A1 to A23 on Figure 1, are inactive, meaning that they have been taken out of salt production. These ponds were mapped and described according to their prescribed management regime, and encompass approximately 7377 acres. The salinity and hydrologic circulation regimes outlined in the ISP (Life Science 2003) result in five types of pond management systems: System, Full Tidal, High Salinity (Batch), Seasonal, and Mixed (e.g., Seasonal /High Salinity) Ponds. A sixth pond type, categorized under Related Projects and encompassing approximately 1436 acres, is not under a current management regime; the fate of these ponds is unknown at this time. Each of these pond types is described below:

> **<u>System Ponds (ISP Management).</u>** The System Ponds, with approximately 4638 acres of salt ponds, are second only to mudflat habitat as the most abundant habitat found in the Study Area, and are by far the most extensive type of salt pond in the Study Area (Figure 1). They primarily occur along the east-west extent of the southern portion of the South Bay baylands, with two (Ponds A16 and A17) separated from the other System Ponds by the three high-salinity ponds. System Ponds are managed to have water circulating through a series of ponds linked by water control structures that are controlled to reduce or maintain ambient salinities. Management of these ponds under the ISP focuses primarily on meeting discharge requirements for salinity and dissolved oxygen; management for selected habitat conditions (e.g., shallow water for shorebirds, deeper water for waterfowl and diving birds) occurs as feasible while meeting water quality requirements.
>
> **<u>Full Tidal Ponds (ISP Management).</u>** Approximately 477 acres of former salt ponds fully restored to tidal action occur within the three Island Ponds (A19, A20, A21), which are located between Coyote Creek and Mud Slough in the northern portion of the Alviso Pond complex (Figure 1). Levees were breached in March 2006 to allow full tidal action to be reintroduced to the pond.
>
> **<u>High Salinity Ponds (ISP Management).</u>** Approximately 826 acres of high-salinity ponds (A12, A13, A15) occur within the east-central portion of the Study Area located between Coyote

Creek and Alviso Slough (Figure 1). High-salinity ponds are also referred to as batch ponds. This management strategy consists of a series of ponds, managed to maintain higher salinity levels to provide habitat for salt pond-associated bird species.

Seasonal Ponds (ISP Management). The two seasonal ponds (A22, A23) lie in the northern portion of the Alviso Pond complex and encompass approximately 712 acres (Figure 1). Seasonal ponds have no bay-water inputs; water levels rise and recede depending on precipitation and groundwater hydrology.

Seasonal Ponds/High-Salinity Ponds (ISP Management). Approximately 724 acres of seasonal/high-salinity ponds are located between the upper reaches of Alviso Slough and Guadalupe Slough in the pond complex (A8 North and South) and along the lower reach of Guadalupe Slough around the central portion of the Study Area (A3N) (Figure 1). These ponds are also referred to as mixed ponds. These ponds are managed differently at different times of the year, or managed adaptively.

Related Projects (Ponds). Approximately 1436 acres of former salt ponds in the Study Area, including Ponds A4 and A18 and the Crittenden Marsh area in the northern part of Moffett Field, are associated with related projects (Figure 1). Currently, the management plans for these ponds are actively being designed and future management of these ponds is uncertain. Future habitat enhancement options may include, but are not limited to, tidal restoration, managed pond, and diked or muted tidal wetland.

Generally, salt ponds in the South Bay are characterized by expanses of non-tidal open water, bare mud, or bare salt flats surrounded by mostly barren levees. Vegetation is sparse and where it does occur, it is limited primarily to levees. Due to the paucity of vegetation, salt ponds provide little to no cover for small mammals or reptiles, and provide nesting habitat only for species that nest on the bare levees and the occasional islands that have been created (by breaching of levees or deposition of material dredged from borrow ditches) within the ponds. Furthermore, much of the biomass produced by these ponds is unavailable to birds due to water depth and fish due to high salinity, which precludes these vertebrates' use of most of the invertebrates in the deeper, higher-salinity ponds.

At least 16 species of fish occur in the lower-salinity intake ponds, where they feed on an abundant supply of benthic and pelagic invertebrate prey. The native topsmelt (*Atherinops affinis*), longjaw mudsucker (*Gillichthys mirabilis*), staghorn sculpin (*Leptocottus armatus*), and non-native yellowfin goby (*Acanthogobius flavimanus*) and rainwater killifish (*Lucania parva*), are among the most common fish within these ponds (Takekawa et al. 2005). Because most of these fish cannot tolerate salinity > 70-80 ppt (Carpelan 1957; Lonzarich 1989), piscivorous birds in salt ponds generally forage only in the lower salinity intake ponds. Dabbling ducks are also usually present in highest concentrations in the lower salinity ponds, where they take both invertebrates and aquatic vegetation.

Salt ponds in the San Francisco Bay area provide habitat for more than one million waterbirds each year, including large percentages of the populations of some shorebird, duck, and tern species (Accurso 1992;

Harrington and Perry 1995; Page et al. 1999; Stenzel and Page 1988; Takekawa et al. 2001). Numerous waterbirds use the salt ponds and their associated islands and levees primarily for roosting, either at night or during high tide when their preferred foraging habitats are submerged. Large mixed-species flocks of shorebirds, gulls, terns, cormorants, pelicans, herons, and other birds are often seen roosting or loafing on levees, in shallow water, or on exposed mud in the ponds. A few species, including the black-necked stilt (*Himantopus mexicanus*), American avocet (*Recurvirostra americana*), western snowy plover, Caspian tern (*Sterna caspia*), Forster's tern, black skimmer (*Rhynchops niger*), California Gull (*Larus californicus*), and double-crested cormorant nest on islands or levees within the ponds, particularly those that are not accessible by mammalian predators, or in the case of the western snowy plover and California Gull, on barren salt flats on the bottoms of dried ponds.

The highest-salinity ponds support little, if any, wildlife. Above a salinity of 200 ppt, even brine shrimp cannot survive, and thus there is no prey to support predatory wildlife. Although birds may occasionally roost in these hypersaline ponds, the high salinity may have adverse effects on the birds, such as impairing the waterproofing of their feathers (Rubega and Robinson 1997), and little use is made of such ponds by wildlife (Takekawa et al. 2000).

Unvegetated Areas. Approximately 77 acres of unvegetated islands exist within several of the salt ponds (Figure 1). The majority of this acreage was mapped in ponds A6 and A2E. This habitat occasionally occurs on levee side slopes below approximately MHW. Unvegetated areas are typically confined to salt pond basins and consist of bare ground and salt flat areas. Most of the salt-pond basins were historically subject to regular tidal inundation and were vegetated with salt marsh species, but salinity resulting from their use as salt ponds over decades has resulted in conditions too saline to support even halophytic vegetation. While these areas typically lie below the MHW mark, they are no longer subject to tidal flooding.

Vernal Pool Grassland. There are approximately 481 acres of vernal pool grassland located in the northeastern portion of the Study Area in the Warm Springs area (Figure 1). Here, vernal pools occur within a grassland matrix, and no attempt has been made to map individual pools on Figure 1 or quantify their acreage. The vernal pool complex in the Study Area is adjacent to the backshore of historical tidal marshlands located near Warm Springs and consists mostly of small, distinct depressions among more diffuse swales. These vernal pools harbor the Contra Costa goldfields (*Lasthenia conjugens*) listed as endangered by the federal government. Upland grassland habitat containing vernal pool habitat is located landward from the salt ponds, between the salt ponds and urbanized areas.

Vernal pools are seasonally flooded depressions that occur on ancient soils that thinly cover an impermeable substrate of hardpan, clay, or bedrock above the tideline. The impermeable substrate causes the vernal pools to retain rainwater and local runoff seasonally, but to dessicate as evaporation drains their shallow topography. Because, vernal pools are essentially temporary wetlands, they undergo distinct vegetative phases: aquatic, flowering, and drought. During the aquatic phase of the vernal pool habitat, algae may flourish, along with the aquatic stages of coyote thistle (*Eryngium* sp.) and other vernal pool plant species. Later, after the winter rainstorms have ended, the pool will begin to dry and these plant species will flower, producing rings of color around the reducing pool, with the most water-tolerant species occurring within the middle portions of the pool. During the drought phase, upland plant species may move into the vernal pool, resulting in an area that contains upland species, bare earth, dessicated hydrophytes, and residual algal matting during the late summer months.

Vernal pools in the Study Area provide important habitat for two rare wildlife species, the vernal pool tadpole shrimp (*Lepidurus packardi*) and California tiger salamander (*Ambystoma californiense*). These pools also provide seasonal foraging habitat for shorebirds, dabbling ducks, and egrets.

Peripheral Halophytes. Approximately 119 acres of peripheral halophytes are found along the banks and tops of levees surrounding the baylands and along the levees separating the salt ponds in the Study Area (Figure 1). The extent of peripheral halophytic vegetation is primarily determined by the salinity of the levee soils and how recently the levee soils were excavated from borrow pits in adjacent salt ponds. Peripheral halophytes typically include non-native, ruderal ("disturbance-loving") species such as iceplant (*Mesembryanthemum nodiflorum*), New Zealand spinach (*Tetragonia tetragonioides*), Russian thistle (*Salsola soda*), and Australian saltbush (*Atriplex semibaccata*), which usually occur only above the MHHW mark. Native high marsh species also occasionally form peripheral halophytic habitat along levee banks as conditions permit. These species include marsh gumplant, alkali heath, spearscale, and saltgrass. In addition, pickleweed may occur on levee banks; assemblages of pickleweed and peripheral halophytes are mapped as salt marsh if pickleweed is dominant in the area. Low-lying, or eroded levees between salt ponds are usually too saline to support halophytes. Levees contiguous with uplands are typically dominated by upland species (described below) rather than peripheral halophytes.

Peripheral halophytes are used as foraging (and occasionally nesting) sites by ducks, song sparrows, and savannah sparrows, and provide foraging habitat and cover for several additional sparrows and finches during the nonbreeding season. In addition, peripheral halophytic vegetation provides important refugial habitat for salt marsh wildlife species during high tides.

Upland Vegetation/Golf Courses. There are approximately 1465 acres of upland habitat within the Study Area (mostly non-native grassland habitat), the majority of which consists of parcels of ruderal vegetation in the eastern and southern undeveloped portions of the Study Area (Figure 1). A small area of upland vegetation was also found bordering sections of freshwater and brackish marshes within the Study Area. In addition, 990 acres of golf course land, primarily within the southern extent of the Study Area, were identified.

Aside from numerous ornamental plant species occurring in landscaped areas, assemblages of annual, non-native plants that thrive in disturbed areas (ruderal species) dominate most of the upland habitat. These species include most tree, shrub, and herbaceous species found in upland areas. The predominant upland species surrounding the ponds include Italian ryegrass (*Lolium multiflorum*), ripgut brome (*Bromus diandrus*), black mustard (*Brassica nigra*), wild radish (*Raphanus sativus*), Mediterranean barley (*Hordeum marinum* ssp. *gussoneanum*), wild oats (*Avena fatua*), yellow star-thistle (*Centaurea solstitialis*), common sow thistle (*Sonchus oleraceus*), bull thistle (*Cirsium vulgare*), bristly ox-tongue (*Picris echioides*), rabbitsfoot grass, brass buttons, alkali heath, and coyote brush (*Baccharis pilularis*).

Most of the wildlife species found in peripheral upland areas are common species adapted to urban or ruderal habitats. Reptiles such as the western fence lizard (*Sceloporus occidentialis*), gopher snake (*Pituophis melanoleucus*), and southern alligator lizard (*Elgaria multicaranata*), and mammals such as the house mouse (*Mus musculus*), California vole (*Microtus californicus*), western harvest mouse (*Reithrodontomys megalotis*), California ground squirrel (*Spermophilus beecheyi*), black-tailed jack rabbit (*Lepus californicus*), cottontail (*Sylvilagus audubonii*), brush rabbit (*S. bachmani*), valley pocket gopher (*Thomomys bottae*), and striped skunk (*Mephitis mephitis*), all occur in the upland transitional areas along the edge of the Bay. A small, isolated population of western pond turtles (*Emys marmorata*) is present in brackish habitats near the Sunnyvale WPCP and Moffett Field, and California tiger salamanders occur in vernal pool habitats in the Warm Springs area.

In most areas, the bird species that occur in the peripheral habitats are also common, widespread species. These include permanent residents such as the Anna's hummingbird (*Calypte anna*), mourning dove (*Zenaida macroura*), black phoebe (*Sayornis nigricans*), northern mockingbird (*Mimus polyglottos*), bushtit (*Psaltriparus minimus*), California towhee (*Pipilo crissalis*), red-winged blackbird (*Agelaius phoeniceus*), Brewer's blackbird (*Euphagus cyanocephalus*), house finch (*Carpodacus mexicanus*), lesser goldfinch (*Carduelis psaltria*), summer residents such as the barn swallow (*Hirundo rustica*) and cliff swallow (*Petrochelidon pyrrhonota*), transients (some of which breed at higher elevations in the Bay Area), including the orange-crowned warbler (*Vermivora celata*) and Swainson's thrush (*Catharus ustulatus*), and winter residents such as the hermit thrush (*Catharus guttatus*), white-crowned sparrow (*Zonotrichia leucophrys*), golden-crowned sparrow (*Zonotrichia atricapilla*), yellow-rumped warbler (*Dendroica coronata*), and American pipit (*Anthus rubescens*). Burrowing owls (*Athene cunicularia*) are also present in ruderal habitats and non-native grasslands in scattered areas surrounding the South Bay salt ponds and marshes. The extent of the upland fields that once probably provided extensive alternate foraging habitat for shorebirds has been reduced considerably by development. Nevertheless, shorebirds such as killdeer (*Charadrius vociferus*), long-billed curlews (*Numenius americanus*), and dunlin (*Calidris alpina*) occasionally forage in more extensive upland fields in the Alviso, Fremont, and Newark areas during the wet season, and greater yellowlegs (*Tringa melanoleuca*) and least sandpipers (*Calidris minutilla*) may forage around ponded water in such fields in winter.

Parks/Upland Grassland. Approximately 466 acres of parks/upland grassland were found within the survey area, mostly located along the southern extent of the undeveloped portion of the Study Area (Figure 1). Included in this habitat description are areas within the Study Area designated as city or county parkland, including fallowed agricultural fields, manicured irrigation basins, and large areas of landscaped vegetation. Wildlife species in this habitat type are similar to those described for upland vegetation/golf courses above.

Levee. Approximately 416 acres of levees were mapped throughout the Study Area, found along the periphery of the baylands and separating many of the individual ponds in the salt pond complex (Figure 1). Levees are linear, barren, earthen structures that separate salt ponds from tidal areas and adjacent salt ponds. The levees in the South Bay salt pond complexes were typically constructed from soils excavated from borrow pits in former salt marshes which have since been developed into salt ponds; standing water can usually be found in the borrow ditches of otherwise empty salt ponds. The levee substrate is therefore primarily saline, silty clay. Dirt roadways along the upland perimeters of salt ponds or bayfronts were typically mapped as levee. Portions of levees dominated by peripheral halophytes, or upland vegetation, were categorized as either of those habitat types, rather than as levee habitat.

Developed. Approximately 14,480 acres of developed areas make up the largest land use category within the Study Area. Development is found along the entire periphery of the Study Area boundary and extends towards the South Bay to the outward edge of the baylands (Figure 1). Approximately 1487 acres of lands designated for water/sewage treatment use are found in the Study Area. The majority of this acreage includes the water pollution control plants for the cities of San Jose and Sunnyvale. Approximately 779 acres of lands designated for landfill use are found in the including Newby Island, the Zanker Road Landfill, and Palo Alto Baylands. Approximately 975 acres of lands designated for airport use are found in the Study Area. Moffett Field makes up the majority of this airport designation.

Developed areas within each complex include roadways, parking areas, building complexes, pump facilities, water/sewage treatment areas, landfills, airports, and powerline facilities. Such areas are typically maintained free of vegetation, but may occasionally support isolated ruderal upland vegetation (described above). Larger areas of upland or ornamental (landscaping) vegetation in developed settings are categorized as parks/upland grassland. Sludge ponds, oxidation ponds, drying beds, and associated impoundments at the South Bayside System Authority Wastewater Treatment Works in Redwood City, the San Jose-Santa Clara WPCP in Alviso, and the Sunnyvale WPCP support high densities of breeding dabbling ducks, Canada geese (*Branta canadensis*), and black-necked stilts, and depending on pond conditions can support very high densities of migrant and wintering waterfowl.

Table 1 - Habitat Types mapped in the Shoreline Study Area (acreages).

Habitat Type	Acres
Muted Tidal/Diked Marsh	1250
Brackish Marsh	955
Salt Marsh	725
Freshwater Marsh	489
Riparian/Creek Corridor	260
Wetland/Riparian subtotal	**3679**
Mudflat	7498
System Ponds (ISP Management)	4638
Open Water	2664
Water/Sewage Treatment	1487
Related Projects	1436
High Salinity Ponds (ISP Management)	826
Seasonal Ponds/High Salinity Ponds (ISP Management)	724
Seasonal Ponds (ISP Management)	712
Full Tidal (ISP Management)	477
Salt Ponds (Active)	235

Habitat Type	Acres
Pond/Open Water subtotal	**20,697**
Developed	14,480
Parks/Upland Grassland	466
Airport	975
Upland Vegetation	1465
Landfill	779
Golf Course	990
Vernal Pool Grassland	481
Levee	416
Peripheral Halophytes	119
Unvegetated	77
Other subtotal	**20,248**
Total	**44,624**

Table 2 - Summary Table for the Habitat Types in the Shoreline Study Area.

Habitat Type	Acres	Proportion of Total
Wetland/Riparian	3679	8.2%
Pond/Open Water	20,697	46.4%
Other	20,248	45.4%
Total Area Mapped	**44,624**	**100%**

3.4 Special-Status Plant Species

Historically, special-status plant species were neither commonly occurring nor widely distributed within the upper zones of the tidal salt marsh and brackish marshes of the San Francisco Bay. However, those special-status species with broad edaphic tolerances were, and are today, locally common. For example, marsh gumplant (*Grindelia stricta* var. *angustifolia*), is limited to the upper marsh zone of the Bay, but tolerates disturbed fill soils; it is abundant within South Bay marshes and was recently removed from the California Native Plant Society (CNPS) Inventory of Rare and Endangered Plants (2001). Similarly, Congdon's tarplant (*Centromadia parryi* ssp. *congdonii*), while limited in distribution (CNPS List 1b), is associated with alkaline upper marsh habitats as well as with low-lying alkaline soils; large stands occur well east of the San Francisco Bay. Conversely, plants with highly restrictive growth requirements, such as for coarse substrates on high-energy shorelines, salt panne edges, or channel edges within tidal brackish marsh, are now extremely rare in the urban estuary of the Bay due to the limited acreage and distribution of these habitat types within the area. The continued persistence of these plants is further threatened by non-native, invasive plant species, particularly perennial pepperweed, which generally thrive under disturbed conditions with increased urban runoff.

3.4.1 Special-Status Plant Assessment

The California Natural Diversity Database (CNDDB, CDFG 2007) was queried to identify special-status plant species potentially occurring within the Palo Alto, Mountain View, and Milpitas USGS 7.5 minute quadrangles in which the majority of the Study Area occurs, as well as the ten quadrangles surrounding the Study Area, and the Newark and Redwood Point quadrangles that contain very small portions of the Study Area. In addition, to be inclusive of all species that may occur within the Study Area, particularly within grassland fringe areas with saline or alkaline soils, valley and foothill grassland, marsh and swamp, and vernal pool habitats were queried within the CNPS database (http://cnps.web.aplus.net/cgi-bin/inv/inventory.cgi, accessed 8 February 2007) for Alameda, San Mateo, and Santa Clara Counties.

Numerous occurrences of six species, including Point Reyes bird's-beak (*Cordylanthus maritimus* ssp. *palustris*), Hoover's button-celery (*Eryngium aristulatum* var. *hooveri*), Congdon's tarplant, alkali milk-vetch (*Astragalus tener* var. *tener*), Contra Costa goldfields (*Lasthenia conjugens*), and San Joaquin spearscale (*Atriplex joaquiniana*), have been documented in the immediate vicinity of the Study Area; the latter five species are known from the Study Area primarily from the Warm Springs Unit of the Don Edwards San Francisco Bay National Wildlife Refuge (SFBNWR) and the adjacent Pacific Commons Preserve in Fremont. Historical (likely extirpated) populations of alkali milk-vetch and Point Reyes bird's-beak are documented in the vicinity of Alviso. One additional species, Pacific cordgrass (*Spartina foliosa*), has been considered for inclusion in the USFWS draft recovery plan and is common in the area, but was not included in this assessment.

CNDDB (2006) records list 22 species as occurring within five miles (eight km) of the Study Area: San Joaquin spearscale, Congdon's tarplant, Contra Costa goldfields, alkali milk-vetch, hairless popcorn flower (*Plagiobotrys glaber*), robust spineflower (*Chorizanthe robusta* var. *robusta*), Hoover's button-celery, California seablight (*Suaeda californica*), arcuate bush mallow (*Malacathamnus arcuatus*), Point Reyes bird's-beak, slender-leaved pondweed (*Potamogeton filiformis*), lost thistle (*Cirsium praeteriens*), San Mateo thorn-mint (*Acanthomintha duttonii*), Marin western flax (*Hesperolinon congestum*), Franciscan onion (*Allium peninsulare* var. *franciscanum*), fragrant fritillary (*Fritillaria liliacea*), caper-fruited tropidocarpum (*Tropidocarpum capparideum*), western leatherwood (*Dirca occidentalis*), San Francisco collinsia (*Collinsia multicolor*), Hall's bush mallow (*Malacothamnus hallii*), most beautiful jewel-flower (*Streptanthus albidus* ssp. *peramoenus*), and Davidson's bush mallow (*Malacothamnus davidsonii*).

From this analysis, 49 special-status plant species have been identified that occur in similar Alameda, San Mateo, and Santa Clara county habitats and elevations, or are found within the USGS quads listed above, based on the query, including 22 special-status plant species that have been recorded within a five mile radius of the Study Area (CNDDB, CDFG 2007). All species selected from these queries were then cross referenced with the most recent state and federal listing update according to the California Department of Fish and Game to verify listing status and identify any recently listed species.

Presence of suitable habitat was the principal criterion used for inclusion in the list of species potentially occurring within the Study Area. Many of the special-status plant species that occur in Alameda, San Mateo, and Santa Clara Counties are associated with habitat or soil types that did not occur in the Study Area historically, or no longer occur in the Study Area due to the extensive removal of soil and addition of fill material. Following an analysis of the microhabitat conditions associated with these species, and the edaphic factors that favor their occurrence, 36 plant species of the original 49 are considered absent from the Study Area (Table 3a). The majority of the species were rejected for occurrence based on one or more of the following reasons:

1. The species would not occur within the Study Area due to the limited extent of degraded, upland habitat within the pond complexes or adjacent to developed areas and the highly saline and/or ruderal nature of these areas
2. The species occurs in chaparral habitat or cismontane woodland habitat, which do not exist within the Study Area.
3. The species nearly always or always occurs on serpentinite outcroppings, of which none were observed within the Study Area. Also, no serpentinite soil series are mapped in this area as being present by SCS (1968), and are not indicated as being present in the region by the Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area.
4. The species' published elevation range is outside the range of elevations found along the Study Area.
5. The species has a highly endemic range that does not include areas within or reasonably near to the Study Area, or the species is considered by CNPS to be extirpated or absent from Alameda, Santa Clara, and San Mateo Counties

Table 3a - Plant Species considered, but rejected for occurrence within the South San Francisco Bay Shoreline Study Area (Santa Clara and Alameda Counties).

Scientific Name	Common Name	Lack of Chaparral or Other Suitable Habitat	Lack of Mesic Habitat	Lack of Serpentine Soils	Other Edaphic Factors Absent from the Site	Associated Species Absent from the Site	CNPS Records List the Species as Extirpated or Never Occurred	Suitable Habitat on Site Disturbed/Degraded
Acanthomintha duttonii	San Mateo thorn-mint	X		X			X	
Allium peninsulare var. *franciscanum*	Franciscan onion			X	X			
Amsinckia lunaris	bent-flowered fiddleneck	X						
Atriplex cordulata	heartscale				X	X		
Atriplex coronata var. *coronata*	crownscale		X			X		
Atriplex depressa	brittlescale		X			X		
Centromadia parryi ssp. *parryi*	pappose tarplant						X	
Chorizanthe robusta var. *robusta*	robust spineflower	X			X			
Cirsium praeteriens	lost thistle						X	

Scientific Name	Common Name	Lack of Chaparral or Other Suitable Habitat	Lack of Mesic Habitat	Lack of Serpentine Soils	Other Edaphic Factors Absent from the Site	Associated Species Absent from the Site	CNPS Records List the Species as Extirpated or Never Occurred	Suitable Habitat on Site Disturbed/Degraded
Collinsia multicolor	San Francisco collinsia	X		X				
Cordylanthus maritimus ssp. *palustris*	Point Reyes bird's-beak						X	
Dirca occidentalis	western leatherwood	X			X			
Eriogonum truncatum	Mt. Diablo buckwheat				X			
Eryngium aristulatum var. *hooveri*	Hoover's button celery					X		X
Erysimum franciscanum	San Francisco wallflower			X				
Eschscholzia rhombipetala	diamond-petaled California poppy					X		X
Fritillaria liliacea	fragrant fritillary			X				
Hesperevax caulescens	hogwallow starfish				X			
Hesperolinon congestum	Marin western flax	X		X			X	
Hordeum intercedens	vernal barley						X	
Leptosiphon grandiflorus	large-flowered leptosiphon							
Lilium maritimum	coast lily	X			X		X	
Limnanthes douglasii ssp. *sulphurea*	Point Reyes meadowfoam				X		X	
Lotus formosissimus	harlequin lotus	X			X		X	
Malacathamnus arcuatus	Arcuate bush mallow	X						
Malacothamnus davidsonii	Davidson's bush mallow	X					X	
Malacothamnus hallii	Hall's bush mallow	X						
Microseris paludosa	marsh microseris	X					X	
Navarretia cotulifolia	cotula navarretia				X			
Perideridia gairdneri ssp. *gairdneri*	Gairdner's yampah					X		X
Plagiobotrys glaber	hairless popcorn flower						X	
Potamogeton filiformis	Slender-leaved pondweed						X	
Streptanthus albidus ssp. *peramoenus*	most beautiful jewel-flower	X		X				
Suaeda californica	California seablite						X	
Trifolium amoenum	showy Indian clover			X			X	
Tropidocarpum capparideum	caper-fruited tropidocarpum						X	

The remaining 13 species considered for occurrence within the Study Area did not match any of the above rejection criteria, and could not be reasonably excluded due to the range of habitat types and ecotones present on-site; these species are considered in Table 3b. These include three species (Contra Costa goldfields, Congdon's tarplant, and prostrate navarretia) that are known to occur in the Study Area;

two species (San Joaquin spearscale and alkali milk-vetch) that are not known to occur in the Study Area but that occur immediately adjacent to the Study Area in the Pacific Commons Preserve, and thus have the potential to occur in the Study Area; one species (Delta tule pea [*Lathyrus jepsonii* var. *jepsonii*]) that is not known from extant occurrences in the South Bay but which could potentially occur in the Study Area; five species (palmate-bracted bird's-beak [*Cordylanthus palmatus*], hispid bird's-beak [*Cordylanthus mollis* ssp. *hispidus*], recurved larkspur [*Delphinium recurvatum*], Delta woolly-marbles [*Psilocarphus brevissimus* var. *multiflorus*], and saline clover [*Trifolium depauperatum* var. *hydrophilum*]) that are unlikely to occur in the Study Area; and two species (Mason's lilaeopsis [*Lilaeopsis masonii*] and Coastal Marsh milk-vetch [*Astragalus pycnostachyus* var. *pycnostachyus*]) that are considered absent from the Study Area, which probably has never provided suitable habitat for these two species. The ecology, distribution, and potential for reintroduction of these species are provided below.

Three terrestrial communities of concern appeared on CNNDB (2007) records within a five mile radius of the Study Area: Northern Coastal Salt Marsh, Serpentine Bunchgrass, and Valley Oak Woodland. Of these habitat types, only Northern Coastal salt marsh habitat occurs within the Study Area, as described above within the listed habitat descriptions.

Table 3b – Special-status plant species, their status, and potential occurrence in the Shoreline Study Area.

NAME	STATUS*	HABITAT/ DESCRIPTION	POTENTIAL FOR OCCURRENCE ON SITE
Federal or State Threatened or Endangered Species			
Palmate-bracted bird's-beak (*Cordylanthus palmatus*)	FE, SE, CNPS 1B	Chenopod scrub, Valley and foothill grassland/alkaline. Known from Alameda, Colusa, Fresno, Glenn, Madera, and Yolo Counties. Believed to be extirpated from San Joaquin County. Annual hemiparasitic herb that blooms May through October.	**Unlikely.** Due to the general degraded nature or lack of alkaline flat substrate within the Study Area, the occurrence of Palmate-bracted bird's-beak within the Study Area is unlikely.
Contra Costa goldfields (*Lasthenia conjugens*)	FE, CNPS 1B	Saline/alkaline vernal pools, mesic areas within grassland. Known from Alameda, Solano, Monterey, Contra Costa, and Napa counties. Annual; blooms March through June.	**Present.** Two large colonies associated with grassy seasonal wetlands in Fremont vicnity; otherwise occurs in disjunct populations in Monterey and North Bay. The Warm Springs portion of the Study Area provides suitable habitat and is included within the vernal pool critical habitat for Contra Costa Goldfields (Unit 8).
Mason's lilaeopsis (*Lilaeopsis masonii*)	SR, CNPS 1B	Exposed banks of tidal meanders and channels within brackish to freshwater marsh. Locally common in Suisun Marsh. Perennial; blooms April through November.	**Absent.** Not known to occur in the South Bay; historical and current records in Suisun Bay only.
State Rare and CNPS Species			
Coastal marsh milk-vetch (*Astragalus pycnostachyus* var. *pycnostachyus*)	FSC, CNPS 1B	Coastal salt marshes, streamsides, and mesic coastal dunes in Marin and San Mateo counties. Perennial; blooms April to October.	**Absent.** Not known to occur in South Bay; no suitable habitat in Shoreline Study Area (Extant populations associated with maritime salt marsh).
Alkali milk-vetch (*Astragalus tener* var. *tener*)	FSC, CNPS 1B	Alkaline soils in playas, vernal pools, and adobe clay areas within grassland. Alameda, Merced, Solano, and Yolo counties. Annual; blooms March to June.	**Potential**. Recently rediscovered in seasonal wetlands near Fremont, on Pacific Commons Preserve immediately outside Shoreline Study Area. Considered extirpated from Santa Clara County. Currently suitable vernal pool habitat occurs within the Warm Springs portion of the Shoreline Study area.
San Joaquin spearscale (*Atriplex joaquiniana*)	FSC, CNPS 1B	Alkaline soils within chenopod scrub, meadows, playas, and grasslands in 14 central California counties. Annual; blooms April through October.	**Potential.** Occurs in seasonal wetlands in Warm Springs vicinity; known from Pacific Commons Preserve. Potential habitat present in Warms Springs portion of Shoreline Study Area.
Congdon's tarplant (*Centromadia parryi* ssp. *congdonii*)	CNPS 1B	Moist, alkaline soils within grassland. Tolerates disturbance. Annual; blooms June through November. Known from Alameda, Monterey, San Luis Obispo, and Santa Clara counties.	**Present.** Occurs in seasonal wetlands in Warm Springs vicinity; known from Pacific Commons Preserve. Also recently recorded in Alviso and at Sunnyvale Baylands Park. May occur in peripheral halophyte or disturbed upland zones in Shoreline Study Area, but not currently associated with salt marsh.

NAME	STATUS*	HABITAT/ DESCRIPTION	POTENTIAL FOR OCCURRENCE ON SITE
Hispid bird's-beak (*Cordylanthus mollis* ssp. *hispidus*)	CNPS 1B	Meadows and seeps, Playas, Valley and foothill grassland/alkaline. Known from Alameda, Fresno, Kern, Merced, Placer, and Solano counties. Annual hemiparasitic herb that bloomsJune through September.	**Unlikely.** Due to the general degraded nature or lack of saline flats substrate within the Study Area, the occurrence of Hispid bird's-beak within the Study Area is unlikely.
Recurved larkspur (*Delphinium recurvatum*)	CNPS 1B	Chenopod scrub, Cismontane woodland, Valley and foothill grassland/alkaline. Known from Alameda, Contra Costa, Fresno, Glenn Glenn, Kings, Kern, Madera, Merced, Monterey, San Joaquin, San Luis Obispo, Solano, and Tulare Counties. It is believed to be extirpated from Butte and Colusa counties. Perennial herb that blooms from March through June.	**Unlikely.** Due to the general degraded nature or lack of grassland habitat with alkaline soils within the Study Area, the occurrence of recurved larkspur within the Study Area is unlikely.
Delta tule pea (*Lathyrus jepsonii* var. *jepsonii*)	CNPS 1B	High marsh zone in brackish and freshwater marshes. Known from Suisun Marsh (Sacramento, San Joaquin, Solano and Contra Costa counties) and Napa marshes. Perennial; blooms May through September.	**Potential.** Historical and current records are from the North Bay only. However, marginal habitat is present within the Study Area, and there is some potential for occurrence.
Prostrate navarretia (*Navarretia prostrata*)	FSC, CNPS 1B	Seasonal wetlands and vernal pools within grassland and coastal scrub. Ranges from Monterey County south to San Diego. Annual; blooms April through July.	**Present.** In South Bay, known only from Pacific Commons Preserve and the Warm Springs unit of the SFBNWR.
Delta woolly-marbles (*Psilocarphus brevissimus* var. *multiflorus*)	CNPS 4	Dried beds of vernal pools and flats, especially in grasslands, in Alameda and Santa Clara counties north to Yolo County. Annual; blooms April to June.	**Unlikely.** Currently the Warm Springs area presents potentially suitable habitat within the Shoreline Study Area.
Saline clover (*Trifolium depauperatum* var. *hydrophilum*)	FSC, CNPS 1B	Edges of salt marshes, alkali meadows, and vernal pools along the coast from Sonoma County south to San Luis Obispo, as well as in the inland counties of Solano and Colusa. Annual; blooms April through June.	**Unlikely.** Historical collection (type locality) from Belmont; not recorded since in South Bay. Currently the Warm Springs area presents potentially suitable habitat within the Shoreline Study Area.

CNPS LISTS:
1A – Plants presumed extinct in California
1B – Plants rare, threatened, or endangered in California and elsewhere
2 – Plants rare, threatened, or endangered in California, but more common elsewhere
3 – Plants about which more information is needed – a review list
4 – Plants of limited distribution – a watch list

Other Listed Status:
FE –Federally Endangered
FSC –Federal Species of Concern
SR –State Rare
SE –State Endangered

Palmate-bracted bird's-beak (*Cordylanthus palmatus*). Federal Status: Endangered; State Status: Endangered; CNPS Status: List 1B. Palmate-bracted bird's-beak is a hemiparasitic annual herb in the Scrophulariaceae typically found in chenopod scrub or alkaline valley and foothill grassland habitat at elevations of five to 155 meters. Plants are between ten to 30 centimeters, gray-green, and soft-hairy. Flowers are whitish and appear from May to October.

Palmate-bracted bird's-beak is known from only nine occurrences (CNPS 2001) and is threatened by agriculture, urbanization, grazing, and industrial development. No local occurrences exist in CNDDB records (2007). It is expected to occur within alkaline flats in the Study Area.

Potential for occurrence in the Study Area. Due to the general degraded nature or lack of alkaline flat substrate within the Study Area, the occurrence of palmate-bracted bird's-beak within the Study Area is unlikely.

Contra Costa goldfields (*Lasthenia conjugens*). Federal Status: Endangered; State Status: None; CNPS Status: List 1B. Contra Costa goldfields is a small, ephemeral annual sunflower typically occurring in mesic depressions within open, grassy habitats. Plants range in height from four to 12 inches and bear one to several flowerheads from March through June. Both ray and disk flowers are yellow. Contra Costa goldfields is distinguished from other common, co-occurring *Lasthenia* species by its lack of a pappus (an appendage arising from the ovary) on individual flowers.

Contra Costa goldfields occurs in 20 widely scattered populations in Alameda, Contra Costa, Mendocino, Monterey, Napa, and Solano Counties (CDFG 2004a). Extant populations in the South Bay area occur at the Pacific Commons Preserve (seasonal wetlands) and at the nearby Don Edwards San Francisco Bay NWR, Warm Springs Unit (vernal pools and swales). Management of both preserve areas focuses on the conservation of the species (USFWS and CDFG 2003; Wetlands Research Associates 1999).

Contra Costa goldfields is not expected to occur within tidal wetlands, but may occur in seasonal wetlands in the upland transition zone. According to the critical habitat designation for this species (Department of the Interior 2003), Contra Costa goldfields is most often found in vernal pools, swales, moist flats and depressions within grassland. However, Baye (2000) discusses the historical association of Contra Costa goldfields with saline seasonal wetlands at the marsh/upland boundary, as well as an apparent collection from a salt evaporator pond. Typical associated species include brass buttons (*Cotula coronipifolia*) and alkali heath, two common species of the upper and middle marsh, as well as the freshwater wetland species downingia (*Downingia* spp.), button celery (*Eryngium* spp.), water starwort (*Callitriche marginata*), and other species of goldfields (*Lasthenia glaberrima, L. fremontii*).

Potential for occurrence in the Study Area. Contra Costa Goldfields is present within the Study Area. Two large colonies associated with grassy seasonal wetlands occur in the Warm Springs unit of the SFBNWR. The Warm Springs portion of the Study Area provides suitable habitat and is included within the vernal pool critical habitat for Contra Costat Goldfields (Unit 8).

Mason's lilaeopsis (*Lilaeopsis masonii*). Federal Status: Species of Concern; State Status: Rare; CNPS Status: List 1B. Mason's lilaeopsis is a small, rhizomatous perennial in the carrot family (Apiaceae). Reaching heights of approximately three inches, plants form dense, turf-like colonies ranging from approximately 50 to over 7500 ft^2 (CDFG 2004a). Inflorescences of white or maroon flowers appear on short (≤1 inch), open umbels from April through November. Mason's lilaeopsis colonizes recently deposited, fine-grained soils on the edges of tidal meanders, sloughs, and saline-influenced reaches of creeks and rivers. This species is not known to occur in the highly saline environment of tidal salt marsh; rather, it favors the edges of marshes with significant fresh water inputs (i.e., the low brackish marsh zone). As such, populations are concentrated in the northern portion of the Bay, particularly in the Delta region, where large expanses of tidal brackish marsh occur.

Mason's lilaeopsis occurs on exposed tidal meanders and flats in the northeastern portion of the San Francisco Bay area. Associated species include marsh pennywort (*Hydrocotyle verticillata*), aquatic pygmy-weed (*Crassula aquatica*), tule (*Schoenoplectus californicus*, formerly known as *Scirpus californicus* var. *acutus*), and rushes (*Juncus* spp.) According to herbarium records catalogued by the University of California, the majority of reported occurrences of Mason's lilaeopsis are in San Joaquin, Sacramento, Contra Costa, and Solano Counties (CalFlora 2004). Although two Alameda County records exist, both apparently refer to a population south of Clifton Court Forebay at the Contra Costa County line (CalFlora 2004; CDFG 2004a).

Historically, creek flows into the South Bay were intermittent, and broad expanses of riparian vegetation and seasonal wetlands ringing the Bay retained runoff of rainwater prior to its reaching the marshes. Extremely high salinities at the edges of South Bay marshes are apparent in the historical distribution of salt pannes and natural salt ponds (San Francisco Estuary Institute 1999). Currently, salinity in the South Bay typically approaches that of seawater (Life Science 2004). This may account for the lack of historical records of Mason's lilaeopsis from the Alameda/San Mateo/Santa Clara counties region, although fringing brackish marshes do occur at Mud Slough, Coyote Creek, Artesian Slough, Alviso Slough, and Guadalupe Slough (Baye et al. 2000), and are currently increasing in extent (H. T. Harvey & Associates 1997b). Furthermore, extensive brackish marsh occurs at Petaluma Marsh, and Mason's lilaeopsis has not been documented there. Detailed studies of the distribution and abundance of this species are not available.

Potential for occurrence in the Study Area. Populations of Mason's lilaeopsis are absent from the South Bay, perhaps due to the lack of appropriate brackish habitat. Because Mason's lilaeopsis has never been documented in the Study Area, it is considered to be absent within the Shoreline Study Area.

Coastal marsh milk-vetch (*Astragalus pycnostachyus* var. *pycnostachyus*). Federal Status: Species of Concern; State Status: None; CNPS Status: List 1B. Coastal marsh milk-vetch is a stout, perennial herb in the pea family (Fabaceae) associated with maritime salt marshes, seeps, and mesic sites within dunes in Humboldt, Marin, and San Mateo counties. Plants have an open, clumping habit and are densely soft-hairy, with long pinnate leaves and distinctive papery, inflated fruits. Many greenish-white or cream colored flowers appear on in the axils of leaves from April through October.

Coastal marsh milk-vetch is known from three locations in coastal San Mateo County (Pescadero Marsh, Pomponio State Beach, San Gregorio State Beach), where plants are associated with sandy-clay or gravelly soils. Little published information is available on the ecological requirements of this plant, but suitable microhabitat apparently occurs within a range of plant communities. One population occurs on a steep slope within coastal scrub, associated with coyote brush (*Baccharis pilularis*), sea lettuce (*Dudleya farinosa*), and sticky monkeyflower (*Mimulus aurentiacus*). The Pescadero Marsh population, on the other hand, persists in a diked area with peripheral halophytes, including alkali heath and marsh gumplant. Approximately ten extant populations/occurrences are documented in Marin and Humboldt counties (CDFG 2004a), predominantly associated with the upper marsh ecotone. Coastal marsh milk-vetch's southern relative, Ventura marsh milkvetch (*A. p.* ssp. *lanosissimus*) is listed as endangered.

Potential for occurrence in the Study Area. Coastal marsh milk-vetch is found exclusively on course substrates such as sandy clay and gravel and has never been observed east of the immediate coast. Despite the relative tolerance of this species to disturbed habitats such as levees, it is considered to be absent from the Study Area due to historical and current patterns of sediment deposition. Furthermore, the Study Area is outside the known range of this species.

Alkali milk-vetch (*Astragalus tener* var. *tener*). Federal Status: None; State Status: None; CNPS Status: List 1B. Alkali milk-vetch is a delicate annual plant associated with vernal pools, alkaline flats, and vernally moist meadows and grasslands in Alameda, Merced, Napa, Solano, and Yolo counties. Plants range in height from two to 12 inches, appearing in late winter as erect or ascending stems with glabrous, pinnately compound leaves. Pinkish-purple flowers appear from March through June, depending on timing of soil saturation/inundation and drying. All taxa within this species complex are associated with moist, vernally mesic soils and are extremely rare.

Alkali milk-vetch is associated with seasonal wetland species such as owl's clover (*Orthocarpus* spp.), downingia, semaphore grass (*Pleuropogon californicus*), and popcorn-flower (*Plagiobothrys* spp.), and occasionally with peripheral halophytes such as salt grass and alkali heath, within alkali meadows. Plants occur on the upper edges of vernal pools, within grasslands underlain by heavy, moisture-retentive clay soils, and within the upper floodplains of rivers. Populations are often associated with, and threatened by, non-native annual grasses and forbs. At least one location, a population of alkali milk-vetch is threatened by management activities for waterfowl, which create perennially-inundated conditions unsuitable for supporting the species (CDFG 2004a). Approximately 30 extant populations/occurrences of alkali milk-vetch are documented by CDFG (2004a). The majority of these occurrences is the result of intensive surveys of historical locations, and is likely an accurate representation of the actual current range of the species.

Potential for Occurrence in the Study Area. Many historical locations of alkali milk-vetch in the South Bay (i.e., Alviso, Milpitas, and "Mayfield", now Palo Alto) are now heavily developed or degraded and, until recently, the species was presumed to be extirpated from the Bay Area. However, a population of alkali milk-vetch was discovered along the upper boundaries of created vernal pools at the Pacific Commons Preserve in 1999 (Wetlands Research Associates 1999). This population has persisted at least through 2006. This site is the location of a historical collection of the species, which likely persisted through years of unfavorable conditions by remaining dormant in the seedbank. It is therefore possible that other sites along the outer edges of the baylands of the Study Area, particularly those within the marsh/upland transition zone, contain viable alkali milk-vetch propagules. Currently suitable vernal pool habitat occurs within the Warm Springs portion of the Shoreline Study Area.

San Joaquin spearscale (*Atriplex joaquiniana*). Federal Status: None; State Status: None; CNPS Status: List 1B. San Joaquin spearscale is an annual, grey-scaly, ascending plant in the goosefoot family (Chenopodiaceae). Like all *Atriplex* species, San Joaquin spearscale lacks petals, and flowers instead appear as dense clusters of fleshy, grey-green perianth parts in terminal inflorescences. This species flowers over a long period from April to October, depending on hydrological characteristics of the associated mesic habitat.

San Joaquin spearscale occurs on moist alkaline soils within a range of habitats, including non-native annual grassland, alkali meadow and scald, alkali sink, and the cut banks of eroded vernal pools. Huge populations occur in the vicinity of the Springtown Wetlands Preserve (in Livermore, CA, which is outside of the Study Area), most commonly associated with alkali heath, alkali weed (*Cressa truxillensis*), saltgrass, and tarweeds (*Centromadia* spp.) (Boursier 1997.). CDFG documents 69 populations/ occurrences of this species, nearly all of which were observed relatively recently and are presumed to be extant (CDFG 2004a).

Potential for Occurrence in the Study Area. San Joaquin spearscale, like alkali milk-vetch, was recently discovered growing along the margins of created vernal pools at the Pacific Commons Preserve in Fremont, adjacent to the Warm Springs Unit of the SFBNWR. Plants occur along the upper edges of created vernal pools, where they are associated with non-native grasses and forbs. No other occurrences are documented in the Study Area. Because the Pacific Commons population likely resulted from an existing seedbank, areas of suitable habitat in the Study Area may harbor dormant populations.

Congdon's tarplant (*Centromadia parryi* ssp. *congdonii*). Federal Status: None; State Status: None; CNPS Status: List 1B. Congdon's tarplant is a spiny, resinous annual herb in the sunflower family associated with moist, alkaline grasslands. Populations are frequently located within sumps or disturbed areas where water collects, and may be favored by moderate levels of disturbance that reduce the cover of non-native grasses and forbs. Unlike many of its community associates, this species matures in late summer and can flower into mid-fall; tarweeds in general are among the latest-blooming wildflowers of the area. Congdon's tarplant can be differentiated from co-occurring species of tarweed by the lack of tack-shaped glands on the leaves and flower bracts and the structure of its chaff scales (dry bracts among individual flowers).

Known populations of Congdon's tarplant occur in Monterey, San Luis Obispo, and Santa Clara counties, where CNNDB documents 62 occurrences. Congdon's tarplant was once common along salt marsh edges in the South Bay (Munz and Keck 1959) and, as evidenced by recent observations of small, remnant colonies, has a slight potential for occurrence on levees and adjacent upland areas throughout the Alviso Complex. Associated species include Italian rye (*Lolium multiflorum*) alkali heath, and salt grass.

Potential for Occurrence in the Study Area. In the Study Area, several populations are known from disturbed annual grassland habitat in the vicinity of Alviso (H. T. Harvey & Associates 2002b; LSA Associates 1999), in the Warm Springs district of Fremont, near Milpitas, and in the Sunnyvale Baylands Park (CDFG 2004a). Congdon's tarplant has been reported from near the mouth of Stevens Creek, where a small, remnant occurrence of a historical population was observed in hard-packed gravel along the levee road north of the end of Crittenden Road (CDFG 2004a). Populations are also known from slightly saline grasslands in the Warm Springs district, and historical observations are reported from Cooley Landing in Menlo Park and from East Palo Alto (in the vicinity of the Ravenswood Complex). Congdon's tarplant is frequently associated with disturbed, alkaline habitats that pond water in the late winter and spring. As such, suitable habitat occurs on the margins of evaporation ponds or within the peripheral halophyte zone along the levees, and several occurrences are noted within the Study Area.

Hispid bird's-beak (*Cordylanthus mollis* ssp. *hispidus*). Federal Status: None; State Status: None; CNPS Status: List 1B. Hispid bird's-beak is a hemiparasitic annual herb in the Scrophulariaceae typically found in meadows and seeps, playas, or valley and foothill grassland habitats in alkaline soils at elevations of five to 155 meters. Plants are bristly and between ten and 40 centimeters, gray-green, often tinged purple, and long-non-glandular hairy. Flowers are whitish and appear from June to September.

Hispid bird's-beak is extirpated from much of the lower San Joaquin Valley (CNPS 2001) and is threatened by agricultural conversion, development, and grazing. No local occurrences exist in CNDDB records (2007). It is expected to occur within saline marshes and flats in the Study Area.

Potential for Occurrence in the Study Area. Due to the general degraded nature or lack of saline flats substrate within the Study Area, the occurrence of Hispid bird's-beak within the Study Area is unlikely.

Recurved larkspur (*Delphinium recurvatum*). Federal Status: None; State Status: None; CNPS Status: List 1B. Recurved larkspur is a perennial herb in the Ranunculaceae typically found in chenopod scrub, cismontane woodland, and valley and foothill grassland habitats in alkaline soils at elevations of three to 750 meters. Plants are between 18 and 85 centimeters, with flowers generally consisting of light-blue sepals and white petals, blooming from March to May.

Recurved larkspur is known from many historical occurrences (CNPS 2001), although much habitat has been converted to agriculture. It is also threatened by grazing. No local occurrences exist in CNDDB records (2007). It is expected to occur within poorly drained, fine, alkaline soils in grassland habitat in the Study Area.

Potential for Occurrence in the Study Area. Due to the general degraded nature or lack of grassland habitat with alkaline soils within the Study Area, the occurrence of recurved larkspur within the Study Area is unlikely.

Delta tule pea (*Lathyrus jepsonii* var. *jepsonii*). Federal Status: Species of Concern; State Status: None; CNPS Status: List 1B. Delta tule pea is a robust, climbing perennial plant in the Pea family (Fabaceae) associated with freshwater and brackish marsh. Plants often occur in large colonies, where they are found twining through associated vegetation or as tangled masses; individual plants can reach six feet in length. Rose-purple flowers appear from May through June, after which plants gradually senesce to overwinter as underground rootstocks. Key characters distinguishing Delta tule pea from common taxa, include the co-occurring California tule pea, are compound leaves with elongated tendrils and ten to 16 leaflets, broadly-winged stems, and lack of hairs on the stems and leaves.

Populations of Delta tule pea are restricted to the edges of marshes and sloughs with significant freshwater inputs. Plants typically occur in relatively well-drained areas, often on slight topographic relief above the marsh plain (Baye et al. 2000), and are most frequently associated with cattail, bulrush, California rose (*Rosa californica*), and coyote brush (*Baccharis pilularis*). Several populations are associated with plants more typical of the high salt marsh, including saltgrass, pickleweed, and jaumea. The center of population distribution is in the Delta region, where plants may co-occur with other rare species such as Suisun Marsh aster (*Aster lentus*) and Mason's lilaeopsis. Delta tule pea is reported to occur in the vicinity of Niles in Alameda County, but is considered extirpated in Santa Clara County (CNPS 2001).

*Potential for Occurrence in the Study Area***:** Although reportedly extant in Alameda County (CNPS 2001), no populations of Delta tule pea have been documented in the South Bay area (CDFG 2004a). Like Mason's lilaeopsis, Delta tule pea is associated with a brackish to freshwater marsh habitat that was never common in the Study Area and is considered to be absent from the area.

Prostrate navarretia (*Navarretia prostrata*). Federal Status: Species of Concern; State Status: None; CNPS Status: List 1B. Prostrate navarretia is a small annual herb in the Phlox family (*Polemoniaceae*) associated with vernal pools and mesic, alkaline areas within grassland. Plants have a stalkless, central flower head with many prostrate flowering branches spreading radially from beneath, and leaves are long, narrow, and deeply pinnately-lobed. White to violet flowers appear from April through July as dense clusters surrounded by spiny bracts.

Prostrate navarretia is associated with relatively coarse-grained sediments in small depressions within mesic areas. Associated species include the typical vernal pool indicator species coyote-thistle (*Eryngium vaseyi*), popcorn-flower (*Plagiobothrys* spp.), and spike rush (*Eleocharis macrostachya*). The majority of known populations of prostrate navarretia occur in southern California, where plants are associated with the large vernal pool complexes of the Santa Rosa Plateau, mima mound topography in Los Angeles County, and mesas south through San Diego. Significant populations also occur on military lands in southern Monterey County and at the Kesterson National Wildlife Refuge near Merced. In the South Bay area, prostrate navarretia is known only from the seasonal wetlands and created vernal pools at the Pacific Commons Preserve.

*Potential for Occurrence in the Study Area***:** Populations of prostrate navarretia occur in the Study Area within the Warm Springs unit of the SFBNWR. This species is also present in the immediately adjacent Pacific Commons Preserve. Currently the Warm Springs area presents the only potentially suitable habitat within the Shoreline Study Area.

Delta woolly-marbles (*Psilocarphys brevissimus* var. *multiflorus*). Federal Status: None; State Status: None; CNPS Status: List 4. Delta woolly-marbles is an annual, vernal-pool endemic in the Sunflower family (Asteraceae) with silky-hairy foliage and several spreading stems from the base. Plants are grey-green throughout and produce small (less than 1 centimeter) oval heads of pale, cobweb-like flowers from May through June. Delta woolly-marbles occur along the drying edges of vernal pools within grassland.

Potential for Occurrence in the Study Area: Populations are not known, or expected, to occur in the Study Area. While vernal pool habitat occurs in the Study Area (e.g., in the Warm Springs unit of the SFBNWR) and its vicinity (e.g., in the Pacific Commons Preserve), none of these areas currently support populations of Delta woolly marbles. With no known seed source, it is highly unlikely that this species would naturally colonize the Study Area.

Saline clover (*Trifolium depauperatum* var. *hydrophilum*). Federal Status: Species of Concern; State Status: None; CNPS Status: List 1B. Saline clover is a very small, fleshy annual plant in the Pea family. Plants are decumbent to erect, with pink-purple, white-tipped flowers appearing from April through June. Flowers become inflated as fruits mature.

This species is associated with saline-alkaline soils within grasslands, seasonal wetlands, and, at Moss Landing in Monterey County, along the margins of upper salt marsh habitat. Throughout most of its known range, saline clover is associated with typical seasonal wetland plants such as meadow barley (*Hordeum brachyantherum*), semaphore grass, and downingia, or with alkali associations of brass buttons, saltgrass, and Italian rye. Populations near Moss Landing occur at the brackish marsh-grassland ecotone.

Potential for Occurrence in the Study Area. Historical records of saline clover from seasonal wetlands in the Belmont and Alameda areas document extirpated populations; and no extant populations are known from the South Bay area. While potential habitat is present in the Study Area, there are no known occurrences of the species in the vicinity. With no known seed source, it is highly unlikely that this species would naturally colonize the Study Area, despite the presence of suitable habitat.

3.4.2 Occurrence of Non-native Plant Species within the Shoreline Study Area

Research has shown that a number of variables control the distribution of plant species in coastal marshes, including depth and duration of flooding over the marsh surface (Mendelssohn and McKee 1988; Pennings and Callaway 1992; Webb and Mendelssohn 1996; Webb et al. 1995), accumulation of phytotoxins such as hydrogen sulfide in marsh soils (DeLaune et al. 1983; King et al. 1982; Koch and Mendelssohn 1989; Webb and Mendelssohn 1996; Webb et al. 1995), interstitial nutrient concentrations (Bradley and Morris 1990; Koch and Mendelssohn 1989; Koch et al. 1990; Morris 1980), and soil mineral and organic matter content (DeLaune et al. 1979; Nyman et al. 1990). Natural variability in abiotic factors such as precipitation, tidal fluctuation, and evapotranspiration, as well as anthropogenic changes to those factors such as freshwater discharges, non-point source pollution (nutrients and sediments), and regional/global climate changes (drought, temperature, sea level) influence these variables (Boyer and Zedler 1999, Kennish 2001). Among these variables, hydroperiod and salinity are the primary abiotic factors that control the distribution of the dominant plant species in a tidal marsh (H. T. Harvey & Associates et al. 1982; Josselyn and San Francisco State Univ. 1983; Zedler et al. 1992; Zedler et al. 1999).

Competition between different plant species (interspecific) with similar environmental tolerances also influences their distribution. Although environmental tolerance and competitive ability are inversely related (Bertness 1991; Grace and Wetzel 1981; Zedler 1982), competition still plays a role among species with similar environmental tolerances (Ervin and Wetzel 2002). For example, Zedler (1982) found that competitive interactions occur in salt marshes, and concluded that pickleweed does compete with cordgrass for light and, to some extent, nutrients. Furthermore, competitive interaction is what allows for the successful invasion of non-indigeneous species into wetland habitat and the subsequent alteration of plant distribution that is commonly observed (Vitousek 1990, Hooper and Vitousek 1997).

Many invasive plant species are known to occur or may potentially occur within the Shoreline Study Area. These species out-compete native plants, displacing entire communities of plants and associated wildlife. Control of these species is important throughout the Shoreline Study Area. While the scope of this analysis does not include a species-by-species prescription for removal, the California Invasive Plant Council (Cal-IPC) publishes the Weed Worker's Handbook (1994) describes the biology and tested methods of removal for 35 of the most noxious weeds in the Bay Area. The following species occur or may occur within the Shoreline Study Area: 1) Salt wheatgrass (*Agropyron elongatum*) has been planted along many levees to stabilize levee banks throughout the San Francisco Bay, and has spread in areas near Union City and along the levee slopes within the Palo Alto floodbasin; 2) Perennial pepperweed (*Lepidium latifoium*) has invaded many wetland areas within the San Francisco Bay, including areas within the Shoreline Study Area, but also occurs in upland areas with ruderal grassland habitat dominated by Italian ryegrass, varius non-native bromes, Mediterranean barley, and wild oats; 3) black mustard (*Brassica nigra*) and wild radish (*Raphanus sativus*) dominate the banks of the levees within much of the Shoreline Study Area; 4) non-native smooth cordgrass (*Spartina alternifolia*) and hybrids between smooth and Pacific cordgrass have spread throughout tidal salt marshes in much of the San Francisco Bay area, and the Invasive Spartina Project is actively engaged in controlling this non-native; 5) pampas grass (*Cortaderia* sp.) occurs in ruderal areas including adjacent to developed areas; 6) French broom (*Genista monspessulana*) and Scotch broom (*Cytisus scoparius*) occur in upland, disturbed areas; 7) giant reed (*Arundo donax*) invades freshwater marsh and creeks; 8) sweet fennel (Foeniculum vulgare) spreads quickly within ruderal areas; 9) common reed (*Phragmites australis*) which may have strains that are not native to California and which has invaded portions of the Palo Alto Flood Basin; and, 9) yellow star-thistle (*Centaurea solstitialis*), purple star-thistle (*Centaurea calcitrapa*), and Italian thistle (*Carduus pycnocephalus*) quickly invade and dominate grassland areas. With the restoration of the SBSP areas and this Shoreline Study, documentation of infestation by non-native plant species should allow for better planning of the removal/containment of these species.

4. WILDLIFE RESOURCES

4.1 Introduction

The San Francisco Estuary is an extremely productive, diverse ecosystem. Despite the loss of more than 90% of its original wetlands to diking, draining, and filling (Goals Project 1999; Harvey et al. 1988), wildlife diversity is high, with more than 250 species of birds, 120 species of fish, 81 mammals, 30 reptiles, and 14 amphibians regularly occurring in the estuary (Siegel and Bachand 2002). More importantly, the San Francisco Bay supports populations of a number of species that are of regional, hemispheric, or even global importance. A number of endemic, endangered, threatened, and rare wildlife species or subspecies reside in the San Francisco Bay area.

Though surrounded by urban development and highly altered by the diking of wetlands for salt production, the South Bay supports some of the most important remaining habitat in the entire estuary for a number of special-status wildlife species. In this section, the existing conditions of wildlife resources in the South Bay are described, specifically pointing to the species composition and structure of invertebrate, fish, reptile, amphibian, mammal, and bird communities. The life histories and habitat requirements of these species are also described, as well as the spatial and temporal variation in their presence/distribution in the region. In addition, the occurrence of special-status wildlife species within the South Bay is summarized.

Slight variations in microhabitat conditions, plant structure, or species composition occur within the various habitat types of the South Bay (see Section 3.3). Such variations may result in important changes in ecological conditions that affect wildlife populations and communities. However, as they pertain to wildlife use of the Study Area, the previously described habitat types can generally be divided into several broad categories: open waters of the Bay, tidal sloughs and channels, intertidal mudflats, vegetated tidal marsh, salt ponds, vernal pool grasslands, riparian habitats, and upland habitats. Note that existing South Bay salt ponds (and former salt ponds) provide habitat that is used by large numbers of a number of wildlife species, particulary birds. Thus, in the descriptions of wildlife habitat use within Shoreline Study Area, salt ponds are included and the interchange that occurs between these and other habitats in the region is discussed. The freshwater stream, riparian, and vernal pool resources within the Study Area are also discussed.

4.1.1 Overview of Wildlife Resources in the South Bay

The ecology of South Bay wildlife communities is characterized by:

- High productivity of tidal marshes, with export of organic matter from tidal marshes to tidal sloughs, channels, and mudflats, and to the Bay, supporting high abundance of invertebrates, fish, and birds.
- High productivity of salt ponds and former salt ponds, supporting an abundance of invertebrates (particularly in higher-salinity ponds) and high numbers of fish in lower-salinity ponds, but with

virtually no export of organic matter to other habitats aside from variable (and at times, very heavy) use of the salt ponds by birds.

- A heavily invaded aquatic invertebrate community dominated by non-native species, particularly in the estuarine and salt pond habitats.
- Heavy use of South Bay habitats by waterbirds, including significant proportions of Pacific Coast migratory shorebird populations.
- Highly dynamic bird and fish communities, with use of different areas varying several times a day with tide height, and with abundance and community composition varying seasonally depending on migration, precipitation, temperature, salinity, and other factors. In particular, large numbers of shorebirds forage on intertidal mudflats at low tide and use salt ponds and other alternative habitats (e.g., water treatment plant ponds) for roosting and/or foraging, particularly at high tide, and steelhead use bay habitats during their migrations as adults to spawn in tributaries and as juveniles moving from tributaries to the sea.
- The presence of rare San Francisco Bay endemics, including the California clapper rail and salt marsh harvest mouse, in remnant tidal marsh habitat.
- The presence of rare vernal pool-associated species, including the vernal pool tadpole shrimp and California tiger salamander, in vernal pools within the Warm Springs unit of the SFBNWR.
- The presence of several freshwater streams flowing into the South Bay; woody riparian habitat is limited to narrow corridors, or is highly degraded or even absent, along these streams, although moderately high-quality riparian habitat is present along lower Coyote Creek, and riparian habitats in the Study Area support very high densities of birds.

In summary, the diversity and high productivity of habitat types present within the South Bay support a diverse assortment of wildlife species in surprisingly large numbers. A detailed discussion of the biology of wildlife species present within the Study Area is provided below.

4.2 Methods

Resource agencies such as the USFWS, CDFG, and the U.S. Geological Survey; non-profit organizations and research groups such as PRBO and SFBBO; consultants working for private landowners, municipalities, and public resource agencies; researchers; and private individuals (e.g., birders) together have collected a vast amount of data on wildlife use of the South Bay. Much of the data on the wildlife species and communities of the South Bay were summarized for the Goals Project (2000). In preparing this existing conditions document, the team relied primarily on previously collected information rather than fieldwork conducted specifically for the preparation of this document. However, the wildlife ecologists have a solid understanding of the wildlife and habitats of the South Bay during all seasons. Reconnaissance-level wildlife surveys by foot and car were performed during summer and fall 2004 for the existing conditions report for the South Bay Salt Ponds Project. H.T. Harvey & Associates ecologists have made numerous visits to the Study Area since that time, and additional surveys were conducted in March 2007 specifically to assess wildlife habitat in portions of the Shoreline Study Area outside the SBSP Project Area.

4.3 Description of Wildlife Communities in the South Bay

4.3.1 Invertebrates

Invertebrate communities of the South Bay are important consumers, controlling phytoplankton biomass in the Bay, and are key prey for fish and birds. They are also important in nutrient and contaminant recycling and the accumulation of contaminants (Thompson and Shouse 2004). Invertebrate communities vary considerably among different habitats in the South Bay. This section includes a separate description of invertebrates in subtidal/intertidal habitats, tidal marshes, salt ponds, terrestrial habitats, and freshwater habitats, as well as a discussion of invasive invertebrates and mosquitoes.

Subtidal/Intertidal Invertebrate Communities. Intertidal mudflats contain three main groups of invertebrates: benthic infauna (less mobile invertebrates living in or on the mudflats), epifauna (more mobile species on the mud's surface), and pelagic fauna (highly mobile species living in the water column). Most research has focused on benthic infauna. Because of the instability caused by nearly constant erosion and deposition of sediments, as well as dramatic fluctuations in salinity, benthic infauna are dominated by species that can easily colonize mudflats, many of which are non-native species (Nichols 1979). Within the San Francisco Estuary, the South Bay contains by far the highest invertebrate biomass, likely due to greater stability of salinity and sediments, large detritus biomass, and the abundance of several introduced bivalve species (Nichols 1979; Nichols and Pamatmat 1988). The estimated biomass of invertebrates in the South Bay in winter (637 g/0.1m^2) and summer (609 g/0.1m^2) is nearly six times that for the Central Bay, San Pablo Bay, and Suisun Bay combined (115 g/0.1m^2 and 112 g/0.1m^2 in winter and summer, respectively) (Meiorin et al. 1991; Nichols and Pamatmat 1988). Studying infaunal productivity on mudflats in the South Bay, Nichols (1979) determined rates of annual productivity varying from 53 to 100 grams/meter^2/year. Although biomass was dominated by two or three common bivalves, the standing crop of invertebrates was abundant throughout the year. Migratory shorebirds were thought to be the primary consumers of invertebrate biomass on South Bay mudflats.

Much of the food for benthic invertebrates on mudflats of the South Bay comes from phytoplankton that settle to the bottom of the water column (Meiorin et al. 1991) and diatoms and blue-green algae growing on the surface of the sediment (Nichols and Pamatmat 1988). Both phytoplankton and microalgae blooms occur in the South Bay primarily in spring, in turn supporting large numbers of filter-feeders (Nichols and Pamatmat 1988). The South Bay tidal invertebrate community is dominated primarily by filter/suspension feeders such as shrimp, clams, and mussels that obtain food from phytoplankton and organic debris and bacteria, and deposit feeders, which include worms and some clams that obtain food primarily from organic debris on the surface of the mud.

Several studies of the infaunal invertebrate communities of South Bay mudflats have been conducted. Nichols and Pamatmat (1988) and Nichols and Thompson (Nichols and Thompson 1985a; Nichols and Thompson 1985b) determined that the numerically dominant species on mudflats in the vicinity of the Alviso salt ponds are the gem clam (*Gemma gemma*), the amphipod *Ampelisca abdita*, and the polychaete worm *Streblospio benedicti*. Although less abundant, the Baltic clam (*Macoma balthica/petulam*), soft-shelled clam (*Mya arenaria*), and eastern mud snail (*Illyanassa obsoleta*) "often represent the bulk of benthic invertebrate biomass" (Nichols and Thompson 1985a). All of these dominant species except for the Baltic clam are introduced.

The benthic infaunal community has been studied in the South Bay at three stations on intertidal mudflats near the Palo Alto Water Quality Control Plant since 1974 (Thompson and Shouse 2004). The number of invertebrate species at each of three stations ranged from ten to 16 and included five bivalves, one cnidarian, seven crustaceans, two gastropods, and 14 polychaetes and oligochaetes. *Gemma*, *Streblospio* and *Ampelisca* dominated the community until the 1980s, but since 1998 *Gemma* has been the overwhelming dominant on the Palo Alto flats. Since trace element concentrations at the plant were reduced in the mid-1980s, this research has noted a substantial decline in metals accumulation in the Baltic clam and an increase in the species' reproductive activity (Hornberger et al. 2000).

Sampling nearby areas along lower San Francisquito Creek and the Palo Alto Water Quality Control Plant outfall channel, Cressey (1997) had somewhat different results. He found simple invertebrate communities in these areas, with the most abundant taxa consisting of four annelids (*Neanthes succinea*, *Eteoni lighti*, *Tubificidae* sp., and *Heteromastus filiformis*), three arthropods (*Nippoleucon hinumensis*, *Corophium alienense*, and *Grandidierella japonica*), and two mollusks (the Baltic clam and the Asian clam *Potamocurbula amurensis*); all except the Asian clam were found at all stations in both channels, in a variety of salinities from one to 27 ppt. The 1994-1996 Benthic Pilot Study of San Francisco Estuary Regional Monitoring Program (1997) found that in muddy estuarine sediments of the South Bay, the most abundant species were *Potamocurbula amurensis*, *Ampelisca abdita*, *Nippoleucon hinumensis*, *Corophium heteroceratum*, *C. alienense*, *Grandidierella japonica*, *Balanus improvisus*, *Tubificidae* sp., *Neanthes succinea*, and *Streblospio benedicti*.

More recently, the USGS sampled invertebrates in eight South Bay sloughs in 2004 (Takekawa et al. 2005). *Heteromastus*, *Streblospio*, and Tubeficoides were the dominant taxa in these sloughs. The clam *Gemma gemma* was numerous in Mt. Eden Creek and Alameda Creek. *Macoma balthica* was present in all sloughs sampled. Low insect diversity was observed; insects were recorded in only three sloughs, with four species in Mt. Eden Creek representing the highest diversity in any of the sloughs sampled.

Bivalve mollusks, which represent the majority of the invertebrate biomass of the San Francisco Estuary (Nichols 1979), are primarily filter feeders, taking in large quantities of phytoplankton. A variety of clams and mussels, many of which are introduced, occur in the South Bay. Of the native species, the Baltic clam is the only one that is still common in the South Bay. The Baltic clam is the largest-bodied infaunal invertebrate in the South Bay and thus contributes significantly to the biomass of the region. It is eaten by birds (Painter 1966) and bat rays (*Myliobatus californica*) (Thompson and Shouse 2004) and likely by a number of other fish species as well. In the mid-1800s, the eastern oyster (*Crassostrea virginica*) and Pacific oyster (*C. gigas*) were introduced into San Francisco Bay, replacing much of the fishery for the native oyster (*Ostrea lurida*). Until around 1910, extensive oyster beds were located in the South Bay south of Dumbarton Bridge, and off Eden Landing and Redwood City. However, the introduced oysters declined in the early 1900s due in part to reduced Bay water quality; the loss of marshes may have also influenced the decline in oyster populations, as much of the oysters' food is detritus that is derived from tidal marshes (Harvey et al. 1977) . A native oyster bed was present in Salt Pond A-9 in Alviso until the 1970s (Laine, pers. comm.).

Thompson (1999), studying the spatial and temporal distribution of bivalves in the South Bay (primarily between the San Mateo and Dumbarton Bridges but with some stations scattered throughout the far South Bay, from 1991 to 1995), found that bivalves mostly disappeared from shallower areas in winter and spring; they declined in, but did not disappear from, deeper areas in winter. Recruitment varied among years, but was more likely to be limited in higher-elevation mudflats in some years than in deeper mudflats closer to channels, possibly due to predation by shorebirds and bat rays. Thompson and Shouse (2004) hypothesized that recruitment of bivalves onto South Bay mudflats where they are available to birds is dependent on the abundance of adult bivalves in deeper water and circulation patterns that transport larvae from either deeper water or from North Bay areas.

Tidal invertebrates in South Bay estuarine habitats must either be able to tolerate daily and seasonal changes in salinity (e.g., benthic invertebrates) or be mobile enough to follow preferred salinities. During particularly wet years, species intolerant of fresher water (e.g., *Mya arenaria*, *Corophium acherusicum*, *Ampelisca abdita*, and *Streblospio benedicti*) virtually disappear from portions of the upper San Pablo Bay and shallow areas of the Bay. During a two-year drought, these same species colonized Suisun Bay, which is usually too fresh for these species (Nichols and Thompson 1985a). Similarly, Hopkins (1987) noted that several intertidal invertebrate species disappeared during an unusually wet winter but had re-established the following year under normal conditions; two of his four intertidal study sites were near Palo Alto and Hayward. In contrast, limited observational data following unplanned breaches of Napa ponds 2a and 3, with releases of water having salinity of 50 and >60 ppt into South Slough, revealed no extensive losses of benthic invertebrates, suggesting that this elevated salinity did not have a significant impact on benthics.

The epifaunal invertebrate community in the South Bay is dominated by several species of shrimps and crabs. Two native caridean shrimps, the California bay shrimp (*Crangon franciscorum*) and blacktail bay shrimp (*C. nigricauda*), are common in tidal sloughs and in the Bay itself. The California bay shrimp supports the only commercial fishery remaining in the South Bay aside from the limited harvest of brine shrimp that occurs in salt ponds (as discussed below). Each year, two to four boats are involved in shrimping in the South Bay, catching approximately 75,000 lb valued between $154K and $312K per year (Hansen 2003), although shrimping activity and success have declined in recent decades (Laine, pers. comm.). Most shrimping activity occurs between the Dumbarton Bridge and Calaveras Point, with limited activity above Calaveras Point in Coyote Creek (Hansen 2003).

According to Hatfield (1985), adult California bay shrimp spawn in the ocean in March and April. The planktonic larvae are carried into the San Francisco Bay by tides, and by currents into the Suisun and South Bays. Juvenile bay shrimp arrive in the South Bay in May, and use shallow waters having lower salinities as nurseries. These juveniles migrate up sloughs to brackish water, seeking out waters with salinities of three to 19 ppt, preferring a range of ten to 15 ppt (Baxter et al. 1999). Thus, they use the Guadalupe, Alviso, and Coyote Slough systems, and likely other South Bay tributaries as well, for feeding and growth through the summer. As they mature, the shrimp migrate to deeper, more saline Bay waters until they migrate out of the Bay to spawn in the ocean in winter (Baxter et al. 1999; Kinnetic Laboratories 1987). California bay shrimp are present in the South Bay year-round, but they are most abundant September-October and least abundant March-April (Hansen 2003). Bay shrimp are sensitive to changes in salinity and water quality, and may abandon sloughs in the far South Bay for deeper, more saline waters during periods of high freshwater runoff. Effluent from wastewater treatment plants may have altered the distribution of bay shrimp as well, as this species has declined in abundance in the far South Bay in recent decades (Laine, pers. comm.).

Crabs of South Bay tidal habitats include the yellow shore crab (*Hemigrapsus oregonensis*), lined shore crab (*Pachygrapsus crassipes*), Dungeness crab (*Cancer magister*), brown rock crab (*Cancer antennarius*), red rock crab (*Cancer productus*), and several introduced species, including the xanthid crab (*Rothropanopeus harrisii*), Chinese mitten crab (*Eriocheir sinensis*), and European green crab (*Carcinus maenas*) (Josselyn and San Francisco State Univ. 1983). Most of these species forage both in tidal sloughs and on mudflats and deeper waters of the South Bay. Although Dungeness crabs, and particularly larger individuals, occur much more commonly in the north and central Bay, this species was historically more common in the South Bay (i.e., into the 1970s) (Laine, pers. comm.). The *Cancer* crabs do not support a fishery within the South Bay, but use of South Bay marshes by juveniles of these species, and detrital export to the Central Bay from South Bay marshes, may help to support the economically important ocean fishery for these crabs. Crabs tagged as juveniles in the Bay have been caught by commercial fishermen in the ocean (Harvey et al. 1977). Furthermore, Dungeness crabs in the Bay mature nearly twice as fast as populations outside the Bay, presumably because of higher Bay water temperatures but possibly also due to the high productivity of the estuary (Life Science 2004). Early larval stages of the Dungeness crab are currently limited primarily to the Central Bay, but later planktonic larvae and juveniles may be found throughout the Bay (Life Science 2004).

The California Department of Fish and Game has conducted a fishery survey for shrimp and crabs within the San Francisco Bay since 1980, with monthly surveys in deeper subtidal areas and some beach seine sampling (CDFG data Life Science 2004). These surveys include data from three open-water stations (Stations 102, 101, and 140) located near the San Mateo and Dumbarton Bridges, and two beach seine stations (171 and 172) also located in the South Bay. Between 1980 and 2001, Dungeness crabs accounted for 52.6, 43.8, and 73.3% of crabs caught at Stations 101, 102, and 140. Chinese mitten crabs were 42.1, 12.5, and 18.8% of the total crab captures at these stations. Graceful rock crabs (*Cancer gracilis*) and brown rock crabs were, collectively, 18.8% of the total catch at Station 102 but <3% of the crab catch at the other two stations. California bay shrimp accounted for 79.5, 58.8, and 78.7% of shrimp captures at Stations 101, 102, and 140, while blacktail bay shrimp were 12.8, 34.2, and 14.0% of captures. Other shrimp species, including blackspotted bay shrimp (*Crangon nigromaculata*), oriental shrimp (*Palaemon macrodactylus*), stout coastal shrimp (*Heptacarpus brevirostris*), miniature spinyhead (*Mesocrangon munitella*), ridgetail prawn (*Exopalaemon carinicauda*), and visored shrimp (*Betasus longidactylus*), were all represented but were much less abundant in the South Bay.

Tidal Marsh Invertebrate Communities. The invertebrates of the vegetated portions of tidal salt and brackish marshes, which include benthic infauna, epifauna, and terrestrial species, have not received as much study as those of intertidal habitats, in part because much of the invertebrate biomass within tidal marshes occurs within the intertidal and subtidal zones of sloughs and smaller marsh channels. However, tidal salt marsh invertebrates perform a variety of important ecological services, as discussed by Maffei (2000b).

Within tidal salt marshes in the South Bay, common invertebrates include the ribbed mussel (*Ischadium demissum*), the Baltic clam, the mud snail (*Illyanassa obsoleta*), and the yellow shore crab (*Hemigrapsus oregonensis*) (Niesen and Lyke 1981). The introduced ribbed mussel is common within the lower zone of tidal marshes (among Pacific cordgrass), and the Baltic clam may occur up into the cordgrass zone as well (Josselyn and San Francisco State Univ. 1983; Vassallo 1969). The native hornsnail *Cerithidea californica* formerly occurred in pickleweed marshes and on mudflats throughout much of the Bay, but it has been displaced from much of its former habitat and range by the introduced mud snail, and it is now restricted to high salt pannes in the South Bay (Race 1981). The mud snail is abundant in intertidal habitats and sloughs. The marsh snails *Assiminea californica* and *Ovatella myosotis* inhabit dense pickleweed marshes (Fowler 1977). Several amphipod species, including *Anisogammarus confervicolus*, *Orchestria traskiana*, *Hyale plumulosa*, and *Grandidierella japonica*, occur within the ground litter in pickleweed-dominated marshes (Josselyn and San Francisco State Univ. 1983). The amphipod *Traskorchestia traskiana* is abundant in at least some pickleweed marshes of the San Francisco Bay (Obrebski et al. 2000). This detritivore tolerates salinities up to 50 ppt (Koch 1989), and is one of the only invertebrates known to consume pickleweed (Page 1997).

Terrestrial invertebrate assemblages of salt marshes are dominated by a variety of insects and spiders. Diptera (true flies) are a major component of South Bay cordgrass/pickleweed marshes, while the orders Homoptera (plant hoppers and aphids) and Lepidoptera (butterflies and moths) are also well represented (Lane 1969). Reticulate water boatmen, brine flies, chironomid midges, and other species dominate open-water areas such as marsh ponds within the tidal marsh (Barnby et al. 1985; Maffei 2000b).

Detritus from macrophytic vegetation in the tidal marsh is an important component of the food web of the tidal marsh itself, as Teal (1962) demonstrated in Atlantic tidal salt marshes. Cameron (1972) determined that half of the detritus produced in San Pablo Bay marshes was exported out of the marsh, where it serves as an extremely important source of nutrients and carbon for the aquatic components of the Bay ecosystem (Harvey et al. 1977; Warwick and Price 1975).

Salt Pond Invertebrate Communities. Invertebrate communities in South Bay salt ponds have been extensively studied (Carpelan 1957; Anderson 1970; Swarth et al. 1982; Lonzarich and Smith 1997). Carpelan (1957), studied the floral and faunal communities in six Alviso salt ponds ranging in salinity from a mean of 27.5 ppt in the intake ponds to 94 ppt in the highest-salinity pond. Only one vascular plant species, wigeon grass, was present in this study; it only occurred one of the lower-salinity ponds for a brief period in mid-summer. Thus, the flora of the salt ponds is dominated by the macroscopic green algae *Rhizoclonium* and *Enteromorpha* in the lower-salinity ponds and by unicellular algae, particularly *Stichococcus bacilaris*, in higher-salinity ponds.

In salt ponds, invertebrate species richness decreases, and biomass increases (to a point) as salinity increases, primarily because of the increase in brine shrimp (Anderson 1970; Britton and Johnson 1987; Carpelan 1957; Lonzarich 1989; Swarth et al. 1982; Williams et al. 1990). In lower-salinity ponds, numerous nematodes occur in decaying organic matter and mud. The most prevalent worm in lower-salinity ponds is the polychaete *Polydora ligni*. This polychaete serves as prey for fish and the nemertinean *Tubulanus sexlineatus*, which is common in decomposing algae in the lowest-salinity ponds. Carpelan (1957) found few mollusks within the salt ponds. The introduced mud snail, which was abundant on the adjacent tidal mudflats, was found in scattered areas, although in its limited areas of distribution it was the dominant benthic species. Anderson (1970) reported that mud snails did not survive long in the Newark-area ponds he studied, and that although the ribbed mussel and native oyster were present in the adjacent slough, they did not become established in the intake ponds. A number of other non-arthropod species of varying abundance, including roundworms, rotifers, protozoans, and coelenterates, occur throughout the salt ponds (Anderson 1970; Carpelan 1957).

A survey of benthic invertebrates in Alviso salt ponds by Lonzarich (1989) found three mollusks (*Gemma gemma*, *Ilyanassa obsoleta*, and *Tryonia imitator*), two annelids (*Nereis succinea* and *Tubificoides* sp.), and six crustaceans (*Anisogammarus confervicolus*, *Crangon* sp., *Hemigrapsus oregonensis*, *Ostracoda* sp., *Palaemon macrodactylus*, and *Sphaeroma quoyana*) in ponds that seasonally reached salinities of 40 ppt, but not in higher-salinity ponds. Only the annelid *Polydora ligni* and the crustaceans *Artemia franciscana*, *Balanus* sp., *Copepoda* sp., and *Corophium* sp. tolerated salinities in the ponds that averaged 22-84 ppt.

Studying North Bay salt ponds, Takekawa et al. (2004) recorded 20 zooplankton taxa, with more taxa in lower-salinity ponds and highest abundance at mid-salinities. Copepods and brine shrimp accounted for 66.1 and 28.2% of all zooplankton sampled; copepods dominated low and mid-salinity ponds (23-48 ppt), while brine shrimp dominated higher-salinity ponds (170 ppt). Brine flies were also common in higher-salinity ponds. Total zooplankton abundance was highest in spring and early summer, with biomass several orders of magnitude higher in a pond having a salinity of 170 ppt than in lower-salinity ponds due to the abundance of brine shrimp. The diversity of macroinvertebrates was also higher in lower-salinity ponds (23 ppt), which contained 50-55 taxa (only three to four at high densities, including the polychaete *Heteromastus*, the bivalve *Gemma*, and the amphipods *Corophium* and *Ericthonius*). Mid-salinity ponds (48 ppt) contained 25 taxa dominated by the polychaetes *Polydora*, *Capitella*, and *Streblospio*, by *Corophium*, and by water boatmen, while a high-salinity pond (170 ppt) contained 12 taxa dominated by brine shrimp and brine flies.

Sampling of South Bay salt ponds between 2003 and 2005, Takekawa et al. (2005) recorded 58 taxonomic groups of macroinvertebrates. Crustaceans were the best represented group, with 17 taxa, followed by 12 annelid taxa; these taxa were predominantly in lower-salinity ponds (i.e., below 60 ppt). Five species of bivalves and nine insect families were also recorded, with overall taxa richness occurring in the ponds with the lowest salinity (27-44 ppt).

Arthropods are the dominant, and ecologically most important, group of invertebrates inhabiting salt ponds in the South Bay. The brine shrimp (*Artemia franciscana*) is the predominant animal in higher-salinity ponds. Although it can occur in salinities near that of seawater (Persoone and Sorgeloos 1980), the brine shrimp's aquatic predators (e.g., insects such as water boatmen) are more abundant in less saline water (Wurtsbaugh 1992), allowing brine shrimp to reach high densities only in their optimal hypersaline environments (70 to 170 ppt) (Carpelan 1957). Herbst (2001) found water boatmen to be most abundant in lower-salinity ponds while brine shrimp were most abundant in moderate to high salinity salt ponds in the Mojave Desert. Brine shrimp are absent from crystallizer ponds with salinities exceeding 200 ppt (Larsson 2000). Historically, brine shrimp occurred in the San Francisco Bay area in salt pannes and ponds with hypersaline conditions. They still occur in these natural features within tidal salt marshes in the South Bay, in addition to salt ponds.

Carpelan (1957) estimated that brine shrimp in the Alviso salt ponds produced up to eight generations/year, with winter eggs having delayed hatching. Larsson (2000) reported that females produce an average of ten broods during their 50-75 day lifespan in the lab, although under natural conditions three to four broods may be more likely. Productivity of brine shrimp in the highest-salinity pond in Carpelan's study area was estimated at 56 lb/acre/year. Brine shrimp are so abundant in some ponds that they have supported a small commercial industry, primarily as food for aquarium fish. According to Thomas Laine (pers. comm.), these shrimping operations can regularly obtain 10,000-13,000 lb of shrimp per day, with two people once collecting 27,000 lb in a day in South Bay ponds, and a 42-day operation netting 500,000 lb of brine shrimp in South Bay salt ponds. Brine shrimp are still harvested in Newark salt ponds, where they fetch $0.55/lb (Laine, pers. comm.).

Two insect groups are also important components of the South Bay invertebrate fauna due to numerical abundance and importance to foraging birds. Adult reticulate water boatmen inhabit salt ponds year-round. Carpelan (1957) found that egg-laying occurs in spring, summer, and fall, with the main hatch in spring; many nymphs are observed in April and May. Water boatmen have been reported to occur in water ranging from brackish to 170 ppt (Carpelan 1957; Cox 1969; Jang 1977), and Carpelan (1957) found them in Alviso salt ponds with salinities from 23 to 153 ppt. However, they occur and reproduce in greatest abundance in ponds with salinities between 35 and 80 ppt (Maffei 2000c). A number of species of brine flies occur within the San Francisco Bay area; the most common species within the Shoreline Study Area are *Ephydra millbrae*, *E. cinerea*, and *Lipochaeta slossonae*, which occur in variable numbers in natural salt pannes and marsh ponds, and in artificial salt ponds and crystallizers (Carpelan 1957; Maffei 2000b). *E. millbrae* has been reported to occur in pools with salinity concentrations up to 42 ppt (Jones 1906), while *E. cinerea* and *Lipochaeta slossonae* occur in saline and hypersaline environments, with *Lipochaeta* found commonly in crystallizers (Maffei 2000a). Even as adults, water boatmen are primarily aquatic, although they can fly. In the South Bay, adult brine flies become common by early March and can be seen in dense swarms on the edges of high-salinity ponds from April through September (Swarth et al. 1982).

The biomass of brine shrimp in South Bay salt ponds may be four times that of water boatmen (Swarth et al. 1982), and brine shrimp have been found to be a numerically important component of the diet of the western sandpiper, Wilson's and red-necked phalaropes, and other waterbirds (Anderson 1970; Colwell and J.R. Jehl 1994; Hamilton 1975; Harvey et al. 1992; 1988; Jehl 1988). Despite the high biomass of brine shrimp in salt ponds, the nutritive value of brine shrimp to foraging shorebirds may be limited, as

Rubega and Inouye (1994) found that red-necked phalaropes could not survive foraging on brine shrimp alone. As a result, brine flies (both adults and larvae) and reticulate water boatmen are also very important to shorebirds that forage in mid- to high-salinity South Bay salt ponds. Amphipods, most notably *Corophium* spp., are numerous in South Bay salt ponds as well (Carpelan 1957), serving as additional prey items important to shorebirds and fish.

Freshwater Macroinvertebrate Communities. Stream macroinvertebrate communities are structured largely by physical factors, such as temperature, light, current velocity, and substrate composition, and chemical factors, such as oxygen levels, pH, nutrients, and chemical pollutants. These communities are comprised of a diverse array of species that can generally be grouped into functional assemblages based on their feeding mechanisms and the roles that they play in stream ecology. Within a given taxonomic group, different species often assume different ecological functions and feeding preferences.

Collectors and filterers include certain decapods (freshwater crayfish), or larvae of some tricopterans (caddisflies), plecopterans (stoneflies), ephemeropterans (mayflies), and others. Many of these species filter fine particulate organic matter directly from the water column; and members of this functional group typically dominate invertebrate communities in larger-order, lower-gradient streams because of the high concentrations of particulate detritus suspended within the water column within these river mouth habitats. Representative South Bay groups include larval common midges (*Chironomus* sp., Diptera:Chironomidae) which are abundant filterers of living phytoplankton from the water column, and leptocerid caddisflies (Trichoptera:Leptoceridae), which are indiscriminant detritus feeders that are common in ponds and slow-moving river mouths.

Grazers can include large invertebrates such as gastropods (freshwater snails), or larval insects such as other species of caddisflies and nematoceran true flies. These groups are more prevalent in open areas with ample light and substantial algal growth, such as mid-order riverine systems and open ponds. Common Bay Area groups include the northern snailshell caddisfly (*Helicopsyche borealis*, Trichoptera:Helicopsychidae), which actually constructs a larval case that looks like a snail's shell. Larval psycodid gnats such as the lance-winged moth fly (*Maruina lanceolata*, Diptera: Psychodidae) are frequently found in foothill streams around the South Bay, where they graze on algal or diatomaceaous films (Powell and Hogue 1979). In contrast, shaded, steeper, lower-order streams in higher elevation areas support more vegetation shredders, because most of the plant material in these areas of streams is large and relatively undecayed. Shredders include larval or naiad members of many caddisflies, mayflies, and diperans (true flies).

Predatory invertebrates, such as larva of species in the Order Odonata (dragonflies and damselflies), larval culicid flies (mosquitos), some larval stoneflies, and adults of certain hemipterans (true bugs) and coleopterans (beetles), occur throughout all stream types. Some predaceous insects are so large and powerful that their prey can include tadpoles or even small fish. Giant water striders (*Gerris reigis*, Hemiptera:Gerridae) are common on many types of surface aquatic habitats across the area from smaller high elevation streams to stock tanks, while toad bugs (*Gelastocoris oculatus*, Hemiptera:Gelastocoridae) hunt for prey along the shores of water bodies. Other impressively large and common aquatic hemipterans include the large water boatman (*Hesperocorixa laevigata*, Hemiptera:Corixidae) and common water scorpion (*Ranatra brevicollis*, Hemiptera:Nepidae). Aquatic predaceous beetles such as dytiscids and gyrinids are predaceous both as larval and adult forms, and common species or genera in the area include giant green water beetles (*Dytiscus marginicollis*, Coleoptera:Dytiscidae), river beetles (*Agabus* sp., Coleoptera:Dytiscidae), and common whirligig beetles (*Gyrinus* sp., Coleoptera:Gyrinidae).

In the South Bay, studies of freshwater invertebrates have focused primarily on invertebrate assemblages in the middle and upper reaches of streams entering the Bay. In comparison, there are relatively few data on the downstream reaches of these streams, the reaches that are present within the Shoreline Study Area. A 1997 study of stream macroinvertebrates in the Santa Clara Valley identified 261 taxa at 44 sites along seven streams (Carter and Fend 2000). Taxon richness decreased from upstream to downstream sampling locations. Generally, higher-elevation sites supported higher taxon richness and a higher percentage composition of the Orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), while lower-elevation sites supported a higher percentage composition of taxa contained within the Chironomidae (midges) and Oligochaeta (worms). These results parallel perceived gradients in stream water quality, with mayflies, stoneflies, and caddisflies generally having low tolerance of stream pollutants and midges and oligochaete worms being much more tolerant of low water quality.

In the vernal pool habitats of the Warm Springs Unit of the SFBNWR, studies of invertebrates have focused primarily on the federally endangered vernal pool tadpole shrimp; this species is discussed in detail below under Section 4.3.1).

Upland Invertebrate Communities. As in much of the American West, there has been limited published data providing comprehensive species lists for the upland invertebrate communities of the South Bay. In fact, much like annual plants, insect populations can be extremely ephemeral from year to year, with a given species reaching large densities in some years and appearing completely absent from the fauna in others. The following provides a very general description of the species that would be most likely found in upland habitat, since a more detailed description would go far beyond the scope of this document. When considering ecosystem function, four pricipal groups bear discussion: soil fauna, responsible for consuming decayed organic matter (detrivores) or those that predate upon soil detrivores; phytophagous invertebrates, which consume tissue from living plants, zoophagous invertebrates, which predate or parasitize other invertebrates or larger animals; and pollinators, responsible for reproduction of many flowering plants. Upland habitat contains an immensely diverse array of terrestrial invertebrates including multiple species in the Hexapoda (insects), Diplopoda (millipedes), Chilopoda (centipedes), Arachnida (arachnoids, including spiders, mites, and ticks), Gastropoda (terrestrial snails and slugs), Malacostraca (terrestrial crustaceans), and Oligochaeta (worms).

Invertebrates that reside primarily in soil or under tree bark on fallen, dead logs comprise an important component of the terrestrial habitat of the South Bay and include a diverse array of species that specialize in feeding on decaying organic material, or that predate on other detrivores in the soil profile. Soil macrofauna carry out extremely important ecosystem functions by facilitating nutrient cycling through their feeding activities and soil pedturbation. Some represenative examples of soil macrofauna include colonial insects such as ants (Hymenoptera:Formicidae) and termites (Isoptera). The South Bay hosts colonies of invasive Argentine ants (*Iridomyrmex humilis*, Hymenoptera:Formicidae), as well as red mound ants (*Formica* sp., Hymenoptera:Formicidae). Western subterranean termites (*Reticulitermes hesperus*, Isoptera:Rhinotermitidae) may be the most common termite within the South Bay, and is responsible for structural damage to buildings. Many beetles are also present in the soil, including dung beetles such as the European dung beetle (*Aphodius fimetarius*, Coleoptera:Scarabidae), which is common wherever livestock is kept; and carrion or burying beetles such as *Nicophorus* sp. (Coleoptera: Silphidae), which are important processors of mammalian carcasses. Although not well known as a group due to their tiny size, entognathous (internal mouth-part) insects (orders Protura, Diplura, and Collembola) are extremely numerous in all non-saturated soil samples, and are concomitantly some of the most important detrivores. Springtails (Collembola) are among the best-known entognathous insects, including lawn springtails (*Bourletiella arvalis*, Collembola), which can be found almost anywhere in California, and obese springtails (*Morulina multatuberculata*, Collembola), which prefer hilly, wooded areas. There are also large, common, non-hexapodous invertebrates such as earthworms, millipedes, centipedes and pillbugs.

Phytophagous invertebrates in the Study Area include numerous insect species in the Coleoptera (e.g., weevils, leaf beetles, bark beetles), Homoptera (hoppers, cicadas, aphids, whiteflies and scale insects), Hemiptera (e.g., seed bugs and leaf bugs), Thysanoptera (thrips), larval Lepidoptera (caterpillars), Orthoptera (grasshoppers, crickets, and katydids), Phasmida (walking sticks and leaf insects), Psocoptera (woodlice and booklice), and Neuroptera (lacewings), as well as arachnid mites (Acarina) and terrestrial gastropods (snails and slugs). This terrestrial group is important as a major ecosystem pathway for converting low-protein, high-cellulose plant tissue into high-protein, easily-digestible animal tissue. While these groups can be pests when dealing with gardens, lawns, or crops, they also control and structure plant populations. This group is very speciose, as physical and chemical plant defenses against invertebrate pests are often formidable and require specific adaptations. Many phytophagous insects are resticted to particular plant families, genera, or even species, and other groups are further resticted to certain plant parts, such as the thrips, which feed only within flower blossoms.

Zoophagous invertebrates include both those groups that feed on other invertebrates, as well as those adapted to be parasities of larger animals such as birds and mammals (e.g. ticks, lice, and fleas). Invertebrates that predate upon other invertebrates are important for structuring invertebrate communities and controlling numbers of insect pests. This group includes many species within the Diptera (e.g., asilid and tabanid flies), Neuroptera (e.g. snakeflies, antlions, and dobsonflies), Hymenoptera (parasitic and predatory wasps, ants, and bees), Strepsiptera (twisted wing parasites), Mantoidea (mantises), Hemiptera (assassin bugs and toe biters) and Coleoptera (e.g., ladybugs and tiger beetles). Another categorization within the zoophagous invertebrates includes those species that are parasites of birds and mammals, such as biting lice (Mallophaga), which specialize on bird hosts; sucking lice (Anoplura), which typically specialize on mammalian hosts; Siphonaptera (fleas); dipterans such as mosquitos (Diptera:Culicidae) and biting gnats (Diptera:Ceratopoginidae); and Acarina (ticks). These species are important vectors of mammalian and avian diseases.

Those invertebrates that serve as potential pollinators in the upland habitats of the South Bay include insects in the Orders Hymenoptera, Diptera, Lepidoptera and Coleoptera. Not all flower-visiting insects are competent pollinators, as they must sequentially visit flowers of the same species, and have compatable behavior and morphology with the floral parts so that pollen picked up and deposited on receptive stigmatic surfaces. Bees (Apiodea) are hymeopterans specifically apdapted to collecting pollen and nectar from plants, and are often, although not always, competent pollinators of the plants that they visit. European honeybees (*Apis mellifera*, Hymenoptera:Apidae) are extremely important naturalized pollinators of many South Bay plants. Native bees include bumblebees (*Bombus* sp., Hymenoptera:Apidae), the short leafcutter bee (*Megachile brevis*, Hymenoptera:Megachilidae), loosely colonial minute sweat bees (*Halictus* and *Lasioglossum* sp., Hymenoptera:Halictidae), and common burrowing bees (*Andrena* sp., Hymenoptera:Andrenidae). Wasps (Vespidae, Specidae, Tiphidae) are other hymenopterans that may pollinate plants, but also predate upon or parasitize other insects for their larva. Several flies in the Syrphidae (flower flies) and Bombyliidae (bee flies) are also pollinators, although these are often generally considered less competent at pollen movement than bees. Lepidopteran adults are also often observed visiting flowers, although their morphology is such that they also tend to carry less pollen than bees. Coleopteran pollinators include beetles in the Meloidae (blister beetles) and Cerambycidae (longhorn beetles), including the special status species the Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*, Coleoptera:Cerambycidae). Flower-visiting beetles consume a large proportion of the pollen produced by the plants they visit, and only incidently move pollen while foraging.

Invasive Invertebrates of the South Bay. According to Cohen and Carlton (2003), the San Francisco Estuary is the most invaded aquatic ecosystem in North America. This study is the most recent and most inclusive compilation of information on aquatic invasive species in the San Francisco Estuary. Previous lists and/or descriptions of introduced aquatic species include works on fish fauna by Moyle (1976) and McGinnis (1984), freshwater mollusks by Hanna (1966) and Taylor (1981), marine mollusks by Nichols et al. (1986), and introduced marine and estuarine invertebrates by Carlton (Carlton 1975; Carlton 1979a; Carlton 1979b; Carlton et al. 1990). Collectively, these non-native species have significant impacts on the San Francisco Estuary through aggressive predation, highly efficient filter feeding, and competition, which, when magnified by the great abundance of some of these species, has the potential to change (or already has changed) the trophic structure and dynamics of the Bay ecosystem (Josselyn et al. 2004).

Cohen and Carlton (2003) note that at least 212 species, 69% of which are invertebrates, have been introduced to the Bay and Delta since 1850. The most important include a number of clams, many of which were introduced into the Bay via releases of ballast water (Cohen and Carlton 1995), such as the introduced Asian species of *Venerupis* and *Musculista,* and the Atlantic clam *Gemma.* With the exception of the Baltic clam, the numerically dominant mollusks of the South Bay are all non-native species (Nichols and Pamatmat 1988). Collectively, these introduced clam species are capable of filtering the entire volume of the South Bay daily, in addition to having dramatic impacts on the Bay's phytoplankton populations. Cohen and Carlton (2003) suggest that the phytoplankton populations of the northern reaches of the San Francisco Bay may be continuously and permanently controlled by introduced clams.

The Asian clam *Potamocorbula amurensis*, the most abundant clam in the San Francisco Bay, was introduced via ballast water around 1986 (Cohen 1998). Since then, this filter feeder has impacted phytoplankton populations in the North Bay (Alpine and Cloern 1992), preventing summer phytoplankton blooms since its introduction and altering the trophic structure of the North Bay. Although similar large-scale impacts on the South Bay have not yet been detected, the species is present in the South Bay. This clam was found by a CDFG study to be the most important prey of scoters in Suisun Bay (Harvey et al. 1982). The gem clam (*Gemma gemma*) occurs throughout the South Bay, in both deep subtidal and high intertidal habitats. It occurs in lower-salinity salt ponds as well. This clam is eaten by a variety of shorebirds (Recher 1966) and waterfowl (Painter 1966), and thus benefits some native wildlife species. The Atlantic ribbed marsh mussel (*Arcuatula demissa*) was introduced in the late 1800s, and is now common throughout much of the Bay. Although it is apparently "a major food source" for the clapper rail, rails have been known to drown after getting their beaks or toes caught in the open valves of the mussel (Takekawa 1993). The soft-shell clam (*Mya arenaria*) was introduced for commercial purposes, and maintained an important fishery in the Bay in the late 1800s and early 1900s (Skinner 1962). Although it is still present in the Bay, most individuals are small (Thompson and Shouse 2004). It is an important prey item for bat rays, flounder, and in the Suisun Bay, canvasbacks (Harvey et al. 1982). Thompson (1999) found that it disappeared rapidly from areas where it recruits, suggesting that it is preyed upon heavily by these fish, and possibly by birds and other invertebrates.

A carnivorous opisthobranch, *Philine auriformis*, invaded the South Bay in 1982, and has been noted in abundance in bottom trawls by the Marine Sciences Institute (Thompson and Shouse 2004). This species, which has been found most frequently in deeper water, preys on bivalves. The polychaete worm *Streblospio benedicti* was first detected in the Bay in 1932. This species readily colonizes the Bay in both deep and shallow intertidal habitats, and is consistently one of the dominant species on South Bay mudflats.

The dominant crustaceans of the South Bay are all introduced as well. The tube-dwelling amphipod *Ampelisca abdita* was first detected in the Bay in the 1950s. Since then, it has increased in abundance, and can achieve very dense beds at a variety of depths. This species was a dominant species on Palo Alto mudflats until the 1990s, when abundance declined (though it has remained common) (Thompson and Shouse 2004). The other dominant crustaceans in the South Bay include several burrowing amphipods, including *Grandidierella japonica* and several non-native *Corophium* species. Both of these genera tolerate poor water quality, and readily colonize available habitat throughout the South Bay. These crustaceans are important prey species for shorebirds on intertidal mudflats.

The European green crab (*Carcinus maenas*) became established in the San Francisco Bay in 1989-1990. This opportunistic omnivore eats a variety of plant and animal matter, including bivalves and shore crabs, and has the potential to impact native species considerably (Josselyn et al. 2004). After its invasion of Bodega Bay in 1993, a 90-95% decline in the abundance of native bivalves and grapsid shore crabs was observed (Grosholz et al. 2000).

Two non-native species could physically impact South Bay marshes, levees, streambanks, and other structures. The Australian-New Zealand boring isopod (*Sphaeroma quoyanum*) burrows into mud banks and levees throughout the Bay, potentially weakening these features and making them prone to erosion (Talley et al. 2001). Another burrowing species that may cause the same problem is the Chinese mitten crab (*Eriocheir sinensis*), which has been known to accelerate bank erosions in Germany. First detected in the Bay in 1992, the mitten crab has undergone rapid population increases throughout the Bay and its tributaries. This catadramous species migrates upstream (in virtually all of the Bay's tributaries) year-round, peaking in spring. Downstream migration to saltwater (approximately 25 ppt) breeding areas occurs primarily August-January, with a peak in September-October (Veldhuizen and Stanish 1999). The Chinese mitten crab is common in the South Bay. Halat (1996) has reported that the burrows of this crab reach densities of 30 burrows/m^2 along San Francisquito Creek. Halat did not report any bank erosion even at this density of mitten crab borrows but suggested that if bank erosion does occur it is likely to occur along steep clay banks in tidally influenced alluvial controlled reaches of the Bay. Thompson and Shouse (2004) noted abundant Chinese mitten crab burrows in a salt marsh bank in Palo Alto, possibly due to its proximity to San Francisquito Creek, and speculated that the erosion of the salt marsh bank observed since the mitten crab's invasion in the early 1990s may have been caused by the crab's burrowing. Surveys by the Marine Science Institute recorded burrow densities as high as 6.2/m^2 in December 1995 and 8.9/m^2 in March 2000 along Alviso Slough. These densities are three to 4.5 times greater than the next highest density for the South Bay.

Mosquitoes. There is an extensive body of literature on mosquitoes associated with tidal and seasonal wetlands of the South Bay region, as summarized by Bohart and Washino (1978), Durso (1996), and Maffei (2000d; 2000e; 2000f; 2000g; 2000h). More than 20 species occur in the San Francisco Bay area, but five of these, the summer salt marsh mosquito (*Aedes dorsalis*), winter salt marsh mosquito (*Aedes squamiger*), Washino's mosquito (*Aedes washinoi*), western encephalitis mosquito (*Culex tarsalis*), and winter marsh mosquito (*Culiseta inornata*), are routinely controlled by the mosquito and vector control agencies within each of the counties of South San Francisco Bay. Within the Shoreline Study Area, the Alameda County Mosquito Abatement District and the Santa Clara Vector Control District are responsible for managing the populations of mosquitoes for their respective communities.

The Goals Project's Baylands Ecosystem Species and Community Profiles (Maffei 2000d; 2000e; 2000f; 2000g; 2000h) included a detailed discussion of the ecology of mosquitoes in the South Bay, including preferred habitats, salinity tolerances, reproductive rates, flight characteristics, adult hosts and vector/nuisance potential. Adult females feed on blood; the hosts vary depending on the species, but include mammals, birds, reptiles, and amphibians. Adult males feed on plant juices, while larvae generally feed on particulate matter, unicellular algae, and other microorganisms. Larvae serve as prey for a variety of aquatic organisms, shorebirds, and waterfowl, while birds such as the swallow and other insects feed on adult mosquitoes. Larval survivorship is typically low, with most losses attributable to predation. The rate of larval development is often a function of water temperature and food availability.

The summer salt marsh mosquito is widespread throughout most of the United States and southern Canada, and is found in Europe and Asia as well (Carpenter and LaCasse 1955; Darsie and Ward 1981). In California, it inhabits coastal salt marshes and brackish marshes of the Sacramento/San Joaquin River Delta (Bohart and Washino 1978). In the San Francisco Bay area, this species occurs primarily in temporarily flooded tidal marsh pannes, heavily vegetated ditches, and brackish seasonal wetlands, while adults occur in open habitats such as grasslands, salt marsh, and woodland edges (Maffei 2000d). The summer salt marsh mosquito lays its eggs on mud at the edges of tidal pools or brackish seasonal wetlands, with larvae often occupying the same pools occupied by the tidal pool brine fly (*Ephydra millbrae*) and reticulate water boatman (Maffei 2000d). Eggs may hatch in the spring, but they can remain viable for years, and subsequent hatching can occur when the larval habitat is reflooded. Although survivorship may be highest in water having a salinity near seawater (Washino and Jensen 1990), larvae have successfully completed development at the Great Salt Lake in water with salinities as high as 120 ppt (Rees and Nielsen 1947). Up to 12 broods and eight generations were found to occur during a single breeding season in Marin County (Telford 1958). Adults are highly mobile, aggressive, day-biting mosquitoes that may be able to disperse more than 30 miles (Rees and Nielsen 1947).

The winter salt marsh mosquito occurs along the Pacific Coast from Sonoma County south to Baja California, including much of the immediate area around Southern and Northern protions of San Francisco Bay (Maffei 2000h). Tidal and diked pickleweed marshes with salt marsh pools diluted by rains provide the preferred habitat of this species. This species has not been found in freshwater marshes, instead occurring in brackish and salt marshes having salt concentrations from 1.2 to 35 ppt, with optimal conditions for larval development at salinities of five to 15 ppt. Egg laying occurs in spring on plants and on mud close to the edges of marsh pools. The eggs lie dormant until fall rains inundate them, although hatching as early as late September has been noted due to water diversion into a marsh. Some eggs do not hatch until later re-floodings. Most adults emerge from salt marsh pools in late February and March and disperse widely into surrounding areas, sometimes dispersing as far as 15 miles or more from larval areas. Feeding occurs from March through June, with biting occurring during daytime and early dusk.

Washino's mosquito occurs from Oregon south to Santa Barbara, California, including the entire San Francisco Bay area (Maffei 2000e). In the Bay area, shallow pools and fresh to slightly brackish sites in uplands near salt marshes or in riparian areas, often dominated by willow, cottonwood, or blackberry, provide this species' preferred habitat. Females deposit eggs in mud along the receding water line of larval habitat. The eggs hatch when these pools are reflooded the following winter. Adults emerge from the larval depressions in late winter and early spring, and are present into June. Females are day-biting mosquitoes, and may travel up to 1.5 miles from their larval habitat along artificial canals (Maffei 2000e).

The western encephalitis mosquito is widespread in a variety of habitats and locations in western North America, with larvae occurring in most freshwater habitats (Maffei 2000f). Typical larval habitat includes poorly drained fields and pastures, rice fields, marshes, ponds, and seeps, although most artificial waterbodies in urban areas provide potential habitat for this species as well. The species has been found in salt marsh pools with salt concentrations up to ten ppt (Telford 1958). Adults may be present year-round but enter facultative diapause in winter. Females lay eggs in groups directly into the water. Adult females usually feed at night. This species seems to be able to disperse readily with wind, and dispersal distances of 20-25 miles are suspected for some Sacramento Valley populations (Bailey et al. 1965). The western encephalitis mosquito is the main vector of western equine encephalitis and St. Louis encephalitis in most of the western United States (Maffei 2000f), and is a vector of avian malaria.

The winter marsh mosquito occurs in a wide range of habitats throughout much of western North America. Larval habitat includes a variety of pools, ponds, marshes, and other water bodies, in salinities ranging from eight to 26 ppt (Maffei 2000g; Telford 1958). Adults are present from fall through spring, entering facultative diapause in summer. Females lay groups of eggs directly on the water. San Francisco Bay populations tend to remain within two miles of their larval source, although they may disperse up to 14 miles (Clarke 1943). Larvae of the summer salt marsh mosquito, winter salt marsh mosquito, and winter marsh mosquito are often found in the same locations (Maffei 2000h). Mosquito species occurring in the major habitats in the Shoreline Study Area are listed in Table 4 below.

Table 4 – Mosquito Species Found in Marsh Habitats in the Shoreline Study Area.

Habitat	**Mosquito Species**
Open salt pond with vigorous wave action	none
Fully tidal salt marsh: Higher ground with pools or borrow channels that do not flush	*Aedes squamiger* (winter), *Aedes melanimon* (fall), *Aedes dorsalis* (summer), *Aedes taeniorhynchus* (summer), *Culiseta inornata* (winter)
Muted tidal salt marsh: Pools and channels that do not flush vigorously	*Aedes squamiger* (winter), *Aedes melanimon* (fall), *Aedes dorsalis* (summer), *Aedes taeniorhynchus* (summer), *Culiseta inornata* (winter)
Seasonal wetland: Brackish to nearly freshwater pools with vegetated margins	*Aedes squamiger* (winter), *Aedes melanimon* (fall), *Aedes dorsalis* (summer), *Aedes taeniorhynchus* (summer), *Aedes washinoi* (winter fresh water), *Culex tarsalis* (spring, summer), *Culex erythrothorax* (summer in tules), *Culex pipiens* (foul fresh water), *Culiseta incidens* (spring, fall fresh water), *Culiseta inornata* (winter)
Vernal pools, upland freshwater marsh	*Aedes washinoi* (winter), *Culex tarsalis* (spring, summer), *Culex erythrothorax* (summer in tules), *Culex pipiens* (foul fresh water), *Culiseta incidens* (spring, fall fresh water), *Culiseta inornata* (winter)

Marshes that lack vigorous tidal flow can provide suitable mosquito breeding habitat. Salt marshes at the southern end of the San Fransisco Bay produce a single seasonal brood of the winter salt marsh mosquito and multiple broods of the summer salt marsh mosquito each season. Because both of these mosquito species can fly considerable distances and are aggressive biters, control of mosquitos at the source (i.e., in salt marshes) is necessary to reduce the inconvenience to humans in the South Bay.

Detailed records are maintained by the local mosquito and vector control districts concerning major mosquito breeding areas, population densities, and control techniques and materials. In Santa Clara County, areas with known or potential mosquito problems include Coyote Reach 1A, New Chicago Marsh, Sunnyvale Baylands Park, the Moffett Field Flood Control Basin, Mountain View Demonstration Marsh, the Palo Alto Flood Basin (Palo Alto Baylands Park), the Zanker Landfill Marsh, Dow-Corning Marsh, Alviso Marshes, ITT Marsh (near the Palo Alto Water Quality Control Plant), the Palo Alto Municipal Airport, and the Palo Alto Municipal Golf Course (Strickman 2005). In the Alameda County portion of the Study Area, south of the San Mateo Bridge, sites that can produce large numbers of mosquitoes if not treated include the Perry Duck Club, Alameda Creek Marshes, Union City Marshes, Coyote Hills Marshes, Mayhew's Landing, and the upper ends of major sloughs (Mowry, Newark, Plummer, Albrae, and Mud Sloughs). Fully tidal marshes such as Hook Island (Palo Alto), Triangle Marsh (Coyote Creek), and Greco Island, do not produce significant numbers of mosquitoes.

Mosquito control techniques employed by these agencies emphasize minimization and disruption of suitable habitat, and control of larvae through chemical and biological means, as opposed to spraying of adults. Control techniques most often include source reduction, source prevention, larviciding, use of mosquito fish (*Gambusia affinis*) as larval predators, and monitoring of mosquito populations and vector-borne diseases (Alameda County Mosquito Abatement District 1999). Larvicides employed by the San Mateo County Mosquito Abatement District include Golden Bear 11 11 (a short-lived petroleum distillate that is applied to the surface of the water and causes mosquito larvae to drown), methoprene (a juvenile growth hormone that specifically targets mosquito larvae and prevents their maturation), *Bacillus thuringensis israelis* (a bacteria that is toxic to mosquito larvae), and *Bacillus sphaericus* spores and toxin (for *Culex* species) (http://www.smcmad.org/preventative_approach.htm).

In salt marshes, attempts to control mosquito populations by ditching have resulted in marsh degradation. Ditching is not necessary to reduce mosquito populations in tidal marshes. Rather, functional tidal marshes do not provide high-quality habitat for the most troublesome mosquito species in the Bay area, and maintenance and restoration of natural tidal flushing in these marshes is effective at limiting mosquito populations while sustaining the natural hydrology of the marsh (San Francisco Bay Joint Venture 2004).

Mosquitos serve as vectors for several diseases that pose health concerns for humans and domestic animals. The western encephalitis mosquito is a vector of avian malaria and the main vector of western equine encephalitis and St. Louis encephalitis in the western United States (Maffei 2000f). Anopheles mosquitos carry the organism that causes malaria. The West Nile virus is a mosquito-borne disease that has been found in parts of Asia, Eastern Europe, Africa and the Middle East. First detected in the U.S. in 1999 in New York City, West Nile virus has since spread through most of the U.S. West Nile Virus is typically spread from an infected mosquito, usually in the genus *Culex*, to a bird that then disperses or migrates, spreading the virus after being bitten by other mosquitos. Most people and domestic animals that become infected with the virus have few or no symptoms, but in rare cases they can become seriously ill. In 2006, West Nile virus was detected in 54 of 58 California counties, with 276 human infections from 30 counties in California (http://westnile.ca.gov/latest_activity.htm). In 2006, 58 infections of horses from 23 counties in California were reported, along with 1446 dead birds that tested positive for the virus.

4.3.2 Fishes

Fishes play very important ecological roles in the South Bay system. Information on South Bay fish communities is somewhat limited, likely due to the lack of a commercial fin-fishing industry in this part of the Bay. However, a dataset from the CDFG and several other studies provide information on fishes of the South Bay's tidal habitats, while several studies have identified the fish present in South Bay salt ponds (Anderson 1970; Carpelan 1957; Lonzarich 1989; Takekawa et al. 2005) and freshwater streams (summarized in Buchan et al. 2002). Information on key species is also available in the Goals Project's Baylands Ecosystem Species and Community Profiles (Goals Project 2000).

Fish Communities of Tidal Habitats. More than 100 fish species have been recorded in the tidal waters of the South Bay (Laine, pers. comm.). The California Department of Fish and Game has conducted a fish survey within the San Francisco Bay since 1980, with monthly surveys in deeper subtidal areas and some beach seine sampling in shallow water habitats (CDFG data in Life Science 2004). These surveys include data from three open-water stations (Stations 102, 101, and 140) located near the San Mateo and Dumbarton Bridges, and two beach seine stations (171 and 172) that are also located in the South Bay. Three sampling methods were used in the open-water stations: the otter trawl (which was towed on the bottom for five minutes against the current, then retrieved), midwater trawl (which was towed with the current for 12 minutes then retrieved obliquely), and plankton net (which was towed on the bottom for five minutes then retrieved obliquely).

A total of 65 fish species was captured at Stations 102, 101, and 140 during CDFG's surveys between 1980 and 2002, with 51 species captured by the otter trawl, 48 species by the midwater trawl, and 27 by the plankton net. Table 5 summarizes the most abundant fish species captured during these surveys. Numerically, the dominant fish were the northern anchovy (*Engraulis mordax*), shiner surfperch (*Cymatogaster aggregata*), longfin smelt (*Spirinchus thaleichthys*), white croaker (*Genyonemus lineatus*), Pacific staghorn sculpin, bay goby (*Lepidogobius lepidus*), plainfin midshipman (*Porichthys notatus*), English sole (*Parophrys vetulus*), cheekspot goby (*Ilypnus gilberti*), and Pacific herring (*Clupea pallasi*). The dominant fish captured at the beach seine stations were topsmelt (37.3%), arrow goby (*Clevelandia ios*, 22.6%), yellowfin goby (16.9%), jacksmelt (*Atherinopsis californiensis*, 16.2%), and Pacific staghorn sculpin (3.3%), with 22 other species representing <2% of the catch at Station 171, and topsmelt (54.4%), jacksmelt (23.4%), Pacific herring (9.7%), Pacific staghorn sculpin (3.0%), and northern anchovy (2.0%), with 28 other species representing <2% of the catch at Station 172.

Kinnetics (1987) collected fish from two locations in Coyote Creek and one location in Guadalupe Slough between 1982 and 1985. The dominant species collected from these sloughs included the staghorn sculpin, northern anchovy, starry flounder (*Platichthys stellatus*), shiner perch, yellowfin goby, threadfin shad (*Dorosma petenense*), and longfin smelt. Fish sampling in the nearby open waters of the Bay revealed species composition similar to that in the sloughs, with white croaker and striped bass (*Morone saxatilis*) also occurring as dominants. Sampling fish in lower San Francisquito Creek and the Palo Alto Water Quality Control Plant outfall channel, Cressey (1997) recorded the northern anchovy, topsmelt, yellowfin goby, staghorn sculpin, and threespine stickleback (*Gasterosteus aculeatus*).

Surveys of South Bay tidal sloughs by the USGS (Takekawa et al. 2005) from March 2004 to June 2005 recorded a total of 16 fish species in Alviso Slough, Coyote Creek, and Stevens Creek. Northern anchovies and topsmelt were by far the most abundant species caught; the American shad (*Alosa sapidissima*), threadfin shad, longjaw mudsucker, longfin smelt, common carp (*Cyprinus carpio*), starry flounder, rainwater killifish, bat ray, leopard shark (*Triakis semifasciata*), Sacramento sucker (*Catostomus occidentalis occidentalis*), striped bass, staghorn sculpin, shiner surfperch, and yellowfin goby were also recorded.

Many of the fish recorded in the South Bay, including the bat ray, leopard shark, northern anchovy, gobies, and many others, occur in tidal channels within marshes, in sloughs, and/or on mudflats at high tide when they are inundated. Thus, these tidal channels and mudflats are productive foraging habitats for estuarine fish in this system (Harvey 1988).

The spatial and temporal distribution of different estuarine fish in the South Bay, vary widely among species, as does the degree to which different specied use the Bay for breeding and foraging. The South Bay is particularly important to the leopard shark. Pupping (live birth) in the San Francisco Bay occurs almost exclusively in the South Bay (CDFG Bay Trawl data cited in McGowan (2000a)). This species appears to be most abundant in the areas on either side of the Dumbarton Bridge, where it forages in shallow mud and sand flats (Compagno 1984). Leopard sharks occur in the Bay year-round, although individuals may move in and out of the Bay (McGowan 2000b). The Bay is also important for northern anchovies, which spawn in the South Bay, including areas south of the Dumbarton Bridge (McGowan 1986). Spawning occurs in marsh channels; larvae forage over shallow flats after hatching (McGowan 2000b). Adult anchovies generally leave the Bay for the open ocean in fall, but some late-spawned juveniles remain in the Bay throughout the winter. Jacksmelt likely spawn in the South Bay as well. Here, spawning occurs from October to early August (Wang 1986), when adults move inshore from marine habitats and lay eggs on aquatic vegetation and other substrates. Apparently preferring more saline waters, the jacksmelt is most common in the Central and South Bays during years of high freshwater flows from the Delta (CDFG 1987 in Saiki [2000b]).

Table 5 – Summary of the most abundant fish species captured during California Department of Fish and Game South Bay fishery surveys, 1980-2002. Data are from Stations 101, 102, and 140 between the San Mateo and Dumbarton Bridges.

Species	**Station 101**			**Station 102**			**Station 140**		
	Otter Trawl	**Midwater Trawl**	**Plankton Net**	**Otter Trawl**	**Midwater Trawl**	**Plankton Net**	**Otter Trawl**	**Midwater Trawl**	**Plankton Net**
Northern Anchovy[1]	34.8	93.5	85.5	24.6	92.8	82.2	7.7	87.7	36.7
Shiner Perch	19.2			17.1			34.7	2.3	
Longfin Smelt	13.9								
White Croaker	9.8			3.5			4.4	3.2	
Pacific Staghorn Sculpin	4.5						7.0		
Bay Goby	4.3			19.1			8.3		
Plainfin Midshipman	3.1						7.9		
English Sole				12.0			7.4		
Cheekspot Goby				5.7					
Speckled Sanddab				4.0			2.1		
Pacific Herring			5.7	3.5		10.3			2.3
California Tonguefish							3.9		
White Seaperch							3.0		
Brown Smoothhound							2.4		
Topsmelt					2.2				
Jacksmelt					2.0				
Walleye Surfperch								2.1	

Arrow/Cheekspot Goby			2.8						21.1
Yellowfin Goby			2.3						
Goby Type II			2.2			2.0			3.8
Unidentified Fish									34.1
Total Species Richness	42	36	22	46	42	24	48	42	27
Other Species (Percent)	10.4	6.5	1.5	10.5	3.0	5.5	11.2	4.7	2.0

[1] Only species that make up at least 2.0% of the catch for a given sampling method at a given station are included. Data are the percentage of the total number of fish caught that were composed of each species.

Adult topsmelt enter shallow sloughs and mudflats to spawn in late spring and summer, which has been observed in the South Bay near the Dumbarton Bridge (Wang 1986). Eggs are laid on submerged vegetation. Locally this species is most abundant in the South Bay; where mudflats and sloughs are used for spawning and feeding, and as nursery areas for juveniles (Saiki 2000c). The Pacific staghorn sculpin is most abundant in central and north San Francisco Bay, but in some years it occurs commonly in the South Bay as well (CDFG 1987 in Tasto (2000b)). This sculpin spawns from November to March in shallow subtidal to intertidal water, and the young gradually shift their foraging areas from shallow intertidal habitats to deeper subtidal habitats as they mature (Tasto 2000b). The arrow goby occurs on shallow intertidal flats and in salt-marsh channels throughout much of the South Bay, where it is often commensal with burrowing invertebrates (Hieb 2000a). This species breeds primarily in spring and early summer, with peak larval occurrence from April through July. The bay goby occurs in somewhat deeper-water habitats than the arrow goby, and is also a common breeding species in the South Bay (Hieb 2000b). The longjaw mudsucker resides on mudflats and in tidal channels and sloughs. Marshes with complex channels provide the highest-quality habitat, although this species also breeds in lower-salinity salt ponds (Hieb 2000c). The longjaw mudsucker spawns from November through June in the South Bay, constructing burrows for breeding.

Other species forage in the South Bay but are not known to breed here. Pacific Herring are present in the North Bay from November through March, when spawning occurs; larvae and juveniles occur more widely, during which time they occur in the South Bay (though abundance decreases southward). Most individuals depart the Bay by August (Tasto 2000a). Longfin smelt spawn in fresh water in the upper end of Suisun Bay and in the Delta, occurring in the South Bay year-round as pre-spawning adults and yearling juveniles (Wernette 2000). Striped bass were introduced into the San Francisco Estuary in 1879, and are now the most important sport fish in the San Francisco Estuary, bringing in approximately $45 million per year into the local economies of the Estuary (Sommer 2000). Adults congregate in the San Pablo and Suisun Bays in fall and move into the Delta to spawn primarily in the Sacramento/San Joaquin Rivers in May and June. Striped bass in the South Bay are likely subadult fish foraging widely in the Bay, as this species is not known to breed in the South Bay. The California halibut (*Paralichthys californicus*) forages to some extent in the South Bay, but is not known to breed anywhere inside San Francisco Bay (Saiki 2000a). Juvenile starry flounders (*Platichthys stellatus*) occur fairly commonly in

South Bay sloughs, tidal marsh channels, and mudflats, although this species is not known to breed in the Bay (Kline 2000).

Adult steelhead (*Oncorhynchus mykiss*; Central California coast DPS) migrate through the Shoreline Study area into freshwater streams within the South Bay typically from December through April. Outmigration of smolts mainly occurs from February through June (Roessler et al. 2001, SCVWD unpublished data). Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley Fall-Run ESU, also migrate through the Study area during adult upstream migration from August through December, and during the downstream migration of juveniles typically from February through June (Roessler et al. 2001, SCVWD unpublished data). Relatively few data are available regarding use of South Bay marshes by salmonids, due to the difficulty of sampling small fish in this habitat. Steelhead were not captured by the CDFG during its South Bay surveys, and Chinook salmon were captured only in very low numbers. These species are discussed in detail in the Special-Status Wildlife Species section below (Section 3.7).

The diets of South Bay fish vary widely (Goals Project 2000; Harvey et al. 1977). Herring, anchovies, perch, and a variety of other fish and shrimp species provide prey for striped bass. The American shad feeds on copepods, larval fish, and *Corophium*. Northern anchovies are filter feeders that capture zooplankton and phytoplankton. Gobies prey on small fish and crustaceans. Jacksmelt eat a variety of copepods, insects, and polychaetes. Longfin smelt feed on zooplankton, shrimp, and copepods. Chinook salmon (*Oncorhynchus tshawytscha*) prey on insects, shrimp, amphipods, and isopods. The Pacific sardine (*Sardinops sagax*) is a filter and particulate feeder. The bat ray feeds on benthic mollusks, polychaete worms, and crustaceans. Leopard sharks eat a variety of crabs, shrimp, and small fish.

The history of the fisheries in the San Francisco Bay area, based on commercial catch data, was well described by Skinner (1962), but information specific to the South Bay in that text is very limited. According to Thomas Laine (pers. comm.), saltwater fish have declined in abundance in the far South Bay, with an apparent decline being particularly noticeable in the Alviso area since the 1970s. Although no commercial fishery for fin-fishes has existed in the Alviso area, this area was important for recreational fishing, particularly for sturgeon and striped bass, when the boat ramp at the Alviso marina was operational, and fishing derbies for sturgeon in the 1970s attracted as many as 700 entrants (Laine, pers. comm.). Large sturgeon and striped bass are still caught in the South Bay, but public boating access is limited to boat launches at the SFBNWR headquarters entrance in Newark and in the Redwood City area (except for the few boats currently moored along Alviso Slough).

Salt Pond Fish Communities. Fish community composition and abundance within the salt ponds of the South Bay are primarily a function of salinity, with more diverse communities and greater abundance in lower-salinity ponds, and generally no fish surviving salinities greater than 100 ppt. Carpelan (1957) found that in the Alviso salt ponds he studied, the primary fish species were topsmelt and threespine stickleback. Stickleback, primarily a freshwater species, occurred in low-salinity ponds, where they were often noted in clear water above macrophytic green algae. Topsmelt were the most abundant fish species, occurring in ponds with salinities up to 55 ppt. These fish feed in the salt ponds primarily on copepods. The longjaw mudsucker and the Pacific staghorn sculpin also occurred in the lower salinity Alviso ponds, but in lower abundance.

Lonzarich and Smith (1997) more recently studied fish assemblages in Alviso ponds A9 through A12, finding topsmelt, threespine stickleback, and longjaw mudsucker to be common in low- to mid-salinity ponds (35-90 ppt). Adult topsmelt occurred in ponds with salinities up to 90 ppt, and juvenile topsmelt occurred in ponds up to 75 ppt. Rainwater killifish (*Luciana parva*) and yellowfin gobies were also resident in most ponds studied. Nine additional fish species recorded in salt ponds by Lonzarich and Smith (1997), including staghorn sculpin, leopard shark (*Triakas semifasciata*), and northern anchovy, were apparently seasonal transients from adjacent Bay waters.

Surveys by USGS (Takekawa et al. 2005) recorded 14 fish species in Alviso salt ponds between March 2004 and June 2005; these results are similar to those of Lonzarich and Smith (1997), with longjaw mudsucker, rainwater killifish, topsmelt, and yellowfin goby being the most abundant fish, although very few sticklebacks were caught by USGS. Other species recorded in the Alviso salt ponds by USGS included northern anchovy, bay pipefish, staghorn sculpin, chameleon goby (*Tridentiger trigonocephalus*), leopard shark, shiner surfperch, striped bass, starry flounder, and bat ray.

Freshwater Stream Fish Communities. Fishes in the freshwater streams entering the Bay in the Shoreline Study Area consist of a moderately diverse assemblage of native species augmented by a number of non-natives. Coyote Creek has been the best studied of the creeks entering the Study Area in terms of its fish communities; such studies were summarized in Appendix C of Buchan et al. (2002). Native species recorded along lower Coyote Creek between 1858 and 2000, and thought to be extant as of 2000, include the splittail (*Pogonichthys macrolepidotus*), Pacific lamprey (*Lampetra tridentata*), steelhead/rainbow trout, California roach (*Lavinia symmetricus*), hitch (*Lavinia exilicauda*), Sacramento blackfish (*Orthodon microlepidotus*), Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento sucker, threespine stickleback, prickly sculpin, riffle sculpin (*Cottus gulosus*), and staghorn sculpin (Buchan et al. 2002, Buchan and Randall 2003). Other natives, such as the thicktail chub (*Gila crassicauda*), Sacramento perch (*Archoplites interruptus*), coho salmon (*Oncorhynchus kisutch*), speckled dace (*Rhinichthys osculus*) were recorded historically in lower Coyote Creek but may have been extirpated.

Anadromous fish, such as the Central California Coast steelhead and Chinook salmon use the reaches of freshwater streams in the Study Area primarily during movements between upstream spawning areas and estuarine/oceanic habitats. Coho salmon (*Oncorhynchus kisutch*) formerly spawned in the Coyote Creek watershed, but was apparently extirpated by the 1970s.

A variety of non-native fish introduced either unintentionally or intentionally for angling or mosquito control, occurs in South Bay freshwater streams. These include the mosquitofish (*Gambusia affinis*), channel catfish (*Ictalurus punctatus*), brown bullhead (*Ictalurus nebulosus*), yellow bullhead (*Ameiurus natakis*), black bullhead (*Ameiurus melas*), white crappie (Pomoxis annularis), black crappie (*Pomoxis nigromaculatus*), red shiner (*Notropis lutrensis*), inland silverside (*Menidia beryllina*), carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), fathead minnow (*Pimephales promelas*), redear sunfish (*Lepomis microlophus*), bluegill (*Lepomis macrochirus*), green sunfish (*Lepomis cyanellus*), largemouth bass (*Micropterus salmoides*), golden shiner (*Notemigonus crysoleucas*), and others (Buchan et al. 2002, Buchan and Randall 2003). Many of these non-natives are widespread in streams throughout central

California, and are fairly tolerant of marginal water quality and a variety of stream conditions. The number of non-native fish species recorded along lower Coyote Creek increased from zero during the period 1858-1940 to 21 during the period 1987-2000 (Buchan et al. 2002).

4.3.3 Reptiles and Amphibians

Relatively few species of reptiles and amphibians occur in the Shoreline Study Area, and consequently, there has been little study of these taxa within the Study Area. The western fence lizard (*Sceloporus occidentialis*), a ubiquitous lizard in California, occurs in a variety of habitats in the Study Area. Other reptile species that occur within the Study Area include garter snakes (*Thamnophis couchi*, *T. elegans*, and *T. sirtalis*), gopher snakes (*Pituophis melanoleucus*), and southern alligator lizards (*Elgaria multicaranata*), all of which occur along edges of well-vegetated levees, in riparian habitats, and in grassland and ruderal habitats.

A small, isolated population of western pond turtles (*Clemmys marmorata*) occurs in brackish habitats near the Sunnyvale WPCP and Moffett Field, and this species is also present in small numbers along the lower reaches of Coyote Creek and the Guadalupe River (see Special-Status Wildlife Species in Section 3.7). Small numbers of a several species of non-native turtles, most likely pets that have been released, are present in South Bay streams as well.

Due to the paucity of freshwater habitats within the immediate Study Area, amphibian use of the Study Area is even more limited. Where fresh water occurs along the inland margins of the Study Area, the Pacific treefrog (*Hyla regilla*), western toad (*Bufo boreas*), and non-native bullfrog (*Rana catesbeiana*) are present. California slender salamanders (*Batrachoseps attenuatus*) and arboreal salamanders (*Aneides lugubris*) occur in moist riparian areas along the margins of the Study Area, but are much more abundant in higher-elevation, more wooded, less urbanized sites outside the Study Area. California tiger salamanders (*Ambystoma californiense*) occur in vernal pool habitats in the Warm Springs area, primarily on SFBNWR lands.

4.3.4 Mammals

Relatively few species of mammals occur in the Shoreline Study Area owing to the intense disturbance and habitat conversion that has occurred within the area. Within the Study Area, most research attention on mammals has focused on the ecology of special-status salt marsh associated species (i.e., the salt marsh harvest mouse and salt marsh wandering shrew, along with other small mammals using salt marshes), the use of South Bay waters and tidal habitats by the Pacific harbor seal, and the presence and impacts of non-native mammals. Upland habitats within the Study Area are primarily ruderal, although some non-native grassland habitat and the riparian corridor of Coyote Creek do support a variety of small mammal species.

Salt marsh harvest mice and salt marsh wandering shrews occur in the Study Area primarily in pickleweed-dominated salt marshes. Harbor seals, the only marine mammals that regularly occur in the

South Bay, forage in Bay waters and sloughs and breed and loaf on the edges of tidal marshes and mudflats. Because these three species are discussed in detail in the Special-Status Wildlife Species section (Section 3.7), they are not discussed further in this section.

Trapping studies for the salt marsh harvest mouse in the South Bay have revealed much about the status of other small mammals in marsh habitats of the region. House mice (*Mus musculus*) and California voles are common in diked and tidal salt marshes, particularly in the pickleweed-dominated high marsh and the peripheral halophyte zone, where the western harvest mouse (*Reithrodontomys megalotis*) also occurs in the high marsh. Deer mice (*Peromyscus maniculatus*), shrews, and both black rats (*Rattus rattus*) and Norway rats (*Rattus norvegicus*) are also recorded in these marshes during salt marsh harvest mouse trapping studies. Table 6 below lists the results of a small sample of such studies to indicate the relative abundance (relative to trapping effort and among species) of these species in South Bay marshes (Environmental Science Associates 1991; H. T. Harvey & Associates 1988; 1989; 1990; 1991; Harvey and Stanley Associates 1985; 1986; Muench 1985; Shellhammer et al. 1988; Wondolleck et al. 1972).

Aside from the introduced house mouse, which occurs commonly in a variety of habitats in the South Bay, the most abundant mammal trapped during the studies listed in Table 6 was the California vole. This species is a common inhabitat of grasslands, ruderal habitats, and wetlands around the South Bay, and is a keystone species in grasslands due to its importance as a prey species to mammals and raptors (Pearson 1985) and the significant effect this species may have on vegetation during populations peaks (Lidicker 1989; Lidicker 2000). Studies of populations in upland areas have demonstrated dramatic fluctuations in abundance, and when it is particularly abundant, the California vole may have adverse effects on other small mammals. For example, western harvest mice are impacted strongly, presumably via competitive interactions, during vole outbreaks, and it is possible that high densities of voles may have the same negative impacts on salt marsh harvest mice, as has been suggested by Geissel et al. (1988).

Several species of bats, such as the Mexican free-tailed bat (*Tadarida brasiliensis*), forage over the salt ponds, marshes, and grasslands of the South Bay. Native mammals such as the California vole, western harvest mouse, deer mouse, Botta's pocket gopher (*Thomomys bottae*), California ground squirrel, black-tailed jack rabbit, Audubon's cottontail, brush rabbit, striped skunk (*Mephitis mephitis*), and long-tailed weasel (*Mustela frenata*) occur on salt pond levees, at the margins of marshes, and in upland ruderal and grassland habitats around the periphery of the Study Area.

Several non-native mammal species occur in the South Bay, including the red fox (*Vulpes vulpes regalis*), Norway rat, black rat, feral cat (*Felis felis*), and Virginia opossum (*Didelphis virginiana*). These species have the potential to impact populations of California clapper rails and other native species in the South Bay considerably. The red fox was first reported in the South San Francisco Bay area in 1986 (Foerster and Takekawa 1991), and it has since increased and expanded to become established throughout the Bay area. It dens in a variety of habitats, including salt pond levees (Foerster and Takekawa 1991).

Table 6 – Relative abundance of small mammals captured during selected salt marsh harvest mouse trapping studies in the South Bay.

Site and Habitat	Year(s)	Trap Nights	Species*							Reference
			Salt Marsh Harvest Mouse	Western Harvest Mouse	House Mouse	Deer Mouse	California Vole	Shrew spp.	Black / Norway Rat	
1990 Bay Road, East Palo Alto (tidal salt marsh)	1990-91	1000	20		3	1	3		3	Environmental Science Associates 1991
Dumbarton Marsh (tidal salt marsh)	1990-91	1000	18		8	1	16	1		Environmental Science Associates 1991
Palo Alto Baylands (salt marsh)	1972	2058	196		74		39	3		Wondolleck et al. 1972
Western Alameda and Northeastern Santa Clara Counties (diked marsh)	1983-86	12,800	140	45	717	54	478	10	3	Shellhammer et al. 1988
Western Alameda County (tidal salt marsh)	1983-86	1200	13	7	72		129	2		Shellhammer et al. 1988
Lower Calabazas Creek at Hwy. 237, Alviso (fresh/brackish tidal marsh)	1988	1000		3	46					H. T. Harvey & Associates 1988
Coyote Creek Flood Control Project (ruderal/alkali habitat)	1990	1000	7	4 (harvest mouse sp.)	21	2	1			H. T. Harvey & Associates 1990c
Mayhews Landing (mixed grassland, diked marsh, fresh/brackish marsh)	1988-89	3120	36		101		7			H. T. Harvey & Associates 1989
Warm Spring International Industrial Park (diked pickleweed marsh)	1985	900	1		36					Harvey and Stanley Associates 1985
Warm Springs II/Fremont Airport (diked pickleweed/grassland)	1985	2400	27		≤ 154		1			Harvey and Stanley Associates 1986
Triangle Marsh (tidal salt marsh) and New Chicago Marsh (diked salt marsh)	1985	776	1	1	161		6	1		Muench 1985
Triangle Marsh (tidal salt marsh)	1990	500	10		8	3	18			H. T. Harvey & Associates 1991c

Site and Habitat	Year(s)	Trap Nights	Species*							Reference
			Salt Marsh Harvest Mouse	Western Harvest Mouse	House Mouse	Deer Mouse	California Vole	Shrew spp.	Black / Norway Rat	
Calaveras Point Marsh (tidal salt marsh)	1990	400	22				1			H. T. Harvey & Associates 1991c
Warm Springs Marsh (tidal brackish marsh)	1990	500			35	3	57			H. T. Harvey & Associates 1991c
Coyote Creek Flood Control Project (ruderal/alkali habitat)	2001	800		3	22		4			H. T. Harvey & Associates 2001
Stevens Creek Marsh (tidal salt marsh)	2005	400	2	1	40		5			H. T. Harvey & Associates 2005
Calaveras Point Marsh (tidal salt marsh)	2006	2000	15		4		6			H. T. Harvey & Associates 2007
Triangle Marsh (tidal salt marsh)	2006	2000	28		37		53			H. T. Harvey & Associates 2007
Warm Springs Marsh (tidal brackish marsh)	2006	2000	10		18		29			H. T. Harvey & Associates 2007

* In these studies, species other than salt marsh harvest mice were not uniquely marked for identification, and hence the numbers listed for species other than the salt marsh harvest mouse include an unknown number of recaptures. However, the house mouse and California vole were still found to be the most abundance species in many marshes.

Clapper rail predation by both red foxes and feral cats has been directly documented in the South Bay by the tracking of radio-marked rails that were depredated in 1991 and 1992 (Albertson 1995). In addition, the remains of clapper rails were found at a fox den in a tidal marsh on the SFBNWR (Harding et al. 1998), and at the entrance to a den in the outboard levee along salt pond A9 (Steve Rottenborn, pers. obs.). Norway rats are thought to be one of the main predators of California clapper rail eggs (Foerster et al. 1990; Harvey 1988), and raccoons have also been known to prey on California clapper rail eggs (Foerster et al. 1990). In addition to impacts to clapper rails, red fox predation on nests of the federally threatened western snowy plover has been recorded, and fox predation has resulted in the abandonment of important colonies of Caspian terns (at Mowry and Bair Island) and herons (at Bair Island) in the South Bay in 1991 (Strong 2004a).

The feral cat is fairly common in upland habitats around the South Bay (Foerster and Takekawa 1991; Takekawa 1993), whereas the Norway rat and roof rat occur in most habitat types in the Study Area. Both rats are known nest predators of California clapper rails, and up to one-third of clapper rail eggs in the South Bay may be depredated by Norway rats (BDOC Unpublished; Josselyn et al. 2004). Rats have depredated California Gull nests in the South Bay as well (Jones 1986).

In 1991, the San Francisco Bay NWR implemented a predator management plan directed at the removal of red foxes, raccoons (*Procyon lotor*), striped skunks, and feral cats to protect the federally listed California clapper rail and western snowy plover (Harding et al. 1998). From spring 1991 to fall 1996, the average number of individuals removed from NWR lands per year included 90 red foxes, 27 feral cats, 26 striped skunks, and two raccoons. In addition, 38 non-native opossums and 25 native gray foxes (*Urocyon cinereoargenteus*) were captured and released. The number of red foxes trapped was consistent from 1991 to 1996, but trapping rates declined because more traps were used in successive years. Successful trapping required 46 traps/fox in 1991-1992 and 83 traps/fox in 1995-1996, suggesting that the trapping program was successful in reducing fox populations. More than half of the cats and skunks trapped were in the Warm Springs/Fremont area. In 2003, the CDFG implemented a predator-control program at the Eden Landing Ecological Reserve to reduce predation on listed species (John Krause, pers. comm.).

4.3.5 Birds

The birds of the South Bay have been studied more than any other wildlife group. This focused attention results from the high diversity of birds in the region, the presence of several San Francisco Bay-area endemics and state and federally listed species, the plasticity demonstrated by a number of species in adapting to the anthropogenic changes (including salt pond development and urbanization) that have occurred in the South Bay, and the intensity of interest in the birdlife of the region by professional and amateur ornithologists. The birds of the Bay and associated salt ponds and marshes represent the most significant contribution of the South Bay to the avifauna of the Pacific Flyway, and the following discussion focuses primarily on birds associated with these areas. In addition, riparian habitats in the Study Area, though limited in extent, provide important foraging habitat for migrants and wintering birds and valuable breeding habitat for a few riparian-associated species.

Overview of Baylands Bird Communities. The San Francisco Bay area is extremely important to breeding birds and, particularly, to migratory waterbirds in the Pacific Flyway. The Bay provides important foraging and roosting habitat for more than one million waterbirds each year, supporting large proportions of the populations of some shorebird and duck species (Accurso 1992; Harrington and Perry 1995; Page et al. 1999; Stenzel et al. 1989; Stenzel and Page 1988; Takekawa et al. 2001). With its extensive mudflats, remnant salt marsh, and salt ponds, the South Bay in particular supports very high diversity and abundance of waterbirds (Harvey et al. 1992; Takekawa et al. 2000; Warnock 2004b). More than 250 bird species occur in the greater South Bay area with some regularity, and many of these are common inhabitants of the Shoreline Study Area and its immediate vicinity. More than 75 species of waterbirds use the salt ponds, tidal marshes, mudflats, subtidal habitats, and surrounding managed marshes, water treatment plants, and managed ponds regularly, with more than 50 species more occurring rarely and/or in low numbers. Species richness in the South Bay system is generally highest in fall and lowest in summer and winter, while waterbird abundance is highest in spring and winter (Strong 2003; Takekawa et al. 2001; Takekawa et al. 2004). In Bay-wide surveys, Bollman et al. (1970) found waterbird abundance to be lowest in summer, increasing rapidly in early September and peaking in December.

The high waterbird diversity in the South Bay is a function of the diversity of wetland and aquatic habitats in the region, while high bird abundance is a function of the high productivity of the South Bay estuary and, secondarily, of alternative habitats such as salt ponds. Despite the extensive loss and degradation of the South Bay's tidal marsh, and the invasion of the South Bay benthic invertebrate community by non-native species, this system is still extremely productive. The remnant tidal marshes not only provide habitat for marsh obligates such as the California clapper rail, they also play important roles as sources of nutrients and carbon for the aquatic system, resulting in high abundance of invertebrates on the mudflats and shallow subtidal areas (Warwick and Price 1975), and ultimately high fish populations. These invertebrates and fish in turn serve as prey to the myriad shorebirds, waterfowl, herons, egrets, gulls, terns, grebes, and other waterbirds that use the South Bay.

Salt ponds and other alternative habitats (such as artificial ponds and lakes, water treatment plant settling and oxidation ponds, muted and managed marshes, and managed ponds) also provide important habitat for waterbirds in the South Bay (Hanson and Kopec 1994; Harvey et al. 1992; Stralberg et al. 2003; Takekawa et al. 2000; Takekawa et al. 2001; Warnock 2004b). Though salt ponds are more or less closed systems, providing little input of carbon or nutrients to the estuary itself, the concentration of superabundant invertebrate prey in salt ponds, provision of alternate foraging habitat during high tide, provision of roosting sites, and concentration of fish in lower-salinity ponds results in suitable foraging conditions for a variety of waterbirds. For some species, such as the Wilson's phalarope, red-necked phalarope, black-necked stilt, American avocet, western snowy plover, Bonaparte's gull, American white pelican, and breeding gulls and terns, these ponds provide higher-quality nesting and/or foraging habitat than the existing tidal marshes or intertidal habitats. A number of other species use salt ponds primarily when their preferred intertidal habitats are inundated, or when high densities may cause some birds to forage in less optimal areas (Warnock and Takekawa 1995). For such species, the question of whether salt ponds and other alternate habitats are required for foraging, or whether they are required primarily for high-tide roost sites, varies among species, and possibly among seasons (i.e., being more important for foraging when densities are high). Alternate habitats such as salt ponds and levees are required for high-tide roosting sites, refugia from strong winds, and foraging sites during prolonged winter storms, when winds, rain, and high water may limit foraging efficiency and limit the availability of intertidal foraging areas (Davidson and Evans 1986; Evans 1976; Pienkowski 1981).

Although birds may be very abundant in salt ponds during high tide, most bird activity is concentrated in small areas within the larger salt pond complexes. For example, Stralberg et al. (2003) reported that 90% of the small shorebirds and dabbling ducks in their South Bay study area were recorded in six of 22 ponds under study, while 90% of the larger shorebirds were recorded in ten of 22 ponds. This concentration is a result of the dispersion of suitable foraging habitat and prey availability, which may be concentrated in relatively few ponds having suitable water depths and salinities. It has been reported that salt ponds close to the edge of the Bay have greater bird use than those farther from the Bay, and that many shorebirds use mudflats and salt ponds in close proximity to one another (Warnock and Takekawa 1996), thus reducing commuting distances between low-tide intertidal foraging habitat and high-tide refugia within the ponds for birds that use both habitats. Studies of color-marked or radio-tagged shorebirds in the South Bay indicate that many individuals have high site fidelity and small home ranges, often using the same roosting and foraging sites consistently (Kelly and Cogswell 1979; Warnock and Takekawa 1996). Wintering western sandpipers in the South Bay were found to have a mean home range size of 22 km^2, and the mean distance between feeding and roosting areas was 2.2 ± 0.1 km, although some birds moved around quite a bit, particularly within pond complexes. Warnock and Takekawa (1996) found less movement from one side of the Bay to the other. While the ponds supporting the greatest use do tend to be closer to the Bay (Takekawa et al. 2005), and many birds may repeatedly use the same small areas, waterbirds in some areas are known to repeatedly travel longer distances (e.g., thousands of shorebirds regularly commuting more than four miles between intertidal foraging areas and high-tide roosting areas near the NWR headquarters in Newark; (Morris 2004)). The sudden appearance of large numbers of shorebirds when salt ponds were drained during ISP implementation (Krause, pers. comm.; H. T. Harvey & Associates Unpublished), or of large numbers of piscivores at prey fish "blooms" (Steve Rottenborn, pers. obs.), is also indicative of these birds' potential for significant local movement to exploit favorable foraging conditions.

A few studies have compared the use of salt ponds with the use of other available habitats (e.g., tidal marsh, mudflats, and subtidal areas) in the South Bay. Within salt ponds and nearby mudflats near Coyote Hills, Swarth et al. (1982) found higher bird species richness in low-salinity ponds than in higher-salinity ponds or mudflats, although relatively few species used the salt ponds at low tide. In contrast, Takekawa et al. (2001) found species richness and diversity in the North Bay to be higher in natural baylands (i.e., tidal marsh and mudflats) than in salt ponds during all seasons, while overall bird density was higher in salt ponds than in baylands in winter and spring (and overall was twice as high in salt ponds than in baylands). During Bay-wide surveys, Bollman et al. (1970) found that salt ponds supported densities of waterbirds (57-73 birds/acre) two to three times higher than mudflats (29-30 birds/acre) and open water (15-18 birds/acre). At any given time, the proportion of a salt pond or mudflat in use by foraging birds may be relatively small, as birds often concentrate in areas providing the most suitable conditions, complicating the comparison of densities among these habitat types. Studies of shorebird use of different South Bay habitats during high tide, coordinated by SFBBO, are summarized under Shorebirds, below.

Stralberg et al. (2003), comparing use of salt ponds with a limited sampling of tidal marshes (though not including tidal mudflats in the comparison), found that salt ponds had significantly higher species richness than tidal marshes, with a mean of 47 species/pond. However, salt ponds supported high densities of relatively few species, with only occasional use by many of the species contributing to the high species richness in the ponds; in contrast, tidal marsh was used at lower densities by many species. Warnock et al. (2002) confirmed this finding, reporting that ten species (out of 75 recorded) composed >85% of all birds recorded in 22 salt ponds in the South Bay. Thus, tidal marsh provides habitat for more species more consistently; salt pond use by most species is more limited or irregular, but may be very important (to large numbers of individuals of at least some species) at times. Within salt ponds, species richness decreases with salinity, though many species use a wide range of salinities. Of the 50 most common species in salt ponds, the core salinity range for 34 included low-salinity (20-60 ppt) ponds, with 18 found only in this range; mid-salinity (60-120 ppt) ponds were within the core salinity range for 31 species. No species were restricted only to high-salinity ponds (Stralberg et al. 2003).

Stralberg et al. (2003) found waterbird species richness and diversity in tidal marshes negatively associated with the proportion of salt ponds in the surrounding landscape and positively associated with the proportion of surrounding mudflat and marsh. Within marshes, waterbird diversity was higher in marshes with more large channels, and the densities of ducks, larids, and shorebirds increased with increasing amounts of open water within the marsh; waders and other piscivores increased with larger channels in marsh.

The use of individual salt ponds, and foraging locations within those salt ponds, by foraging waterbirds is determined primarily by prey availability, which is mainly a function of salinity and water depth. Warnock et al. (2002) reported bird diversity in South Bay salt ponds to be highest at mid-salinity ponds (±126 ppt), while bird density on salt ponds peaks at higher salinities (±140 ppt). Due to variations in bill and leg length, foraging behavior (i.e., swimming, wading, or diving), and prey preferences, different waterbird species are able to, or prefer to, forage in water of different depths (Isola et al. 2000). Thus, ponds with more topographic heterogeneity, such as islands and uneven bottoms, are important in providing habitat for a greater diversity of foraging guilds by providing a range of foraging depths (Anderson 1970; Takekawa et al. 2004; Velasquez 1993; Warnock 2004b).

The most recent and comprehensive dataset on bird use of the South Bay salt ponds themselves has been compiled by USGS, which has been conducting monthly bird surveys at 53 ponds in the South Bay Salt Ponds complexes (USGS, unpubl. preliminary data). Surveys have been conducted since January 2002 in some of the Alviso Complex ponds (and at all Alviso ponds since January 2003). In addition, the Cargill-managed ponds in the Mowry, Newark, and Coyote Hills pond complexes have been surveyed by SFBBO (using the same methods used by USGS) since 2005. Because management of the salt ponds included in this study may have differed from prior management in anticipation of the purchase of these ponds (and/or their mineral rights) from Cargill (Takekawa, pers. comm.) and because these surveys overlap the implementation of ISP management in some ponds, these data cannot be clearly related to pre-ISP or to

ISP conditions, making it difficult to ascribe mechanisms to the patterns observed. Nevertheless, this dataset is useful in characterizing the general temporal and spatial distributions of birds in the Study Area salt ponds at the present time.

From October 2002 to June 2005, the surveys by USGS had recorded 75 species of waterbirds in the Alviso Complex. Excluding Ponds A19-A23 (since these ponds were not surveyed as many times as the remaining ponds), the number of species/pond ranged from a low of 30 species in the mostly dry Pond A6 to 59 in Pond A9. Ponds A1, A5, A7, A10, and AB2 supported 50-56 species each, while ponds with the lowest species richness included A6, A12, A13, A15, and A17. Although it is likely not possible to determine the mechanisms responsible for these patterns, since ISP conditions were implemented during the study period in some ponds, those ponds having high species richness tended to be large ponds with high topographic variability that included both shallow and deep water, thus providing foraging habitat for a number of foraging guilds. Low-diversity ponds tended to be deep-water ponds with little topographic heterogeneity or ponds that contained little water during the year. Ponds supporting high waterbird abundance during the period October 2002 to June 2005 in the Alviso Complex were Ponds A5 (due largely to high western sandpiper abundance, and high abundance of other species), A6 (due to the large California gull colony in this pond), and A9 (due to high abundance of many species, particularly ducks); Ponds A12, A13, A15, A16, A17, and AB1 supported the lowest bird abundance.

Continued surveys by USGS from July 2005 to August 2006 recorded more than 1.75 million observations of waterbirds representing 67 species in the Alviso Complex salt ponds (Takekawa et al. 2006). These ponds supported higher abundance of certain groups than the Ravenswood and Eden Landing complexes surveyed simultaneously, hosting 96% of the gulls, 84% of dabbling ducks, 83% of diving ducks, 74% of piscivores, and 71% of herons recorded among the three pond complexes. The complex consisting of A1, A2W, A2E, AB1, AB2, A3N, and A3W supported 55% of the diving ducks in the Alviso complex. Ponds A5, A6, and A8 collectively supported 80% of the small shorebirds and 42% of the medium shorebirds in the Alviso complex. The high-salinity ponds, such as pond A13, supported the highest numbers of phalaropes and eared grebes.

The majority of the information on birds of the salt ponds within the Study Area is based on data collected prior to ISP implementation since the ISP has been only recently implemented in some salt ponds (and the effects of this implementation on wildlife use have not yet been fully identified) and has not yet been implemented in other ponds. Ongoing studies by USGS, SFBBO, and others will help to refine the response of wildlife to implementation of the ISP. Already, monitoring data indicates an overall reduction in numbers of salt pond-specialist birds (e.g., eared grebes and phalaropes) as fewer ponds are managed for high-salinity conditions, an increase (at least locally, at the pond or pond complex level) in abundance of small shorebirds in ponds managed for shallow depths, and an increase in abundance of dabbling ducks in ponds that are converted from high-salinity to low-salinity ponds.

Birds in the South Bay overlap considerably in habitat preference and resource use, but general groups of species can be distinguished based on their physical adaptations, habitat associations, foraging behavior, dietary requirements and prey, the ways in which they use salt ponds as habitats (e.g., for nesting, foraging, or roosting), and their temporal occurrence in the Study Area. For the purposes of describing the existing conditions of the bird community in the South Bay, six general groups of species have been identified: shorebirds; waterfowl (ducks and geese); large waders (herons, egrets, and ibis) and other piscivores (fish-eating grebes, cormorants, and pelicans); larids (gulls and terns); other waterbirds (eared grebes, coots, and rails); and landbirds (including raptors and passerines). Each of these groups is discussed in detail below.

Shorebirds. Perhaps no other group of birds using the South San Francisco Bay has been better studied than shorebirds, which include plovers, sandpipers, stilts, avocets, and phalaropes, and perhaps no other group relies more heavily on the South Bay. Comprehensive shorebird surveys of the Pacific Coast of the U.S., summarized by Page et al. (1999), have documented that the San Francisco Bay supports 41-97% (mean 67%) of estimated totals for key species for the entire West Coast in fall, 38-90% (mean 55.7%) in winter, and 24-86% (mean 52.3%) in spring. No other site on the West Coast of the U.S. supports a mean greater than 8% in any season. For 11 shorebird species, the San Francisco Bay supports >50% of the individuals recorded in all U.S. Pacific Coast wetlands in at least one season. The percentage of the total West Coast population of individual shorebird species that occurs in San Francisco Bay in fall, winter, and spring, respectively, include numbers as high as 62%, 59%, and 56% for black-bellied plovers (*Pluvialis squatarola*); 59%, 68%, and 54% for western sandpipers; 67%, 39%, and 73% for least sandpipers; 78%, 90%, and 58% for black-necked stilts; 97%, 88%, and 86% for American avocets; and 69%, 59%, and 57% for willets (*Catoptrophorus semipalmatus*). The San Francisco Bay supports an average of more than 40% of the West Coast populations over these three seasons for semipalmated plover (*Charadrius semipalmatus*), red knot (*Calidris canutus*), dowitchers (*Limnodromus* spp.), long-billed curlews (*Numenius americanus*), and marbled godwits (*Limosa fedoa*) as well. The San Francisco Bay likely supports more than one million shorebirds in spring and hundreds of thousands in the fall and winter (Stenzel et al. 1989). As a result of these numbers, the San Francisco/San Pablo Bay area has been designated as a site of hemispheric importance by the Western Hemisphere Shorebird Reserve Network (Harrington and Perry 1995), and the Don Edwards San Francisco Bay NWR has been designated a Globally Important Bird Area by the American Bird Conservancy (2004).

The South Bay is the most important part of the larger San Francisco Bay from the perspective of use by breeding, migrant, and wintering shorebirds. Of 838,000 shorebirds counted during a Bay-wide survey 16-18 April 1988, 70% were recorded south of the San Mateo Bridge, with the highest concentration at low tide occurring on the broad intertidal flats on the east side of the Bay between the San Mateo and Dumbarton bridges (Stenzel and Page 1988). Mudflats and salt ponds on the east side of the Bay between these two bridges supported approximately 305,000 shorebirds during this survey, compared to 62,000 on the west side of the Bay between the bridges and 224,000 south of the Dumbarton Bridge. Of nearly 379,000 shorebirds counted during another Bay-wide survey 9-12 September 1988, 75% were recorded south of the San Mateo Bridge; within this area, 128,000 shorebirds were south of the Dumbarton Bridge, compared to 25,000 on the west shore and 77,000 on the east shore between the Dumbarton and San Mateo Bridges (Stenzel et al. 1989). The wintering shorebird population in the South Bay was estimated by Harvey et al. (1988) to exceed 200,000.

Most of the shorebirds that use the South Bay do so only for foraging and roosting but do not breed here. Only four shorebird species breed within the baylands habitats of the South Bay, while 20 species regularly use the South Bay for foraging and roosting as nonbreeders, and 19 additional shorebird species occur only as rare visitors to the area. Most individuals of most shorebird species in the South Bay forage primarily on intertidal mudflats when these flats are available at low tide. These individuals then seek high-tide refugia in salt ponds, on levees, in other alternative habitats in the area (e.g., water treatment plants, managed ponds, and muted or managed marshes), and to a limited extent in tidal marsh; here, most individuals of the larger shorebird species simply roost until the tide recedes again, while some individuals of the smaller shorebird species forage in their high-tide habitats. A few shorebird species remain in these alternative habitats throughout the tidal cycle, using salt ponds, water treatment plants, and managed ponds and marshes for foraging regardless of tide height.

Shorebird abundance in the South Bay is highest in spring and winter. For most species, the spring migration is rapid and compressed to a relatively brief period from early April to mid-May (Recher 1966; Stenzel and Page 1989), resulting in large numbers of individuals using the South Bay simultaneously. In contrast, the fall migration is more protracted for most species, as different sexes and age classes migrate in fall at different times. Shorebird abundance is lowest during summer, when only breeding individuals of four species and low numbers of non-breeders of other species are present. However, the summer period for shorebirds is very short in the South Bay – late spring migrants may move through the area as late as late May or early June, and the first fall migrants (usually Wilson's phalaropes) begin to arrive in mid-June, with the first southbound arrivals of a number of other species appearing by late June and early July. Fall migration then continues through October.

Breeding. Prior to conversion of tidal marshes to salt ponds in the San Francisco Bay area in the mid 1800s, only one shorebird species, the killdeer likely bred in the South Bay. This species breeds on open ground in a variety of habitats, and open sand, gravel, or soil suitable for breeding was likely present historically. However, the creation of salt ponds in the South Bay has enhanced breeding habitat for several species. The western snowy plover, which nests on salt flats and islands within salt ponds, likely did not breed in the South Bay prior to late 1800s; although salinas were present in the tidal salt marsh, they were not extensive and may not have been large enough to support breeding by this species (Goals Project 1999). This species was first recorded breeding in salt ponds in 1918 (Harvey et al. 1992), and today, snowy plovers nest on levees, islands, and salt flats throughout the South Bay salt ponds, occurring in highest concentrations in the Eden Landing area. This species is discussed in greater detail below in the Special-Status Wildlife Species section (Section 3.7).

The American avocet and black-necked stilt also did not breed in the San Francisco Bay area prior to the creation of salt ponds. These species were first recorded breeding in Bay-area salt ponds in 1926 and 1927, respectively (Gill 1977; Harvey et al. 1992). Since then, their populations have increased considerably, with avocet population estimates of 1800 pairs in 1971 (Gill 1977) and 540 pairs in 1981 (Rigney and Rigney 1981), and stilt population estimates of 400-500 pairs in 1971 (Gill 1977) and 600-650 pairs in 1981 (Rigney and Rigney 1981). More recently, a breeding-season survey of the South Bay by Rintoul and others (2003) counted 1184 black-necked stilts and 2765 American avocets, with the number of breeding pairs estimated at 135-590 for stilts and 440-1380 for avocets. No other coastal site along the Pacific Coast supports such high abundance of these two species (Rintoul et al. 2003).

Both stilts and avocets nest at scattered locations throughout the Shoreline Study Area, although Rintoul et al. (2003) noted particularly large concentrations of both species in New Chicago Marsh in Alviso, with another concentration of avocets in the Warm Springs area along the upper edges of the salt ponds and marshes (Figure 2). Rintoul et al. (2003) noted an increase in the importance of the Eden Landing area for nesting stilts and avocets since 1981 (Rigney and Rigney 1981). It is not clear whether their surveys covered the San Jose/Santa Clara WPCP, where on 10 May 1997, more than 30 stilt nests were found scattered over the sludge ponds during an informal survey (Steve Rottenborn, pers. obs.).

Rintoul et al. (2003) found 21% of 137 black-necked stilt nests in marshes and 69% around salt ponds; of 409 American avocet nests, 3% were in marshes and 93% were around salt ponds. Stilts used salt ponds and marshes in proportion to availability, while avocets favored salt ponds. Within marshes, stilts tended to use more heavily vegetated areas than avocets. Both species used similar habitats for brooding young (mostly salt ponds, with lesser numbers in marshes). Less than 20% of nests found were on levees; most were on islands, as reported by others (Gill 1973; Harvey et al. 1988; Rigney and Rigney 1981; Robinson et al. 1997; Robinson et al. 1999; Swarth et al. 1982). Both species commonly nest among nesting Forster's terns on islands.

Feeding. As noted previously, the South Bay is the single most important area on the west coast, south of Alaska, for use by migrant and wintering shorebirds. Surveys have documented more than 590,000 shorebirds present simultaneously 16-18 April 1988 (Stenzel and Page 1988) and 230,000 present 9-12 September 1988 (Stenzel et al. 1989) in the South Bay. Because these were only snap-shot surveys, and thus capture only a fraction of the shorebirds that use the South Bay as migratory stopover or staging areas, the actual number of birds that use the South Bay for foraging during migration is much higher. The San Francisco Bay is the northernmost location used by large numbers of shorebirds in winter on the West Coast (Warnock 2004a), and wintering shorebird numbers in the South Bay were estimated by Harvey et al. (1988) to exceed 200,000.

Shorebirds tend to forage in habitats, at times, under conditions, and on prey that provide high foraging efficiency while balancing predation risk and other adverse factors (Goss-Custard 1970; Goss-Custard 1979; Goss-Custard et al. 1977; Van de Kam et al. 2004). Shorebirds tend to concentrate foraging activity where suitable prey is most dense (Skagen and Oman 1996) and/or where such prey is most available (i.e., where the birds can reach and obtain food), although they may alter their behavior (e.g., foraging duration or foraging locations) based on competition from other shorebirds or energetic needs. For example, western sandpipers in the South Bay make more use of salt ponds during spring than during other seasons (Warnock and Takekawa 1996), possibly because high spring shorebird densities force some birds to spread out from preferred intertidal mudflats and forage more heavily in less optimal habitats. In winter, shorebirds may spend more time foraging and less time roosting due to decreased daylength, more rapid energy loss due to cool temperatures, and adverse effects of low temperature on food availability and foraging efficiency (Goss-Custard et al. 1977; Heppleston 1971; Kelly and Cogswell 1979; Van de Kam et al. 2004).

Most shorebird species in the South Bay are mudflat specialists, foraging primarily on intertidal mudflats when these flats are available at low tide (Anderson 1970; Kelly and Cogswell 1979; Recher 1966;

Stralberg et al. 2003; Swarth et al. 1982; Warnock et al. 2002; Warnock et al. 1995). These birds move to mudflats as they uncover on an ebbing tide, often concentrating at the edge of the receding tideline. Near the waterline, worms, crustaceans, and bivalves occur close to the surface, whereas these prey species recede deeper into the mud as the water level drops. Near the waterline, microhabitat use often varies among species based on bill and leg length; Semipalmated and black-bellied plovers feed on recently exposed mud, small sandpipers such as western and least sandpipers forage on recently uncovered mud and shallow water, mid-sized birds such as dunlin, red knots, long-billed dowitchers, and short-billed dowitchers forage in slightly deeper water, and larger shorebirds such as willets, long-billed curlews, and marbled godwits probe in deeper water.

Some authors have reported that the greatest concentrations of shorebirds occur at the receding tideline (Recher and Recher 1969; Stenzel and Page 1988; Storer 1951). Gerstenberg (1979) reported that shorebirds forage along the tideline until it reaches its ebb, then spread out over the tidal flats (especially when bird abundance is high), although he also noted that shorebirds may concentrate along the waterline on both the receding and incoming tide. All of these scenarios have been observed in the South Bay, where shorebirds may be observed foraging along the receding and incoming waterline, and often spread out over the flats as well (Steve Rottenborn, pers. obs.). It is likely that shorebirds use more of the tidal flats when densities are higher, as competition for space and food resources requires the birds to spread out over the flats more.

After the mudflat specialists have finished foraging on the mudflats, they may roost temporarily on the upper mudflats before leaving as the tide rises, or fly directly to alternate sites to roost or, to varying degrees, forage during high tide. Although sites such as water treatment plants, managed ponds (e.g., the Coyote Creek Reach 1A pond), managed/muted tidal marshes, and wet fields are used (heavily at times) by mudflat specialists during high tide, most shorebirds move to the salt ponds. Surveys of South Bay high-tide roosting and foraging sites, coordinated by SFBBO between October 1992 and May 1993, documented 51% of shorebirds using salt ponds at high tide, with 10% on levees around and within salt ponds and other habitats, 10% in tidal marsh, 12% in diked marsh, and up to 4% in inactive salt ponds, uplands, freshwater ponds (including sewage treatment ponds), tidal islands, and salt pannes (Hanson and Kopec 1994).

The use of salt ponds for foraging by mudflat specialists varies considerably among species, and for some species, it varies among individuals, seasons, and possibly age classes. Of the mudflat specialist species, most of the individuals observed in salt ponds at high tide are roosting rather than foraging. For example, over all surveys and all shorebird species recorded during SFBBO's 1992-1993 study, roosting composed 68% of activity at these high-tide areas, while foraging composed 26% of shorebird activity (Hanson and Kopec 1994). The percentage of birds in a given location that were foraging at high tide varied considerably among surveys; for example, <1% of more than 24,400 shorebirds in Pond R1 on 22 March 1993 were foraging, whereas 70% of the 6200+ birds (of similar species composition) in the same pond on 3 May 1993 were foraging at high tide. At times, nearly all birds in a given location were observed foraging at high tide, with foraging activity being particularly high in spring.

Long-billed curlews, marbled godwits, and black-bellied plovers roost in salt ponds but do not use them heavily for foraging (Warnock et al. 2002). Black-bellied plovers, willets, and dowitchers make somewhat greater use of salt ponds for foraging, but still do not forage in salt ponds to a great extent. Most western sandpipers and dunlin use salt ponds primarily for roosting, but forage on moist mud and in shallow water to a greater extent. A greater proportion of least sandpipers seems to use salt ponds for foraging than is observed in other mudflat specialists (Steve Rottenborn, pers. obs.).

Telemetry studies by Warnock and Takekawa (1995; 1996) determined that western sandpipers made greater use of salt pond levees and shallows for foraging during spring, when densities in the South Bay were higher, than during winter. These results suggest that birds depositing fat prior to spring migration may need to spend more time foraging (and thus forage in salt ponds during high tide), and that at higher densities (such as occur during spring migration), more birds are relegated to less preferred habitats, such as salt ponds. Some individuals of other mudflat specialists, particularly least sandpipers, dunlin, and semipalmated plovers, may also take advantage of suitable foraging conditions within salt ponds and remain in these ponds throughout the tidal cycle; even within salt ponds, these birds forage primarily at low tide, with most individuals roosting at high tide (Hanson and Kopec 1994; Warnock et al. 2002).

The mild microclimate of the South Bay may help to explain its high bird use during winter (Warnock and Takekawa 1996). Nevertheless, alternate foraging sites may be particularly important for mudflat specialists during the wet season. High winter tides, combined with sustained strong winds and/or flooding, may reduce the extent to which intertidal mudflats are uncovered, temporarily limiting the availability of these preferred foraging habitats (Storer 1951). Flooding may also wash silt onto mudflats, reducing prey availability or foraging efficiency (Gerstenberg 1979; Warnock and Takekawa 1996). Studies have demonstrated that dunlin in coastal areas may move inland to forage after heavy rains (Warnock et al. 1995).

Several species of shorebirds make little or no use of intertidal mudflats, instead preferring the “alternate” habitats for foraging regardless of tide height (Harvey et al. 1988; Stenzel and Page 1988; Storer 1951; Swarth et al. 1982; Warnock et al. 2002). American avocets forage in shallow pools and wet mud on mudflats, and occasionally in deeper water near the tideline (Hamilton 1975; Storer 1951; Warnock et al. 2002), and snowy plovers may use mudflats for foraging as well, but these species are most abundant in the South Bay in salt ponds. Black-necked stilts and Wilson’s and red-necked phalaropes also occur in the South Bay primarily in salt ponds, rarely foraging in tidal habitats. Greater yellowlegs and lesser yellowlegs (*Tringa flavipes*) forage in a variety of nontidal habitats in the South Bay, including salt ponds, and occur less frequently on tidal mudflats. While these seven pond specialists may occur by the hundreds or thousands in alternate habitats other than salt ponds, the salt ponds support the vast majority of the South Bay’s populations of these species.

Within the salt ponds, water depth and salinity influence the distribution of foraging shorebirds. The abundant invertebrates of the mid- and high-salinity ponds (60-200 ppt), namely brine shrimp, brine flies, and reticulate water boatmen, are important food sources for shorebirds (Larsson 2000; Maffei 2000b; Stralberg et al. 2003; Warnock et al. 2002), but their availability to shorebirds is limited by water depth. Most shorebirds forage in water less than ten to 15 centimeters deep, with depths below four centimeters being preferred by smaller species such as the western sandpiper, least sandpiper, and dunlin (Isola et al. 2000; Safran et al. 1997). Thus, only the moist soils along the edges of salt ponds, and moist soil or very shallow water within the ponds, provide suitable foraging habitat for these wading species.

The extent of shorebird foraging habitat present within the salt ponds varies considerably among ponds and seasons, but at any given time a relatively small proportion of the salt pond complexes provides suitable conditions (e.g., moist soil or shallow water <ten centimeters deep) for foraging by most shorebirds. Deeper ponds without shallowly sloping sides provide foraging habitat only in a very narrow zone along their immediate periphery. For example, a 12 in-wide strip of moist-soil and shallow-water foraging habitat around the edge of pond A2W (which represent the ponds that lack shallowly sloping sides and are usually flooded) would represent only ±0.1% of the area of this pond.

Calculating the area of suitable foraging habitat for shorebirds over an entire pond complex and across multiple seasons is problematic. Water depth in seasonal ponds may vary considerably among years, seasons, and even months or weeks depending on precipitation levels and temperature. Even in ponds where water levels are managed more actively, the lack of data on microtopography of the pond bottoms and the vagaries of management make it difficult to predict the extent of areas providing water <ten centimeters deep, and floating mats of algae in late summer and fall may provide foraging habitat for birds in ponds >ten centimeters deep. Furthermore, extensive dry flats with thick salt crusts provide only marginal foraging habitat for shorebirds, as prey densities may be low away from the moist-soil and ponded areas. Rough estimates suggest that at any one time, less than 15% of the total salt pond area provides foraging habitat for most shorebirds under ISP management during winter and early spring (when ponds contain the most water), and less than 25% of the salt pond area provides suitable foraging habitat during late summer and fall (when ponds are driest).

In contrast, phalaropes, and American avocets to a lesser extent, can forage while swimming. Thus, these birds are able to use the entire surface area of a pond, taking advantage of prey near the surface of the water. Phalaropes can draw invertebrates from deeper water upward in the water column by spinning on the water's surface. However, much of the invertebrate biomass of the mid- and high-salinity salt ponds may still occur at depths greater than those that can be used by these shorebirds (Laine, pers. comm.). Although brine shrimp account for most of the biomass of the invertebrates within these high-salinity ponds, the nutritive value of brine shrimp to foraging shorebirds may be limited, as Rubega and Inouye (1994) found that red-necked phalaropes could not survive foraging on brine shrimp alone. Brine flies (both adults and larvae), and water boatmen to a lesser extent, are thus very important to shorebirds that forage in South Bay salt ponds (Anderson 1970).

Most vegetated tidal marsh receives little use by foraging shorebirds because of the height and/or density of marsh vegetation. However, more open areas within the marsh are used for foraging by some species. Willets forage in the vegetated portions of tidal marshes (Gerstenberg 1979; Kelly and Cogswell 1979; Long and Ralph 2001), particularly when these areas are flooded during very high tides but occasionally even during low tide (Kelly and Cogswell 1979). Long-billed curlews, marbled godwits, least sandpipers, and other species occasionally forage in vegetated tidal marsh areas as well, usually in more sparsely vegetated areas but occasionally in dense (but short) pickleweed. Large numbers forage on intertidal flats along the larger sloughs within marshes when the flats are exposed, but most shorebirds avoid areas with dense, tall vegetation, and therefore do not forage in most of the marsh plain. These birds will forage, sometimes abundantly, in shallow marsh ponds and pannes within the high marsh, and in areas where bare mud and shallow water is interspersed with short pickleweed vegetation. Stralberg et al. (2003) reported that the proportion of small shorebirds foraging (rather than roosting) was higher in tidal marsh than in salt ponds. Thousands of individuals of a variety of species use New Chicago Marsh, a managed marsh (i.e., not considered a tidal marsh) in Alviso, for foraging at both low and high tide, as this marsh provides extensive shallow-water marsh pond/panne habitat interspersed with low pickleweed. However, most such areas that formerly occurred within South Bay tidal marshes have been destroyed by fill and diking, and at this time, high marsh habitat within fully tidal marshes is of limited importance for foraging shorebirds in the South Bay.

Birds are often classified by their foraging methods and habitats, which are largely a reflection of their physical adaptations for foraging and their preferred prey, into foraging groups or guilds. As indicated in the USGS unpublished preliminary bird data from Alviso salt ponds, shorebirds in the South Bay are generally grouped into three foraging guilds – shallow probers, deep probers, and sweepers.

Shallow probers are species that pick prey off the surface of the water or sediment (generally after locating the prey visually), or that probe at shallow depths within mud or moist sand to locate prey tactilely. The more common shallow probers in the South Bay include the killdeer, black-bellied plover, semipalmated plover, snowy plover, red knot, dunlin, least sandpiper, and western sandpiper. This guild represents the majority of the migrant and wintering shorebirds in the South Bay, with hundreds of thousands of western sandpipers, tens of thousands of least sandpipers and dunlin, thousands of black-bellied plovers and semipalmated plovers, and hundreds of snowy plovers and red knots using the South Bay at times (Harvey et al. 1992; Stenzel et al. 1989; Stenzel and Page 1988). Warnock and Bishop (1998) have identified the San Francisco Bay as a major staging area for the western sandpiper because individuals are present for longer periods of time and presumably put on more fat than in the stopover areas that are used, but are less important, elsewhere along the central California coast. The western sandpiper is by far the most abundant shorebird species present in the South Bay.

Deep probers include species generally having larger bodies and longer legs and bills than the shallow probers. These species, which probe more deeply into moist sediment and burrows for prey and do less picking of items from the surface (except for yellowlegs), include short-billed dowitchers (*Limnodromus griseus*), long-billed dowitchers, long-billed curlews, marbled godwits, whimbrels (*Numenius phaeopus*), and willets. Though not nearly as abundant in the South Bay as the shallow probers, this guild is still represented by tens of thousands of dowitchers, 10,000+ willets and marbled godwits, and hundreds of long-billed curlews, whimbrels, and greater and lesser yellowlegs during migration and winter (Harvey et al. 1992; Stenzel et al. 1989; Stenzel and Page 1988). The salt pond surveys by USGS identified the highest abundance of both shallow and deep probers (the vast majority of which were likely roosting, rather than foraging, in these ponds) in Alviso Ponds A5 and A7 (Takekawa et al. 2005).

Sweepers include the American avocet, black-necked stilt, Wilson's phalarope, and red-necked phalarope. All of these species forage by picking visually identified prey from the soil surface or water column, but avocets also forage by sweeping their bills from side to side through water and mud, tactilely detecting prey. Phalaropes may create a vortex by spinning in the water and drawing prey to the surface. In the South Bay, breeding populations of American avocets and black-necked stilts are augmented in winter, when up to 24,500 avocets and 11,500 stilts are present (Harvey et al. 1988). High counts of phalaropes in the South Bay include counts of 37,462 Wilson's phalaropes on 6 August 1984 and 19,000 red-necked phalaropes on 18 August 1981 (Harvey et al. 1992), with combined phalarope counts of as many as 70,000 individuals (Harvey et al. 1988). Both species are much less common in spring than in late summer and fall in the South Bay. Due to the presence of the South Bay salt ponds, the San Francisco Bay is one of five major staging areas for adult Wilson's phalaropes prior to their non-stop migration to South America (Colwell and J.R. Jehl 1994). The salt pond surveys by USGS identified the highest abundance of sweepers in Alviso Ponds A1, A5, A7, A8, A9, A14, A16, and AB2 (Takekawa et al. 2005).

Shorebirds in the South Bay eat a wide variety of invertebrates, and occasionally small fish. Brine shrimp, brine flies, and reticulate water boatmen probably compose the bulk of the prey taken in salt ponds, although *Corophium* spp., annelids, polychaetes, and other invertebrates are known to be taken in salt ponds as well (Anderson 1970). *Corophium* spp., polychaetes, bivalves, and snails likely compose the bulk of the prey taken on mudflats (Harvey et al. 1992; Recher 1966; Swarth et al. 1982). Shorebirds are very flexible and opportunistic in their diets, with considerable dietary overlap among species and foraging guilds (Skagen and Oman 1996). They often take prey in accordance with availability, concentrating where prey is most dense (Goss-Custard 1970; Goss-Custard 1977; Goss-Custard 1979). Thus, the hydrologic regimes and ecosystem processes that maintain abundant invertebrate populations are more important than the specific invertebrate taxa available. As a result, shorebirds are still abundant in the South Bay, and still show a preference for foraging on intertidal mudflats, despite the widespread and pervasive invasions of the South Bay benthic invertebrate community by nonnative species.

Roosting. Shorebirds generally roost, resting and preening, when they are not foraging. Many mudflat specialists roost on the upper flats after initially foraging on the receding tide, then fly to alternate habitats to roost as the mudflats flood. In the South Bay, the most commonly used high-tide roosts for both pond specialists and mudflat specialists are shallows and bare sediment within salt ponds, levees surrounding and (especially) between salt ponds, and islands and artificial structures such as boardwalks within these ponds (Warnock et al. 2002). Surveys coordinated by SFBBO in 1992 and 1993 (Hanson and Kopec 1994) found that 28% of all birds were in shallow water of salt ponds at high tide (most roosting), with an additional 23% on islands within salt ponds and another 10% on levees around a variety of habitats, including salt ponds. Islands within salt ponds were found to be used primarily for roosting, whereas shallow water within salt ponds was used by similar numbers for foraging and roosting. Levees were used for roosting more in spring than in winter, and infrequently in fall.

Although some shorebirds forage at high tide within salt ponds, most birds, including both pond specialists and mudflat specialists, roost during high tide (Hanson and Kopec 1994; Warnock et al. 2002). Major high tide shorebird roosts in the South Bay, based on the unpublished preliminary USGS bird survey data and SFBBO's 1992-1993 study (Hanson and Kopec 1994), are indicated on Figure 3, which also depicts the sites of major western sandpiper roosts in the South Bay identified by Warnock and Takekawa (1995).

Shallowly flooded marsh ponds, marsh pannes, managed marshes, managed ponds, and water treatment plant drying ponds are also used for roosting, and American avocets, willets, long-billed curlews, marbled godwits, dunlin, and dowitchers roost to some extent in tidal marshes with short vegetation (PRBO Conservation Science 2004; Storer 1951). Diked and tidal marshes along the Foster City/Redwood Shores shoreline provide roosting sites for large numbers of birds at times, particularly larger species such as willets, marbled godwits, and black-bellied plovers (Hanson and Kopec 1994).

Due to their proximity to foraging habitat, protection from predators, and protection from wind and wave action, some high-tide roosts are used consistently, and studies of color-marked or radio-tagged shorebirds in the South Bay indicate that many individuals use the same roosting sites consistently (Kelly and Cogswell 1979; Warnock and Takekawa 1995). Other shorebird roosts, however, may be more ephemeral or inconsistently used (Colwell et al. 2003). For foraging shorebirds, site fidelity is tied to consistently suitable conditions at certain locations (e.g., certain ponds that consistently provide shallow foraging habitat for shorebirds) rather than the locations themselves. While the same is likely true of shorebird roost sites, fidelity to a roost site is less easily explained given the abundant, widespread nature of ostensibly suitable roosting habitat on salt pond levees throughout the South Bay.

Waterfowl. Historical accounts of waterfowl numbers in the San Francisco Bay area attest to the abundance of ducks and, to a lesser extent, geese using the Bay area during migration and winter; for example, more than 300,000 ducks were sold in San Francisco markets during the 1911-1912 waterfowl season (Skinner 1962). The South Bay undoubtedly supported large wintering waterfowl populations, as reported by Skinner (1962) for the Alvarado area and the Santa Clara Valley, and the town of Drawbridge near Alviso "became a resort solely for duck hunters arriving from San Francisco by regular trains in the 1880s" (Harvey et al. 1992). The loss of 90% of the Bay's wetlands, along with hunting pressures, contamination, and other factors led to a decline in waterfowl populations, although this decline is not well documented for the South Bay. Currently, the South Bay supports fairly large migrant and wintering populations of ducks, with several breeding species as well.

More than 32 species of waterfowl use the baylands and immediately adjacent habitats of the South Bay. Of these, eight species breed regularly (with populations augmented considerably during the nonbreeding season), nine additional species occur regularly during migration and winter, and at least 15 more occur irregularly and/or in very low numbers in the baylands as nonbreeders. Harvey et al. (1988) reported that wintering waterfowl in the South Bay (south of the San Mateo Bridge) in 1981 exceeded 75,000 individuals, with more ducks on salt ponds than in the Bay, especially from January through April. Surveys in 1987-1990 revealed approximately 57,000 dabbling ducks (ducks that feed without submerging their entire bodies) and 220,000 diving ducks (Goals Project 1999) in the Bay area. The South Bay salt ponds were found to support up to 76,000 wintering waterfowl, representing more than one-quarter of the Bay's waterfowl population, including 89% of the Bay's northern shovelers, 67% of the ruddy ducks, half of the buffleheads, and 17% of the canvasbacks wintering in the Bay (Accurso 1992; Takekawa et al. 2000).

Breeding. Though not nearly as important to nesting waterfowl in the Bay Area as the Suisun Bay (Goals Project 1999; Harvey et al. 1992), the baylands habitats of the South Bay support eight regularly nesting waterfowl species: the mallard, gadwall, and Canada goose (breeding populations of which are introduced) are fairly common breeders, while the cinnamon teal, northern pintail (*Anas acuta*), ruddy duck, lesser scaup, and northern shoveler breed in smaller numbers. Several other species, including the green-winged teal (*Anas crecca*), blue-winged teal (*Anas discors*), canvasback (*Aythya valisineria*), and redhead (*Aythya americana*), have been recorded breeding only a few times in the Study Area (Santa Clara County Bird Data Unpublished).

Few data exist on breeding population estimates for these waterfowl species in the South Bay. The most comprehensive survey and population estimate for this area was by Gill (1977). During the 1971 breeding season, he found 21 nests or broods of the northern pintail, 19 of the gadwall, eight of the mallard, five of the ruddy duck, four of the cinnamon teal, and one of the northern shoveler in the South Bay. Based on his observations, Gill estimated breeding populations of these species at 50-100 pairs of pintails, 100-150 pairs each of gadwalls and mallards, 50-100 pairs of ruddy ducks, 75-100 pairs of cinnamon teal, and one to five pairs of shovelers in the South Bay. Based on breeding bird atlas work and other observations by birders, current populations of these species likely exceed Gill's 1971 estimates. For example, 650 gadwalls (including 25 broods of young) on 24 July 1993 at the Sunnyvale WPCP (Steve Rottenborn, pers. obs.) attest to much higher breeding abundance than was estimated by Gill. In addition, the lesser scaup has become a regular breeder (albeit in low numbers, likely ten to 20 pairs or more) in the South Bay since Gill's studies (Santa Clara County Bird Data Unpublished).

None of the 41 nesting attempts observed by Gill in salt marsh was successful, leading him to postulate that breeding populations in the South Bay were limited by the availability of freshwater habitats. The nesting microhabitats of these waterfowl within the South Bay are poorly known since nests are usually well hidden, and most breeding is detected by the observation of adults with broods of precocial young. Nesting by most of these species likely occurs in dense herbaceous vegetation in the upper tidal marsh, managed wetlands, upland transition areas, ruderal vegetation on levees, and upland areas surrounding ponds, sloughs, and ditches, such as weedy lots and fields. In contrast, the ruddy duck builds its nests in emergent vegetation in freshwater marshes and the marshy borders of freshwater ponds and ditches.

Important breeding areas for waterfowl in the South Bay combine freshwater or brackish seasonal wetlands with extensive grassy or ruderal vegetation for nesting and fresh, brackish, or low-salinity ponds and marshes for brooding of young. Such areas occur in the Study Area in the Palo Alto Flood Control Basin and vicinity, the Moffett Field/Crittenden Marsh area, the Sunnyvale and San Jose-Santa Clara WPCPs, the Sunnyvale Baylands, and the Coyote Creek Reach 1A waterbird pond.

Foraging and Roosting. The South Bay is an important foraging area for migrant and wintering waterfowl. All of the breeding species are present in much greater abundance during the nonbreeding season than during summer, and they are joined by other species that occur in the South Bay solely as nonbreeders. Duck abundance in the South Bay increases in August and September as migrants, particularly northern shovelers, arrive in salt ponds and marshes. Numbers of other dabbling ducks and several species of diving ducks increase through the fall and into winter, and remain high into March (Santa Clara County Bird Data Unpublished; Takekawa et al. 2005).

Dabbling ducks forage in a variety of habitats in the South Bay, including mudflats, shallow subtidal habitats, tidal sloughs and marsh channels, marsh ponds, managed and muted tidal marsh, seasonal wetlands, managed ponds, and water treatment plants. In these areas, dabbling ducks feed on a variety of aquatic plants and invertebrates. Because these species do not typically dive for food, dabbling ducks usually forage in water less than 30 centimeters deep (Page 2001). Within salt ponds, salinity is also important for these birds. The plants on which many dabbling ducks feed cannot tolerate high salinities, and thus dabbling duck abundance tends to be highest on lower salinity ponds (20-63 ppt) ponds, with few in ponds >154 ppt (Accurso 1992).

The most abundant dabbling ducks wintering in the South Bay are the northern shoveler, American wigeon (*Anas americana*), northern pintail, mallard, and gadwall (Takekawa et al. 2005). Shovelers are both abundant and flexible in habitat use in the South Bay, although they do not use tidal habitats frequently (Swarth et al. 1982). The northern shoveler was the third most abundant species recorded at the Coyote Creek Reach 1A waterbird pond during monitoring from 1992 to 2003, composing 81% of the waterfowl recorded there (Strong 2003), and counts of 4750 (19 Dec 1999) at the San Jose-Santa Clara WPCP and 5500 (20 December 1996) at the Sunnyvale WPCP have been recorded (Santa Clara County Bird Data Unpublished). Swarth et al. (1982) found shovelers to be much more abundant on salt ponds than in tidal habitats, with 16,500 shovelers counted on two salt ponds during a census in early November. In contrast, these observers found American wigeon, canvasback, scaup, and surf scoters to be much more abundant on the Bay than in salt ponds. Ruddy ducks and northern pintails were common in both habitats.

Diving ducks are the most abundant wintering waterfowl in the South Bay. Common species include the lesser scaup, greater scaup (*Aythya marila*), ruddy duck, canvasback, bufflehead (*Bucephala albeola*), surf scoter, common goldeneye (*Bucephala clangula*), and red-breasted merganser (*Mergus serrator*). These species may "tip up" for food in shallow water, but more frequently dive completely underwater to obtain food. Bivalves, including large numbers of Baltic clams, are a favored food item for diving ducks such as scaup, canvasbacks, and surf scoters, and canvasbacks often congregate over bivalve beds (Miles 2000b; Takekawa and Marn 2000; White et al. 1988). Ruddy ducks forage on aquatic vegetation (such as wigeon grass), which grows primarily in lower-salinity ponds, and invertebrates, including mollusks and water boatmen (Anderson 1970; Miles 2000a). Brine fly larvae/puparie are important to lesser scaup foraging on South Bay salt ponds (Anderson 1970).

Diving ducks are common in the open waters of the Bay, where large flocks of lesser and greater scaup, canvasbacks, and other species often congregate to roost. Although diving ducks may forage in water up to ten meters deep (Miles 2000b), these birds forage primarily in water only a few meters deep (John Takekawa, pers. comm.), and therefore much of the Bay is not available to (or does not provide high-quality foraging conditions for) these birds for foraging, and foraging flocks of diving ducks tend to congregate over shoals and over intertidal flats when they are inundated at high tide. Diving ducks are also common on salt ponds, in larger sloughs, and on some artificial lakes, such as Shoreline Lake in Mountain View.

Surveys conducted between October 1987 and March 1988 found that scaup composed 41%, scoters 21%, northern shovelers 11%, ruddy ducks 9% and canvasbacks 6% of all waterfowl on the open waters of the Bay (Takekawa et al. 1988). A large percentage (up to 25% or more) of the Bay's wintering populations of scaup and surf scoters occur in the South Bay, but most forage on the Bay itself, whereas buffleheads and ruddy ducks forage more extensively in salt ponds (Takekawa et al. 1988). Conducting winter censuses (November 2000 – February 2001) of the Bay south of the Bay Bridge, Ford et al. (2002) estimated more than 168,000 scoters, 164,000 scaup, and 53,000 ducks of other species on the open waters of the Bay. Although the center of abundance moved around somewhat among surveys, the greatest concentrations of scoters were north of the San Mateo Bridge, while several centers of abundance for scaup included areas between the Dumbarton and San Mateo Bridges and south of the Dumbarton Bridge.

Although total numbers of waterfowl are higher on the Bay than in salt ponds in the South Bay, lower-salinity salt ponds (20-63 ppt) of moderate size (50-175 ha) support the highest densities of waterfowl in the Study Area (Siegel and Bachand 2002). Ponds A9 and A10 in Alviso, and the Sunnyvale WPCP ponds, have been identified as being particularly important to northern pintail populations in the South Bay (Casazza and Miller 2000). Results of the salt pond surveys by USGS (Takekawa et al. 2005) indicate that in the Alviso Complex, Ponds A1, A2E, A2W, A5, A7, A9, and AB2 support high numbers of dabbling ducks, with the higher salinity Ponds A12, A13, and A19-A23 supporting few dabblers. Ponds A1, A2W, A9, and A10 support large numbers of diving ducks, primarily ruddy ducks and scaup, with fewer buffleheads and canvasbacks.

On decommissioned salt ponds in the North Bay, Takekawa et al. (2004) found that diving benthivores, primarily diving ducks, dominated the bird community on the salt ponds. Diving duck densities were four times higher in salt ponds than in the natural baylands in winter and spring, as contrasted with dabbling ducks, which were consistently higher in baylands habitats than in salt ponds. In South Bay salt ponds, dabbling ducks tend to dominate the salt pond bird communities, with northern shovelers accounting for 41-46% of all birds in ponds at low tide (Warnock et al. 2002). Ruddy ducks are the next most abundant duck wintering on South Bay salt ponds (primarily on low-salinity ponds), with up to 19,000 recorded on these ponds (Accurso 1992). In contrast to shorebirds, the vast majority of which use salt ponds primarily at high tide, duck numbers on South Bay salt ponds are similar at high and low tides (Warnock et al. 2002).

Stralberg et al. (2003) found that dabbling duck species richness in the South Bay tended to be higher in marshes than in salt ponds, and that dabbling ducks were more abundant in marshes at low tide, while diving ducks were more abundant at high tide. Dabbling ducks reached peak densities in salt ponds in fall and early winter, while diving ducks peaked in early spring. Dabbling duck densities tended to be higher in salt ponds with more natural upland, less tidal marsh, and less development surrounding the pond, while diving ducks tended to be higher in ponds closer to the Bay. Ninety percent of the dabbling ducks recorded during this study were recorded in just six of 22 ponds, while 90% of the diving ducks were recorded in nine ponds, indicating that the majority of ponds support few ducks.

Diving ducks, and many dabbling ducks, often roost while swimming in the open waters of the Bay, on sloughs, and in salt ponds. Dabbling ducks, and diving ducks to a lesser extent, also roost on the edges of mudflats and marshes, on islands and levees within ponds, and on mud and shallow water within the bottoms of salt ponds.

Large waders and other piscivores. This category includes a diverse group of approximately 20 species of piscivorous (i.e., fish-eating) waterbirds that occur in the South Bay, including pied-billed grebes (*Podilymbus podiceps*), western grebes (*Aechmophorus occidentalis*), Clark's grebes (*Aechmophorus clarkii*), loons (which are uncommon to rare visitors), double-crested cormorants, American white pelicans, brown pelicans (*Pelecanus occidentalis*), and large waders (i.e., herons, egrets, and ibis). Several other species, including gulls, terns, mergansers, and belted kingfishers (*Ceryle alcyon*) also forage for fish in the Study Area but are treated in other categories.

While a number of piscivores breed in the South Bay, numbers of most of these species are highest during the nonbreeding season. Western and Clark's grebes do not nest in the baylands of the South Bay but may occur in the area, particularly on salt ponds and in the open Bay, year-round (being most abundant in winter). Brown pelicans typically occur in San Francisco Bay as post-breeding dispersants during summer and fall (Ainley 2000a). American white pelicans are most abundant from June through December.

Breeding. Several piscivorous species in this category nest in the South Bay. Pied-billed grebes nest in freshwater wetlands, building floating nests of vegetation, in scattered areas surrounding the salt ponds and tidal wetlands in the Study Area. Double-crested cormorants nest on electrical transmission towers at several locations in the Study Area, and on the levee between Ponds A9 and A10 in Alviso (see Figure 5); this species and the white-faced ibis (*Plegadis chihi*) are discussed in greater detail in the Special-Status Wildlife Species section below (Section 3.7).

Herons and egrets nest in the Study Area as well (Figure 4). A sizeable colony of waders was detected at Mallard Slough in Alviso in the mid 1970s (Harvey et al. 1992). This colony steadily increased in size, peaking at over 800 nests, through the 1990s. Ten nesting pairs of great egrets were discovered in 1977, increasing to 30 pairs in 1990, when an estimated 266 pairs of snowy egrets and 115 pairs of black-crowned night-herons were present. Up to nine pairs of cattle egrets (*Bubulcus ibis*) and one or more pairs of little blue herons (*Egretta caerulea*) and white-faced ibis also nested in the Mallard Slough colony in the early 1990s. However, this colony was abandoned for unknown reasons in 1999. That year, a small colony of great egrets, containing up to 30 adults and eight nests, became established nearby along lower Coyote Creek near the Reach 1A waterbird pond. Twelve great egret nests were found here in 2000, and seven pairs of great blue herons nested at this location in 2001 (Santa Clara County Bird Data Unpublished). However, this colony has since been abandoned.

Since 1998, small heron rookies have appeared on islands in inland reservoirs in the South Bay (e.g., Lake Cunningham, Almaden Lake, and Vasona Reservoir), and several other small colonies have appeared in the immediate Study Area. Currently, heron rookeries in the vicinity of the Alviso Complex include a colony of snowy egrets and black-crowned night-herons at the Palo Alto Baylands duck pond; small numbers of great blue herons nesting on transmission towers in Ponds A2W, A2E, A3N, and A19 (and on a duck blind in Pond A2E); great egrets, snowy egrets, and black-crowned night-herons nesting in California bulrush at the west end of the Coyote Creek Lagoon near Newby Island (first noted in 2000); and great egrets, snowy egrets, black-crowned night-herons, and little blue herons in Guadalupe Slough between ponds A4 and A5 (Santa Clara County Bird Data Unpublished; Strong 2004a). Green herons (*Butorides virescens*) nest at low densities in scattered locations throughout the South Bay, including mixed-species heronries but also as isolated pairs or in small monospecific groups on duck blinds, along sloughs, and in trees and brush.

Foraging and Roosting. The piscivorous birds of the South Bay forage in a variety of habitats and locations where prey fish are available. The low-salinity salt ponds that support fish, tidal sloughs and channels, edges of intertidal mudflats, nontidal ponds and channels, and artificial lakes such as Shoreline Lake provide the highest-quality foraging areas, and large frenzies of feeding activity may be observed at these locations, presumably when conditions result in large fish concentrations. Brown pelicans usually plunge-dive for fish and therefore require water several feet deep, but American white pelicans and cormorants swim while feeding and can thus feed in shallower water. Although double-crested cormorants, western and Clark's grebes, and brown pelicans forage to varying degrees within the open waters of the Bay, American white pelicans apparently do not, instead preferring nontidal waterbodies (Cogswell 2000; Harvey et al. 1988). Large wading birds are constrained by water depth, and are usually seen foraging from the edges of a body of water or wading within the shallows. Pied-billed grebes and most of the herons and egrets often forage along freshwater streams and in smaller ponds in the South Bay, and great blue herons and great egrets occasionally forage for small mammals in upland fields and ruderal areas.

The larger piscivores move around the South Bay in search of suitable foraging conditions, allowing them to exploit particularly large concentrations of fish. Cormorants and pelicans exhibit movements between foraging areas at inland reservoirs and the South Bay, although most foraging likely occurs within the baylands habitats (Steve Rottenborn, pers. obs.). Piscivore density tends to be lower in salt ponds at low tide than at high tide, as some birds move to intertidal flats to forage (e.g., herons and egrets) or roost (e.g., pelicans) at low tide (Stralberg et al. 2003).

Within salt ponds, the fish commonly taken by piscivores include the mudsucker, topsmelt, sculpin, and stickleback (Cogswell 2000; Harvey et al. 1988). These fish are usually found in water having salt concentrations up to 70-80 ppt, and most cannot tolerate salinity >40 ppt (Carpelan 1957; Lonzarich 1989). As a result, most piscivore use of salt ponds is concentrated in ponds with lower salinities (Anderson 1970; Swarth et al. 1982).

Swarth et al. (1982) reported that loons and western and Clark's grebes were much more abundant on the Bay than in the salt ponds west of the Coyote Hills (Swarth et al. 1982), noting that piscivorous species were more common in the Alviso ponds than in the Coyote Hills ponds. Approximately 94% of the pelicans and double-crested cormorants recorded by Swarth et al. (1982) were in low-salinity ponds, though most of the cormorants used these ponds only for roosting (primarily on wooden pilings and platforms within the ponds). Although cormorants may take advantage of local concentrations of fish within salt ponds, most apparently feed in the Bay (Ainley 2000b; Anderson 1970). Herons and egrets forage primarily in sloughs and marshes, with only some birds moving to salt ponds at high tide (Anderson 1970; Swarth et al. 1982). However, where temporary concentrations of fish were present (generally in low-salinity ponds in fall), these waders occurred in large concentrations. Takekawa et al. (2001) reported that piscivores were more abundant in natural baylands than in salt ponds in the North Bay during all seasons, while Stralberg et al. (2003) determined that the species richness of large waders tended to be higher in the tidal salt marsh than in salt ponds, although piscivore abundance was higher in salt ponds.

Aerial surveys of the South Bay salt ponds have recorded counts of up to 3147 (on 6 August 1984) American white pelicans using these ponds (Harvey et al. 1992). These surveys only found white pelicans using ponds with salinities between 25 and 90 ppt, with the highest densities in ponds with low salinities (25-30 ppt). Harvey et al. (1992) suggested that the conversion of tidal marsh to salt ponds has benefited white pelicans, and that populations of nonbreeders in the Bay have increased as a result of the provision of sheltered foraging areas that concentrate fish and undisturbed levees for roosting.

Surveys of the South Bay salt ponds by USGS (Takekawa et al. 2005) indicate that species richness of piscivores is more or less constant throughout the year, though abundance is highest in late summer and fall due to the presence of high numbers of herons, egrets, and American white pelicans foraging in salt ponds at this time. Within the Alviso Pond Complex, piscivore abundance is highest in Ponds A1, A2W, A3W, A5, A7, A9, A10, and AB2 and very low in Pond B6 (which contains little water) and the high-salinity ponds A19-A23.

grebes and loons roost entirely on the water, and other swimming piscivores (e.g., pelicans and cormorants) may form floating roosts as well. However, most roosting by pelicans and cormorants occurs on salt pond levees (particularly interior levees between ponds), islands, and artificial structures such as boardwalks. Cormorants often roost in flocks on transmission towers as well. Herons and egrets roost on salt pond levees and in dense marsh vegetation along tidal sloughs.

Larids. Although larids (i.e., birds in the family Laridae, such as gulls, terns, and skimmers) have always used the South Bay for foraging during winter and migration, the use of this area has undoubtedly increased as a result of salt pond creation and, for gulls, the provision of food at landfills, and several species have begun nesting in the South Bay over the last century as a result. Currently, larid populations in the Bay are highest in winter due to the presence of tens of thousands of (if not 100,000+) wintering gulls. However, terns are generally more abundant in the South Bay during the breeding season. Information on special-status larids in the South Bay, including the California gull, California least tern, and black skimmer, can be found in the Special-Status Wildlife Species section below (Section 3.7).

Breeding. In the early 1900s, the Caspian tern was the only larid known to nest in the San Francisco Bay area, with a colony of more than 100 pairs nests present as early as 1916 in marshes near the east end of the Dumbarton Bridge (Grinnell and Miller 1944; Grinnell and Wythe 1927). This colony was reported to occur on a dike between salt ponds as of 1952 (Sibley 1952). As this colony grew to a size of 200 pairs, it split into two colonies in the Newark/Eden Landing area, and a third colony became established on salt pond levees near Mowry Slough in the late 1960s. By 1981, a colony of 1000 pairs was present on Bair Island as well, with approximately 2350 nesting birds present in the South Bay (Rigney and Rigney 1981). However, predation and disturbance by red foxes caused the abandonment of both the Mowry and Bair Island colonies in 1990 and 1991. Subsequently, Caspian terns nested in small numbers at Bair Island in 1993 and 1994 (Harding et al. 1998). Since 1990, breeding within the Study Area has also occurred in Pond A7 (breeding 1997-2006, peaking at 195 individuals in 2001 but with only 30 in 2006) and Ponds A9/A10 (70 individuals present in 1992 only). All nesting in the South Bay currently occurs on isolated portions of levees and islands with little or no vegetation within salt ponds. Although South Bay populations have declined precipitously since the early 1980s, the establishment of a large colony on Brooks Island in the North Bay has allowed Bay-area populations to remain fairly constant, with approximately 2300 individuals breeding in the Bay area in 2003 (Strong 2004a).

Forster's terns were not reported to be nesting in the San Francisco Bay area as of 1944 (Grinnell and Miller 1944), but a colony containing approximately 100 nests was discovered near the east end of the San Mateo Bridge in 1948 (Sibley 1952). Another colony was detected near the east end of the Dumbarton Bridge in 1952, and since then, Forster's tern colonies have appeared at scattered locations throughout the South Bay, with populations peaking at 4386 birds in 1992. However, local populations of Forster's terns have declined significantly since 1984, and a 2003 estimate of the Bay-wide population stands at 2450 individuals (Strong 2004a). In 2003, the 1958 Forster's terns thought to be nesting in the South Bay represented 80% of the total San Francisco Bay population, and represented nearly 25% of the Pacific Coast population and 10% of the North American population estimated in 2001 (McNicholl et al. 2001; Strong et al. 2004a).

Since 1990, Forster's tern colonies have been recorded in the Study Area at the following locations (Figure 4): Charleston Slough and the Palo Alto Flood Control Basin; Alviso Ponds A1, A5, A6, A7, A8, A9/A10, A16, A17, A18, and AB2. These colonies are located on small islands having little or no vegetation (and no tall vegetation) within salt ponds, tidal flats (at Charleston Slough), and managed marsh (Palo Alto Flood Control Basin), with small numbers on duck blinds. In 2006, the largest colonies within the Study Area were at Pond A7 (170 nests) and Pond A16 (132 nests; Strong 2006).

Predation by red foxes, and by avian predators such as California gulls and common ravens (*Corvus corax*), may be impacting tern populations to some extent. In addition, encroachment on Forster's tern nesting sites by an ever-increasing California gull breeding population in the South Bay has taken its toll on nesting terns; for example, islands in Alviso Pond AB2 that were formerly used by nesting Forster's terns have been largely, or entirely, taken over by nesting gulls (Strong 2004a). Because nesting on islands is so important to Forster's terns and black skimmers (and secondarily to the other breeding larids in the South Bay) to deter mammalian predation, population sizes may be limited by available breeding sites.

Least terns, black skimmers, and California gulls are also recent additions to the breeding avifauna of the South Bay; these species are discussed in detail in the Special-Status Wildlife Species section below (Section 3.7). Western gulls (*Larus occidentalis*) nest in very low numbers in the Study Area, with one to three pairs nesting in Pond A6 and on the levee between Mowry Ponds M4 and M5, both within large California gull colonies (Strong 2004a, Strong 2006). The western gull breeds much more commonly near the mouth of the Bay and along the coast.

Foraging and Roosting. Terns and skimmers in the South Bay, which include not only the aforementioned species, but also post-breeding elegant terns (*Sterna elegans*) and occasionally common terns (*Sterna hirundo*), feed primarily on small fish. Foraging occurs commonly within the open waters of the Bay and in low-salinity salt ponds, as well as tidal sloughs and freshwater and brackish channels and ponds. Caspian and Forster's terns often forage at inland ponds and lakes as well, even during the breeding season. Terns may roost on intertidal mudflats at low tide, whereas at high tide and at night they roost primarily on isolated levees, islands, and exposed mud surrounded by water within shallow ponds.

During the nonbreeding season, nesting populations of western and California gulls within the South Bay are augmented not only by nonbreeders of those species (likely including 10,000+ more California gulls and hundreds to 1000+ western gulls), but also by large numbers of herring (tens of thousands), Thayer's (*L. thayeri*; thousands), ring-billed (*L. delawarensis*; thousands to 10,000+), mew (*L. canus*; thousands), glaucous-winged (*L. glaucescens*; hundreds to 1000+), and Bonaparte's (thousands) gulls. With the exception of the Bonaparte's gull, which forages primarily on invertebrates in salt ponds and sewage treatment plants, these gulls are opportunistic foragers. They eat a wide variety of animal matter, including invertebrates, fish, small mammals and birds, and carrion, as well as processed food in landfills. Many gulls forage or roost on intertidal mudflats at low tide (Warnock et al. 2002).

The Newby Island landfill north of Coyote Creek near Alviso in the Study Area and the Tri-Cities Recycling and Disposal Facility located in Fremont immediately adjacent to the Study Area provide food for tens of thousands of wintering gulls, and are likely primarily responsible for the large wintering (and possibly breeding) populations of gulls in the South Bay. Gull abundance is much higher in the vicinity of these landfills than elsewhere in the Study Area, and particularly large concentrations of roosting birds occur in the Alviso and Fremont salt ponds. For example, the location of Ponds A22 and A23 between these two large landfills makes them a particularly attractive roosting location for gulls in winter. California gulls forage extensively at landfills in the South Bay, but they (and mew gulls to some extent) also forage in large numbers on brine flies and other invertebrates within mid- and high-salinity salt ponds, like the Bonaparte's gull (Steve Rottenborn, pers. obs.). Up to 10,000 Bonaparte's gulls forage in the South Bay, primarily on brine shrimp and brine flies in salt ponds having salinities of 90-200 ppt (Harvey et al. 1992). The recent surveys of South Bay salt ponds by USGS (Takekawa et al. 2005) found Bonaparte's gull abundance highest on Alviso Pond A8.

Most of the gulls in the greater South Bay area roost on the Bay or salt ponds/levees at night and large numbers roost in these areas during the day as well. Thousands of gulls disperse inland from the Bay area during the day to forage at inland landfills, on agricultural fields and seasonal wetlands, on athletic fields, and in urban areas, particularly in winter.

Carpelan (1957) indicated that Forster's terns are the main predator on topsmelt in South Bay salt ponds, and Anderson (1970) also suggested that the topsmelt was likely the main prey item of Forster's terns in the South Bay. A study of the diet of breeding Forster's terns in the South Bay in 1972 (Anonymous Unpublished) found that their diet consisted primarily of fish; many were caught in the Bay, but a large percentage was caught in lower-salinity salt ponds as well. Fish most frequently taken at these ponds included small (<six centimeters) Pacific herring (which were often fed to chicks), topsmelt, and anchovies. Observations of adults with prey at four Forster's tern colonies in the South Bay indicated that threespine stickleback outnumbered all other fish combined by an order of magnitude, with several thousand sticklebacks observed as prey. The next five most abundant fish brought to colonies were northern anchovy (90 individuals), topsmelt (82), staghorn sculpin (64), shiner surfperch (50) and dwarf surfperch (*Micometrus minimus*, 45). Ten other fish species, all represented by 27 individuals or fewer, were also used as prey, as well as four individuals of two genera of bay shrimp.

Gill (1976) recorded 21 species of fish found at the Mowry colony of Caspian terns during the 1971 breeding season. The eight species representing greater than 2% of the total number of fish recorded were jacksmelt (33%), shiner perch (16%), staghorn sculpin (16%), longjaw mudsucker (9%), Oriental goby (5%), northern anchovy (6%), rainbow trout (4%), and topsmelt (3%). While the vast majority of fish recorded at this colony were estuarine species, seven species were primarily freshwater fish. The observation of Caspian terns with tagged trout that had been released at Del Valle Reservoir, 25 miles away from the Mowry tern colony, exemplifies this terns' propensity for foraging widely during the breeding season.

Other Waterbirds (eared grebes, coots, and rails). The eared grebe and South Bay members of the family Rallidae, which includes the American coot (*Fulica americana*), common moorhen (*Gallinula chloropus*), and several species of rails, are combined into a separate group for the purposes of this existing conditions report.

The eared grebe is a small diving bird that breeds only occasionally and in small numbers in the South Bay, occurring much more abundantly as a nonbreeding forager from October to April. Eared grebes nest in California on freshwater wetlands in the Central Valley and Great Basin regions fairly commonly, but in the South Bay, breeding has occurred only in a flooded, diked pickleweed marsh in the Moffett Field/Crittenden Marsh area, where nesting occurred in 1983, 1986, 1993, and 1995 (Cogswell 2000; Santa Clara County Bird Data Unpublished).

Nonbreeding eared grebes in the South Bay are closely tied to deeper, higher-salinity salt ponds, where they feed on brine shrimp, brine flies, and reticulate water boatmen (Anderson 1970). Censuses of eared grebes on South Bay salt ponds have exceeded 40,000 individuals (Harvey et al. 1992), and Cogswell (2000) suggested that the total Bay Area wintering/migrant population could be as high as 50,000 to 100,000 birds. The recent surveys of South Bay salt ponds by USGS (Takekawa et al. 2005) found eared grebe abundance highest on Alviso Ponds A8 and A11-A17.

American coots and, in much lower abundance, common moorhens breed in freshwater wetlands, channels, and ponds in and around emergent vegetation in a number of locations throughout the South Bay. These birds are omnivorous, eating a wide variety of plant and animal (particularly invertebrate) material. Coot populations are augmented substantially during winter, when this species occurs by the hundreds or low thousands on lower-salinity salt ponds (Anderson 1970), sewage treatment plant ponds, and other open-water locations.

The status of the California clapper rail and California black rail in the South Bay is described in detail in the Special-Status Wildlife Species section below (Section 3.7). Two other rails occur regularly in the South Bay. Both the sora (*Porzana carolina*) and Virginia rail (*Rallus limicola*) may breed in very small numbers in freshwater wetlands around the South Bay, although they occur much more commonly as nonbreeders from August to May. During the nonbreeding season, these secretive species occur in a wide variety of tidal and nontidal salt, brackish, and freshwater marsh habitats, being most abundant in freshwater and brackish areas. Here, these species forage primarily on invertebrates. Significant depredation of these rails by egrets and herons has been observed during exceptionally high tides in winter, particularly in areas where high tide refugia (such as upland transitional zones in the high marsh or along tidal channels) are lacking.

Terrestrial/Riparian Birds. Although riparian habitats in the Study Area have been highly degraded by vegetation removal, stream channelization, and encroachment by agriculture and urbanization, the riparian habitats within the Study Area still support high abundance and diversity of terrestrial birds. In particular, the remnant mature riparian woodland along lower Coyote Creek, augmented by the habitat restoration efforts of the Santa Clara Valley Water District, provides important breeding and foraging habitat for birds. These bird communities are dominated by insectivorous passerines during summer; representative breeding species include permanent residents such as the song sparrow, saltmarsh common yellowthroat, bushtit, chestnut-backed chickadee (*Poecile rufescens*), downy woodpecker (*Picoides pubescens*), and Anna's hummingbird and summer residents such as the California yellow warbler (*Dendroica petechia brewsteri*), Pacific-slope flycatcher (*Empidonax difficilis*), and black-chinned hummingbird (*Archilochus alexandri*). Breeding raptors include the red-tailed hawk (*Buteo jamaicensis*), red-shouldered hawk (*Buteo lineatus*), Cooper's hawk (*Accipiter cooperii*), and American kestrel (*Falco sparverius*). During spring and fall migration, large numbers of insectivores such as the Swainson's thrush, orange-crowned warbler, Wilson's warbler (*Wilsonia pusilla*), and warbling vireo (*Vireo gilvus*), forage in the riparian trees and shrubs. Seed-eating birds that frequent more open habitats during migration and winter include the white-crowned sparrow, golden-crowned sparrow, Lincoln's sparrow (*Melospiza lincolnii*), and fox sparrow (*Passerella iliaca*), in addition to resident American goldfinch (*Carduelis tristis*) and house finch. The Coyote Creek Field Station of the SFBBO (formerly Coyote Creek Riparian Station) monitors numbers of birds along lower Coyote Creek.

The lower Guadalupe River has fairly well-developed woody riparian habitat in some areas, and supports extensive emergent and ruderal vegetation that provides cover and food for high densities of a few species such as sparrows, red-winged blackbirds, and saltmarsh common yellowthroats. Riparian bird communities are more poorly developed (i.e., supporting fewer taxa and generally lower densities) along other streams within the Study Area due primarily to degradation (or absence) of woody riparian habitat and encroachment of urbanization. For example, the portions of Calabazas, San Tomas Aquinas, Stevens, Matadero, and many other creeks in the Study Area are highly channelized, narrow corridors that support little woody riparian vegetation. Birds present in these areas are generally common stream-associated birds such as the mallard, green heron, and killdeer or common, widespread terrestrial bird, with few riparian-associated passerines.

Only a few passerines breed at all commonly in tidal salt, brackish, and freshwater marsh in the South Bay. Within most tidal salt marsh, the only nesting passerines are the Alameda song sparrow and marsh wren (in the lower marsh dominated by cordgrass and gumplant) and the savannah sparrow, which nests in pickleweed and peripheral halophytes in the upper portions of tidal and diked saltmarsh, along vegetated levees, and in adjacent upland transitional zones. South Bay population estimates for these species in 1971 by Gill (1977) included 1000-1200 pairs of marsh wrens (in cordgrass, but more abundantly in freshwater marshes, especially at Alviso and Guadalupe Sloughs, Coyote Creek and Mud Slough, and the Palo Alto Flood Control Basin), 800-1000 pairs of savannah sparrows, and 1800 pairs of Alameda song sparrows. The saltmarsh common yellowthroat may also nest in South Bay salt marshes in small numbers (Ray 1919; Steve Rottenborn, pers. obs.), although it nests primarily in brackish and freshwater marsh; this species, and the Alameda song sparrow, are discussed in detail in the Special-Status Wildlife Species section below (Section 3.7). Northern harriers, and formerly (or rarely) the short-eared owl (*Asio flammeus*), also nest within tidal salt marshes in broad vegetated marsh plains; these species are also discussed in the Special-Status Wildlife Species section (Section 3.7).

In addition, the red-winged blackbird nests in freshwater marsh in the Study Area, and scattered small trees and shrubs along salt pond levees and upland edges provide nesting sites for white-tailed kites, loggerhead shrikes, California towhees, and other species in limited numbers. Barn and cliff swallows breeding on artificial structures within and adjacent to the baylands forage commonly for flying insects over marshes and salt ponds in the South Bay.

Transmission towers within the marshes and salt ponds in the South Bay provide nesting sites for red-tailed hawks, common ravens, and peregrine falcons. Both species may prey on small mammals, rails, waterfowl, and shorebirds in the South Bay, and common ravens are particularly notorious predators of eggs and young of a variety of birds. Populations of ravens and American crows have increased markedly in recent decades throughout the Bay area, feeding heavily at the landfills around the South Bay but also preying on other wildlife species. Few data are available on the impact of ravens and crows on breeding populations of other species, but it is likely that ravens nesting on towers within tidal marshes and salt ponds have at least some impact on populations of California clapper rails, snowy plovers, and other breeding bird species.

During the nonbreeding season, additional landbirds occur in the baylands, including large numbers of sparrows of several species and several raptors. Short-eared owls occur regularly in small numbers in the more extensive marshes in winter, foraging on small mammals and birds, and merlins (*Falco columbarius*), peregrine falcons (*Falco peregrinus*), and other raptors forage for waterfowl and shorebirds throughout the South Bay.

Other upland habitats include grasslands and developed settings. Non-native grasslands in the South Bay support limited and declining populations of burrowing owl. A variety of birds use annual grasslands as foraging habitat, including savannah sparrows, horned larks (*Eremophila alpestris actia*), American pipits, western meadowlarks (*Sturnella neglecta*), lesser goldfinches, barn swallows, and various raptors. Western meadowlarks and mourning doves may nest in this habitat as well. Birds in developed areas face not only regular human disturbance, but also unique foraging and nesting opportunites. Those that are well adapted to such habitats commonly breed here. These species include the house finch, mourning dove, barn swallow, cliff swallow, and black phoebe and non-native European starling, rock pigeon (*Columba livia*), and house sparrow (*Passer domesticus*).

4.3.6 Notable Wildlife Resources in the Shoreline Study Area

Based on recent monitoring conducted by the USGS, SFBBO, and others, the most prominent wildlife resources and patterns of wildlife distribution in the Shoreline Study Area are as follows:

- Mixed heronries are located along Guadalupe Slough and at the west end of the Coyote Creek Lagoon near Newby Island, and small numbers of great blue herons nest on transmission towers in or adjacent to several salt ponds in this complex.
- Breeding concentrations of black-necked stilts and American avocets occur in New Chicago Marsh, in the vicinity of Pond A22, in Pond A8, and in the Palo Alto Flood Control Basin, with additional concentrations of avocets at the Warm Springs Marsh and Reach 1A waterbird pond, and stilts in the San Jose-Santa Clara WPCP.
- Moderate numbers of western snowy plovers breed in Pond A22 and Pond A8. In the past, western snowy plovers have bred in Pond A6, although they have not nested in this pond years, likely due to the gull colony there. Western snowy plovers have also recently nested in a small impoundment north of the Alviso marina.
- Large numbers of shorebirds forage on the intertidal mudflats ringing the South Bay south of the Dumbarton Bridge during low tide.
- Large numbers of shorebirds roost, and forage to varying degrees, in Ponds AB2, A5, and A7, with high numbers also present in Ponds A3N, A6, A9, A14, and A8, in New Chicago Marsh, in Crittenden Marsh, and at the San Jose-Santa Clara Water Pollution Control Plant at times.
- Several California gull colonies, including the state's second largest colony in Pond A6, are present in the Alviso pond complex.
- Double-crested cormorants nest on transmission towers in Pond A2W, in the AB1/AB2/A3N area, and in Pond A18, and on the levee between Ponds A9 and A10.
- Red-tailed hawks and common ravens nest on transmission towers in several ponds, and in 2007 two pairs of peregrine falcons nested in old raven nests on towers in the Alviso Complex.
- Forster's terns nest on small islands in a number of locations (primarily in salt ponds), and black skimmers nest in the Palo Alto Flood Control Basin and in Ponds A1, AB1, AB2, A8, and A16. Caspian terns nest, or have recently nested, in Pond A7, and on the levee between Ponds A5 and A7.

- The main post-breeding staging area for California least terns is within the Alviso pond complex, primarily in the ponds north of Moffett Field but with birds regularly using a number of other ponds in this pond complex for foraging and roosting. California least terns also forage over the Bay off the Alviso salt ponds.
- California clapper rails occur in a number of locations, although high-quality habitat is limited. The highest numbers are likely in the more extensive tidal salt marshes along Coyote Creek and near Palo Alto, although this species is also present in brackish marshes in the Warm Springs area, along Guadalupe Slough and Alviso Slough, and in smaller marsh remnants along sloughs and the Bay edge.
- Ponds A1, A2E, A2W, A5, A7, A9, and AB2 support high numbers of dabbling ducks, whereas Ponds A1, A2W, A9, and A10 support large numbers of diving ducks.
- Tens of thousands of gulls roost in the Alviso ponds and levees, with many foraging at landfills near Milpitas and in Fremont.
- Within the Alviso pond complex, piscivorous bird abundance is highest in Ponds A1, A2W, A3W, A5, A7, A9, A10, and AB2.
- Ponds A19, A20, and A21 have been restored to tidal action under the ISP. These ponds initially provide intertidal foraging habitat for shorebirds and other waterbirds at low tide, and tidal foraging habitat for waterfowl at high tide. As sediment accumulates (and the gypsum layer is buried and/or deteriorates), tidal marsh vegetation will become established, providing breeding and foraging habitat for the California clapper rail and other marsh species.
- Steelhead occur in San Francisquito Creek, Stevens Creek, the Guadalupe River, and Coyote Creek.
- Chinook salmon occur in the Guadalupe River and Coyote Creek.
- Salt marsh harvest mouse habitat in the Alviso pond complex is limited. Most of the marshes are brackish marshes, areas that are little used by salt marsh-dependent species such as the salt marsh harvest mouse and salt marsh wandering shrew, and the salt marsh that does exist has little to no high marsh or escape cover.
- A small population of western pond turtles (*Emys marmorata*) is present along the northern edge of Moffett Field and the Sunnyvale WPCP, with a few individuals present along the lower Guadalupe River and Coyote Creek as well.
- The Warm Springs portion of the SFBNWR supports vernal pool tadpole shrimp (*Lepidurus packardi*) and California tiger salamanders.
- Burrowing owls occur in grassland habitats fringing the South Bay, with higher concentrations at Shoreline Park, Moffett Field, and the San Jose WPCP buffer lands.
- The riparian corridor of Coyote Creek supports a variety of migrant and resident landbirds.

4.4 Special-Status Wildlife Species

Special-status animal species that occur in the Study Area and adjacent habitats are described below. The legal status and likelihood of occurrence of these species are given in Table 7. Expanded descriptions are included for species for which potentially suitable habitat occurs in the Study Area, or for which the resource agencies have expressed particular concern.

A number of special-status species occur in the Study Area as visitors, migrants, or foragers, but are not known or expected to breed in the immediate area. Expanded species accounts are not provided for these species. Animals that occasionally occur within the Study Area and breed in upland habitats in the greater South Bay Area, but occur only in the Study Area as uncommon to rare foragers, include the bald eagle (*Haliaeetus leucocephalus*), golden eagle (*Aquila chrysaetos*), Vaux's swift (*Chaetura vauxi*), bank swallow (*Riparia riparia*), yellow-breasted chat (*Icteria virens*), and pallid bat (*Antrozous pallidus*). Species that occur in the Study Area regularly as foragers, but have special status only at nesting sites elsewhere in California, include the common loon (*Gavia immer*), American white pelican, sharp-shinned hawk (*Accipiter striatus*), osprey (*Pandion haliaetus*), Barrow's goldeneye (*Bucephala islandica*), long-billed curlew, and elegant tern.

Expanded species accounts are provided below for key special-status wildlife species. More information on most of these species can be found in the Goals Project Baylands Ecosystem Species and Community Profiles (Goals Project 2000).

Table 7 – Special-status animal species, their status, and potential occurrence in the Shoreline Study Area.

Name	**Status***	**Habitat**	**Potential For Occurrence On Site**
Federal or State Threatened or Endangered Species			
Bald Eagle (*Haliaeetus leucocephalus*)	FPD, SE, SP	Occurs mainly along seacoasts, rivers and lakes; nests in tall trees or in cliffs. Feeds mostly on fish.	Occasional visitor, primarily during winter, to the Study Area. May occasionally forage, but does not nest, in the Study Area.
American Peregrine Falcon (*Falco peregrinus anatum*)	SE, SP	Forages in many habitats; nests on cliffs and similar human-made structures.	Regular forager (on other birds) in the Study Area, primarily during migration and winter. Nested in 2006 and 2007 (two nests) in old raven nests on transmission towers in the Alviso pond complex.
California Clapper Rail (*Rallus longirostris obsoletus*)	FE, SE, SP	Salt and brackish marsh habitat usually dominated by pickleweed and cordgrass.	Resident in many tidal marshes in the Study Area.
California Least Tern (*Sterna antillarum browni*)	FE, SE, SP	Nests along the coast on bare or sparsely vegetated flat substrates.	The South Bay is an important post-breeding staging area for least terns, although this species does not currently breed within the Study Area. Recent breeding by small numbers has occurred at Hayward Regional Shoreline and Eden Landing Pond E8A. Forages and roosts in a number of South Bay ponds, especially Alviso ponds in the vicinity of Moffett Field.
California Brown Pelican (*Pelecanus occidentalis californicus*)	FE, SE, SP	Occurs in nearshore marine habitats and coastal bays. Nests on islands in Mexico and southern Calfiornia.	Regular during nonbreeding season (summer and fall) in Study Area. Roosts on levees in the interiors of pond complexes, forages in salt ponds and Bay.
Salt Marsh Harvest Mouse (*Reithrodontomys raviventris raviventris*)	FE, SE, SP	Salt marsh habitat dominated by pickleweed.	Occurs in pickleweed marshes within the Study Area. Also occurs in brackish marshes.
Steelhead – California Central Coast ESU (*Oncorhynchus mykiss*)	FT	Cool streams with suitable spawning habitat and conditions allowing migration, as well as marine habitats.	Known to be present in several South Bay creeks (including Coyote, Stevens, and San Francisquito Creeks, and the Guadalupe River) and associated marshes and small channels in the Study Area, especially as habitat for smolts as they transition to life in a marine environment. Suitable spawning habitat is not present in the Study Area, but this species moves through the area to spawn upstream.
California Black Rail (*Laterallus jamaicensis coturniculus*)	ST, SP	Breeds in fresh, brackish, and tidal salt marsh.	Non-breeding individuals winter in small numbers in tidal marsh within the Study Area, but the species is not currently known to breed in the South Bay.
Western Snowy Plover (*Charadrius alexandrinus nivosus*)	FT, CSSC	Nests on sandy beaches and salt panne habitats.	Breeds and forages at several sites within the Study Area, primarily Ponds A8 and A23. Additional birds occur in the Study Area during winter.
Bank Swallow (*Riparia riparia*)	ST	Colonial nester on vertical banks or cliffs with fine-textured soils near water.	Observed in the study ara as rare transient. No suitable breeding habitat in the Study Area.

Name	Status*	Habitat	Potential For Occurrence On Site
California Tiger Salamander *(Ambystoma californiense)*	FT, CSSC	Vernal or temporary pools in annual grasslands, or open stages of woodlands.	A population is present on SFBNWR lands in the Fremont/Warm Springs area within the Study Area.
Vernal Pool Tadpole Shrimp (*Lepidurus packardi*)	FE	Freshwater vernal pools in grasslands.	Present in small numbers in vernal pools on SFBNWR lands in the Fremont/Warm Springs area.
California Species of Special Concern			
Central Valley Fall- and Late Fall-run Chinook Salmon (*Oncorhynchus tshawytscha*)	CSSC (Late Fall-run only)	Cool rivers and large streams that reach the ocean and that have shallow, partly shaded pools, riffles, and runs.	Centrail Valley Fall-Run Chinook salmon are known to be present in several South Bay creeks (including Coyote Creek, Alameda Creek, and the Guadalupe River) and associated marshes and small channels in the Study Area, especially as habitat for smolts as they transition to life in a marine environment. Suitable spawning habitat is not present in the Study Area, but this species moves through the area to spawn upstream.
Western Pond Turtle *(Clemmys marmorata*)	CSSC	Permanent or nearly permanent fresh or brackish water in a variety of habitats.	Uncommon along the inshore side of pond A3W; a few are occasionally recorded along lower Coyote Creek and the Guadalupe River. May occur rarely in freshwater and brackish creeks and sloughs elsewhere in the Study Area.
Common Loon (*Gavia immer*)	CSSC (nesting)	Nests in freshwater marshes, winters in coastal marine habitats.	Occasional winter visitor; does not breed in the Study Area.
American White Pelican (*Pelecanus erythrorhnchos*)	CSSC (nesting)	Forages in freshwater lakes and rivers, nests on islands in lakes.	Common non-breeder, foraging primarily on salt ponds in the Study Area. Regular visitor from late summer to spring. Not known to breed in the Study Area.
Double-crested Cormorant (*Phalacrocorax auritus*)	CSSC (nesting)	Colonial nester on coastal cliffs, offshore islands, electrical transmission towers, and along interior lake margins. Feeds on fish.	Breeds on electrical transmission towers and on levees within the Study Area, and forages in ponds and other open water habitats in the Study Area.
White-faced Ibis (*Plegadis chihi*)	CSSC (nesting)	Forages in freshwater marshes, and to a lesser extent, brackish areas.	Occasional visitor in fall and winter. Has bred in heron rookery on Mallard Slough, but no current nesting known.
Barrow's Goldeneye (*Bucephala islandica*)	CSSC (nesting)	Nests in freshwater marshes, winters in coastal marine habitats.	Occasional winter visitor; does not breed in the Study Area.
Northern Harrier (*Circus cyaneus*)	CSSC (nesting)	Nests and forages in marshes, grasslands, and ruderal habitats.	Breeds in small numbers in marsh habitats in the Study Area, forages in a variety of habitats.
Sharp-shinned Hawk (*Accipiter striatus*)	CSSC (nesting)	Nests in woodlands, forages in many habitats in winter and migration.	Observed on site as a migrant and winter resident. No breeding habitat in Study Area.
Cooper's Hawk (*Accipiter cooperii*)	CSSC (nesting)	Nests in woodlands, forages in many habitats in winter and migration.	Breeds in limited numbers in upland habitats fringing the South Bay; forages throughout the Study Area.

Name	**Status***	**Habitat**	**Potential For Occurrence On Site**
Osprey (*Pandion haliaetus*)	CSSC (nesting)	Nests in tall trees or cliffs on freshwater lakes and rivers and along seacoast; feeds on fish.	Occasional forager, primarily during the nonbreeding season. No breeding records in the Study Area.
Golden Eagle (*Aquila chrysaetos*)	CSSC	Breeds on cliffs or in large trees or electrical towers, forages in open areas.	Occasional forager, primarily during the nonbreeding season. No nesting records within the Study Area.
Merlin (*Falco columbarius*)	CSSC	Uses many habitats in winter and migration.	Regular in low numbers during migration and winter. Does not nest in California.
Long-billed Curlew (*Numenius americanus*)	CSSC (nesting)	Nests on prairies and short-grass fields; forages on mudflats, marshes, pastures, and agricultural fields.	Forages on mudflats, marshes, and grasslands and roosts on levees, diked marshes, and ponds within the Study Area as a migrant and winter resident. Does not nest in the Study Area.
California Gull (*Larus californicus*)	CSSC (nesting)	Nests on lakes inland and, around S. F. Bay, in salt ponds.	Common resident, breeding on several salt ponds in the Study Area. The colony in Pond A6 is the second largest colony in California. Forages throughout Study Area.
Black Skimmer (*Rynchops niger)*	CSSC (nesting)	Nests on abandoned levees and islands in salt ponds and marshes.	A few pairs breed and forage in the Study Area, on islands in salt ponds.
Short-eared Owl (*Asio flammeus*)	CSSC (nesting)	Nests on ground in tall emergent vegetation or grasses, forages over a variety of open habitats.	Uncommon. Has bred in small numbers within the Study Area, although current breeding status unknown. Most numerous in area in migration and winter.
Western Burrowing Owl (*Athene cunicularia hypugea*)	CSSC	Flat grasslands and ruderal habitats.	Breeds at several upland sites within the Study Area.
Vaux's Swift (*Chaetura vauxi*)	CSSC (nesting)	Nests in snags in coastal coniferous forests or, occasionally, in chimneys; forages aerially.	Forages over Study Area. No nesting habitat within area.
Loggerhead Shrike (*Lanius ludovicianus*)	CSSC (nesting)	Nests in dense shrubs and trees, forages in grasslands, marshes, and ruderal habitats.	Resident in low numbers within the Study Area.
California Horned Lark (*Eremophila alpestris actia*)	CSSC	Short-grass prairie, annual grasslands, coastal plains, and open fields.	Present in low numbers in the Study Area, nesting on salt pond levees, salt flats, and ruderal habitats.
California Yellow Warbler (*Dendroica petechia brewsteri*)	CSSC (nesting)	Breeds in riparian woodlands, particularly those dominated by willows and cottonwoods.	Nests in riparian corridor of Coyote Creek.
Saltmarsh Common Yellowthroat (*Geothlypis trichas sinuosa*)	CSSC	Breeds primarily in fresh and brackish marshes in tall grass, tules, willows; uses salt marshes more in winter.	Common resident, breeding in freshwater and brackish marshes (and possibly to a limited extent in salt marshes), and foraging in all marsh types during the nonbreeding season.
Yellow-breasted Chat (*Icteria virens*)	CSSC	Riparian brush and woodlands.	Rare nonbreeding visitor to riparian habitats during migration.

Name	Status*	Habitat	Potential For Occurrence On Site
Alameda Song Sparrow (*Melospiza melodia pusillula*)	CSSC	Breeds in salt marsh, primarily in marsh gumplant and cordgrass along channels.	Uncommon resident, breeding and foraging in tidal salt marsh.
Tricolored Blackbird (*Agelaius tricolor*)	CSSC (nesting)	Breeds near fresh water in dense emergent vegetation.	Has bred in the Study Area at the San Jose-Santa Clara Water Pollution Control Plant, but occurs in the Study Area primarily as a nonbreeding forager.
Salt Marsh Wandering Shrew (*Sorex vagrans halicoetes*)	CSSC	Medium high marsh with abundant driftwood and pickleweed.	May occur in salt marshes throughout the Study Area, although numbers have declined, and current status is unknown.
State Protected Species or CNPS Species			
White-tailed Kite (*Elanus caeruleus*)	SP (nesting)	Nests in tall shrubs and trees, forages in grasslands, marshes, and ruderal habitats.	Common resident; breeds within the Study Area where suitable nesting habitat occurs.

FE = Federally-listed Endangered
FT = Federally-listed Threatened
FPD = Federally Proposed for Delisting
SE = State-listed Endangered
ST = State-listed Threatened
CSSC = California Species of Special Concern
SP = State Fully Protected Species

4.4.1 Federal or State Threatened or Endangered Species

Vernal Pool Tadpole Shrimp (*Lepidurus packardi*). Federal Listing Status: Endangered; State Listing Status: None. The vernal pool tadpole shrimp is a small crustacean that occurs in ephemeral pools in California. The known range of the species is limited to the Central Valley, and a limited area in, and adjacent to, the Warm Springs Seasonal Wetland Unit of the SFBNWR. Due to the continuing loss of habitat, the vernal pool tadpole shrimp was listed by the USFWS as Endangered in 1994. Critical habitat was designated for the species in 2006 (USFWS 2006a); the Study Area includes two Critical Habitat Units, 14A and 14B, within the Warm Springs Seasonal Wetland Unit of the SFBNWR.

Vernal pool tadpole shrimp spend the majority of their lives as dormant cysts, which may remain viable for up to ten years. When these cysts are inundated in vernal pools, some hatch into shrimp, which live only as long as the pool retains water. Ahl (1991) found that egg cysts hatch within 11 to 26 days (mean = 17 days) after pools refill with water. In contrast to most fairy shrimp, juvenile vernal pool tadpole shrimp develop slowly and require a minimum hydroperiod of about seven to eight weeks to reach reproductive maturity in the field (Gallagher 1996, Helm 1998). Juveniles look like the adults but are merely smaller in overall size and are not reproductively mature. There is only one generation per year. Adults have hard carapaces, and may attain a length of one inch or more.

This shrimp is generally found in sparsely vegetated, grass-bottomed swales on old alluvial soils that are underlaid by hardpan, or in mud-bottomed pools containing highly turbid water. The pools are usually deep (≥ six inches) and typically retain water longer than shallower vernal pools. Unlike fairy shrimp, which actively swim in the water column, tadpole shrimp move about primarily by crawling, but will swim for brief periods. Vernal pool tadpole shrimp are not expected to occur in the Shoreline Study Area outside the area of known distribution in the mixed vernal pool/grassland habitat north/northwest of Pond A22 in the Warm Springs Seasonal Wetland Unit of the SFBNWR.

California Tiger Salamander (*Ambystoma californiense*). Federal Listing Status: Threatened; State Listing Status: Species of Special Concern. The California tiger salamander breeds in temporary (lasting at least 12 weeks) or small permanent ponds in grassland habitats during the winter rainy season. During dry summer months, they aestivate in small mammal burrows in grasslands adjacent to breeding ponds. Adults often emerge from the burrows at night during the first moderate to heavy winter rains and migrate to breeding ponds where they lay their eggs.

The eggs are attached singly or in small clumps to vegetation under water, or directly on the bottom of the pool if emergent vegetation is lacking. The eggs hatch approximately one week after they are deposited. The larvae prey upon invertebrates and other amphibian larvae for between three and six months, during which time they metamorphose into juveniles. Juveniles typically leave the pools in mass during a one to two week period, usually as the ponds dry. The juveniles then search for available burrows. Juveniles feed and grow in these burrows until the following winter. California tiger salamanders take several years to reach maturity and do not necessarily breed every year, even if sufficient habitat is available.

The range of the California tiger salamander is restricted to the Central Valley and the South Coast Range of California from Butte County south to Santa Barbara County. Tiger salamanders have disappeared from a significant portion of their range due to habitat loss from agriculture and urbanization and the introduction of non-native aquatic predators. The California tiger salamander was listed as Threatened under the FESA by the USFWS in July 2004. The USFWS designated Critical Habitat for the California tiger salamander in August 2005 (USFWS 2005). No portion of the Study Area is within Critical Habitat for this species.

California tiger salamanders occur in the mixed vernal pool/grassland habitat north/northwest of Pond A22 in the Warm Springs Seasonal Wetland Unit of the SFBNWR, the only location in the South Bay that they occur adjacent to tidally influenced marsh habitat.

Steelhead (*Oncorhynchus mykiss*), Central California Coast ESU. Federal Listing Status: Threatened; State Listing Status: None. The steelhead is an anadromous form of rainbow trout that migrates upstream from the ocean to spawn. Steelhead in the South Bay usually migrate upstream to spawning areas from late December through early April, with the greatest activity in January through March, when flows are sufficient to allow them to reach suitable habitat in far upstream areas. Spawning occurs between December and June. Steelhead eggs remain in gravel depressions, known as redds, for 1.5 to four months before hatching. After hatching, young-of-the-year steelhead tend to use riffles with cover, while older juveniles use deeper water (such as pools) as rearing habitat, remaining in fresh water for one to four years before migrating to the ocean. This downstream migration of juveniles generally occurs between February and June. After migration, steelhead typically grow rapidly for two to three years before returning to freshwater streams to spawn. Unlike other anadromous salmonids, steelhead do not necessarily die after spawning. Adults may survive and return to the ocean after spawning, coming back to spawn for one or more additional seasons; however, it is unknown if this phenomenon occurs in the South Bay streams.

Steelhead usually spawn in gravel substrates in clear, cool, perennial sections of relatively undisturbed streams. Preferred streams typically support dense canopy cover that provides shade, woody debris, and organic matter, and are usually free of rooted or aquatic vegetation. Steelhead usually cannot survive long in pools or streams with water temperatures above 70 °F, but they can use warmer habitats if food is available, such as at fast water riffles where fish can feed on drifting insects. Steelhead in some coastal estuaries in central California apparently make extensive use of estuarine habitats for foraging (Bush, pers. comm.), although the extent of the use of estuarine habitats by steelhead in many areas, including the South San Francisco Bay area, is virtually unknown.

Steelhead populations in many areas have declined due to degradation of spawning habitat, introduction of barriers to upstream migration, over-harvesting by recreational fisheries, and reduction in winter flows due to damming and spring flows due to water diversion. Steelhead and other salmonids have been categorized into subpopulations, or Distinct Population Segments (DPSs). In 1997, the National Marine Fisheries Service (NMFS) listed the Central California Coast DPS as a threatened species under FESA; threatened status was reaffirmed in 2006. The Central Coast DPS includes all runs from the Russian

River in Sonoma County south to Aptos Creek in Santa Cruz County, including all steelhead spawning in streams flowing into San Francisco Bay streams. In 2005, NMFS designated critical habitat for this and other DPSs as occupied reaches of all rivers and estuaries within the range of each listed DPS. A recovery plan is being developed but has not yet been approved for this DPS.

Steelhead are known to occur in several stream systems in the South San Francisco Bay Area (Figure 5), and this species could potentially spawn in virtually any reach of a stream offering suitable spawning habitat and lacking downstream barriers to dispersal. Information on the fine-scale distribution of steelhead in South San Francisco Bay streams is limited, but steelhead are currently known to run in the Coyote Creek, Guadalupe River, Stevens Creek, and San Francisquito Creek watersheds (Foxgrover et al. 2004, Leidy et al. 2005). Few steelhead are present in any of these South Bay streams (Leidy et al. 2005). Within the Study Area, no suitable steelhead spawning habitat exists. Steelhead may use tidal channels in marshes as well, as such channels (particularly in brackish marshes) may provide habitat for juveniles during the process of smoltification (i.e., physiological adaptation to the saltwater environment). The use of larger sloughs within the Study Area by juvenile salmonids may be limited by the relatively high density of predators, including harbor seals and striped bass (Jerry Smith, pers. comm.).

Chinook Salmon (*Oncorhynchus tshawytscha*), Central Valley Fall- and Late Fall- Run ESU. Federal Listing Status: None; State Listing Status: Species of Special Concern (Late Fall-Run only). Like the steelhead, the Chinook salmon is an anadromous salmonid. Adults of the Central Valley Fall-Run ESU migrate from the ocean to spawning streams in fall and begin spawning in beds of coarse river gravels between September and December. Adults die after spawning. After the eggs hatch, juvenile salmon typically migrate downstream to the Bay or ocean within a few months. Young fish remain in the ocean for several years before returning to freshwater streams and rivers to spawn. Chinook salmon generally spawn in cool waters providing incubation temperatures no warmer than 55 ^{o}F.

Much more is known regarding the use of estuarine habitats by Chinook salmon than steelhead, and in at least some areas, juvenile Chinook make heavy use of estuarine habitats. Juvenile Chinook salmon may spend a significant amount of time, up to 189 days (Simenstad et al. 1982), foraging in estuarine habitats, showing significant growth in some estuaries (MacDonald et al. 1987), as they adapt physiologically to higher-salinity environments (Maragni 2000). In at least some areas, tidal marshes are important habitats for Chinook salmon. Fry forage throughout shallower tidal sloughs and channels, even foraging within the marsh during flood tides, while larger smolts forage in larger primary and secondary channels and subtidal habitats (Maragni 2000).

Fall-run Chinook salmon populations have suffered the effects of over-fishing by commercial fisheries, degradation of spawning habitat, added barriers to upstream migration, and reductions in winter flows due to damming. Approximately 40-50% of the spawning and rearing habitats in Central Valley streams have been lost or degraded. Hatchery-raised fish considerably enhance present populations. Because long-term population trends have been generally stable, NMFS determined that the Central Valley fall- and late fall-run evolutionarily significant unit (ESU) was not a priority for listing as threatened or endangered.

Chinook salmon did not historically spawn in streams flowing into South San Francisco Bay. Since the mid-1980s, however, small numbers of fall-run Chinook salmon have been found in several such streams, including Coyote Creek, Los Gatos Creek, and the Guadalupe River (Leidy et al. 2003). Genetic analysis indicates that fish from Guadalupe River and Coyote Creek are closely related to Central Valley Fall-run Chinook salmon (Garcia-Rossi and Hedgecock 2002).

These fall-run Chinook salmon typically arrive in South San Francisco Bay streams in October or later, although on rare occasions, adult Chinook salmon have been detected in these streams in summer, and spawning has been observed on Los Gatos Creek as early as September (Salsbery, pers. comm.). Seasonal stream flow and temperature conditions in these streams may not be suitable for successful spawning by Sacramento River winter-run Chinook salmon, which typically spawn in late spring and summer, or by Central Valley spring-run Chinook salmon, which typically spawn in late summer and early fall. Therefore, any adult Chinook salmon found in the South San Francisco Bay in the summer are presumed to be Fall-run fish with ancestry to the Central Valley. The use of tidal channels and sloughs within the Study Area by Chinook salmon is unknown. Predation pressure may limit the use of larger sloughs as more than transit habitat, as noted above for steelhead, but it is possible that Chinook salmon use tidal marshes in the South Bay as extensively as has been reported in other areas.

California Brown Pelican (*Pelecanus occidentalis californicus*). Federal Status: Endangered; State Status: Endangered. Brown pelicans are large seabirds found in coastal and nearshore marine habitats along the Atlantic, Gulf and Pacific coasts of North America. In the middle of the 20th century, brown pelican populations were severely reduced. The primary cause of this decline was eggshell thinning related to ingestion of the pesticide DDT, which entered the marine food chain through agricultural runoff and industrial discharge (Anderson and Gress 1983). The brown pelican was listed by the USFWS as Endangered in 1970 and by the state of California in 1971, and the state considers it a fully protected species. A recovery plan for the species was completed in 1983 (U.S. Fish and Wildlife Service 1983); critical habitat has not been designated for the brown pelican. DDT was banned in the United States in 1972, and brown pelican populations began recovering. In 1985, the brown pelican was delisted in the southeastern U.S. as recovered, but west coast populations did not recover as quickly (Shields 2002). However, west coast numbers have increased substantially in the past two decades, and the U.S. Fish and Wildlife Service is considering a proposal to delist the California brown pelican (USFWS 2006b).

The California brown pelican nests in Mexico, on the California Channel Islands, and at the Salton Sea in early spring, approximately January to May (Anderson and Gress 1983; Shields 2002). Much of the postbreeding dispersal occurs northward (as far north as Canada), and by June, many post-breeding birds are present in central California. Local abundance in central California usually peaks from August to October (Briggs et al. 1987; Jaques 1994). Although a small number of non-breeding birds may be found locally year-round, most pelicans return to their southern breeding grounds by January. California brown pelicans feed on northern anchovies and other small fishes, which they capture by plunge-diving. Brown pelicans require secure night-roosts, free of terrestrial predators (Jaques 1994).

Several hundred brown pelicans typically occur in San Francisco Bay during summer and fall, but numbers are variable (Ainley 2000a). Post-breeding dispersants typically begin to arrive in the South Bay in June and July, with most individuals departing by late fall. However, a few may also be found in the South Bay in winter and spring as well (Santa Clara County Bird Data Unpublished). California brown pelicans occur regularly in some South Bay salt ponds, and often roost on salt pond levees. Recent surveys by USGS included 225 individuals in the Alviso Complex in September 2004, although more typical counts number less than 100 at Alviso Ponds (Takekawa et al. 2005). Several ponds in the Alviso Complex are used for roosting by brown pelicans, with the greatest use in the vicinity of Alviso Slough and Guadalupe Slough (Takekawa et al. 2005), although local concentrations may occur in any of the lower-salinity ponds (which provide fish) throughout the Alviso Complex. Although information on daily activity patterns, habitat use, and key foraging areas of brown pelicans in the South Bay is limited, this species uses salt ponds both for foraging (which takes place in the less saline ponds supporting fish) and for roosting (on levees between ponds).

American Peregrine Falcon (*Falco peregrinus anatum*). Federal Listing Status: Delisted; State Listing Status: Endangered, Fully Protected. The peregrine falcon occurs throughout much of the world, and is known as one of the fastest flying birds of prey. Peregrine falcons prey almost entirely on birds, which they kill while in flight. These falcons nest on ledges and caves on steep cliffs, as well as human-made structures like buildings and power towers. In California, they are known to nest along the entire coastline, the northern Coast, and the Cascade Ranges and Sierra Nevada. During winter and migration, this species can be found throughout the state. Peregrine falcons are most likely to be encountered in coastal or inland marsh habitats where large numbers of waterfowl and shorebirds concentrate, as occurs at the Study Area.

A severe decline in populations of the widespread North American subspecies *Falco peregrinus anatum* began in the late 1940s. This decline was attributed the accumulation of DDE, a metabolite of the organochlorine pesticide DDT, in aquatic food chains (Thelander and M. 1994). When concentrated in the bodies of predatory birds such as the peregrine falcon, Bald Eagle, brown pelican, and Osprey, this contaminant led to reproductive effects, such as the thinning of eggshells. The American peregrine falcon was listed as Endangered by the USFWS in 1970 and by the State of California in 1971. Recovery efforts included the banning of DDT in North America and captive breeding programs. The USFWS removed the American peregrine falcon from the Endangered Species List in 1999, though the State of California still lists the species as endangered, and as a fully protected species.

Peregrine falcons are uncommon in the Study Area, but nonbreeders are present in small numbers in fall and winter. These birds often use electrical transmission towers as perches, hunting waterbirds over salt ponds, marshes, and the open bay. Prior to 2006, this species was not known to breed in the Study Area. However, in 2006 a pair nested in an old raven nest on a transmission tower in the Alviso pond complex, and two nests approximately 1.3 kilometers apart were occupied in 2007.

California Clapper Rail (*Rallus longirostris obsoletus*). Federal Listing Status: Endangered; State Listing Status: Endangered. The California clapper rail is a secretive marsh bird currently endemic to the marshes of San Francisco Bay. It formerly bred at several other locations, including Humboldt Bay, Elkhorn Slough (Monterey County), and Morro Bay, but is now extirpated from all sites outside of San Francisco Bay. California clapper rails nest in salt and brackish marshes along the edge of the bay, and are most abundant in extensive salt marshes and brackish marshes dominated by cordgrass, pickleweed, and marsh gumplant, and containing complex networks of tidal channels (Harvey 1980). Shrubby areas adjacent to or within tidal marshes are important for predator avoidance at high tides.

California clapper rails breed from February through August in the vegetation along tidal sloughs. Breeding generally occurs in two pulses, one in April/May, and a second in June/July. Clapper rails lay up to 14 eggs, which are incubated by both parents for just under a month. The young are precocial, but are dependent on their parents for food for five to six weeks (Eddleman and Conway 1998). California clapper rails are non-migratory, although juveniles disperse around the Bay during late summer and autumn. Adults are territorial, and maintain territories throughout the year. Most California clapper rails studied via radio-telemetry had home ranges of about 115 meters in radius (Keldsen 1997). They forage on crabs, clams, and other invertebrates, which they find in exposed mud along tidal channels (usually secondary channels) or in vegetation at the edges of such channels (Shuford 1993).

Since the mid-1800s, about 90% of San Francisco Bay's marshlands have been eliminated through filling, diking, or conversion to salt evaporation ponds (Goals Project 1999). As a result, the California clapper rail lost most of its former habitat, and the population declined severely. The subspecies was listed by the USFWS as Endangered in 1970, and by the State of California as Endangered in 1971, and the state considers it a fully protected species. The USFWS approved a joint recovery plan of the salt marsh harvest mouse and the California clapper rail in 1984 (U.S. Fish and Wildlife Service 1984), and an updated Tidal Marsh Species Recovery Plan is currently under development. Critical habitat has not been proposed for the California clapper rail.

In the 1970s, the Bay-wide population estimate for California clapper rails was 4000-6000 birds, with 55% in the South Bay, 38% in Napa marshes, and the remaining 8% in other North Bay and outer coast marshes (Gill 1979). Based on surveys of most suitable marshes in the San Francisco Bay area in the late 1970s and early 1980s, Harvey (1988) estimated a population of 1500 individuals. The difference between the estimates of Gill (1979) and Harvey (1988) may have reflected a population decline, but was also likely a result of more accurate surveys by Harvey. Nevertheless, density estimates in three South Bay marshes were found to decline from 1.47, 0.89, and 0.69 rails/hectare in 1980 (Harvey 1988) to 0.64, 0.26, and 0 rails/ha, respectively in 1989 (Foerster et al. 1990), indicating an actual, considerable population decline. Populations of rails in five South Bay marshes declined by as much as 85%, apparently as a result of depredation by the non-native red fox (Albertson 1995). By the mid 1980s, approximately 1200-1500 California clapper rails remained, with greater than 80% occurring in the South Bay. By 1988, populations were estimated at 700 rails, and by 1991 the bay-wide total was estimated at 300-500 individuals (Alberston and Evens. 2000).

Clapper rail predation by both red foxes and feral cats has been directly documented in the South Bay by the tracking of radio-marked rails that were depredated in 1991 and 1992 (Albertson 1995). In addition, the remains of clapper rails were found at a fox den in a tidal marsh on the SFBNWR (Harding et al. 1998), and at the entrance to a den in the outboard levee along salt pond A9 (Steve Rottenborn, pers. obs.). Norway rats are thought to be one of the main predators of California clapper rail eggs (Foerster et al. 1990; Harvey 1988), and raccoons have also been known to prey on California clapper rail eggs (Foerster et al. 1990).

A predator management plan implemented by the SFBNWR since 1991 has met with some success in reducing the effects of mammalian predators on clapper rails, resulting in an increase in rail populations (Harding et al. 1998). Between 1991 and 1996, clapper rail population size within a given marsh showed a significant negative relationship with the number of red foxes removed the prior year, and rail population growth rates were significantly related to red fox trapping success the prior year. The most recent population estimate for California clapper rails was approximately 1040 to 1264 birds in 2000 (Alberston and Evens. 2000). Although management of mammalian predators has helped boost clapper rail populations, avian depredation by raptors, common ravens, and possibly gulls still poses a threat, and may be increasing (Alberston, pers. comm.). In 2003, the CDFG implemented a predator-control program at the Eden Landing Ecological Reserve to reduce predation on listed species (John Krause, pers. comm.).

Other ongoing threats to clapper rails include loss of habitat to sea-level rise (Keldsen 1997), human disturbance, and accumulation of mercury and other contaminants. Few data are available regarding the effects of human disturbance on California clapper rails. Clapper rails are typically shy and reclusive, and avoid areas of high human use. Construction-related disturbance has been found to result in abandonment of territories, but in one instance, use of a jack-hammer within 50 feet of a territory did not result in abandonment of that territory (Wetlands Research Associates 1994).

California clapper rail eggs collected from several sites around the San Francisco Bay in 1975, 1986, and 1987 were found to have elevated levels of PCBs, selenium, and mercury (Lonzarich et al. 1992). Analysis of unhatched eggs from the Central Bay by Schwarzbach and Adelsbach (2003) detected mean mercury concentrations of 0.81 ppm on a fresh wet weight basis, concentrations that were considered embryotoxic. The levels and effects of mercury concentrations in South Bay birds are the subjects of ongoing study.

Breeding-season surveys of South San Francisco Bay marshes for California clapper rails through the early 1990s, summarized by Foin et al. (1997), indicated that the most substantial populations of clapper rails in the South Bay were, predictably, in the largest sections of tidal salt marsh: at Mowry Marsh and Dumbarton Marsh (in the east Bay between the Dumbarton Bridge and Mowry Slough), at the Faber/Laumeister Tracts and other marshes in the Palo Alto/East Palo Alto area, and at Greco Island in Redwood City. Mean counts from these areas include 68 birds at Mowry Marsh, 57 at Faber-Laumeister, and 44 at Dumbarton (Foin et al. 1997). Nest searches by San Francisco Bay NWR personnel detected 40 nests in the Faber/Laumeister Tracts, 33 on Greco Island, and 13 in North Mowry Marsh in 1992 (Keldsen 1997). Clapper rails occurred in many other marshes as well, including Ideal Marsh (adjacent to Cargill pond N5), Calaveras Marsh (adjacent to Cargill Ponds M2 and M3), and Triangle Marsh in Alviso. Clapper rails have been found to occasionally use salt pond dredge locks as high-tide refugia (Wetlands Research Associates 1994b). Although site-specific surveys have not been conducted in all suitable habitat for clapper rails in the South Bay, this species is likely to occur in tidal salt marsh habitats in a number of additional areas as well (Figure 5).

Although California clapper rails are typically found in tidal salt marshes, they have also been documented in brackish marshes in the South Bay. Breeding-season surveys conducted in marshes bordering Coyote Creek in 1989 documented breeding California clapper rails in a wide variety of plant associations. Surveys conducted during the 1990 breeding season (H. T. Harvey & Associates 1990d) and winter season (H. T. Harvey & Associates 1990c) found a number of California clapper rails occupying salt/brackish transitional marshes and several brackish, alkali bulrush-dominated marshes, including Warm Springs Marsh (immediately east of Pond A19) and the marshes along upper Coyote Slough even farther east. In addition, California clapper rails were found in nearly pure stands of alkali bulrush along Guadalupe Slough in 1990 and 1991 (H. T. Harvey & Associates 1990c; H. T. Harvey & Associates 1990d; H. T. Harvey & Associates 1991c). Although it has been suggested that habitat quality may be lower in brackish marshes than in salt marshes (Shuford 1993), further studies comparing reproductive success in different marsh types are necessary to determine the value of brackish marshes to California clapper rails.

On rare occasions, California clapper rails have been recorded even farther upstream, in brackish/freshwater transition marshes, particularly during the nonbreeding season. In the Alviso/Sunnyvale area, such individuals have been recorded along upper Alviso Slough near the Gold Street bridge (14 February 1997; Scott B. Terrill, pers. obs.), in nontidal freshwater ponds between Calabazas and San Tomas Aquino Creeks north of Highway 237 in Sunnyvale (16 August 1998; Steve Rottenborn, pers. obs.), and along Artesian Slough near the Environmental Education Center in January 1999 and January-February 2001 (Santa Clara County Bird Data Unpublished).

No Bay-wide breeding-season surveys have been conducted for clapper rails since the 1990s. However, the USFWS, in conjunction with other agencies, conducts annual winter high-tide surveys using an airboat. These surveys attempt to cover all South Bay marshes at least once every two years (although areas with dense cordgrass cannot be surveyed with this method except on the highest tides). Recent winter surveys indicate that clapper rail populations in the Mowry/Dumbarton Slough area appear to be fluctuating, but populations in other areas seem to be more stable, see Table 8 (Alberston, pers. comm.). This may be the result of higher avian predation rates in the Mowry/Dumbarton area, but this hypothesis has not been studied.

Table 8 – High and low winter counts of clapper rails from major tidal salt marshes in the South Bay, 1994-2000 and 2002 (USFWS unpubl. data).

Location	High Count (Year)	Low Count (Year)
Dumbarton	104 (1994)	28 (2000)
Mowry	126 (1997)	4 (2000)
Hooks Island	46 (1997)	16 (2000, 2002)
Palo Alto Harbor	16 (1997)	5 (2002)
Faber	60 (1997)	29 (1995)
Laumeister	48 (1997)	24 (1995)
Greco Island	96 (2002)	87 (2000)

Both winter and breeding season surveys suggest that there is substantial annual variability in local distribution and abundance of clapper rails in the South Bay. For example, at one of the sites where rails were found in brackish marshes in Guadalupe Slough (discussed above), no rails were found during protocol-level surveys the year before (H. T. Harvey & Associates 1990c; H. T. Harvey & Associates 1990d; H. T. Harvey & Associates 1991c). Table 8 shows the high variability in winter counts, and suggests that populations may be particularly high in certain years, such as 1997, presumably following high breeding success.

California Black Rail (*Laterallus janaicensis coturniculus*). Federal Listing Status: None; State Listing Status: Threatened. The California black rail is a small rail that inhabits tidal salt, brackish, and freshwater marshes. This small bird is very secretive, and is most often seen during high tides when it is forced into high marshes. Little information is available regarding the biology of California black rails. They are most abundant in tidal marshes with some freshwater input (Evens et al. 1991). They nest primarily in pickleweed-dominated marshes with patches or borders of *Scirpus*, often near the mouths of creeks. They build nests in tall grasses or marsh vegetation during spring, and lay about six eggs. Nests are usually constructed of pickleweed, and are placed directly on the ground or slightly above ground in vegetation. Black rails feed on terrestrial insects, aquatic invertebrates, and possibly seeds (Trulio and Evens 2000).

The California black rail reportedly bred in the Alviso area in the early 1900s (Wheelock 1916), but currently it is not known to breed in the South Bay. In the San Francisco Bay area, this small rail currently breeds primarily in marshes in the north San Francisco Bay Area (i.e., San Pablo Bay and Suisun Bay). After breeding, some black rails disperse into the South Bay, accounting for most records of the species in this area. Here, the abundance of the black rail during the nonbreeding season is unknown due to its very small size and highly secretive nature. Most observations of black rails in the South Bay consist of only a few birds observed seeking high-tide refugial cover at the edges of the salt marsh in a few areas during spring tides from November to February. Nearly every winter, small numbers (up to ten or more in a day, but usually four or fewer) are seen during such spring tides at the Palo Alto Baylands, and occasionally individuals are observed in the East Palo Alto marshes as well. This species is likely present in small numbers at other scattered locations as well (e.g., there are unconfirmed reports from the Alviso marina during high winter tides), but the inaccessibility of most suitable areas to look for black rails during spring tides, and the species' silence in the South Bay during winter, makes it virtually impossible to survey the species in the Study Area during this season.

Late-season (April) calling black rails have been reported at the Palo Alto Baylands (26-27 April 1993; Santa Clara County Bird Data) and near the east end of the Dumbarton Bridge. There is also a 30 August 1995 record from the vicinity of the Sunnyvale Water Pollution Control Plan (presumably along Guadalupe Slough) (Santa Clara County Bird Data Unpublished). However, there are no records of black rails breeding in the South Bay since at least the 1920s (Trulio and Evens 2000).

The absence (or scarcity) of breeding black rails in the South Bay is presumably a result of habitat loss. Tidal marsh habitat has been lost, but perhaps more important to winter survival is loss of high-tide refugia habitat. Upland transition habitat, both on natural levees within marshes and on landward edges of marshes, has been lost as a result of fill for development, and reductions in marsh size and resultant reductions in natural levees along higher-order channels. Predation by egrets, herons, gulls, and harriers has been observed in these marshes during winter high tides, as black rails are forced into the open by rising water. The importance of this predation on a population level, especially in light of impacts to high tide refugia, is unknown, but it may be a significant factor in the extirpation of breeding populations of the species from the South Bay.

Western Snowy Plover (*Charadrius alexandrinus nivosus*). Federal Listing Status: Threatened; State Listing Status: Species of Special Concern. The snowy plover is a small shorebird that occurs on almost every continent. In North America, there are two races of snowy plover: the western snowy plover (*C. a. nivosus*) occurs west of the Mississippi River, primarily in the Great Basin and along the Pacific coast, and the Cuban snowy plover (*C. a. tenuirostris*) occurs in the southeastern United States (Page et al. 1995). On the Pacific coast, snowy plovers nest on sandy beaches and salt panne habitat from Washington to Baja Mexico. Because they nest during the summer, primarily on beaches in a temperate climate, western snowy plovers are susceptible to nest disturbance and other negative interactions with humans. Much of their nesting habitat, particularly in southern California, has been lost to development and high human use. In addition, introduced predators, especially the non-native red fox, have had dramatic effects on snowy plover nesting success (Neuman et al. 2004). In response to severe population declines, the USFWS listed the Pacific coast population of the western snowy plover as Threatened in 1993. Critical habitat was designated for this population in 1999, and a draft recovery plan was released in 2001 (U.S. Fish and Wildlife Service 2001). None of the breeding sites within San Francisco Bay are considered critical habitat. The State of California lists the western snowy plover as a species of special concern.

In the South San Francisco Bay, snowy plovers nest on low, barren to sparsely vegetated salt pond levees and islands, at pond edges, and on salt panne areas of dry ponds (Page et al. 2000), and preferentially use light-colored substrates such as salt flats (Feeney and Maffei 1991; Marriott 2003). Nesting areas are located near water, where prey (usually brine flies and other insects) are abundant. In some areas, snowy plovers nest within dry salt ponds; in other areas where ponds typically hold water through the summer (e.g., the Newark salt ponds), nests are located primarily on levees. Often, nests are located near disruptive objects such as rocks or surface irregularities, and may be constructed in depressions created by footprints and vehicles (Marriott 2003; Page et al. 1995). Nests consist of a depression scratched into the substrate sometimes lined with shell fragments, pebbles, or similar local materials (Page et al. 2000; Page et al. 1995). Eggs are oval and buff-colored with small, brown- and black-colored spots and scrawls.

According to Page et al. (1995), pairing begins as early as mid February; egg-laying commences in early March, and may continue with multiple broods into early August. The incubation period ranges from 26 to 32 days. Three eggs are typically laid two to five days apart. Replacement clutches are initiated approximately six to eight days after the destruction of a completed clutch. Young birds are precocial, leaving the nest within hours of hatching. Chicks are usually cared for exclusively by the male parent, until they fledge at 28-33 days. Chicks feed themselves, but require the protection of an adult for brooding and evasion of predators. The breeding season of the western snowy plover in California, from nest initiation to fledging of chicks, is considered to be 1 March to 31 September. Although snowy plovers can nest as early as 1 March, damp nesting substrate in salt ponds, from flooding or normal spring rains, may delay nesting in this habitat until the substrate dries.

Some snowy plovers remain in their coastal breeding areas year-round, while others are migratory. Some individuals that nest in the San Francisco Bay Area probably migrate south as far as Mexico (U.S. Fish and Wildlife Service 2001). There is overlap between the San Francisco Bay population and the adjacent coastal nesting population. Birds banded at Monterey Bay and in Oregon have been seen in the San Francisco Bay salt ponds (Feeney and Maffei 1991). Snowy plovers typically live three to four years (Page et al. 1995).

Snowy plovers in the South Bay forage primarily on small flies, especially brine flies (*Ephydra cinerea* and *Lipochaeta slossonae*; (Feeney and Maffei 1991). They also feed on other small invertebrates, including beetles and small marine invertebrates. Snowy plovers forage visually, and often run after prey which they capture in their bills. In the South Bay, western snowy plovers are likely to forage anywhere where prey is available. Brine flies are usually found in greatest densities at the shallow margins of shallow salt ponds or puddles, but snowy plovers also forage in open salt flats, and occasionally, on mudflats adjacent to salt ponds.

It is not known whether this species nested inside San Francisco Bay before conversion of salt marsh to salt evaporation ponds. Breeding habitat may have been present in natural salinas prior to the creation of salt ponds, but such features would have provided limited breeding habitat for snowy plovers, at best. Salt ponds have provided suitable nesting and foraging habitat since the beginning of the 20th century, and as of 1990, about 10% of the California population of snowy plovers bred within San Francisco Bay salt ponds, mostly in the southern part of the Bay (Page et al. 2000; Page et al. 1991). Surveys conducted by PRBO, SFBBO, and others since the 1970s have shown that the breeding population in the South Bay may be declining. Window surveys in the South Bay, which cover most available breeding habitat in a one-week period, detected 351 breeding birds in 1978, 270 in 1984, and 216 in 1989 (Page et al. 2000). In 2004, the results of breeding-season monitoring of the Eden Landing, Alviso, and Ravenswood pond complexes resulted in a maximum of only 113 snowy plovers (Strong et al. 2004b); this total was down to 99 birds in 2006 (Robinson et al. 2006). Numbers of snowy plovers in the South Bay may be considerably higher in winter, when the local population is augmented by wintering birds that likely breed in the Great Basin. In contrast, recent surveys by USGS (Takekawa et al. 2005) found lower abundance in winter in the Alviso pond complex.

Figure 6 depicts the areas where snowy plovers have been recorded breeding in the South Bay since 1989 (although no recent data are available from the Newark and Redwood City salt ponds). During both the winter and breeding seasons, the greatest concentration of snowy plovers in the San Francisco Bay area has consistently occurred in the Eden Landing/Hayward area, with a lower but moderate level of use at Ravenswood and Alviso ponds.

Within the Study Area, substantial breeding populations occur in the Warm Springs salt ponds (Ponds A22 and A23) in the Alviso complex. At Warm Springs, Ponds A22 and A23 are used, with > ten adults found during the 2003 nesting season, a high count of 32 plovers at A22 in 2004 (Strong et al. 2004b), and 13 plovers at A22 in 2006 (Robinson et al. 2006). Low densities of snowy plovers have been recorded during the breeding season, sometimes with nests or chicks, at some other Alviso salt ponds, primarily at A6 and A8 (Ryan and Parkin 1998b; Strong et al. 2004b); the species also nested in the late 1990s in Alviso Pond A3N and in a small impoundment immediately east of Pond A12 (Santa Clara County Bird Data Unpublished). In 2006 and 2007, Pond A8 in Alviso has been used extensively by snowy plovers, after several years with very little plover activity in Alviso. In 2006, up to 36 snowy plovers were seen in A8, and 11 nests were found here (Robinson et al. 2006). In addition, the presence of snowy plover chicks and adults at an impoundment east of the Alviso Marina indicated that snowy plovers nested here, although no nest was found (Robinson et al. 2006).

Habitat conditions (including water depth and predator density) change over time at each of these nesting areas, so the numbers cited above are not necessarily representative of the current distribution of snowy plovers in the South Bay. The snowy plover is opportunistic, capable of moving around among potential breeding areas and breeding where conditions are suitable. The abundance and distribution of snowy plovers in the South Bay shifts annually, and is also dynamic within a given nesting season. Early in each breeding season, many ponds may not be suitable for nesting due to late rains creating muddy substrates, and nesting may be concentrated at a few ponds with suitable conditions. Later in the season, as more ponds dry out and become available for nesting, snowy plovers may be more dispersed among many nesting locations, and nest in lower densities.

Primary threats to the western snowy plover are mammalian and avian predators, and human disturbance (Page et al. 1995). Non-native predators, such as red fox, have had major effects on populations in California; in the South Bay, two snowy plover nests were known to have been depredated by red foxes in 1993 and 1994 in the Coyote Hills and Dumbarton areas (Harding et al. 1998), and such events have probably occurred much more frequently than is known. Efforts to curtail nest depredation by mammalian predators have greatly enhanced nesting success by snowy plovers in some areas (Neuman et al. 2004). In the South Bay, no strong increase in nest success was noted between 1991 and 1996, after a predator management plan was implemented, except at a few nests where exclosures were used; such nests had generally high success rates (Harding et al. 1998). Overall nest success in the South Bay has been fairly high in some recent years, with 80% nest success in 2001 (N=78 nests) and most of 2004 (N=54 nests as of July) (Wilson 2004). However, fledging success is unknown, and may be far less due to predation by avian predators.

Avian predators, particularly California Gulls and corvids (crows and ravens), are increasingly becoming an issue for snowy plover reproductive success (Wilson 2004). California gulls at Mono Lake are known to prey on snowy plover eggs and chicks (Page et al. 1983), and given the abundance of California gulls in the South Bay during the breeding season, even low levels of predation may be important to nesting plovers. American Crows (*Corvus brachyrhynchos*) and common ravens are adept at finding snowy plover nests and preying on eggs. Corvid numbers may be increasing throughout California, at least partially in response to increased availability of food from anthropogenic sources, such as garbage dumps. Other avian predators, including Loggerhead Shrikes, American Kestrels, and Northern Harriers have been documented taking snowy plover chicks, and in some areas, have dramatically reduced fledging success (Neuman, pers. comm.). Human disturbance can also be a serious factor limiting nesting and fledging success. Human disturbance (including disturbance from domestic dogs) can lead to nest abandonment or direct trampling of eggs or chicks (Page et al. 1995). In addition, because young chicks are dependent on adults for protection, human disturbance resulting in the separation of chicks from adults can lead to the death of the chicks.

California Least Tern (*Sterna antillarum browni*). Federal Listing Status: Endangered; State Listing Status: Endangered. Least terns are small fish-eating birds that nest primarily on beaches. The California least tern nests during summer from Baja California north to San Francisco Bay. Least terns are migratory, and spend winter months in coastal areas of Mexico and Central America. Most breeding colonies are located in southern California. The California least tern is listed as endangered on the state and federal levels, and the state considers it a fully protected species.

Currently, the breeding colony at Alameda is one of the most important breeding colonies in the state. In 2003, this colony had 301 breeding pairs (Hurt 2004). This total is up considerably from prior decades: 128 pairs were found in 1993, and only 70 pairs nested in 1982 (Collins 1994). Least terns nesting at Alameda typically arrive at the colony in late April, and fledge chicks from late June to early August. They forage for small fish in shallow coastal waters near the colony, mainly around Alameda Point (Hurt 2004). Adults and juveniles typically start dispersing south from the Alameda colony in early July.

Least terns also nested in 2000 and 2001 at Albany (near Alameda), with up to 12 pairs in 2000. At Pittsburg, on Suisun Bay, 13 pairs nested in 2001 and eight pairs nested in 2003. Historically, small numbers of birds have nested at the Oakland International Airport (last reported in 1995), Bay Farm Island (last reported 1975), Bair Island (last reported 1984), Port Chicago (last reported in 1988), the Bay Bridge Sand Spit (one-time attempt in 1985), and tern Island (one-time attempt in 1990) (Takekawa et al. 2005).

In addition, South Bay salt ponds have been used historically for sporadic and limited nesting attempts. These include attempts on levees at Ponds E10/E11 at Eden Landing (last reported 1985), Ponds N5/N7 (last reported 1983) and N1A in the Newark salt ponds, and Pond R3 in the Ravenswood Compex (Hurt 2004; Wetlands Research Associates 1994). In the South Bay, recent breeding has occurred only at Hayward Regional Shoreline, where eight pairs nested in 2005 and 15 pairs in 2006 (Strong 2006), and at Pond E8A in Eden Landing, where at least five pairs nested in 2007.

Currently, least terns use the Shoreline Study Area only as a post-breeding staging area from about late June through late August, prior to their southward migration. Here, both adult and juvenile least terns roost on salt pond levees (both outboard levees and interior levees between ponds) and boardwalks, and forage both in the salt ponds and over the open waters of the Bay. At the Alameda colony, least terns forage primarily on silversides (e.g., topsmelt), northern anchovies, Pacific herring, and surfperches (Elliott et al. 2004). Although data are unavailable regarding diet during the post-fledging period in the South Bay, diet is likely similar. Least terns have often been observed foraging in South Bay salt ponds, but they also forage heavily in adjacent open Bay waters. For example, 50 of 58 least terns observed foraging in the SBSP project area on 14 July 2004 were doing so over the Bay, with only eight individuals actively foraging in salt ponds (Steve Rottenborn, pers. obs.). However, the relative importance of salt ponds versus Bay waters for foraging by least terns in the South Bay is largely unknown.

In recent years, the main post-breeding (late summer/fall) staging area for least terns in the South Bay has been in the complex of salt ponds immediately north of Moffett Field (Ponds AB1, A2E, and AB2; Figure 5), located in the Study Area. For example, 276 least terns were seen in these three ponds on 27 July 2004 (Steve Rottenborn, pers. obs.). This site is used predictably for roosting and foraging by both adult and juvenile least terns in July and August each year, with typical counts of 20-100 birds. Least terns have also been recorded at a number of other ponds in the Study Area, including A1, A2E, A3N, A3W, A4, A5, A7, A9, A10, A11, and A14 (Hurt 2004).

Salt Marsh Harvest Mouse (*Reithrodontomys raviventris raviventris*). Federal Listing Status: Endangered; State Listing Status: Endangered. The salt marsh harvest mouse is a small mouse endemic to salt marshes of San Francisco Bay. The USFWS listed the salt marsh harvest mouse as an Endangered Species under the authority of the Federal Endangered Species Act on 13 October 1970, based on population declines and loss of habitat. The State of California listed the salt marsh harvest mouse as an Endangered Species on 27 June 1971, and considers it a fully protected species. The USFWS approved a joint recovery plan for the salt marsh harvest mouse and the California clapper rail on 16 November 1984 (U.S. Fish and Wildlife Service 1984). Critical habitat has not been established for either the California clapper rail or salt marsh harvest mouse.

The salt marsh harvest mouse's current distribution includes salt marshes in San Francisco, San Pablo, and Suisun Bays. The species no longer occurs on the Peninsula north of Coyote Point (Shellhammer 2000a). *Reithrodontomys raviventris* is separated into two subspecies, *R. r. raviventris* of the South Bay and *R. r. halicoetes* of the North Bay. *R. r. raviventris* is restricted along both sides of San Francisco Bay to an area from San Mateo County on the west side and Alameda County on the east side, south to Santa Clara County; this subspecies was one of the pivotal species upon which the decision to initially establish a National Wildlife Refuge in the South San Francisco Bay was based (H.R. Bill 17047, (1970), and Senate Bill 2291, (1969)).

These mice are dependent on dense vegetative cover, usually in the form of pickleweed and other salt dependent or salt tolerant vegetation in both tidal and diked salt marshes (Fisler 1965; Shellhammer 1982; Shellhammer 2000a; Shellhammer et al. 1988; Shellhammer et al. 1982). Pickleweed provides more horizontal branches (and therefore more cover) than other halophytic species. Closely tied to the cover of dense pickleweed, salt marsh harvest mice were thought to make little use of pure alkali bulrush or pacific cordgrass stands (Shellhammer 1977; Wondolleck et al. 1976). More recent trapping (H. T. Harvey & Associates 2007) detected salt marsh harvest mice in brackish marshes dominated by alkali bulrush. The extent of their distribution in, and use of, this habitat is not yet known. Grasslands adjacent to pickleweed marshes are generally used only in the spring when new growth affords suitable cover and possibly forage (Johnson and Shellhammer 1988). Salt marsh harvest mice may also use adjacent grasslands on a daily basis to avoid high tide events, but only a small percentage of the edge of the South Bay has grassland or even much in the way of escape cover adjacent to it, hence the salt marsh harvest mice have almost nowhere to go to escape from high tides. Refugial vegetation, especially peripheral halophytes, is necessary in tidal marshes and in diked marshes that flood seasonally. On the highest spring tides in winter, the lack of high-tide refugia exposes salt marsh harvest mice to intense predation, and numerous small mammals (many of which are likely salt marsh harvest mice) have been observed being depredated by gulls, herons, egrets, and raptors on such high tides in the South Bay. Marshes without appropriate cover, and narrow marshes without refugial zones into which the mice can escape during flooding or high tides, generally lack salt marsh harvest mice. Figure 7 depicts areas currently providing pickleweed habitat that is known to support, or could potentially be supporting, salt marsh harvest mice within the Study Area and adjacent areas, as well as locations where this species has and has not been detected during survey efforts, and locations providing suitable escape cover; relatively few areas provide high-quality habitat.

Salt marsh harvest mice build loose nests of dry grasses (Shellhammer 1982). Average litter size ranges from 3.7 to 4.2 mice/litter and most animals are thought to have only one litter/year (Fisler 1965). However, recent evidence shows more frequent reproduction (Geissel et al. 1988), with Grizzly Island Wildlife Area populations reproducing as often as three times per year (Krause, pers. comm.). Reproduction occurs from March through November (Fisler 1965). There are few data on foraging by harvest mice, but they probably subsist on leaves and stems of plant species, primarily pickleweed, found in tidal and diked salt marshes. Fisler (1965) reported a high seasonal variation in stomach contents. In winter, fresh green grasses were preferred, while in the rest of the year, pickleweed and other halophytes such as salt grass were the main food sources. The salt marsh harvest mouse is capable of drinking pure seawater, but it generally prefers brackish water (Fisler 1965).

Historically, the marshes in San Francisco Bay were a complex mosaic of vegetation zones, generally consisting of low marsh adjacent to mudflats dominated by cordgrass, high marsh plains dominated by pickleweed, and broad transitions of peripheral halophytes (salt-tolerant plants that cannot tolerate as much inundation by the tides) into upland habitats, with narrower transitional zones on natural levees along larger channels within the marshes. Most of the tidal marshes around the Bay and especially in the South Bay were eliminated, and those remaining have lost the upper portion of their pickleweed zones as well as the higher zone of peripheral halophytes (Shellhammer 1982; Shellhammer and Duke 2004). For example, detailed mapping by H. T. Harvey & Associates for the South Bay Salt Pond Restoration project reveals that pickleweed dominated habitat and peripheral halophyte habitat comprise only 275 acres and 113 acres, respectively, within the 8000-acre Alviso Complex; much of the peripheral halophyte acreage in the Alviso Complex, however, is adjacent to little used brackish vegetation. Most of the tidal salt marshes in the South Bay are small, isolated strip-like marshes along backshores against levees or other hardened structures that promote predation, inhibit further high marsh development, and are threatened by sea level rise (Shellhammer 1989). Similarly, most of the marshes do not have higher order tidal channels within them and hence lack a pattern of natural levees supporting shrubs such as gum plant, and other peripheral halophytes, within them that might act as escape cover for mice within the marshes. Shellhammer and Duke (2004) note that most of the marshes of the South Bay are de facto corridors, likely not wide enough to support viable populations, but wide enough to function as dispersal corridors.
Recent mapping is also documenting the fragmentation of the habitat (Figure 7). Cover-dependent salt marsh harvest mice are unlikely to move long distances over bare areas, and thus, isolation of suitable

habitat may lead to genetic isolation of populations. While they are known to swim well, especially in comparison with western harvest mice, they have not been documented to move more than four to five meters across water or more than five meters over bare ground (Bias 1994; Geissel et al. 1988). Based on this information, Shellhammer and Duke (2004) have hypothesized that barren areas of land more than five meters wide, reaches of water more than four meters wide, and brackish or freshwater marsh more than 250 meters wide act as barriers to movement of the southern subspecies of the salt marsh harvest mouse, and hence barriers to gene flow. The more recent (2006) discovery of salt marsh harvest mice in brackish marshes tempers the description of barriers somewhat, but there are still broad areas without vegetation. Areas of bare ground, water, or fresh/brackish marsh less than or equal to these distances may act as filters, reducing the movement of animals (and hence the rate of gene flow) between populations or between portions of a semi-fragmented population. The isolation of populations has contributed to the decline of the species (Shellhammer and Duke 2004) and could lead to local extinctions due to demographic processes or genetic "death." Based on their assessment of potential barriers in the South Bay, Shellhammer and Duke (2004) estimated that there were potentially 25 separate populations of salt marsh harvest mice in the South Bay as of 2002 (not including mice that might be present in very small patches of pickleweed). Figure 7 indicates the locations of major barriers and filters to dispersal of salt marsh harvest mice among the tidal salt marsh remnants in the South Bay.

Habitat degradation has also occurred as a result of the conversion of existing tidal salt marsh to brackish or even freshwater marsh over the past four decades. Within the Alviso Complex, the combination of treated effluent discharge, sedimentation that has reduced the tidal prism, and freshwater flows from rivers and streams (especially in high-rainfall years) has created conditions too fresh for pickleweed to compete and survive (H. T. Harvey & Associates 1994; 2002; 2006; Shellhammer 1982; Shellhammer et al. 1988; Shellhammer et al. 1982). The habitat value of brackish marsh needs reexamination after recent results in the Suisun Marsh and more recently in Alvios. Trapping in salt marsh harvest mouse preserves in the range of the northern subspecies in the Suisun Bay by Barthman-Thompson of CDFG has shown that salt marsh harvest mice do use other species of bulrush and cattail (*Typha* spp.) in the area. Preliminary results from a number of mouse trapping projects (most of which were done in the Suisun Bay) suggest that monocultures of peppergrass, which dominate large areas of brackish marsh in the South Bay, are not used by the mice.

As a result of habitat loss, degradation, and fragmentation, salt marsh harvest mouse populations are small. A database for all salt marsh studies carried out in the South San Francisco Bay, including the entire Study Area, was compiled by H. Shellhammer at H. T. Harvey & Associates (Shellhammer and Duke 2004). Trapping records from permits issued by the USFWS and the CDFG were reviewed and compiled. The database, which includes 198 trapping projects (estimated 95% of all such projects and studies) representing 134,204 trap nights (TN) completed through 2003, shows that 37% of all trapping projects (73 of 198, or 49,481 TN of a total of 134,204 TN) captured 0 salt marsh harvest mice. The average capture efficiency (CE, or total effort in TN divided by the number of mice captured) of all trapping projects was 0.013. In terms of unit effort, it took an average of 79 TN to capture one salt marsh harvest mouse. The approximately 64% of the projects in which at least one mouse was captured (153 of 198) had a capture efficiency equal to or less than 0.019, or it took 77 TN to capture a single mouse.

There were few projects in which numerous salt marsh harvest mice were captured; there were only eight projects with a CE $\geq$ 0.06.

The Alviso ponds have had 11 projects in the New Chicago Marsh area (mostly from the 1970s and 1980s), and 11 or more in Triangle Marsh and its western extension (north of Alviso), but again most of them date from the 1970s and 1980s. There are nine or more, widely spaced projects in the middle of the Alviso Complex: two were done along Guadalupe Slough, six on or near the northwestern edge of Moffet Field, and one in the southeastern corner of the Sunnyvale Baylands Park. The highest density of trapping projects in the area of the Alviso Complex is just west of the complex, where 13 projects have been carried out between Charleston Slough and San Francisquito Creek. Most of the harvest mouse trapping projects were carried out in the late 1980s and 1990s. A relatively small number of projects have been carried out in these ponds compared to other parts of the South Bay because they were protected from development for most of the last few decades.

Despite the species' small populations, the salt marsh harvest mouse is known to rapidly colonize restored areas. This species quickly moves into areas of appropriate habitat from nearby inhabited areas as has been shown in numerous trapping projects' reports, including many in the South Bay (H. T. Harvey & Associates 1984a; 1985a; 1985b; 1985c; 1987; 1996; 1997a).

4.4.2 Other Special-Status Species

Western Pond Turtle (*Clemmys marmorata*). Federal Listing Status: None; State Listing Status: Species of Special Concern. The western pond turtle is an aquatic turtle found west of the Sierra Nevada from the Columbia River south to northern Baja California, Mexico. This turtle requires some slack or slow water, although it will occur where enough food resources occur in faster moving water; it usually leaves the aquatic site to reproduce, to aestivate, and to over-winter. Typical habitat includes freshwater ponds and backwaters in slow-moving rivers with abundant aerial and aquatic basking sites. Nesting usually occurs in upland areas from March to July, in hard-packed clay soil. Hatchlings disperse from the nest with winter rains. Threats to the western pond turtle include impacts to nesting habitat from agricultural and grazing activities, human development of habitat, and increased predation pressure from native and non-native predators as a result of human-induced landscape changes. Many of the current records for the species are from the greater San Francisco Bay area, including the Santa Clara Valley (Jennings and Hayes 1994).

Western pond turtles are absent from most of the Shoreline Study Area, due to a lack of suitable freshwater habitat. A small population occurs in brackish habitats near Moffett Field and the Sunnyvale WPCP, in the vicinity of Pond A3W (Alderete and McGowan 2003; Figure 5). Here, up to five turtles were found on 31 May 2002, in the Northern Channel on the south side of A3W (Alderete and McGowan 2003). This population is clearly isolated from other pond turtle populations in the South Bay. A review of western pond turtle records in Santa Clara County in 1999 (H. T. Harvey & Associates 1999b) included a single record along lower Stevens Creek near Moffett Field from 1987, but the next closest records to Moffett Field were more than seven miles away at Lagunita at Stanford, along San Francisquito

Creek in Palo Alto, and in a pond along San Tomas Aquino Creek in Santa Clara. Pond turtles are occasionally seen along lower Coyote Creek and the Guadalupe River; these are likely individuals that have dispersed downstream from populations in the upper watersheds of these streams.

Double-crested Cormorant (*Phalacrocorax auritus*). Federal Listing Status: None; State Listing Status: Species of Special Concern (Rookery Site). Double-crested cormorants are large fish-eating waterbirds resident along the entire coast of California and on inland lakes and estuaries. Breeding occurs at undisturbed sites, typically in trees or on man-made structures beside water. Double-crested cormorants are considered Species of Special Concern by the CDFG only at rookery sites. Double-crested cormorants nest during spring and summer (and occasionally into early fall), and are resident in the South Bay year-round. Numbers are augmented considerably in fall and winter, when non-breeding birds from other locations visit San Francisco Bay (Ainley 2000b).

Double-crested cormorants have increased as breeders in the San Francisco Bay area in recent decades. First breeding records for Alameda County, the bayside of San Mateo County, and Santa Clara County were established only as recently as 1984, 1989, and 1992, respectively. As of 1991, there were approximately 2800 double-crested cormorants nesting around San Francisco Bay, primarily on North Bay bridges(Ainley 2000b). Relatively few, however, breed in the Study Area. Here, this species has recently nested on electrical transmission towers at several sites, including towers in ponds A18, AB1, AB2, and A2W ((Strong 2004a); Figure 5). Santa Clara County Bird Data indicate that cormorants were first recorded nesting in the Alviso Complex on electrical towers in Pond A2W in 1992. Nesting by as many as ten pairs/year at this location has continued through 2004, and new colonies appeared on towers in Ponds AB1/AB2 in 1993 (with up to eight nests in subsequent years) and Pond A18 in 1994 (with a high of 27 nests in 1997). In 2006, 34 nests were counted at Pond A2W (Strong 2006). Double-crested cormorants use salt pond levees in the South Bay primarily for roosting, but a colony established in 1998 on the levee between Ponds A9 and A10 has contained up to 70+ nests in years since. In 2006, 29 nests were counted on this levee (Strong 2006).

These birds probably forage primarily in the open Bay, but cormorants also forage for fish in salt ponds. Counts from USGS censuses in South Bay salt ponds from 2002 through 2004 peaked in October and November, with high counts of 1963 at the Alviso Ponds in October 2003 (Takekawa et al. 2005). Numbers during surveys by USGS were lowest from January through March, with high counts typically under 100 birds at the Alviso Ponds. Large foraging flocks occasionally form around high fish concentrations, as indicated by counts of 1550 in Pond A9 on 9 October 2000 and 1200 on Shoreline Lake in Mountain View on 16 November 1996 (Santa Clara County Bird Data Unpublished).

White-faced Ibis (*Plegadis chihi*). Federal Listing Status: None; State Listing Status: Species of Special Concern (nesting colony). The white-faced ibis is a medium-sized wading bird that is an uncommon breeder in California; it is considered a Species of Special Concern only at nesting colonies. White-faced ibises have nested at only a few locations in California, including the Salton Sea, Honey Lake, isolated locations in the Central Valley, and at Mallard Slough, in the South Bay. Currently, most ibises in California now nest at Kern NWR, in the Central Valley. Nests are built of vegetation, in dense stands of tule, cattail, or similar marsh vegetation.

The only nesting by the white-faced ibis in the South Bay occurred at Mallard Slough (also known as Artesian Slough), between Ponds A16 and A18 (Figure 5). Here, six adults were observed in and around a large mixed-species heronry in 1985, and adults were seen carrying nesting material in 1991 and 1992 (Santa Clara County Bird Data Unpublished). However, successful breeding was not documented, and there has been no subsequent evidence of breeding by this species in the South Bay since that time. White-faced ibises occur irregularly throughout the San Francisco Bay Area during the nonbreeding season.

Northern Harrier (*Circus cyaneus*). Federal Listing Status: None; State Listing Status: Species of Special Concern (nesting). The Northern harrier is a raptor commonly found in open grasslands, agricultural areas, and marshes. Nests are built on the ground in areas where long grasses or marsh plants provide cover and protection. Harriers hunt for a variety of prey, including rodents, birds, frogs, reptiles, and insects by flying low and slowly in a traversing manner. The Northern harrier is considered a Species of Special Concern in California only at nesting sites.

This species is a common forager over San Francisco Bay marshes and extensive areas of ruderal habitat immediately surrounding the Bay, particularly during the non-breeding season (winter) when migrant and wintering birds augment the local resident population. Northern harriers breed in low numbers within the South Bay, nesting in the larger expanses of tidal marsh that remain, such as Triangle Marsh in Alviso, the Warm Springs marshes, and the Palo Alto/East Palo Alto marshes. This species also nests in extensive tracts of tall ruderal vegetation, moist fields, and nontidal or muted tidal marsh, such as occurs on Moffett Field and in the Palo Alto Flood Control Basin. The minimum patch size needed to support a pair of nesting harriers in the South Bay is unknown, and the narrow strips of marsh along some of the sloughs between salt ponds in the Study Area are likely too narrow to provide suitable nesting habitat for this species. However, nest-building along Guadalupe Slough near the Sunnyvale WPCP in 1993 and a successful nesting along Mountain View Slough, between Ponds A1 and A2W in Mountain View, in 2000 indicates that some of these narrower marshes do provide suitable nesting habitat (Santa Clara County Breeding Bird Atlas Committee Unpublished). Northern harriers may be important predators of nesting shorebirds and terns in the South Bay, with individuals or pairs keying in on certain areas having concentrations of nesting waterbirds. This species has been known to take both adult and young snowy plovers in the Eden Landing Complex (Krause, pers. comm.).

White-tailed Kite (*Elanus leucurus*). Federal Listing Status: None; State Listing Status: Fully Protected Species. This raptor species prefers habitats with low ground cover and variable tree growth. Kite nests are usually built near the tops small trees or large shrubs near open habitats, such as partially cleared or cultivated fields, grassy foothills, and marsh. Kites prey primarily on small rodents (especially the California vole), but also feed on birds, insects, reptiles, and amphibians.

This species occurs in the South Bay commonly throughout the year, primarily in the upland fringes of the Shoreline Study Area. Breeding occurs primarily in spring and early summer, although breeding activity as early as February, with young in the nest as late as October, has been noted in the South Bay (Santa Clara County Bird Data Unpublished). This species breeds in a number of locations around the

Study Area where nest sites (e.g., trees and shrubs) occur adjacent to open fields, ruderal habitats (e.g., active and closed landfills), and marshes. The riparian corridor of Coyote Creek is likely to support several breeding pairs each breeding season.

Merlin (*Falco columbarius*). Federal Listing Status: None; State Listing Status: Species of Special Concern (wintering). The merlin is a medium-sized falcon that breeds in North America primarily in Canada. Merlins do not breed in California, but have been listed as a Species of Special Concern due to concerns over the species' wintering populations here. Non-breeding merlins occur in the San Francisco Bay area from September through April.

Like most falcon species, the merlin feeds primarily on small birds. Merlins are widespread, but in low abundance, throughout the entire Bay area during migration and winter, where they forage aerially. Shorebirds (e.g., sandpipers) provide abundant prey, thus merlins can often be found foraging over salt ponds and mudflats. They also forage on a variety of other bird species, and can be found in virtually all habitats in the Shoreline Study Area.

California Gull (*Larus californicus*). Federal Listing Status: None; State Listing Status: Species of Special Concern (nesting colony). The California gull breeds colonially throughout the western United States, often in colonies of several thousand birds. They typically start attending colonies in early April, and lay eggs in early May (Winkler 1996). Incubation takes about 27 days, and chicks hatch in the late May to early June. Chicks remain near the nest until fledging about six weeks after hatching. Typical nesting habitat is barren or sparsely vegetated borders of saline lakes. Abundant nesting populations from the Great Basin (e.g., Great Salt Lake) disperse to coastal California after breeding, greatly augmenting the wintering population in the Bay area.

Historically, California gulls bred primarily on saline inland lakes, and this species was declared a Species of Special Concern at nesting colonies by CDFG due to concern over impacts to inland breeding colonies. In 1980, a small group colonized abandoned levees on Pond A6 in Alviso. This colony steadily increased in size over the next two decades, and by 2000 this colony had grown to over 10,000 nesting individuals, making it the second largest colony in California (Shuford and Ryan 2000). Adult California gulls attend the Pond A6 colony year-round, but numbers increase during spring. Egg laying occurs between mid-April and mid-May, and most young are fledged by mid-August (Shuford and Ryan 2000). Adult California gulls breeding in the South Bay forage on natural prey, such as brine flies and their larvae, and brine shrimp, supplemented by food obtained from human sources, including the Newby Island Landfill near Milpitas and the Tri-Cities Landfill in Fremont. It is likely that the availability of food at these landfills has been at least partly responsible for the increase in South Bay breeding populations, both by providing food during the breeding season and by aiding in the survival of younger birds during the nonbreeding season.

California gulls also prey on the eggs and young of other birds, such as snowy plovers, Forster's terns, American avocets, and black-necked stilts, and they likely take small mammals such as salt marsh harvest mice as well. A study by Ackerman et al. (2006) documented that 15% of American avocet nests monitored with cameras in the South Bay were depredated by California gulls; 61% of American avocet chicks and 23% of black-necked stilt chicks fitted with radio transmitters in this study were determined to be depredated by California gulls. California gulls at Mono Lake are known to prey on snowy plover eggs and chicks (Page et al. 1983), and given the abundance of California gulls in the South Bay during the breeding season, even low levels of predation may be important to nesting waterbirds. Salt marsh harvest mice are particularly vulnerable during extreme high tide events, when most of the pickleweed marsh plains of the South Bay are completely inundated. At these times, salt marsh harvest mice are forced to swim, and gulls (including California gulls) readily forage over the flooded marshes, presumably including salt marsh harvest mice among their prey.

California gulls also nest in smaller numbers at several other sites within the Study Area. As of 2004, they were nesting in at least five colonies in the South Bay. Figure 2 depicts the locations where this species has nested in the South Bay since 1994. In 2006, the largest colonies other than at Pond A6 were at Coyotes Hills ponds 2A/3A (3721 nests) and on the levee between ponds M1 and M2 (2492 nests; Strong 2006). Numbers of California gulls in the South Bay increase during winter, when the local population is augmented considerably by birds moving from interior populations.

Table 9 – Numbers of California gulls at colonies in ponds in the Shoreline Study Area, from 1982 to 2006. All numbers are either total number of adults counted on the colony, or twice the number of nests counted on the colony. Data from Strong (Strong 2004b, Strong 2006).

Year	A1	AB2	A6	A9/10
1982	0	0	412	434
1983	0	0	1342	0
1984	0	0	2000	150
1985	0	0	3000	374
1986	0	0	3000	97
1987	0	0	4000	100
1988	0	0	4600	180
1989	0	0	5310	434
1990	2	0	7600	122
1991	0	0	5250	0
1992	0	0	5500	200
1993	200	82	6912	234
1994	350	556	9000	300
1995	74	300	7236	4
1996	0	282	6558	1410
1997	164	1000	6256	1722
1998	0	400	6562	1628
1999	145	248	9380	2117
2000	0	254	11482	1986
2001	278	624	11216	3056
2002	510	712	11302	3590

Year	A1	AB2	A6	A9/10
2003	862	384	13644	1010
2004*	445	531	8600	1047
2006	190	187	9726	117

* Numbers are based on a single aerial survey, and are likely underestimates.

Black Skimmer (*Rynchops niger*). Federal Listing Status: None; State Listing Status: Species of Special Concern (nesting colony). The black skimmer is a unique species, with a lower mandible longer than the upper mandible. This extended lower mandible allows these birds to fly over the surface of the water, skimming for small fish. Black skimmers nest primarily on the coasts of the Southeast United States, the Gulf of California, and the Pacific Coast of Baja, California, north to San Diego, and in California, the black skimmer is a Species of Special Concern only at nesting sites.

Black skimmers were first detected nesting in California in 1972, and since that time, this species' populations have increased considerably (e.g., to approximately 1200 pairs in 1995 (Collins and Garrett 1996). Until the mid-1990s, the black skimmer was considered a very rare nonbreeding visitor to the San Francisco Bay area. However, the species was documented nesting in San Francisco Bay in 1994, when one pair nested in Pond AB2 in Santa Clara County, and one pair nested at Hayward Regional Shoreline in Alameda County (Layne et al. 1996). Since 1994, this species has occurred in the South Bay every year and has nested at several additional sites in the Study Area, including ponds A1, A2W, AB1, A8, and A16 ([Strong 2004b]; Figure 5). In these areas, black skimmers have usually nested among Forster's terns, on small dredge-spoil islands (including both bare islands and islands vegetated, sometimes heavily, with pickleweed) in salt ponds. Exact nesting locations vary from year to year.

Skimmer populations in the South Bay have slowly but steadily increased (e.g., to a high count of 27 in Pond A8 on 28 September 2003; [Santa Clara County Bird Data Unpublished]). Because nesting success in the South Bay has apparently been low, judging by the low number of chicks surviving to fledging age, this population increase has likely been primarily the result of immigration from the increasing southern California population. Within the Shoreline Study Area, the species is most abundant in the vicinity of the Alviso Complex and most post-breeding flocks have been recorded in this area (e.g., on Pond A8 and in Charleston Slough).

Burrowing Owl (*Athene cunicularia*). Federal Listing Status: None; State Listing Status: Species of Special Concern. The burrowing owl is a small, terrestrial owl of open country. Burrowing owls occupy grasslands and sparsely vegetated shrubland ecosystems. In California, burrowing owls are found in close association with California ground squirrels. Ground squirrels provide nesting and refuge burrows, and maintain areas of short vegetation height, providing foraging habitat and allowing for visual detection of avian predators by burrowing owls. Burrowing owls are semi-colonial nesters, and group size is one of the most significant factors contributing to site constancy by breeding burrowing owls. The nesting season, as recognized by the California Department of Fish and Game, runs from 1 February through 31 August.

Burrowing owl populations in the South San Francisco Bay have been decreasing rapidly and significantly in recent decades. As of 1990, the South Bay burrowing owl population was thought to have declined at least 50% since 1981 (Barclay et al. 1998). A statewide census, the largest and most comprehensive undertaken to that date or since, suggested that the rate of disappearance of South Bay burrowing owls was greater than the rate found for owls in the Central Valley, and that the rate of decline for both regions was accelerating (DeSante et al. 1993; DeSante et al. 1997). A new statewide census was conducted in 2006. Surveyors on this census counted 595 burrowing owls statewide, of which 56 were in Santa Mateo and Santa Clara County.

Despite recent declines, burrowing owls still breed in a number of locations offering suitable burrows and open foraging habitat around the upland perimeter of the South Bay. Such sites include Byxbee Park in Palo Alto, Shoreline Park and Moffett Field in Mountain View, the Sunnyvale Baylands Park, the San Jose/Santa Clara WPCP buffer lands, and the SFBNWR lands in Fremont, and a few other scattered locations in the Shoreline Study Area (Figure 8). Burrowing owls are occasionally observed in shoreline, rocky, and upland habitats that rim the South Bay, and they are believed to nest at least infrequently in salt pond levees (Trulio 2000).

Short-eared Owl (*Asio flammeus*). Federal Listing Status: None; State Listing Status: Species of Special Concern (nesting). Short-eared owls occur in open habitats such as grasslands, wet meadows, and marshes. They require tall herbaceous vegetation for nesting or daytime refuge. Short-eared owls once bred much more widely in California, including the San Francisco Bay Area. However, the species now occurs primarily as a migrant and winter visitor, and is a rare and local breeder in the South Bay. The most recent nesting record in the South Bay was of three pairs producing four fledglings at Bair Island in 1994 (Yee et al. 1994). Other breeding-season records in the South Bay include a pair at the Palo Alto Baylands in 1966 (Chase and Chandik 1966) and two nests in the Palo Alto Flood Control Basin in 1972 (Gill 1977). The species is apparently much more abundant in the North Bay, with over 100 fledglings banded at Grizzly Island (Solano County) in 1987 (Campbell et al. 1987). Potential breeding habitat does occur in the Study Area, but the status of this species as a breeder in the Study Area is unknown. If short-eared owls currently breed in the South Bay, they are likely to nest only in the larger tracts of suitable habitat.

During winter, the species is more widespread, though in low numbers, with many records from bayside locations virtually throughout the Study Area. Locations of more regular observations in winter include Byxbee Park and the Palo Alto Flood Control Basin. Short-eared owls are considered Species of Special Concern only at nesting sites.

Cooper's Hawk (*Accipiter cooperii*). Federal Listing Status: None; State Listing Status: Species of Special Concern. The Cooper's hawk is a medium-sized raptor that preys upon smaller birds (e.g., jays, doves, and quail) and occasionally takes small mammals and reptiles. The Cooper's hawk prefers landscapes where wooded areas occur in patches and groves which facilitates the ambush hunting tactics employed by this species. Breeding pairs in California are often found in stands of live oak woodland or riparian areas, although this species has adapted well to suburban habitats and tolerates human activity. Cooper's hawks typically nest between March and August. During winter, local Cooper's hawks may migrate south, while the local population may increase with immigration of migrants that breed farther north.

Within the Study Area, Cooper's hawks have been found nesting in surburban areas fringing the South Bay. They may nest in a variety of trees in this area, and may also nest in the riparian corridor of Coyote Creek.

Loggerhead Shrike (*Lanius ludovicianus*). Federal Listing Status: None; State Listing Status: Species of Special Concern (nesting). These predatory songbirds are year-round residents in grassland and scrub habitats in California. Shrikes generally build their nests in shrubs and trees in fairly open areas, and nest in spring and early summer. They hunt in open areas, usually from a low perch, such as a fence post or overhead wire. They forage primarily on large insects, lizards, and small mammals, but some individuals also prey on snowy plover chicks and other young shorebirds. Loggerhead shrike numbers have declined dramatically in eastern North America, but populations in California may be more stable. Loggerhead shrikes are considered Species of Special Concern only at nesting sites.

The species nests in low numbers throughout the Shoreline Study Area. Loggerhead shrikes are found in a number of locations around the Study Area where nest sites (e.g., trees and shrubs) occur adjacent to open fields, ruderal habitats (e.g., active and closed landfills), and marshes. Shrikes forage in ruderal habitats, on salt pond levees, and in marshes in the Study Area.

California Horned Lark (*Eremophila alpestris actia*). Federal Listing Status: None; State Listing Status: Species of Special Concern. Horned larks are songbirds that occur over much of North America in bare ground habitats with short grass, scattered bushes, or no vegetation. In winter, they often form large flocks that sometimes contain several subspecies. The California horned lark is a widespread breeder along the coast and in the Central Valley of California. They breed from March through July, with peak activity in May. Horned larks build grass-lined nests directly on the ground, in dry, open habitats with sparse vegetation.

Horned larks occur primarily as migrants and winter visitors in the Shoreline Study Area, when they may be found in small numbers foraging along salt pond levees, in salt pannes within dried-out salt ponds, and in short grassland and ruderal habitats (e.g., active and closed landfills) around the South Bay. A few pairs likely breed in these locations as well, as evidenced by scattered breeding-season records in and around the Alviso Pond Complex (Steve Rottenborn, pers. obs.; Santa Clara County Bird Data Unpublished).

Saltmarsh Common Yellowthroat (*Geothlypis trichas sinuosa)*. Federal Listing Status: None; State Listing Status: Species of Special Concern. The saltmarsh common yellowthroat is a small songbird that inhabits emergent vegetation, primarily in fresh and brackish marshes, and associated upland areas in the San Francisco Bay Area. This subspecies (one of approximately 12 subspecies of common yellowthroat recognized in North America) breeds from mid-March through early August, and pairs frequently raise two clutches/year. Because this subspecies cannot be reliably distinguished in the field from other races that occur in the South Bay as migrants, determination of the presence of saltmarsh common yellowthroats can be achieved only by observation of presence during the summer months when other subspecies are not expected to be present. Although little is known regarding the movements of this taxon, the wintering areas have been described as coastal salt marshes from the San Francisco Bay region to San Diego County (Terrill 2000).

Despite their common name, saltmarsh common yellowthroats breed primarily in fresh and brackish marshes, and in freshwater riparian habitats. In the South Bay, this species is a fairly common breeder in such habitats virtually wherever they occur, although very small patches of marsh often lack this species. Particularly large populations occur in brackish and freshwater marshes in the Alviso Complex (e.g., along the middle and upper reaches of the major sloughs and in the Warm Springs/Alviso marshes). The saltmarsh common yellowthroat likely breeds to some extent in salt marshes providing taller herbaceous vegetation (Ray 1919), as evidenced by the species' presence during the breeding season in such marshes (Santa Clara County Bird Data Unpublished; Santa Clara County Breeding Bird Atlas Committee Unpublished). Saltmarsh common yellowthroats also breed in the riparian corridor of Coyote Creek within the Study Area.

California Yellow Warbler (*Dendroica petechia brewsteri*); Federal Status: None; State Status: Species of Special Concern. The yellow warbler is a small songbird that breeds in well-developed riparian vegetation, and feed on insects. The yellow warbler is a migratory species that is common during migration, but migratory birds in California are mostly of one of the northern subspecies. Yellow warblers that remain to breed in northern and central California are of the race *D. p. brewsteri*. Due to a loss of riparian habitat in California over the last century, this subspecies is listed as a California Species of Special Concern. Most California yellow warblers migrate to Mexico and South America in the fall and return to California to breed from May through August. Yellow warblers are rare breeders in the Study Area, likely nesting only in the riparian corridor along lower Coyote Creek.

Alameda Song Sparrow (*Melospiza melodia pusillula*). Federal Listing Status: None; State Listing Status: Species of Special Concern. The Alameda song sparrow is one of three subspecies of song sparrow breeding only in salt marsh habitats in the San Francisco Bay area. Locally it is most abundant in the taller vegetation found along tidal sloughs, including salt marsh cordgrass and marsh gumplant. Populations of the Alameda song sparrow have declined due to the loss of salt marshes around the Bay, although within suitable habitat it is still fairly common. The location of the interface between populations of the Alameda song sparrow and those of the race breeding in freshwater riparian habitats (*M. m. gouldii*) along most creeks is not known due to difficulties in distinguishing individuals of these two races in the field.

In salt marshes, *pusillula* are most abundant in tall marsh vegetation, particularly in the marsh gumplant/California cord grass association immediately adjacent to tidal sloughs. *Pusillula* are also found in peppergrass in the upper, drier portions of salt marshes and occasionally in brackish marshes dominated by bulrushes (Marshall and Dedrick 1994). Except during very high tides, they make more limited use of the broad expanses of short pickleweed favored by savannah sparrows. Along several streams in the South Bay, song sparrows seem to be distributed continuously from the upper reaches down to tidal salt marsh. This distribution indicates that *gouldii* and *pusillula* come into contact along these streams, probably at the interface of brackish and freshwater habitats, as Grinnell (1901) found at San Francisquito Creek.

Song sparrows nest as early as March, but peak nesting activity probably occurs in May and June. Salt marsh-breeding song sparrows in the Bay area (including *pusillula*) are known to breed about two weeks earlier than *gouldii* (Johnston 1954; Johnston 1956). This early breeding by *pusillula* is apparently an adaptation to breeding in a tidal environment, as high tides in late spring and early summer may destroy large numbers of nests.

Optimum habitat for this subspecies is tidal salt marsh, although it occurs in tidal brackish marsh, seasonal wetlands, salt pond complexes and other adjacent habitats. Alameda song sparrows occur commonly in suitable habitat throughout the South Bay, including the Shoreline Study Area, being particularly abundant in more extensive marshes but also occurring fairly commonly in narrower marshes along tidal sloughs as long as taller herbaceous vegetation for nesting is present.

Tricolored Blackbird (*Agelaius tricolor*). Federal listing status: None; State Listing Status: Species of Special Concern (nesting colony). Tricolored blackbirds are found almost exclusively in the Central Valley and central and southern coastal areas of California. This species was originally listed as a Species of Special Concern (at its nesting colonies) in California due to concerns over the loss of wetland habitats in the state. However, in 1992, surveys by the California Department of Fish and Game determined that the population of this species was much larger than previously believed (Beedy and Hamilton 1997), lessening concern for the species.

The tricolored blackbird is highly colonial in its nesting habits and forms dense breeding colonies, which in some Central Valley areas may consist of up to tens of thousands of pairs. This species typically nests in tall, dense, stands of cattails or tules, but also nests in blackberry, wild rose bushes and tall herbs. Nesting colonies are usually located near standing or flowing fresh water. Tricolored blackbirds form large, often multi-species, flocks during the non-breeding period and range more widely than during the reproductive season.

Appropriate breeding habitat for this species in the Shoreline Study Area is limited, and most breeding sites in the South Bay area are well inland from areas of tidal influence. This species nested in 1992 in ruderal habitat in the San Jose-Santa Clara Water Pollution Control Plant (Santa Clara County Breeding Bird Atlas Committee Unpublished), but no other breeding records are known from the immediate Study Area. Freshwater marshes providing fairly extensive stands of tules and cattails are present along upper Artesian, Alviso, and Guadalupe Sloughs, in the Warm Springs marshes, and along the Moffett Channel. However, the tricolored blackbird typically nests only in nontidal freshwater marshes, and it is therefore unlikely to use such tidal marshes for nesting.

Salt Marsh Wandering Shrew (*Sorex vagrans halicoetes*). Federal Listing Status: None; State Listing Status: Species of Special Concern. Formerly more widely distributed in the Bay area, this small insectivorous mammal is now confined to salt marshes of the South Bay (Findley 1955). Salt marsh wandering shrews occur most often in medium-high wet tidal marsh (six to eight feet above sea level), with abundant driftwood and other debris for cover (Shellhammer 2000b). They have also been recorded occasionally in diked marsh. This species is typically found in fairly tall pickleweed, in which these shrews build nests. They breed and give birth during spring, although very little is known regarding the natural history of the species.

This subspecies was formerly recorded from marshes of San Pablo and San Francisco Bays in Alameda, Contra Costa, San Francisco, San Mateo, and Santa Clara Counties, but captures in recent decades have been very infrequent anywhere in these areas. Shrews are occasionally captured during salt marsh harvest mouse trapping studies (see Table 6 above), but the difficulty in identifying them to species has precluded a better understanding of the current distribution of this species in the South Bay. As of 1986, there were only four locations, including Bair Island, the Alameda Creek mouth, Dumbarton Point, and Mowry Slough, where this species had been positively identified between 1980 and 1985, although the species was considered likely present in a number of other marshes in the South Bay (Western Ecological Services Company (WESCO) 1986).

This species is likely present, albeit probably in low numbers, in extensive tidal salt marshes within the Shoreline Study Area. Much of the previous discussion of the habitat requirements of the salt marsh harvest mouse, such as extensive salt marsh with high-tide refugia, and of the effects of habitat fragmentation and barriers to dispersal, applies to the salt marsh wandering shrew as well.

Pacific Harbor Seal (*Phoca vitulina richardsi*). Federal Listing Status: None; State Listing Status: None. Pacific harbor seals are currently the only marine mammals that are permanent residents of San Francisco Bay. Although they are not listed by the state as a Species of Special Concern, harbor seals are protected under the federal Marine Mammal Protection Act, and are sensitive to human disturbance. NOAA Fisheries (the agency that oversees the protection of marine mammals) recommends a 100-yard disturbance-free buffer around harbor seals. Disturbance can lead to separation of pups from nursing mothers, can add physiological stress to adults, and can lead to long-term abandonment of historical haul-out sites (Lidicker and Ainley 2000).

Pacific harbor seals occur along the Pacific coast of North America from Alaska south to Baja California. In San Francisco Bay, they haul out at a number of sites to rest and pup (give birth). Most pupping occurs during spring, with a peak in April (Fancher and Alcorn 1982). Females nurse pups for about 28 days, during which time they are susceptible to being separated as a result of human disturbance. Haul-out sites are typically mudflats far from areas used regularly by humans, and near deeper water, where seals forage. Harbor seals forage in nearshore marine habitats on variety of fishes and invertebrates. Kopec and Harvey (1995) studied diet at several haul-out sites in 1991-1992, and found that in the South Bay, major diet items included yellowfin goby (*Acanthogobius flavimanus*), staghorn sculpin (*Leptocottus armatus*), and white croaker (*Genyonemus lineatus*).

More than ten sites around the Bay may be used by seals at any given time (Lidicker and Ainley 2000), and any undisturbed intertidal habitat accessible to the open Bay could potentially be used by harbor seals. Primary haul-out sites in San Francisco Bay are Mowry Slough (243 seals in 1999), Castro Rocks near the Richmond-San Rafael Bridge (107 seals in 1999), and Yerba Buena Island (72 seals in 1999;

(Lidicker and Ainley 2000). Mowry Slough, the most important site in the South Bay, produced 78 pups in 1999, 90 in 2000, 102 in 2001 and 144 in both 2002 and 2003 (Green et al. 2004); surveys in April 2004 found 283 seals, including 59 pups, at Mowry Slough and 34 seals, including nine pups, near the mouth of Coyote Creek at Calaveras Point (Bell Unpublished). At both these sites, mudflats and adjacent pickleweed marsh at various locations may be used at any particular time. Use of haul-out sites varies over time, and other South Bay sites, including Guadalupe Slough near the northeastern end of Pond A3N, the mouth of the Alameda Flood Control Channel, Newark Slough, Bair Island, and Greco Island are currently used or have been important haul-outs historically (Bell Unpublished; Fancher and Alcorn 1982; Kopec and Harvey 1995) (Figure 5).

4.4.3 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act requires federal fishery management plans (FMPs) to describe the habitat essential to the fish being managed and describe threats to that habitat from both fishing and non-fishing activities. In addition, in order to protect this Essential Fish Habitat (EFH), federal agencies are required to consult with NOAA Fisheries on activities that may adversely affect EFH.

The Shoreline Study Area includes EFH from three FMPs, the Coastal Pelagic, West Coast Groundfish, and Pacific Coast Salmon FMPs. Fish species covered under these plans that occur in the South Bay are listed in Table 10.

Table 10 - Fisheries Management Plan (FMP) species in the South Bay

Common Name	Scientific Name	Occurrence
Coastal Pelagic FMP		
Northern anchovy	*Engraulis mordax*	Abundant from South to Central Bay; adults and juveniles present in South and South-Central Bay, adults, juveniles, larvae, and eggs present in Central Bay
Pacific sardine	*Sardinops sagax*	Present in South and South-central Bay and rare in Central Bay; adults and juveniles present
Jack mackerel	*Trachurus symmetricus*	Present in Central Bay; eggs and larvae
Pacific Groundfish FMP (Estuarine Composite EFH)		
Leopard shark	*Trikakis semifasciata*	Present from South Bay to Central Bay; adults and juveniles present
Soupfin shark	*Galeorhinus galeus*	Present in South-central and Central Bay and rare in South Bay; adults and juveniles present in Central Bay and rare in South Bay, less known about life stages in South-central Bay
Spiny dogfish	*Squalus acanthias*	Present from South Bay to Central Bay; adults and juveniles in South and Central Bay, less known about life stages in South-central Bay
Big skate	*Raja binoculata*	Present from South Bay to Central Bay; adults and juveniles present in Central Bay, less known about other life stages present in South and South-central Bay

Common Name	Scientific Name	Occurrence
California skate	*Raja inornata*	Present in South Bay (probably rare)
Lingcod	*Ophiodon elongatus*	Present from South to Central Bay but rare in South-central Bay; adults and juveniles present in Central Bay, less known about life stages present in South Bay
Kelp greenling	*Hexagrammos decagrammus*	Present in Central Bay; juveniles and adults
Pacific whiting (hake)	*Merluccius productus*	Present in Central Bay; eggs and larvae
Brown rockfish	*Sebastes auriculatus*	Present from South to Central Bay; juveniles present in South and South-Central Bay, adults and juveniles present in Central Bay
Curlfin sole	*Pleuronichthys decurrens*	Present in Central Bay; juveniles
English sole	*Parophrys vetulus*	Abundant from South to Central Bay; adults and juveniles present
Pacific sanddab	*Cintharichthys sordidus*	Present from South to Central Bay; adults, juvenile, larvae, and eggs present in Central Bay, less known about life stages in South Bay
Sand sole	*Psettichthys melanostictus*	Present in South and Central Bay but rare in South-central Bay; adults, juveniles, and larvae present
Starry flounder	*Platichthys stellatus*	Present from South to South-central Bay and abundant in Central Bay; adults and juveniles present in South Bay and adults juveniles, larvae, and eggs present in Central Bay
Cabezon	*Scorpaenichthys marmoratus*	Rare to few from South to Central Bay; juveniles present in South and South-Central Bay, adults and juveniles present in Central Bay
Bocaccio	*Sebastes paucispinis*	Rare in Central Bay, less known about presence and life stages elsewhere in Bay
Calico rockfish	*Sebastes dalli*	Rare in South Bay, life stages unknown
Rex sole	*Glyptocephalus zachirus*	Rare in South Bay, life stages unknown
Pacific Coast Salmon FMP (Estuarine Composite EFH)		
Chinook salmon Central Valley fall- and late fall-run ESU	*Oncorhynchus tshawytscha*	Spawns in several South Bay streams, including Coyote Creek and the Guadalupe River

The Magnuson-Stevens Act defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." For the Pacific Coast Salmon FMP, the EFH includes freshwater and marine habitats, including habitats for estuarine and ocean rearing and juvenile and adult migration. The important features of EFH include "1) adequate water quality; 2) adequate temperature; 3) adequate prey species and forage base (food); and 4) adequate depth, cover, marine vegetation, and algae in estuarine and near-shore habitats." For the Coastal Pelagic Species FMP, the EFH includes "all marine and estuarine waters from the shoreline along the coasts of California, Oregon and Washington offshore to the limits of the Exclusive Economic Zone (EEZ) and above the thermocline where sea surface temperatures range between ten and 26 degrees C." For the West Coast Groundfish FMP, seven "composite" EFH categories are defined. The estuarine composite includes:

"…those waters substrates and associated biological communities within bays and estuaries of the coasts of Washington, Oregon, and California, seaward from the high tide line (MHHW) or extent of upriver saltwater intrusion. These areas are delineated from the USFWS National Wetland Inventory (NWI) and supplemented from NOAA's Coastal Assessment Framework for the water portion of the Estuarine Drainage Areas for two small estuaries (Klamath River and Rogue River), the Columbia River, and San Francisco Bay. NWI defines estuaries as areas with water greater than 0.5 ppt ocean-derived salt."

Thus, all marine areas within the Study Area below MHHW with salinity of 0.5 ppt or greater are considered EFH.

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6. LIST OF PREPARERS

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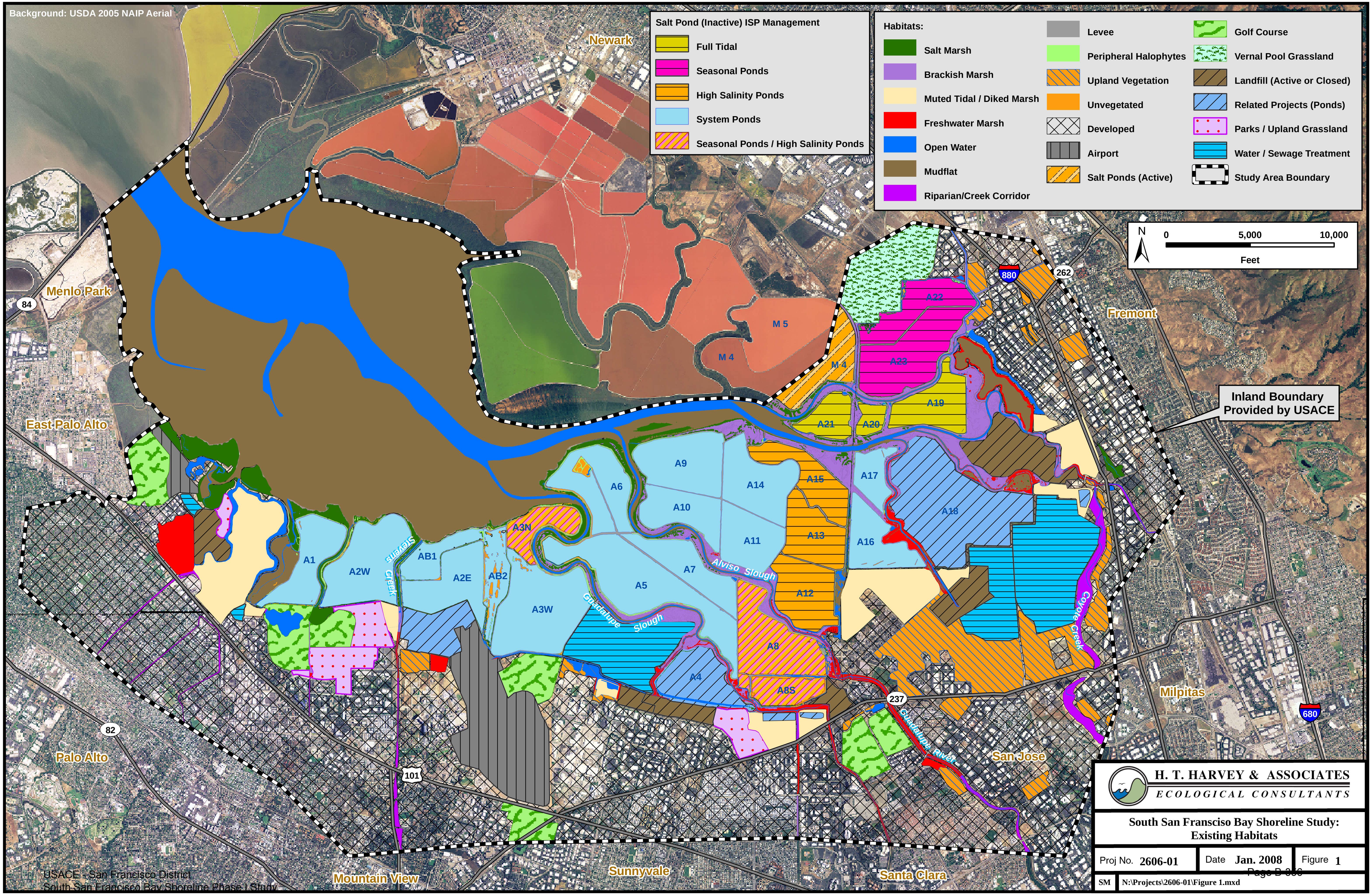
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Salt Pond (Inactive) ISP Management
Full Tidal
Seasonal Ponds
High Salinity Ponds
System Ponds
Seasonal Ponds / High Salinity Ponds
Habitats:
Salt Marsh
Brackish Marsh
Muted Tidal / Diked Marsh
Freshwater Marsh
Open Water
Mudflat
Riparian/Creek Corridor
Levee
Peripheral Halophytes
Upland Vegetation
Unvegetated
Developed
Airport
Salt Ponds (Active)
Golf Course
Vernal Pool Grassland
Landfill (Active or Closed)
Related Projects (Ponds)
Parks / Upland Grassland
Water / Sewage Treatment
Study Area Boundary
N
0
5,000
10,000
Feet
Newark
Menlo Park
East Palo Alto
Palo Alto
Mountain View
Sunnyvale
Santa Clara
San Jose
Milpitas
Fremont
84
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Stevens Creek
Alviso Slough
Guadalupe Slough
Guadalupe River
Coyote Creek
Inland Boundary Provided by USACE
H. T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS
South San Franscisco Bay Shoreline Study: Existing Habitats
Proj No. 2606-01
Date Jan. 2008
Figure 1
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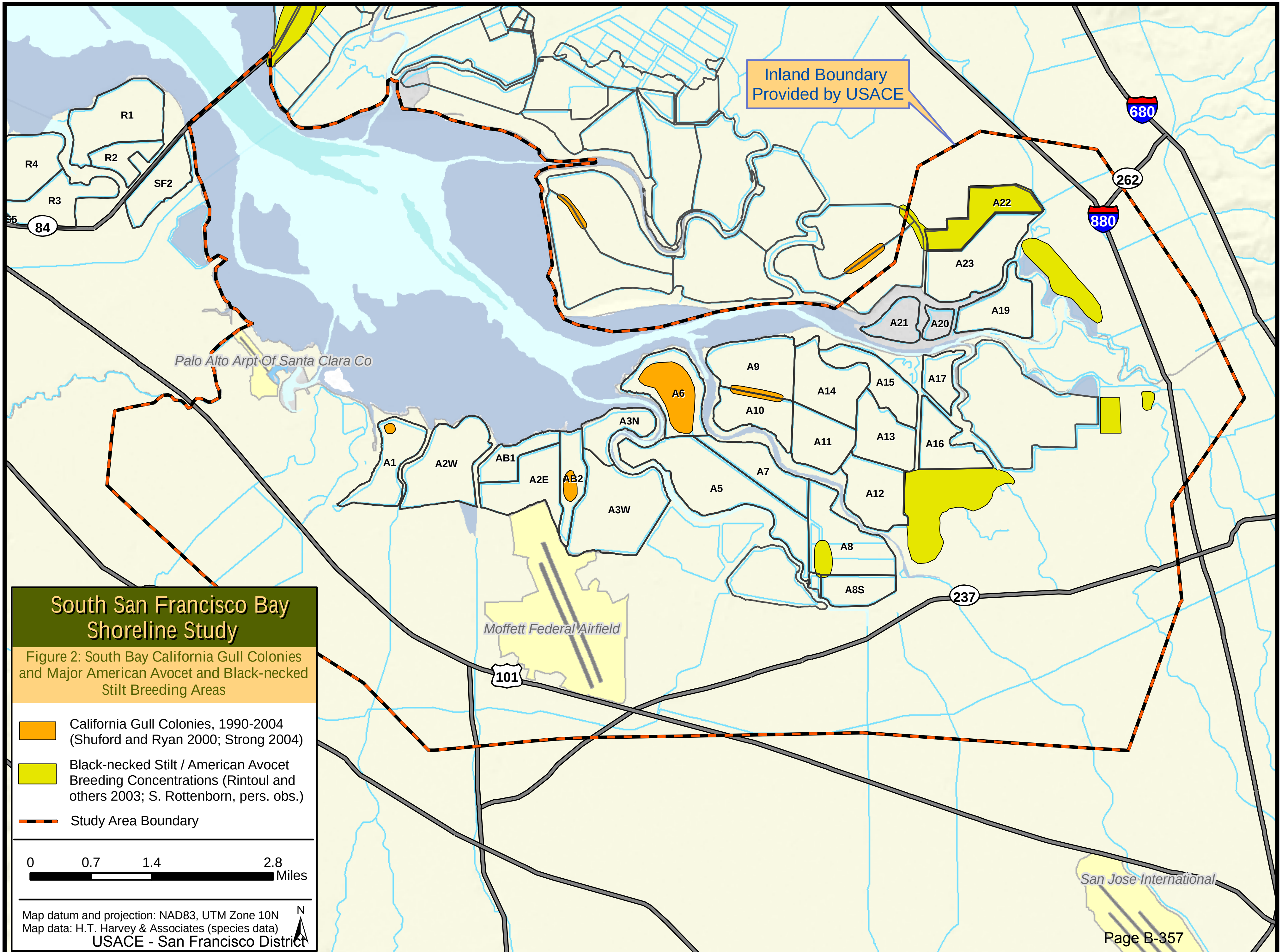
South San Francisco Bay
Shoreline Study
Figure 2: South Bay California Gull Colonies and Major American Avocet and Black-necked Stilt Breeding Areas
California Gull Colonies, 1990-2004 (Shuford and Ryan 2000; Strong 2004)
Black-necked Stilt / American Avocet Breeding Concentrations (Rintoul and others 2003; S. Rottenborn, pers. obs.)
Study Area Boundary
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2.8
Miles
Map datum and projection: NAD83, UTM Zone 10N
Map data: H.T. Harvey & Associates (species data)
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Moffett Federal Airfield
San Jose International
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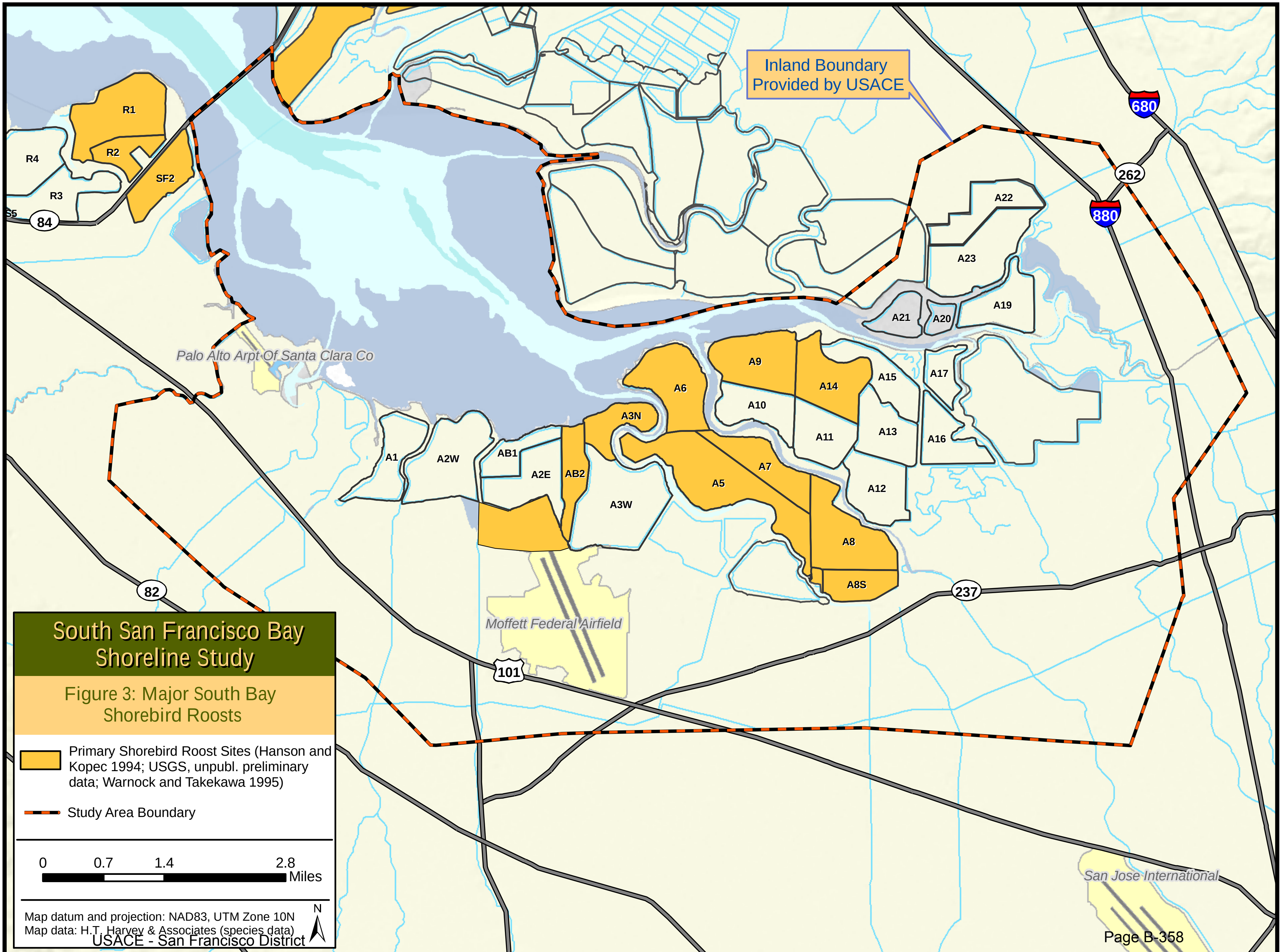
Page B-357


South San Francisco Bay Shoreline Study
Figure 3: Major South Bay Shorebird Roosts
Primary Shorebird Roost Sites (Hanson and Kopec 1994; USGS, unpubl. preliminary data; Warnock and Takekawa 1995)
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0 0.7 1.4 2.8 Miles
Map datum and projection: NAD83, UTM Zone 10N
Map data: H.T. Harvey & Associates (species data)
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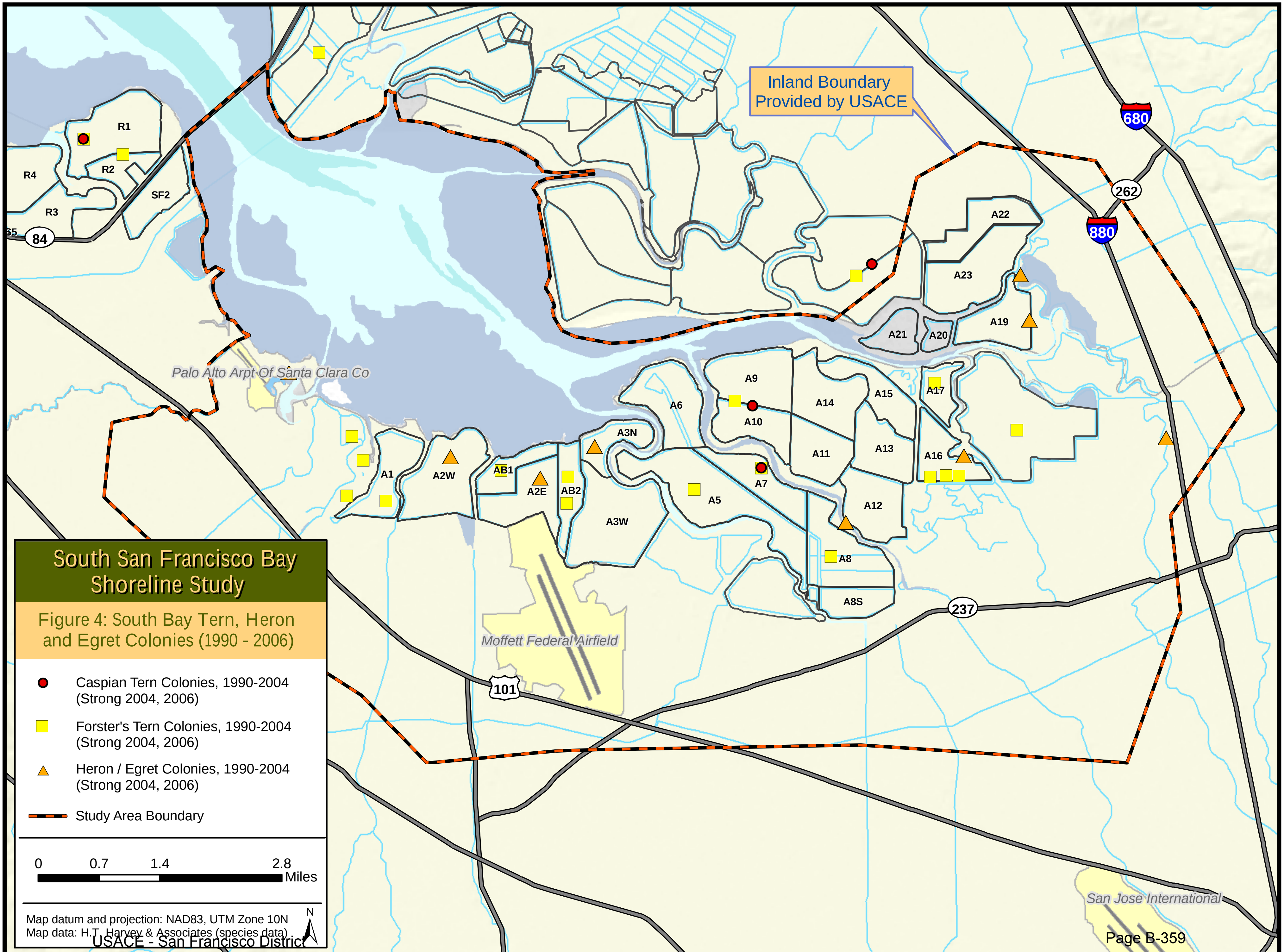

South San Francisco Bay Shoreline Study
Figure 4: South Bay Tern, Heron and Egret Colonies (1990 - 2006)
Caspian Tern Colonies, 1990-2004 (Strong 2004, 2006)
Forster's Tern Colonies, 1990-2004 (Strong 2004, 2006)
Heron / Egret Colonies, 1990-2004 (Strong 2004, 2006)
Study Area Boundary
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2.8
Miles
Map datum and projection: NAD83, UTM Zone 10N
Map data: H.T. Harvey & Associates (species data)
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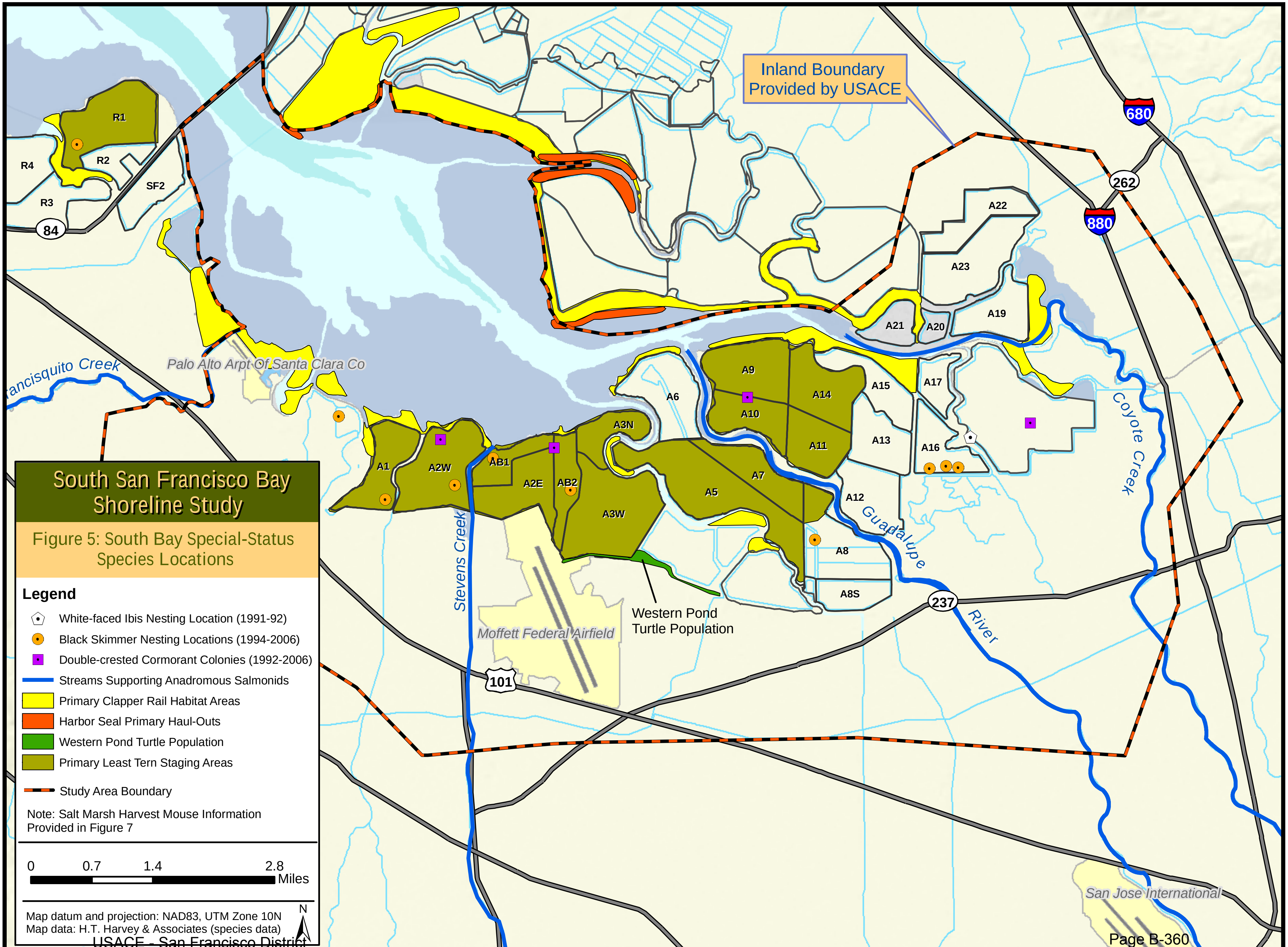
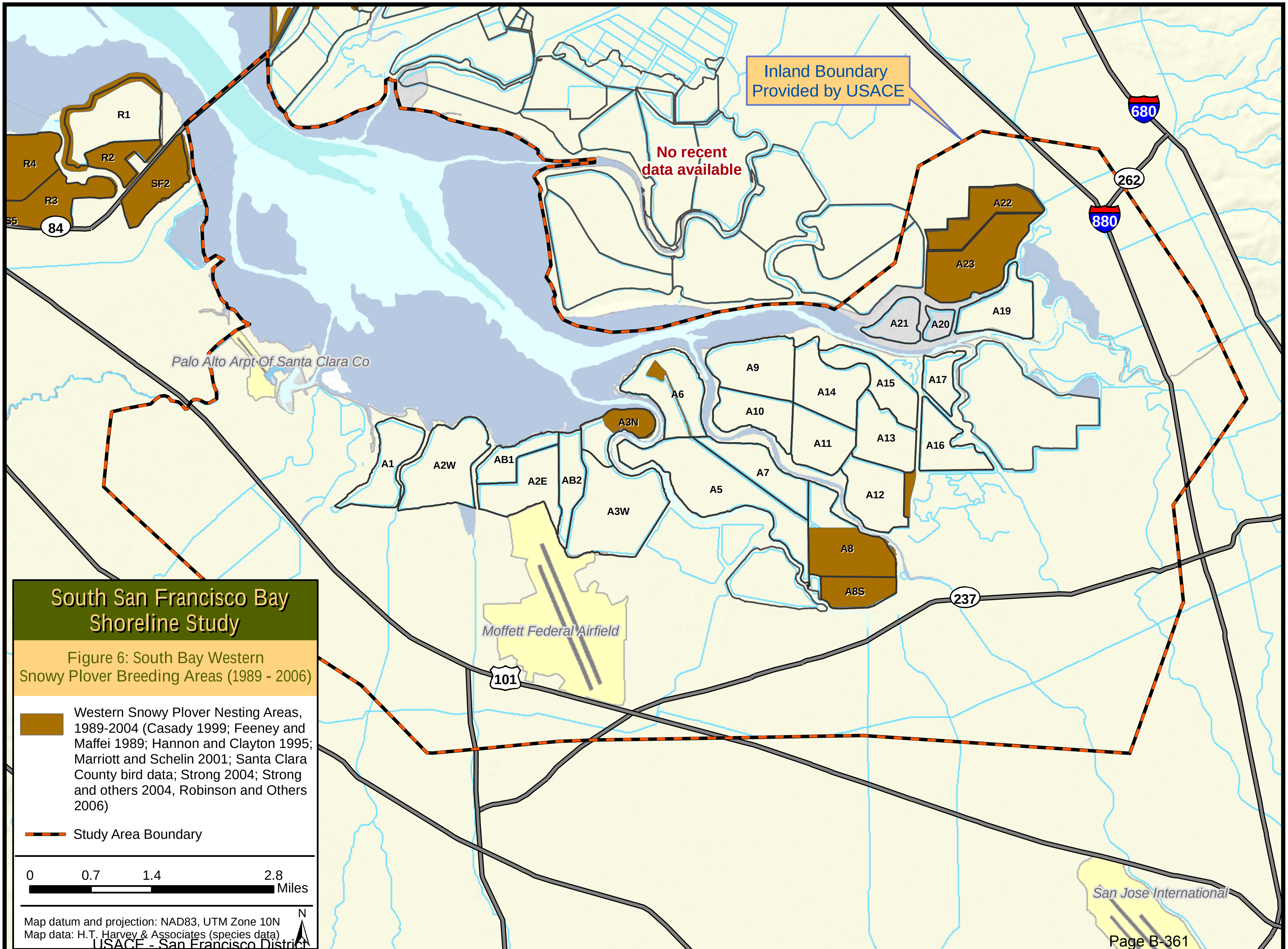


Figure 5: South Bay Special-Status Species Locations



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Moffett Federal Airfield
101
San Jose International
South San Francisco Bay
Shoreline Study
Figure 6: South Bay Western
Snowy Plover Breeding Areas (1989 - 2006)
Western Snowy Plover Nesting Areas, 1989-2004 (Casady 1999; Feeney and Maffei 1989; Hannon and Clayton 1995; Marriott and Schelin 2001; Santa Clara County bird data; Strong 2004; Strong and others 2004, Robinson and Others 2006)
Study Area Boundary
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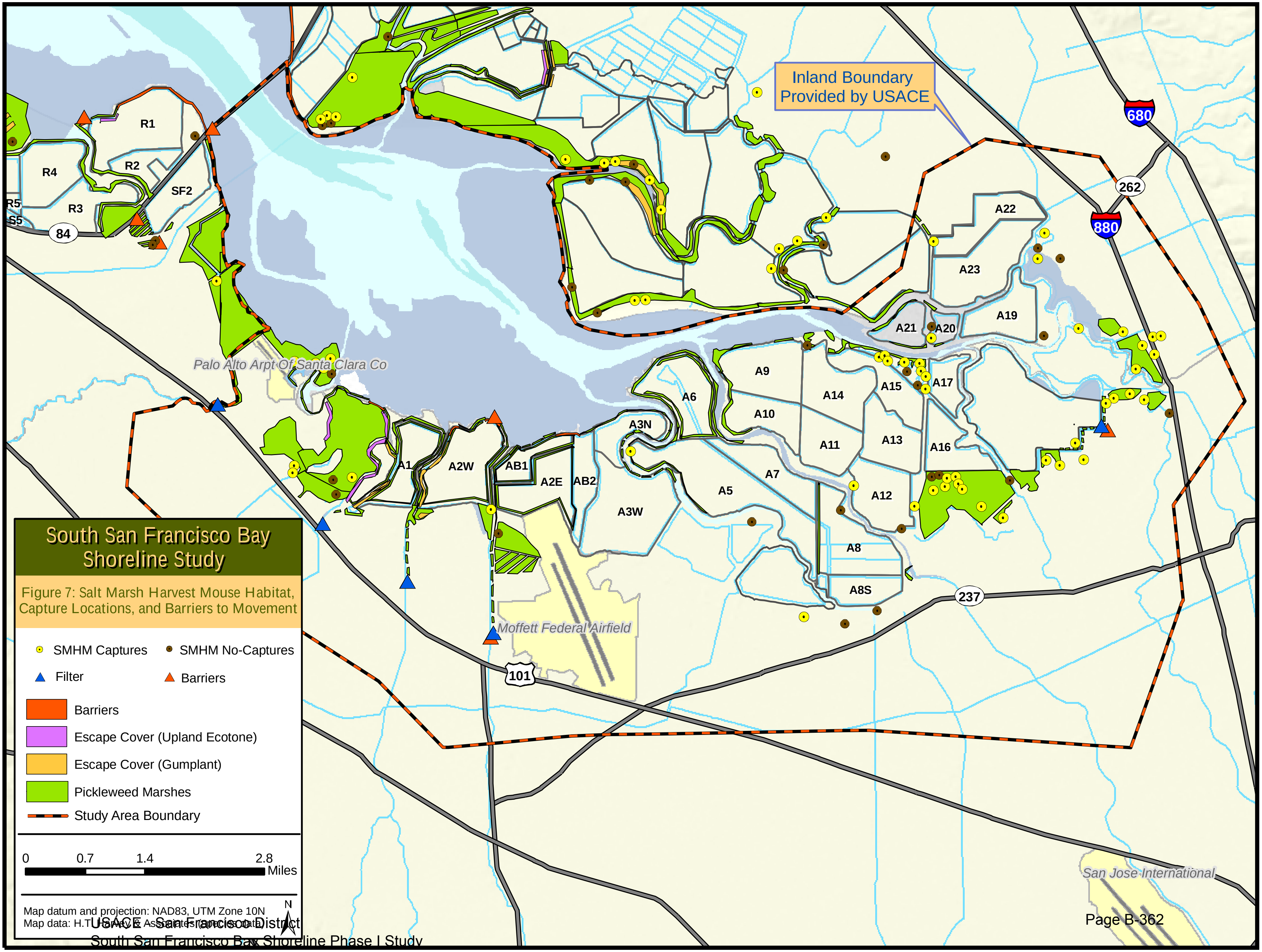
South San Francisco Bay Shoreline Study
Figure 7: Salt Marsh Harvest Mouse Habitat, Capture Locations, and Barriers to Movement
SMHM Captures
SMHM No-Captures
Filter
Barriers
Barriers
Escape Cover (Upland Ecotone)
Escape Cover (Gumplant)
Pickleweed Marshes
Study Area Boundary
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Miles
Map datum and projection: NAD83, UTM Zone 10N
Map data: H.T. Harvey & Associates (2005 data)
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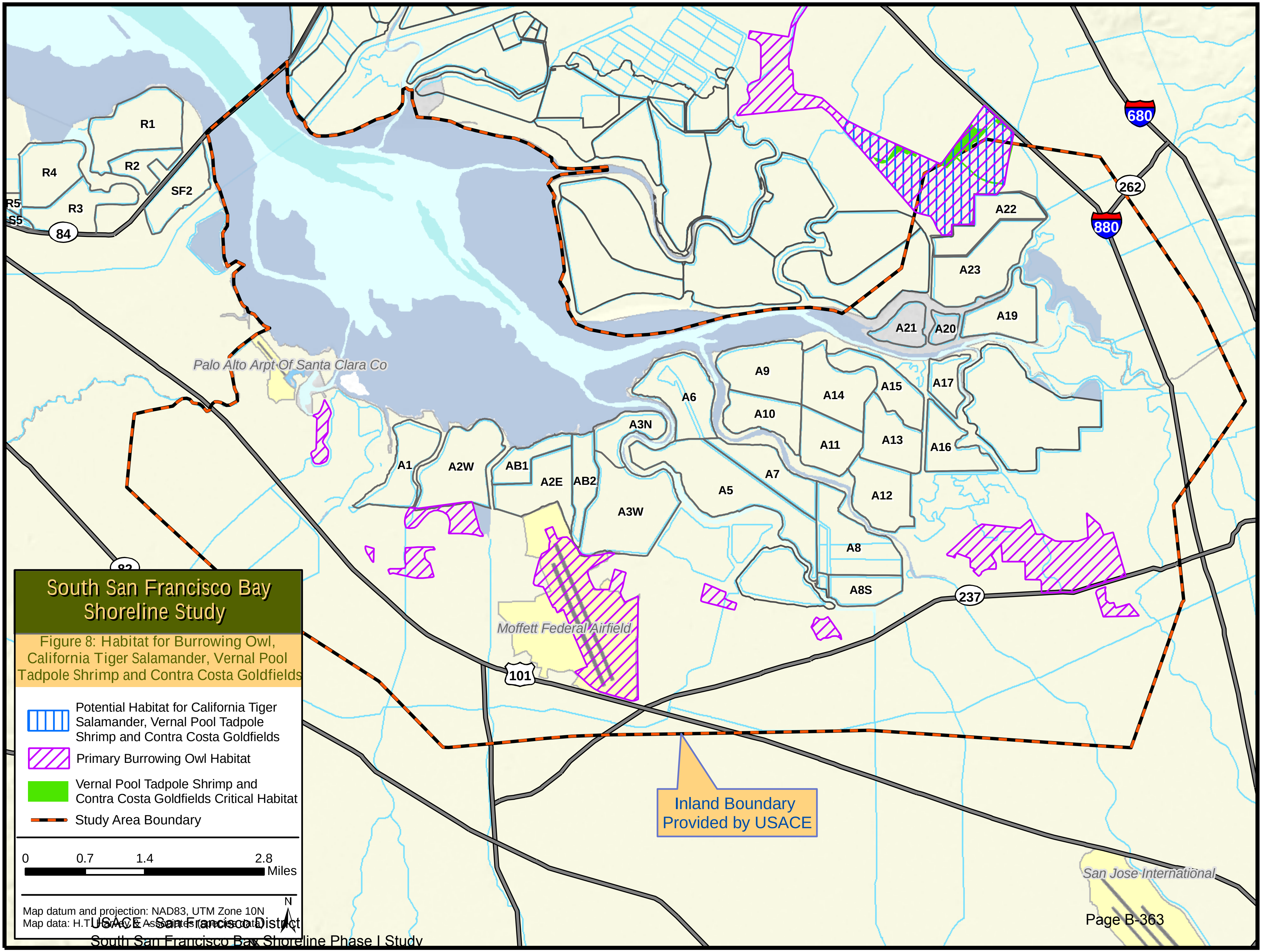

South San Francisco Bay Shoreline Study
Figure 8: Habitat for Burrowing Owl, California Tiger Salamander, Vernal Pool Tadpole Shrimp and Contra Costa Goldfields
Potential Habitat for California Tiger Salamander, Vernal Pool Tadpole Shrimp and Contra Costa Goldfields
Primary Burrowing Owl Habitat
Vernal Pool Tadpole Shrimp and Contra Costa Goldfields Critical Habitat
Study Area Boundary
0 0.7 1.4 2.8 Miles
N
Map datum and projection: NAD83, UTM Zone 10N
Inland Boundary Provided by USACE
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Appendix A.

Special-Status Species Regulations Overview

Overview. Federal and state endangered species legislation gives special status to several plant and animal species known to occur in the vicinity of the Study Area. In addition, state resource agencies and professional organizations, whose lists are recognized by agencies when reviewing environmental documents, have identified as sensitive some species occurring in the vicinity of the Study Area. Such species are referred to collectively as "species of special status" and include plants and animals that are listed, proposed for listing, and candidates for listing as threatened or endangered under the federal Endangered Species Act (ESA) or the California Endangered Species Act (CESA); animals listed as "fully protected" under the California Fish and Game Code; animals designated as "Species of Special Concern" by the CDFG; and plants listed as rare or endangered by the California Native Plant Society (CNPS) in the *Inventory of Rare and Endangered Plants of California* (2001).

ESA provisions protect federally listed threatened and endangered species and their habitats from unlawful take. Under the ESA, to "take" is "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any of the specifically enumerated conduct." The U.S. Fish & Wildlife Service's (USFWS) regulations define harm as "an act which actually kills or injures wildlife." Such an act "may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering" (50 CFR § 17.3). Activities that may result in "take" of individuals are regulated by the USFWS. The USFWS produced an updated list of candidate species May 11, 2005 (50 CFR Part 17). Candidate species are not afforded any legal protection under ESA; however, candidate species typically receive special attention from federal and state agencies during the environmental review process.

Provisions of CESA protect state-listed threatened and endangered species. CDFG regulates activities that may result in "take" of individuals (*i.e.*, "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill"). Habitat degradation or modification is not expressly included in the definition of "take" under the California Fish and Game Code. Additionally, the California Fish and Game Code contains lists of vertebrate species designated as "fully protected" (California Fish & Game Code §§ 3511 [birds], 4700 [mammals], 5050 [reptiles and amphibians], 5515 [fish]). Such species may not be taken or possessed.

In addition to federal and state-listed species, the CDFG also has produced a list of Species of Special Concern to serve as a watch list. Species on this list are of limited distribution or the extent of their habitats has been reduced substantially, such that threat to their populations may be imminent. Species of Special Concern may receive special attention during environmental review, but they do not have statutory protection. USFWS also uses the label "Species of Special Concern" as an informal term that refers to those species that might be in need of concentrated conservation actions. Species of Special Concern receive no legal protection as a result of their designation as Species of Special Concern, and the use of the term does not necessarily mean that the species will eventually be proposed for listing as a threatened or endangered species. However, most, if not all, of these species are currently protected by state and federal laws.

Vascular plants listed as rare or endangered by the CNPS, but which might not have designated status under state endangered species legislation, are defined as follows:

- List 1A Plants considered by the CNPS to be extinct in California.
- List 1B Plants rare, threatened, or endangered in California and elsewhere.
- List 2 Plants rare, threatened, or endangered in California, but more numerous elsewhere.
- List 3 Plants about which more information is needed – a review list.