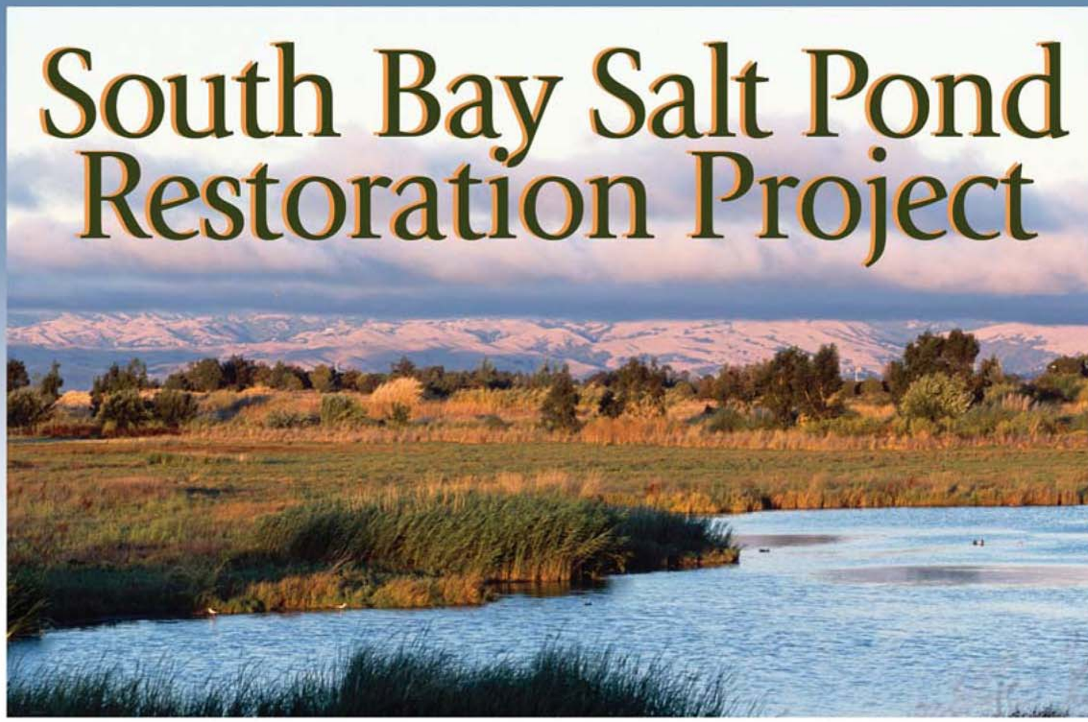

Initial Opportunities and Constraints Summary

Final Report

Submitted to:
California State Coastal Conservancy
U.S. Fish & Wildlife Service
California Department of Fish and Game

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TABLE OF CONTENTS

FIGURES

1. EXECUTIVE SUMMARY

The South Bay Salt Pond (SBSP) Restoration Project presents an unprecedented opportunity to restore the overall health of San Francisco Bay. When met, the established goals for the project will restore habitats for a wide array of fish and wildlife species (including endangered and threatened species), maintain or improve flood management and provide wildlife-oriented recreation and education to the public. To achieve these goals, the project must consider the potential constraints to specific restoration actions. This report describes initial opportunities and constraints relevant to the project objectives; these opportunities and constraints will provide a framework to systematically identify, evaluate and contrast potential restoration alternatives.

The SBSP Restoration Project offers opportunities to achieve numerous beneficial objectives that extend beyond San Francisco Bay. These include:

- Restore thousands of acres of historic tidal salt marsh in South San Francisco Bay
- Manage ponds for greater benefits to waterbirds
- Increase transitional habitat and habitat connectivity throughout the Bay
- Increase flood protection
- Improve water quality in the Bay
- Provide additional public use and recreational opportunities

Based on current understanding of existing conditions, the most pressing potential constraints to the project include:

- Presence of mercury and other contaminants in the salt ponds and in sediments of adjacent sloughs and mudflats
- Presence of invasive plant species such as non-native cordgrass (*Spartina* spp.).
- Protection of existing infrastructure from potential flood impacts
- Health risks related to mosquito breeding areas

Two critical issues have been identified that may, or may not, present additional constraints:

- Sediment availability for tidal marsh habitat development
- Changes in functions and values for a variety of bird species as a result of habitat changes

These two potential constraints will be evaluated and used to inform decisions in the initial alternatives development process.

By understanding and planning for the interdependence of the opportunities and constraints outlined in this report, restoration planning can proceed towards the project goal of a healthier San Francisco Bay. This report is intended to be an initial summary of the opportunities and constraints. The objective is to compile available information on opportunities and constraints early in the process in order to have this information available to inform the alternatives development process. Additional data relevant to opportunities and constraints will be collected as part of several ongoing and future studies (data collection by the U.S. Geological Survey (USGS) and the Point Reyes Bird Observatory (PRBO), preparation of the Existing Conditions Report, sediment and hydrology modeling, etc.).

2. ABBREVIATIONS

ADF	Alternatives Development Framework
CDFG	California Department of Fish and Game
FEMA	Federal Emergency Management Agency
GIS	Geographic Information Systems
ISP	Initial Stewardship Plan
PG&E	Pacific Gas & Electric
PMT	Project Management Team
PRBO	Point Reyes Bird Observatory
SBSP	South Bay Salt Pond
SFEI	San Francisco Estuary Institute
SSC	suspended sediment concentrations
TMDL	total maximum daily load
USACOE	U.S. Army Corp of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

3. INTRODUCTION

This document summarizes the initial opportunities and constraints for the South Bay Salt Pond (SBSP) Restoration Project. The development of alternatives is a critical, early step in the restoration of the salt ponds, and thus South San Francisco Bay (the South Bay) as a whole. Alternatives development will be a collaborative effort between the technical consultant team and the Project Management Team (PMT), Science Team and Stakeholders. Detailed and prioritized opportunities and constraints provide a systematic method to identify, evaluate and contrast alternatives, facilitate consideration of a range of reasonable alternatives, and inform the selection of the preferred alternative. Alternatives development, as described in the Alternatives Development Framework (ADF) (Philip Williams & Associates Ltd. and others 2004c), builds upon the project objectives and, in conjunction with the Initial Opportunities and Constraints Summary, will shape the early formulation of restoration alternatives.

This report is an initial summary of the opportunities and constraints. Its objective is to compile available information in order to inform the early alternatives development process (Philip Williams & Associates Ltd. and others 2004c). Additional data relevant to opportunities and constraints will be collected as part of several ongoing and future studies. The initial opportunities and constraints will be refined through several processes: landscape-scale analyses to assess sediment availability and the potential effects on pond-dependent bird species; ongoing existing conditions assessment; and hydrodynamic modeling to be performed at a later stage. If necessary, opportunities and constraints can be refined at an individual pond scale once additional information has been collected and evaluated.

This report integrates existing opportunities and constraints information from the Science Team, Project Management Team (PMT), Stakeholder Forum and other stakeholders. In addition, it includes prior work such as Siegel & Bachand (2002), new information compiled by the SBSP Restoration Project in the Data Acquisition task, and the opportunities and constraints revealed through earlier and ongoing project work.

This report presents the initial opportunities and constraints posed by the following conditions affecting the project:

- Biology and Habitats
- Hydrodynamics and Sediment Dynamics
- Water and Sediment Quality
- Flood Management and Infrastructure
- Public Access and Recreation

During alternatives development and the permitting process, a range of considerations, such as regulatory permitting and the economics of specific opportunities and constraints, will be also be included.

The initial opportunities and constraints outlined in this report are not comprehensive, but are focused on issues important to decision-making during the planning process.

The Initial Opportunities and Constraints Summary Report contains the following sections:

- **Section 4. Project Objectives.** This section presents the desired outcomes of the project. Opportunities and constraints are discussed in relation to achieving these objectives.
- **Section 5. Current Knowledge.** This section reviews the knowledge gained while compiling the Data Summary Report (Philip Williams & Associates Ltd. and others 2004d). This review is an important starting point for discussing the opportunities and constraints as they relate to our current understanding of the South Bay ecosystem.
- **Section 6. Opportunities and Constraints.** This section describes the initial opportunities and constraints in the context of the project objectives and our existing knowledge of the South Bay ecosystem. Opportunities and constraints have been organized into five (5) subtopics.
- **Section 7. Discussion.** This section prioritizes the opportunities and constraints across subtopics.

4. PROJECT OBJECTIVES

The SBSP Restoration Project's objectives (Table 1) are the basis for the formulation and evaluation of alternatives, as outlined in more detail in the ADF (Philip Williams & Associates Ltd. and others 2004c). The goal of the project is the restoration and enhancement of wetlands in the South San Francisco Bay, while providing for flood management and wildlife oriented public access and recreation. The evaluation criteria and metrics as outlined in the ADF were developed with the intention of producing the desired project benefits, and as such are fundamental to identifying the SBSP Restoration Project's opportunities and constraints.

The development of objectives occurred independent of consideration of mutually exclusive objectives. These trade-offs between the potential gains from achieving one objective, as opposed to another, will begin to be elucidated in this initial assessment of opportunities and constraints.

Cost effectiveness and environmental impacts are also being considered to further assess issues that may provide opportunities or constraints to the project. Cost effectiveness is important, as project implementation funds are limited and may dictate the timing and scope of project phase construction and fulfilling certain objectives. The U.S. Army Corps of Engineers (USACOE) offers the prospect for long-term federal cost-sharing in project implementation funds. To justify a federal interest in the project, the USACOE benefit/cost ratio must be greater than one, and factors affecting the benefit/cost ratio could serve as important measures of various project alternatives. Partnerships between local sponsors and the USACOE will also be important in developing long-term funding. There are also cost sharing/saving opportunities that could be pursued with other agencies for active projects in the area. Finally, to ensure long-term sustainability, projects with lower operations and maintenance costs will be favored.

Environmental impacts are included to identify potential environmental benefits and impacts to humans, in topics other than biology. The objectives that address environmental impacts include cultural resources, public services, land use, traffic, and air quality and noise impacts. Although formal environmental impact analysis will not be conducted until the final project alternatives are identified, including these factors during the screening process will ensure that environmental impacts across alternatives are considered, so that the final project alternatives can be implemented at a desirable level of environmental benefits. For example, identifying cultural resources in the project area during the alternatives evaluation would allow for selection of alternatives that avoid or minimize impacts on cultural resources.

Table 1. Project Objectives for the South Bay Salt Pond Restoration Project

Objective 1. Create, restore, or enhance habitats of sufficient size, function, and appropriate structure to: • **Objective 1A. Promote restoration of native special-status plants and animals that depend on South San Francisco Bay habitat for all or part of their life cycles** • **Objective 1B. Maintain current migratory bird species that utilize existing salt ponds and associated structures such as levees** • **Objective 1C. Support increased abundance and diversity of native species in various South San Francisco Bay aquatic and terrestrial ecosystem components, including plants, invertebrates, fish, mammals, birds, reptiles and amphibians**
Objective 2. Maintain or improve existing levels of flood protection in the South Bay area
Objective 3. Provide public access and recreational opportunities compatible with wildlife and habitat goals
Objective 4. Protect or improve existing levels of water and sediment quality in the South Bay, and take into account ecological risks caused by restoration
Objective 5. Implement design and management measures to maintain, or improve, current levels of vector management, control predation on special-status species, and manage the spread of non-native invasive species
Objective 6. Protect the services provided by existing infrastructure (*e.g.*, power lines, railroads, wastewater treatment plants)

The opportunities and constraints are organized in the following five topics to combine the objectives of the South Bay Salt Pond Restoration Project (above) with the Data Summary Report topics:

- Biology and Habitats
- Hydrodynamics and Sediment Dynamics
- Water and Sediment Quality
- Flood Management and Infrastructure
- Public Access and Recreation

This organization of topics will simplify future reporting, while still encompassing the breadth of issues outlined in both the objectives and the Data Summary Report topics (Section 5).

5. CURRENT KNOWLEDGE

The knowledge presented in the SBSP Data Summary Report (Philip Williams & Associates Ltd. and others 2004d) is critical for assessing opportunities and constraints related to restoring the South Bay ecosystem. The Initial Opportunities and Constraints Summary Report has been developed using the project objectives outlined in Section 3 and the background information in the Data Summary Report (Philip Williams & Associates Ltd. and others 2004d) as the primary filters to identify topics. The team has summarized previous findings that are relevant to the development of opportunities and constraints below. This section is organized according to five subtopics: 1) biology and habitats, 2) hydrodynamics and sediment dynamics, 3) water and sediment quality, 4) flood management and infrastructure, and 5) public access and recreation.

Resolution of the data gaps outlined in the SBSP Data Summary Report (Philip Williams & Associates Ltd. and others 2004d) may result in the inclusion of additional topics as either an opportunity or a constraint. It should be noted that substantial research by the USGS is ongoing in the South Bay; most notably investigations of bathymetry, water quality, and biology of salt ponds. These studies, coupled with the existing setting work to follow, will add considerably to current knowledge and fill some information gaps summarized below.

5.1 Biology and Habitats

5.1.1 Biology

The Baylands Ecosystem Goals Report (Goals Project 1999) made recommendations on "the kinds, amounts, and distribution of wetlands and related habitats that are needed to sustain diverse and healthy communities of fish and wildlife in the San Francisco Bay Area." In general, the population biology of the South Bay vegetation and wildlife is well documented (Goals Project 1999). Community ecology is understood, with the exception of some topics (*i.e.*, food webs) where little work has been performed. A few quantitative studies of some species and groups have been performed, proposed, or are underway (*e.g.*, PRBO bird modeling, San Francisco Estuary Institute (SFEI) invertebrate studies). However there are significant data gaps that may limit restoration planning and formulation of objectives. This is especially true of salt marsh and tidal flat invertebrates, although there has been extensive long-term data collection of invertebrates on the nearby Palo Alto mudflat (Shouse, M. K. and others 2003; Thompson, J. K. and others 2002).

A large increase in intertidal marsh acreage will have a positive effect on the regional population size of some rare, threatened, or endangered species as listed in the objectives as well as on the overall ecological health of the South Bay (Table 1). However, the restoration of these areas must include peripheral halophyte zones and marshes large enough to develop complex patterns of intertidal sloughs. The importance of having "complete" marshes with broad upland ecotones and a dendritic slough network that will support the salt marsh harvest mouse, California Clapper Rail, as well as other plant and animal species cannot be overstated.

At the same time, reducing the proportion and number of salt ponds (by converting ponds into intertidal marsh) may be detrimental to those species currently dependent on artificial salt pond habitat. Through science-based adaptive management of the remaining ponds, the SBSP Restoration Project has the opportunity to maximize pond function and value for specific salt-pond dependent target species. Detailed monitoring of wildlife use in early restoration phases will inform the team on how these species are responding to the restoration, and will be important to implementation and management of subsequent restoration phases.

Given the current bird use of the artificial salt pond habitat it will be important to design for the development of natural salt pond/pan habitat within the restored tidal marsh areas. This habitat element was present historically, especially in the Eden Landing area, and along the upland ecotone of most of the acquisition area (San Francisco Estuary Institute 1998). During the design phase it will also be important to recognize that the U.S. Fish and Wildlife Service (USFWS) Refuge will continue to contain a substantial amount of salt pond habitat that will be part of the surrounding landscape. This USFWS salt pond habitat will provide some of the same functions and values that may be lost through the SBSP Restoration Project's conversion of salt ponds to tidal marsh.

Impacts and control of non-native invasive species in the San Francisco Bay, most notably smooth cordgrass and it's hybrids (*Spartina alterniflora* [hybrids]) , as well as perennial pepperweed (*Lepidium latifolium*), are not completely understood and remain a significant data gap to fill in to avoid unintentional introductions. Current research and management programs for these invasive species can provide guidance for salt pond restoration work (California State Coastal Conservancy and U.S. Fish and Wildlife Service 2003). The SBSP Restoration Project will coordinate restoration activities with the Invasive Spartina Project; however, the SBSP Restoration Project assumes that control and management of *Spartina alterniflora* [hybrids] falls primarily within the scope of the Invasive Spartina Project.

5.1.2 Habitats

There has been considerable work done on the current and historic extent of wildlife habitats in the South Bay (Goals Project 1999). The US Coast Survey produced extremely detailed maps (*e.g.*, the historic "T-sheets"), which portray habitats prior to any alteration by Europeans. These maps greatly contribute to our understanding of the potential spatial extent of habitats in the Baylands. The San Francisco Estuary Institute has compiled these and other data into an electronic "EcoAtlas" that spatially displays South Bay habitats in a geographic information system (GIS) format (San Francisco Estuary Institute 1998). Historic slough alignments are well documented, and are often still visible in the salt ponds.

The carrying capacity, or the number of individuals of a species supported in a given area, may change during the conversion of salt ponds to tidal habitat. When the salt ponds levees are breached habitat will be created for salt marsh-dependant species, but habitat may be lost for salt pond-dependent species. The number of salt pond dependent species will decrease in salt ponds that do not have the requisite depth of water and salinity to satisfy those species. Modifying a pond's configuration, depth, and hydrology can increase the carrying capacity for salt pond-dependent species. If carrying capacities are increased for salt pond-dependent species, then fewer managed ponds may be required to sustain populations of the salt pond species. In addition, salt pond/pan habitats currently and historically found within the existing tidal marshes may support these species and could already provide the area needed to maintain carrying capacities for salt pond-dependent species.

The Goals Project (1999) proposed a ratio of approximately 2:1 restored salt marshes to managed salt ponds to maintain current regional populations of salt pond-dependent species. This ratio refers to all the salt ponds in the South Bay, not just those that are part of the SBSP Restoration Project. Thus, the discussion on how converting salt pond to tidal salt marsh will affect salt pond-dependent species benefits from a landscape perspective where salt ponds outside of the SBSP Restoration Project area are also considered as available habitat for the salt pond-dependent species.

The general ecology of tidal wetland habitats has been well studied, but there are also many gaps in our knowledge. Vegetation dynamics and wildlife use are well documented for most of the South Bay. The unique opportunity to restore historic tidal marshes in the South Bay, although not without its constraints, offers a tremendous opportunity to achieve the habitat goals outlined in the objectives, and provide landscape-scale benefits to the majority of wildlife and native plant species in the area. Restoration, if phased, provides the opportunity to learn more in the science of wetland restoration that can be applied to subsequent project phases.

5.2 Hydrodynamics and Sediment Dynamics

5.2.1 Hydrodynamics

The South Bay is a hydrodynamically complex system, with freshwater tributary inflows, tidal currents, and wind stress on the water surface interacting with basin bathymetry (Walters, R. A. 1982). These forcing mechanisms define the residual circulation patterns and residence time, and determine the level of vertical mixing and stratification. The most important factor influencing circulation patterns in South Bay is bathymetry (Cheng, R. T. and L. H. Smith 1985), and the interaction between the broad shoals and the deep channels. Restoring ponds to tidal action will alter the overall bathymetry of the South Bay through changes in geomorphic processes, increase the tidal prism, and modify the connections of the sloughs with the Bay, thus altering tidal currents and circulation patterns.

As with the residual currents, the residence time is determined by the combination of tidally- and wind-driven flows, bathymetry, and fresh water inflow (Walters, R. A. 1982). The residence time of the South Bay fluctuates seasonally. As a whole, the residence time is less than a month in the winter and early spring during wet years, and considerably longer (on the order of several months) during summer (Powell, M. and others 1986; Walters, R. A. and others 1985). Understanding the residual circulation and residence times in the South Bay is important to SBSP Restoration Project efforts because they influence the potential movement patterns of suspended sediment and other water quality constituents (*e.g.*, pollutants).

The South Bay is generally, vertically, well mixed (*i.e.*, there is little tidally-averaged vertical salinity variation) with near oceanic salinities due to low fresh water inputs to the far South Bay (Cheng, R. T.

and J. W. Gartner 1985). However, density stratification can occur in the winter and early spring during wet years as a result of high fresh water inflows. Large, fresh-water inputs to the North Bay from the San Joaquin and Sacramento Rivers can intrude all the way into the South Bay resulting in strong stratification, and high inflows from local South Bay tributaries can set up density stratification in the main South Bay channel, as well as stratification in the tributaries and sloughs. Salinity stratification in the tributaries and sloughs is also caused by large freshwater inflows from local wastewater treatment plant discharges (Life Science 2003).

5.2.2 Seasonal Pond/Groundwater Interactions

The potential exists for groundwater to contribute as a freshwater source for wetland restoration areas (Fio, J. L. and D. A. Leighton 1995), but water quality conditions (e.g., salinity) could be limiting. Analyzing soil types, infiltration rates, and depth to groundwater around the salt ponds will help determine hydraulic interactions between surface and subsurface waters in the project area. Generally, soils in the project area are fine-grained, distal alluvial and bay mud deposits that are poorly drained with low permeability (U. S. Department of Agriculture Soil Conservation Service and University of California Agricultural Experiment Station 1958; U.S. Department of Agriculture Soil Conservation Service and University of California Agricultural Experiment Station 1980; U.S. Department of Agriculture Soil Conservation Service and University of California Agricultural Experiment Station 1991). Groundwater levels within the project area are relatively high, which may potentially allow hydraulic connectivity between surface and subsurface waters (Fio, J. L. and D. A. Leighton 1995; Groundwater Committee of the California Regional Water Quality Control Board San Francisco Bay Region and others 2003; Whitman, K. and others 1995).

5.2.3 Sediment Dynamics

Suspended sediment concentrations (SSC) in South Bay exhibit highly dynamic, short-term variability, primarily in response to riverine input from tributaries and sloughs, spring-neap variations in tidally driven resuspension, and wind driven resuspension (Cloern, J. and others 1989; Powell, T. and others 1989; Schoellhamer, D. 1996). Wind is probably the most dynamic factor affecting temporal and spatial variability of SSC. Generally, increases in fetch and wind speed will result in larger wind-waves and more erosion potential. The wind direction over the South Bay is typically from the west and northwest in late spring, summer, and early fall, leading to the largest fetch lengths along the eastern shore, with more variable conditions in winter (Cheng, R. T. and J. W. Gartner 1985).

Sediment dynamics also depend on sediment properties, such as the critical shear stress for erosion (McDonald, E. and R. Cheng 1996). This stress varies with the level of consolidation of the sediment-bed layer, and areas that are typically net erosional (*e.g.*, the eastern shoals) likely have a higher critical shear stress for erosion than areas that tend to be net depositional (*e.g.*, the far South Bay) due to the less compacted nature of recently deposited sediments.

Lateral exchange (between the channel and shoal) is also an important mechanism for sediment transport (Schoellhamer, D. 1996). Bathymetric variations in the estuary interact with the tides, freshwater inflow, and wind to modify flow patterns. For example, surface flows between the channel and the shoals result from the phase lag of the flow in the channel relative to the shoals and the interaction of the tidal flow with the channel-shoal bathymetry. These lateral flows can transport a significant amount of sediment to the channel, thereby reducing SSC in the shoal (Jassby, A. and others 1996). The process can also work in reverse, transporting clear water from the channel to the shoal.

The major external sediment inputs to the South Bay are tributary sediment load and exchange between the Central and South Bay (Ogden Beeman & Associates and Ray B. Krone & Associates 1992). The USGS maintains stations within the main channel of the South Bay and in several of the tributary sloughs and creeks, but not all stations collect SSC data. In addition, the data from the South Bay channel stations contain numerous gaps. The level of sediment exchange between central and south bay is poorly understood. However, recent investigations have shown that the South Bay as a whole is net erosional (although the far South Bay remains depositional), resulting in a net loss of sediment to the Central Bay (Foxgrover, A. C. and others 2004).

5.2.4 Imported Sediment Supply and Quality

Sediment produced from dredge operations throughout the South San Francisco Bay and from rivers and creeks upstream of the Bay may serve as a fill source for restoration areas (U.S. Army Corps of Engineers South Pacific Division and others 2001). A preliminary estimate based on personal interviews within the Bay dredging community has determined that approximately one million cubic yards of sediment are dredged annually for regular maintenance in the South Bay (Ackerman, H.; Amdur, J. tbd; Blake, H. 2004; Bonebakker, C. P. 2004; Braganolo, L. 2004; Cardoza, L. tbd; Cermignani, G. 2004; Chan, N. 2004; Chase, B. 2004; Drury, D. tbd; Dwinell, D. tbd; Farr, T. 2004; Ferrari, R. 2004; Fetzer, D. 2004; Goulart, R. 2004; Gustafson, H. tbd; Isley, D. 2004; Johnson, R. tbd; Kistie, J. 2004; Martinez, J. 2004; Maudlin, C. 2004; McGrath, J. tbd; Moorhead, M. 2004; Nybakken, J. 2004; Pederson, K. 2004; Rhoads, R. 2002 amended 2003; Rosenberg, S. v. tbd; Schurman, R. 2004; Snaman, D. tbd; Snodgras, D. 2004; Timothy, D. 2004; Walters, B. 2004; Weaver, R. 2004; Woods, S. 2004). The sediment quality varies with respect to organic content, grain size, mineral composition, and pollutants, as many different sources contribute to the estimated total amount available. Additional Bay sediment sources include dredge projects that are expected to occur only once. The availability of sediment from such projects is difficult to predict.

Other Bay Area projects may also potentially provide sediment and/or excavated soils for the project. The San Francisco Public Utilities Commission (SFPUC) Capital Improvements Project (CIP) is one such project. The amount of sediment that will be available for import from the CIP has not yet been determined. Any usage of sediment or excavated fill would need to comply with Dredged Material Management Office (DMMO) requirements.

The Santa Clara Valley Water District and other agencies in the East Bay and Peninsula remove significant amounts of sediment from rivers and creeks tributary to the Bay each year (Santa Clara Valley Water District 2002). The amount of sediment potentially available from riverine sources has not been quantified. The quality of riverine-source sediments from some areas could be a limitation, given the high levels of mercury present.

5.3 Water and Sediment Quality

The Project provides a unique opportunity to restore habitat for a wide variety of biota within the wetland ecosystem habitat. However, coupled with this opportunity is the concern that legacy pollutants, especially mercury, contained within the pond water and sediment could adversely impact the restoration process. With adaptive management, this project offers the chance to study the effects and potential management measures for legacy pollutants, particularly mercury, which will contribute to the overall scientific knowledge that is emerging regarding mercury methylation and wetland restoration.

Numerous studies and monitoring data have identified adverse water and sediment quality conditions within some of the ponds and the surrounding sloughs and creeks in the project area (Brown and Caldwell 2004; Trulio, L. A. and others 2004) (Siegel, S. W. and P. A. M. Bachand 2002). Mercury is the primary contaminant of concern (Davis, J. and others 1991). PCBs and other organic contaminants have also been noted as secondary concerns (Trulio, L. A. and others 2004). Algae proliferation has historically been an issue in the low-salinity salt ponds (30-50 ppt) (Siegel, S. W. and P. A. M. Bachand 2002). Nutrient loads compounded with shallow, warm water and sufficient sunlight promote algal growth within the ponds (CFR 1989). Consequently, dissolved oxygen levels decrease as a result of algal decomposition and hydrogen sulfide is produced, which leads to odor problems (Oswald, W. J. 1986).

Knowledge about mercury is still developing, both in terms of site-specific conditions in the South Bay Salt Ponds and more generally in how various factors affect mercury fate, transport and toxicity (Brown and Caldwell 2004). Methylmercury is the most bioavailable form of mercury and leads to bioaccumulation at the base of the food chain and subsequent biomagnification up the food chain. Many factors can affect mercury methylation and demethylation rates (*e.g.*, mercury concentrations, mercury speciation, microbial activity, sulfate, salinity, oxygen, organic carbon, turbidity, solar radiation, and vegetation), and interactions between these factors are not well understood. Total mercury levels in sediment or water are a relatively poor predictor of an ecosystem's potential to produce methylmercury and bioaccumulate it in the local food web. Small concentrations of total mercury can produce problematic levels of methyl mercury under conditions that favor methylation and the incorporation of the methylated mercury into biota.

The bioaccumulation/biomagnification process requires several steps: 1) mercury pollution, 2) methylation of mercury, 3) transfer of methylmercury from sediments to the water column, 4) transfer of methylmercury from the water column to the base of the food web, and 5) biomagnification up the food web (Brown and Caldwell 2004). Given improved understanding, it may be possible to limit mercury bioaccumulation by affecting these steps. The "Mercury Strategy for Bay-Delta Ecosystem" (Wiener, J. G. and others 2003) places an emphasis on examining two effects of restoration: 1) the bioavailability of inorganic mercury for methylation, and 2) the microbial production of methylmercury. The creation of tidal wetlands, while providing multiple benefits including expanded critical habitat for South Bay biota, may create conditions that increases methylation of mercury. As such, there is concern about the ecological risk of bioaccumulation both in the SBSP Restoration Project area and the greater Bay Area.

Mercury data in the Salt Ponds is currently limited, but existing data indicate that average levels of total mercury (THg) in sediments in the Alviso Ponds commonly exceed ambient levels in the San Francisco Bay. In contrast, THg levels in sediments from the Eden Landing and Ravenswood Ponds are consistently below ambient levels for the Bay. Average methylmercury (MeHg) levels in surface sediments for some ponds are higher than MeHg concentrations found in sediments in the open Bay. Levels in pond sediment are more typical of MeHg concentrations observed at the bay margins and in impounded sediments in the Guadalupe River watershed (1 to 30 ppb) (Heim, W. A. and others 2003; Thomas, M. A. and others 2002).

Important information gaps include methylmercury levels in both sediments and the water column of the South Bay Ponds, the "reactivity" of mercury in sediments (*i.e.*, the potential of the mercury in sediment to be methylated by microorganisms), and the potential for methylation across salinity gradients and across habitat types (*e.g.*, tidal marsh, mudflats, moderate salinity ponds, and high salinity ponds). Information on the relative rates of various factors in methylation and bioaccumulation in tidal wetlands and salt ponds is critical to predict potential impacts of restoration and generate approaches to mitigate mercury accumulation in biota.

5.4 Flood Management and Infrastructure

5.4.1 Flood Protection

Flooding in nearshore areas adjacent to the SBSP Restoration Project sites results from a combination of fluvial (rainfall-runoff) discharges and coastal flooding (U.S. Army Corps of Engineers 1988; U.S. Army Corps of Engineers 1989). Fluvial discharges include the contribution from primary drainages (major streams) and secondary drainages (including small creeks, existing culverts and storm water outfalls). Coastal flooding results from exceptionally high astronomical tides, increased by storm surge and wind wave action. Storm surge refers to the elevation of water levels due to meteorological conditions, such as elevated water due to low barometric pressure, setup of the water surface due to on-shore winds, and climatic effects such as the high-water levels that occur during El Niño conditions. Overtopping of levees resulting from wind-wave induced erosion and wave run-up (the maximum vertical elevation above still water) can exacerbate coastal flooding. Near shore flooding often results from the joint occurrence of high tides and large rainstorm events. These two effects are often correlated, since large winter rainstorms often cause conditions producing storm surge. During these combination events, the elevation of the tide may inundate upland zones directly, or may prevent rainfall runoff from flowing to the Bay, resulting in localized ponding.

Flood-prone areas (referred to as "floodplains") are mapped by the federal government, and flood management is provided by county and city agencies. In addition, the U.S. Army Corps of Engineers (USACOE) conducts studies on flood hazards and often participates in flood-management projects with the local agencies. The federal government has determined that the "100-year flood" (flood with a 1-percent chance of occurring during any given year) represents the level of flood hazard to be mapped, and for which most flood control projects are designed. Current 100-year floodplains are delineated in the

Federal Emergency Management Agency (FEMA) floodplain insurance maps (Figure 1). These flood zones represent flooding from fluvial, coastal, or combined fluvial-coastal flood processes.
The salt ponds and associated levees (Figure 2) provide limited protection against coastal flooding by sheltering inland areas from direct wave attack and providing floodplain storage for overtopped waters. The shallow water depths in the ponds may also limit wind wave development. The levees do not meet flood protection criteria, but have been effective through frequent maintenance by Cargill. Many of the berms and levees associated with the salt ponds will require improvement, or replacement, if they are to provide the level of flood protection required for FEMA flood standards. Levee enhancement can be achieved by maintenance and retrofitting of existing levees or the construction of new levees. The primary physical processes affecting flood potential are high bay water levels and wind-wave action. Potential flood elevations depend on local site characteristics, as well as on regional differences in the forcing processes.

In the SBSP Restoration Project area the floodplain can be defined utilizing multiple methods (USACOE or FEMA methodologies), resulting in substantially different floodplain limits (U.S. Army Corps of Engineers 1988; U.S. Army Corps of Engineers 1989). The FEMA floodplains are determined utilizing the conservative assumption that the salt pond levees (which do not meet standard FEMA flood protection stability criteria) would fail, providing a reduction of wave action but not inhibiting inundation from the high bay water level. Hence, the floodplain subject to FEMA's Flood Insurance Program, which affects development and insurance requirements, is based on a projection of the 100-yr bay water level (Figure 1). The actual extent of inundation in a 100-year, coastal flood would be much less, owing to the flood protection afforded by the existing salt ponds, as historically maintained by Cargill. In San Francisco Bay Shoreline Studies, the USACOE analyzed the hydraulics of wave runup, and associated overtopping and erosion of levees. The extent of flooding calculated by the USACOE is depicted in Figure 1, and covers a much smaller area than the FEMA floodplain. These estimated 100-year coastal flood limits are based on analyses completed in the 1980s and early 1990s. The USACOE floodplain assumes that existing salt pond levees will be maintained. This assumption is an important consideration during the interim and restoration project phases.

Multiple rivers and creeks flow into the South Bay restoration areas, providing flow conveyance from upland, rainfall-runoff sources. In the SBSP Restoration Project vicinity, the fluvial flooding along these channels results from the constriction of flows to a relatively narrow corridor, usually by levees, to protect the adjacent developed areas (upstream) or the salt ponds (downstream). During a large rainstorm, high runoff flows cannot be conveyed by the channels, resulting in high water surface elevations and eventual overtopping of the levees and inundation of the near-channel areas.

Many of the flood management opportunities and constraints are site-specific within the salt ponds and are dependent on the primary modes of flooding (fluvial or coastal) appropriate to a particular site. For example, the town of Alviso has experienced flooding as a result of high fluvial flows and high tides. Loss of channel conveyance within Alameda Creek and Old Alameda Creek has occurred due to sedimentation. These sites, among others, provide localized opportunities for increased flood protection and conveyance. The following sections provide a regional perspective on these opportunities and constraints.

5.4.2 Existing State of Levees

The existing levees typically are not well-engineered embankments. The outboard levees (*i.e.*, bayfront and slough/creek levees adjacent to tidal waters) are salt pond levees that were built to enclose evaporation ponds on former tidal marshes and mudflats and to protect the salt ponds from bay inundation. These levees are typically constructed with bay mud dredged from adjacent borrow ditches or pond areas which received little or no compaction. Bay mud fill has been added to these levees in the past to compensate for land subsidence, and have been periodically maintained by former owners to compensate for erosion and settlement resulting from consolidation and/or displacement of the compressible levee fill material and weak underlying bay mud deposits. These levees were not constructed or maintained following a well-defined standard.

The inboard (or shoreline) levees (*i.e.*, pond levees constructed inland along the old Bay margin) are predominantly former salt pond levees that offer the last line of defense against flooding of low-lying, inland areas. These inboard levees separate the individual salt ponds from each other and are typically smaller than the outboard levees. Some have been modified or raised to improve flood protection but, as with the outboard levees, have not been constructed to a well-defined standard. Bay mud constitutes the basic construction material, but in some instances along readily accessible alignments, imported fill also has been used. Bay mud deposits also underlie these levees; however, the muds are generally thinner than the bay mud underlying the outboard levees. It is possible that some of these levees are not situated on any bay mud but instead on stronger, less-compressible alluvial soils (*i.e.*, generally sands, silts, and clays).

5.4.3 Infrastructure

The presence of existing infrastructure within the project area is extensive and abundant (Figure 3). Infrastructure of concern includes Pacific Gas and Electric (PG&E) electrical and natural gas lines, private petroleum pipelines, sewer pipelines and outfalls, storm-water pipelines and outfalls, pump stations, roads, railways, landfills, historic structures, and fiber-optic cables. The identification of such infrastructure on GIS layers directly affects the restoration planning alternatives, as access and maintenance will be of significant concern.

5.5 Public Access and Recreation

Public access and recreation at the SBSP Restoration Project area is limited for a variety of reasons including the remote location of project lands, the previous Cargill ownership, and tidal inundation. Previous private ownership of most of the project area also limits existing information about recreation and public access. Other than salt operations, the primary access was for waterfowl hunting through agreements that Cargill held with individual hunters (Morris, C. 2004). No research on visitor use or demand exists within the project area lands except for estimated visitor attendance data on USFWS lands managed as part of the Don Edwards National Wildlife Refuge (Morris, C. 2004).

Current knowledge on public access and recreation on project area lands and the surrounding vicinity has been collected primarily from ‘All Stakeholder Meetings’ since February 2004, GIS data compiled for this project, personal communications, site tours, and existing plans, policies, regulations, and codes, including the South Bay Salt Ponds Initial Stewardship Plan (ISP). Figure 4 shows the compilation of available GIS data related to existing public access and recreation including, trail information within and in the vicinity of the project area, regional open space areas and lands protected by municipal ownership, existing road networks, and railroad infrastructure. The sources of GIS data are listed in the Data Summary Report (Philip Williams & Associates Ltd. and others 2004d).

The Baumberg pond complex, also known as the Eden Landing Ecological Reserve (Reserve), is owned and managed by the California Department of Fish and Game (CDFG). CDFG management of Ecological Reserves, including public access, is guided primarily by the California Fish and Game Code Section 1580 and California Code of Regulations Title 14 Section 630 which provides General Regulations stating "Ecological reserves are established for rare, threatened or endangered native plants, wildlife, aquatic organisms and specialized terrestrial or aquatic habitat types. Public entry and use shall be compatible with the primary purposes of such reserves…" Additionally, Section 630 (b) (45) provides "Special Regulations for Use" on the Eden Landing Ecological Reserve.

The northern extent of the Reserve, constituting 885 acres, was established in 1996 for restoration. The restoration plan for this part of the Reserve (Ponds 1B-6B, 7C, 8B-17B, 17C and 20B as per CDFG Map of Eden Landing Ecological Reserve, February 2004) is to restore former salt ponds and crystallizers to tidal salt marsh and seasonal wetlands (Life Science 2003). This restoration is underway and includes alignment for the Bay Trail Spine, connecting from the Hayward Shoreline Park and Interpretive Center in the north to points south, being established in partnership with the East Bay Regional Park District. The remaining lands within the Reserve were added as part of the Cargill purchase in 2002. Hunting on the Reserve takes places on all lands outside of the 885 restoration area except for pond E6A by a lottery conducted by CDFG which allows public hunting access for a limited number of days per year, based on suitable water levels. Currently, other public access and recreation does not exist on the Reserve.

The Alviso and Ravenswood pond complexes are owned and managed by the USFWS. Portions of these complexes were part of the Don Edwards National Wildlife Refuge (Refuge), under management by USFWS prior to the 2002 purchase from Cargill, however Cargill retained the rights for salt production operation over some ponds. Currently, Cargill still operates salt ponds over lands within the Refuge, outside of the project area.

The USFWS manages its lands pursuant to the National Wildlife Refuge System Administration Act of 1966 and the Refuge Recreation Act of 1962 as well as other laws, Executive Orders, Regulations and Policies. The National Wildlife Refuge System Improvement Act of 1997 established six wildlife-oriented public uses that take priority over all others (wildlife observation, wildlife photography, environmental interpretation, environmental education, hunting and fishing) (Morris 2004). Waterfowl hunting remains over some of the Refuge lands operated by Cargill as well as other lands in the Refuge as part of the ISP. Hunting is permitted on portions of the Ravenswood complex however, and as part of the ISP hunting is permitted on some ponds within the Alviso complex. The Refuge Environmental Education Center exists in the Alviso complex as well as hiking trails including the Alviso loop trail over ponds A9, 10, 11, 12 13, 14 and 15.

The Refuge headquarters and Visitor Center are located in Fremont on lands outside of the SBSP Restoration Project area. Interpretive displays exist in the Visitor Center as well as outside the facility along with hiking trails, wildlife observation opportunities and kayak and canoe launching. The Refuge Environmental Education Center is located in the Alviso complex. Figure 4 shows the SBSP Restoration Project area and these adjacent areas in the context of local public access and recreation, and connectivity to existing trails and transit.

Limited data exist on the ability of SBSP Restoration Project areas to accommodate visitors. Supply and demand data would help to analyze visitor use and quality of visitor experience and ultimately visitor use, and would be related to the ecological carrying capacity previously mentioned in Section 4.1.2. Carrying capacity of the project area and surrounding public recreation uses and facilities will be useful in planning new public access and facilities. Many opportunities exist for improving public access and recreation in and around the project area. Certain constraints such as public access within restored wildlife breeding and foraging areas may create limitations for new trails, however these constraints will not be fully discernable until the restoration alternatives related to habitat and flood protection are more fully developed. Summaries of specific opportunities and constraints for public access and recreation are in sections 5.1.5 and 5.2.5 respectively.

6. OPPORTUNITIES AND CONSTRAINTS

Initial opportunities and constraints for the Salt Pond Restoration Project are described below in general terms with some schematic graphics. An opportunity is defined as an identifiable benefit that can be achieved through implementation of the SBSP Restoration Project that contributes to the Project's overall goals of restoring and enhancing a mix of wetland habitats, providing for flood management, and providing public access and recreation opportunities. A constraint is defined as factor that may limit the SBSP Restoration Project alternatives selection, or that may limit the extent that the Project's goals are met. These initial opportunities and constraints influence the ability to achieve target objectives and drive design parameters; constraints, in particular, can prevent desirable restoration elements from being incorporated. In most cases, more than one opportunity and constraint applies to a given pond and complex of ponds.

6.1 Opportunities

Below are the key initial project opportunities organized by the five subtopics. Opportunities are listed in order of relative importance within each subtopic. The ranking of relative importance reflects the opportunities that would contribute the most to achieving the SBSP Restoration Project's objectives, and to increasing the overall health of the San Francisco Bay ecosystem.

6.1.1 Biology and Habitats

The large-scale biological opportunities afforded by this project are not easily portrayed graphically due to the magnitude of the project. Figure 5 shows the historic extent of the Bay marsh habitats and the distribution of historic ponds and pans, with the current salt-pond levees superimposed over them (San Francisco Estuary Institute (SFEI), unpublished data). The following biological opportunities should be viewed in the context of restoring habitats that have been lost through development of the Bay-edge habitats (Goals Project 1999). These opportunities are focused on the objective of using an ecosystem approach to develop a sustainable ecosystem that considers all habitat types.

- *Substantially increase subtidal habitat, intertidal mudflat, middle, upper marsh, and transitional ecotones over the long term.* The conversion from ponds to these habitats will have a net benefit to invertebrates, birds, fishes, small mammals, seals, and native plants. This opportunity will serve to increase the overall health of the San Francisco Bay ecosystem.
- C*ontribute to the recovery of the South Bay subspecies of the salt marsh harvest mouse (Reithrodontomys raviventris*). By restoring pickleweed-dominated tidal salt marsh for the salt marsh harvest mouse, we have an opportunity to substantially contribute to the recovery of this endangered subspecies. Restored tidal salt marshes should be complete, meaning the restored marshes contain: 1. upper-elevation, pickleweed zones, 2. broad bands of peripheral halophytes, 3. broad transitional zones into upland vegetation, as well as, 4. the cordgrass and lower pickleweed zones that currently exist. Broad corridors of appropriate vegetation should be established between restored tidal marshes to allow for population interchange. As shown in Figure 6 (Shellhammer, H. S. and R. Duke 2004), current occupied and potential habitats for the salt marsh harvest mouse (habitat quality of these marshes not depicted) are fragmented and, in many cases widely isolated. Such fragmentation may

effectively prevent genetic flow among local populations. Creating new salt marshes, interconnected with existing suitable habitat, will greatly improve the opportunities for recovery of the subspecies. These efforts would also benefit other rare animals such as the salt marsh wandering shrew (*Sorex vagrans haliocoetes*) the Alameda Song Sparrow (*Melospiza melodia pusillula*), the Salt Marsh Common Yellowthroat (*Geothlypis trichas sinuosa*) and the California Clapper Rail (*Rallus longirostris obsoletus*). This is an important opportunity to collaborate with the Tidal Marsh Ecosystem Recovery Plan (U.S. Fish and Wildlife Service).

- *Meet objectives of the South Bay California Clapper Rail Recovery Plan.* The endangered California Clapper Rail is found only in San Francisco Bay wetlands. The California Clapper Rail's available nesting/foraging habitat will benefit from tidal-marsh restoration that enlarges existing saline and brackish-saline salt marshes and restoration that develops extensive systems of marsh channels. Linking existing marsh habitats with tracts of similar habitat that allow for interaction and movement between eastern and western-bay populations will enhance rail dispersal. Restoration of habitat for this species will also benefit others, such as Alameda Song Sparrow and Salt Marsh Common Yellowthroat. This is an important opportunity to collaborate with the Tidal Marsh Ecosystem Recovery Plan (U.S. Fish and Wildlife Service 2002).
- *Meet Snowy Plover* (*Charadrius alexandrinus*) *recovery goals.* Maintaining populations of the threatened Snowy Plover at the current level will depend on the creation of habitat mosaics that combine salt pan, island or isolated levee-nesting habitat adjacent to foraging areas. Predator access, primarily by corvids (American Crows (*Corvus brachyrhynchos*), Common Ravens (*Corvus corax*), and related species), raccoons (*Procyon lotor*), and red foxes (*Vulpes fulva*) can be a concern in these areas. Therefore, Snowy Plover nesting areas will have to be managed (both spatially and temporally) to minimize predation, and continued predator management (removal) will be necessary. This effort will provide enhanced nesting opportunities to many other species as well, including terns, American Avocets (*Recurvirostra americana*), Black-necked Stilts (*Himantopus mexicanus*), and waterfowl.
- *Increase in habitat for special-status plant species.* This goal includes re-establishing populations of California sea-blite (*Suaeda californica*) and associated rare, high-marsh plant species such as Pt. Reyes birds beak (*Cordylanthus maritimus* ssp. *palustris*). In San Luis Obispo County, where the sole remaining natural populations of California sea-blite persist, plants colonize the coarse substrates of sandy, salt marsh edges and marshy beach ridges. The conversion of open-water habitat to marsh habitat will also increase suitable habitat for a number of other special-status plants including Contra Costa goldfields (*Lasthenia conjugens*) and others.
- *Increase (or balance the decrease) in mudflat areas for foraging waterfowl, and shorebirds.* Mudflat foraging habitat should be increased for migratory birds, such as shorebirds and waterfowl. Salt ponds that are opened to tidal action will revert to intertidal mudflat and salt marsh (which includes mudflat along tidal sloughs). These new mudflats, depending on the timing of colonization of vegetation, will provide valuable habitat for shorebirds, waterfowl and their avian predators. With the possibility that current mudflats may be lost, either due to current erosional processes or increased scour due to increased tidal prism, these newly created mudflats take on an increased importance in the estuary.
- *Ability to manage retained ponds specifically for waterbirds.* Salt ponds are used extensively by many waterbird species in the South San Francisco Bay. However, when managed for salt production, only a low proportion of the ponds are suitable foraging habitat for most waterbirds, and

only a portion of those ponds are available for foraging by various avian species depending on water depth (*i.e.*, the fringe of the pond for small shorebirds) and salinity. Additionally, salt pond levees provide comparatively few opportunities for breeding. There is a tremendous opportunity to manage ponds more effectively for a variety of purposes (*e.g.*, breeding, roosting, foraging). For example, maintenance of extensive shallow water areas could provide high-tide foraging habitat for shorebirds (Figure 7). Island complexes and isolated levees, like those designed in San Joaquin Valley experiments (Gordus, A. G. and others 1996; Terrill, S. B. and others 1996; Terrill, S. B. and J. Seay 2001), could greatly increase the area available for breeding and if distributed widely could increase breeding populations (Figure 8). Ponds that are not restored to tidal action can be managed for a variety of salinities to benefit different wildlife species (moderate or low salinity for most waterfowl species, higher salinity for salt pond specialists, *e.g.*, Wilson's Phalaropes (*Phalaropus tricolor*)).

- *Enhance habitat for Terns.* The South Bay Salt Ponds supported 20%, 80% and 96% of the Caspian Terns (*Sterna caspia*) (438 birds), Forster's Terns (*Sterna forsteri*) (1,958), and California Gulls (*Larus californicus*), respectively, nesting in the San Francisco Bay estuary, in 2003 (Strong, C. M. and others 2004). These larids nest on flat, minimally vegetated, islands offering a wide view. Enhancement opportunities for this suite of species include the creation of sizeable tracts of islands specifically designed to provide nesting habitat for terns, which should be in place soon after the restoration has been implemented. These islands also would offer additional, high-quality roosting habitat for shorebirds during high tides. Although the California Least Tern (*Sterna antillarum browni*) does not currently nest in South Bay salt ponds, these ponds serve as staging areas for Least Terns, providing foraging and roosting habitat for post-breeding birds. Enhancement of these ponds through the provision of additional roost sites and possible pond management to increase fish availability within the ponds could enhance conditions for Least Terns. In addition, restoration of tidal marsh would benefit San Francisco Bay fish populations, potentially enhancing foraging opportunities for Least Terns within the Bay itself.

- *Restore transitional ecotone between tidal marsh and adjacent wetland and upland habitats.* A diversity of habitats is included in this transition, including the peripheral halophyte zone, moist grasslands, vernal pools, salinas, backshore pans, and closely associated riparian vegetation and willow groves. This restoration will benefit rare plant species and provide refugia for tidal-marsh species and shorebirds, and could increase California tiger salamander (*Ambystoma californiense*) and vernal pool tadpole shrimp (*Lepidurus packardi*) populations via a link between the vernal pool complex in the Warm Springs area and the Alviso Pond complex. Other opportunities include enhancing seasonal wetlands in Sunnyvale and connecting wetlands to riparian corridors at San Francisquito Creek, Guadalupe Slough, Coyote Creek, and elsewhere.

- *Reduce the human-health risk from mosquito-borne disease in the region.* Project design will be performed in conjunction with vector control experts to minimize the amount of potential mosquito breeding habitat in the SBSP Restoration Project area and thereby, reduce the levels of vector management required. Restoration designs will reduce the stagnant water ponds adjacent to communities and convert these ponds from being seasonal ponds by increasing tidal connection and flow.

- *Improve protection from predators and reduce need for predator management*. Creating large blocks of habitat, especially insular areas, will facilitate protection of wildlife from upland-based predators such as the red fox. The creation of more and wider buffers of upper marsh, peripheral halophytes and upland transition vegetation, particularly around marshes with high densities of California

Clapper Rails and habitat for other critical species, may reduce some predator access to special-status species. Also, removing or lowering levees can help isolate new tidal marshes from potential predators. Removing rip-rap that harbors rats and other predators will also benefit native species. The project offers an opportunity to implement predator management on a regional scale.

- *Enhance South Bay fish populations.* Creation of new tidal marsh, with a healthy complex of large and small tidal sloughs, will create important nursery habitat for a variety of fishes, including commercially valuable species and forage fishes for other wildlife species. This could contribute to piscivorous birds that forage in the wind-protected areas of large sloughs. Enhancement of tributary streams will also benefit small populations of salmonids, such as the Central California coast steelhead trout (*Oncorhynchus mykiss*), using channels within the restored marshes during their migration to and from South Bay streams such as the Guadalupe River, Coyote Creek, Stevens Creek, San Francisquito Creek, and Alameda Creek (and their tributaries).
- *Protect harbor seal* (*Phoca vitulina richardsi*) *populations.* This can be accomplished by enhancing seal foraging habitat and forage availability and creating isolated, haul-out areas along large slough channels in restored tidal marshes.
- *Enhance habitat for intertidal invertebrate populations by contributing to the detrital and grazing food webs.* A larger, intact, marsh ecosystem in the South Bay will benefit benthic invertebrates, and their predators, including birds and fish. Currently, the salt pond ecosystem is isolated from the intertidal mudflats. Restoring tidal action, and eventually tidal marshes, will contribute to the entire mudflat system by providing new sources of primary productivity, and as well as new detrital sources.
- *Beneficial use of freshwater outflow from wastewater treatment facilities*. The potential exists to utilize the freshwater outflow from treated wastewater effluent to create estuarine habitat, freshwater wetlands, and willow groves that would increase these desirable habitat types while decreasing the impact of these inputs upon saline habitats. Potential water quality effects associated with waste water would need to be taken into account.
- *Levee lowering to create habitat.* Removing or lowering levees provides potential flood-control benefits described elsewhere, but also provides opportunities for rapid habitat development. Levee lowering can immediately bring habitat to the correct elevation to restore vegetation (*e.g.* pickleweed), even in a deeply subsided pond. Additionally, breaching levees not only allows greater tidal access to restored areas, but can also create island habitat.
- *Restore oyster shell ridges, which provide habitat for some unique and rare plants and provide roost sites for shorebirds (Ravenswood), and possibly provide nesting substrate for Forster's, Caspian, and California Least Terns.* This task would involve both the re-creation of shell/chenier ridges, and reintroduction of uncommon high marsh plant species that were historically present at sheltered shell ridges.
- *Systematic and controlled approach to landscape-scale restoration*. The project will utilize the lessons learned from current projects and historic marshes in the Bay. Examples include the use of reference sites, including the more 'pristine' tidal marsh sites in the South Bay (*e.g.*, Dumbarton Marsh, Greco Island), recently restored sites (*e.g.*, Cooley Landing), and the island ponds that will be breached during the Initial Stewardship Plan, could be used as reference sites for assessing a variety of topics including vegetation colonization, wildlife use, mercury dynamics, food web relationships, hydrology and sediment transport.

- *Create new, and enhance existing, freshwater riverine emergent/riparian habitat along primary drainages in the watershed.* There are few opportunities to create this kind of habitat, based on the boundaries of the planning area and the limits of freshwater influence (see Constraints section). However, if freshwater, riverine habitats can be included in the list of target habitats, the added benefit to wildlife and fauna of recreating an historic marsh-upland ecotonal interface mix of habitats characteristic of the period before extensive alteration of the Bay estuary, would be tremendous. Such habitats could largely be created by other planning efforts (*i.e.* flood control projects) upstream of the current planning areas. Flood control options in these upstream areas may be broader and allow for more such habitats, with the potential to use newly created flood plain habitat downstream to help reduce the flooding risks.
- *Enhance biological resources of adjacent land areas.* Lands that are adjacent to the SBSP Restoration Project area that currently used by wildlife or that contain native plant communities can benefit by being connected spatially to the larger SBSP Restoration Project area. Important factors affected include linking compatible habitats, which will increase native plant and wildlife dispersal.

6.1.2 Hydrodynamics and Sediment Dynamics

Hydrodynamics

- *Restore hydrologic connections to tidal waters.* Some of the salt ponds may be more easily restored due to direct, hydrologic connections to tides, such as ponds along the Bay edge, and ponds adjacent to tidal sloughs. Such connections facilitate tidal restoration. The increased tidal influence in the sloughs may increase the salinity levels, which would in turn drive succession of marsh types within the sloughs from brackish to salt, or freshwater to brackish.
- *Restore historic slough channel alignments.* In addition to enhancing flood protection, the recovery of historic slough channels will also enhance restoration functions by increasing the extent of intertidal slough, mudflat, and marsh edge habitats. It will likely also help improve tidal action in areas that may be limited by the current extent of high order slough channels. It may also help restoration match historic conditions, limiting the need for adaptive management.
- *Increased mixing.* Alternations in the tidal regime could enhance mixing, particularly in the far South Bay, which will decrease salinity gradients in the South Bay (e.g., decrease vertical and/or longitudinal salinity stratification). Increased mixing could also reduce salinity stratification that develops in sloughs due to freshwater discharges, which could push the longitudinal salinity gradient upstream, increase the salinity in the sloughs, and potentially increase tidal, salt marsh habitats in the far South Bay.
- *Decreased wave energy on levees.* New marsh areas and mudflat may dissipate wave energy and reduce erosion of the levees.
- *Reduction in high-tide water levels.* Restoration will increase the tidal prism of the South Bay and may lower high water levels, benefiting flood management implementation. However, reductions in water levels are also constraints for habitat (see Constraints section).

Sediment Dynamics

- *Available Sediment supply from natural sedimentation.* Many of the pond bottoms are subsided below natural marshplain elevations (see Figure 9), and sedimentation will be relied upon to raise ground elevations (Siegel, S. W. and P. A. M. Bachand 2002). The South Bay typically has high suspended sediment concentrations, and a portion of this sediment load is believed to be lost to the Central Bay under existing conditions. Tidal restoration will capture a fraction of the sediment within the restored ponds, and levee breaches to tidal sloughs will take advantage of high sediment concentrations in the creeks to enhance sedimentation of adjacent ponds.
- *Creation of sheltered mudflats and deep water within managed ponds.* Some ponds can be managed to provide extensive sheltered mudflats that will be better protected from wind-wave driven erosion and provide important habitat for shorebirds. Other ponds may be managed to provide deep-water habitat for waterfowl and diving birds.
- *Connectivity with existing marsh.* Levee removal, where possible, will facilitate the connection of existing marsh habitat and mudflats with restored habitat, providing large areas of contiguous habitat for use by fish and wildlife. Tidal restoration and levee removal will also allow the natural transgression of the shoreline landward in the face of sea-level rise.
- *Potential for increasing transitional habitat.* Some restorable ponds appear to have areas higher than marsh elevations. These areas can be restored as transitional (ecotone) habitat.
- *Deepening of subtidal channels.* Many of the tributary sloughs in the South Bay have experienced significant sedimentation and reduced conveyance. Restoration efforts will increase the tidal prism in the sloughs, thereby enhancing channel scour, increasing conveyance, and improving passive drainage potential.
- *Use of bayside and internal levees to shelter restoring sites.* The bayside and internal levees provide fetch breaks and reduce the potential for wind wave resuspension of sediments, thus enhancing sedimentation and fostering the creation of habitat. Internal levees could also be graded to provide high marsh and upland refugia. Removal of bayside levees can expand the area of intertidal mudflats.
- *Recovery of antecedent channels.* Antecedent historic channels are present in many of the ponds. Restoration efforts will rejuvenate the relict channel networks and create a high-order channel system within the marsh.
- *Grading or fill to elevations conducive for marsh vegetation establishment, transitional habitat, and/or salt pans.* Grading, such as lowering levee crests to marshplain elevations, and filling, can be used to create desired potential habitat areas. Material dredged from on-site slough channels or levee removal could provide a larger source of fill for placement, as needed.

Imported Sediment Supply and Quantity

- *Bay dredged material sediment supply.* An estimated one million cubic yards of dredged bay sediment is available annually from regular maintenance activities in areas south of the San Rafael-Richmond Bay Bridge. Additional material could also be available from one-time, project specific dredging. This material could be utilized to decrease the timeline of restoration, bury byproducts of salt production (*i.e.*, Whale's Tail marsh), or create elevational gradients and ecotonal habitats.

- *High sediment quality of Bay deepening projects.* Because deepening projects often dig into older native sediment, this material is generally the cleanest material available for wetland creation. The current uses of various annual maintenance dredge project material for surcharging, or drying ponds, does not indicate suitability for wetland use, though some or all of this may meet wetland non-cover criteria.
- *Riverine dredge sediment supply.* An unquantified amount of riverine material could be available from dredging projects in rivers and creeks in the South Bay area. Sediment quality could be an issue, particularly mercury, and could dictate how and where the sediment might be used.
- *Other Bay Area projects.* Other Bay Area projects may also potentially provide sediment and/or excavated soils for the project. The San Francisco Public Utilities Commission Capital Improvements Project (CIP) is one such project. The amount of sediment that will be available for import from the CIP has not yet been determined. Any usage of sediment or excavated fill would need to comply with Dredged Material Management Office requirements.

6.1.3 Water and Sediment Quality

- *Improve water and sediment quality within the project area*. Restoration has the potential to improve existing problems with contaminated sediments and water quality through changes in the environment, sources, and/or maintenance of the areas. With the conversion of salt ponds to tidal marsh, relatively clean sediment may be used to cap in place existing contaminants and reduce interaction with the water column. Ponds (e.g., Pond A8) could potentially be used to capture and sequester sediment and associated pollutant loads, but this would require further investigation. Future maintenance and/or modifications of salt ponds and/or reduction of nutrient inputs could reduce excessive algae growth and help to maintain more aesthetically acceptable conditions.
- *Maintain and improve water quality of the Bay.* This broad mandate includes management of ecological risk associated with mercury methylation and bioaccumulation, and controlling mobilization of contaminants present in sediments. Improvement of existing water quality (surface and ground water) will be accomplished in part through the restoration of tidal-marsh ecosystems and the ability of wetlands to filter and improve water quality.
- *Reduce existing mercury methylation in salt ponds.* Adaptive management principals incorporated into the wetland restoration process could be applied to reduce mercury methylation rates in existing salt ponds by maintaining more aerobic conditions, through a reduction of water depth and/or other steps to maintain higher oxygen levels. Reduction of methylation rates could translate into less bioaccumulation of MeHg into the aquatic food chain. Methylation could also be minimized by maintaining ponds at targeted salinity levels shown to impede methylation. As noted above, definitive data showing how salinity impacts methylation is not currently available.
- *Adaptively manage mercury methylation with wetland restoration.* The ISP and SBSP Restoration projects offer a unique opportunity to quantify potential impacts of restoration on mercury methylation and the value of various measures to effectively limit methylation. These data would not only benefit the SBSP Restoration Project, but other ecosystem restoration efforts in the Bay Area and elsewhere.

6.1.4 Flood Management and Infrastructure

From a flood-management perspective, there are two potential approaches to reduce fluvial flooding: providing increased channel-flow conveyance or providing increased flood storage (detention). Increased conveyance is obtained by increasing the width or depth of the channel/floodplain system, providing additional cross-sectional area for flow. One approach to permanently increasing channel cross-section is to provide increased tidal prism that can provide ongoing scour of existing channels and therefore result in augmented channel conveyance without repeated dredging costs and impacts. Flooding impacts can also be reduced by providing temporary storage of floodwater. Temporary off-channel detention storage can reduce in-channel water surface elevations, which is an important consideration during very high tides. Routing channel discharge through the restored pond system will decrease downstream water levels and reduce upstream water levels and flood hazards.

Flood Management

- *Scouring of flood control channels.* Removal or breaching and lowering of bayside levees will allow ponds to experience the full tidal range. Development of tidal marsh will increase the tidal prism (average daily volume of tidal exchange) between the ponds and the Bay, via the associated sloughs/channels, likely resulting in scour of adjacent flood control channel (Figure 10). This scouring could reduce or eliminate costly maintenance dredging. The expansion of the cross-section will increase channel flood flow conveyance and thereby reduce upstream water levels/flood hazards.
- *Increased storage in managed ponds*. Conversion of ponds to muted tidal or seasonal wetland with flood-flow diversion could increase storage of fluvial flood waters, resulting in decreased water levels and reduced flood hazards in the tributary channel (Figure 11).
- *Increased flood conveyance by levee setback or removal*. Expansion of the tributary channels and associated floodplain via removal and/or reconstruction of levees farther from the channel (levee setback) may provide an increase in flood storage and increase in conveyance of fluvial flood waters. The associated increase in tidal prism may also scour the channel, resulting in expansion of the channel cross-section and decreased water levels in the tributary channel.
- *Wave attenuation by vegetated marsh.* Restoration of tidal wetlands and broad offshore mudflats may aid in wave attenuation by increasing drag forces and reducing wave runup (Figure 12). Over the long-term, the extent of shoreline transgression in response to continued sea level rise and the ability of vegetated marshes to dissipate wave energy would diminish as they begin to erode.

Infrastructure

- *Public access assisted by roads.* Within the development of public access plans, the accessibility of emergency vehicles to recreational points will be a consideration. Existing roads will provide such accessibility in some places.
- *Well-constructed/maintained levees.* While the construction and condition of all project levees have not been assessed, it is likely that some levees will be of better construction or have been well-maintained, perhaps by a regional agency or municipality. It is also possible that some levees have performed well and/or have required little maintenance. Opportunities may exist to utilize well-

constructed/maintained levees in some restoration or public access alternatives. Such levees likely exist where they overlie little or no soft bay mud deposits. New levees, placed in support of the restoration process, may increase accessibility to infrastructure.

- *Fresh-water sources.* Storm water outfalls to the bay may provide fresh water sources for restoration areas, provided that the outflow water quality is acceptable. The quality of storm water runoff and potential associated impacts would need to be assessed.
- *Existing pond infrastructure*. The existing ponds include numerous water-control structures and some pumping facilities that were used by Cargill to move water between ponds for salt production. The ISP also includes revisions to pond infrastructure (Life Science 2003). Many of these will be useful in the subsequent water management of the ponds for habitat.

6.1.5 Public Access and Recreation

The following opportunities have been identified for public access and recreation and are based on the objectives, site visits and the detailed work and knowledge of the Work Group participants as recorded on maps and written materials from February to May 2004. Figure 13 illustrates some of the initial opportunities graphically portrayed with the existing public access and recreation data to elucidate these ideas geographically. The following opportunities are based on the broad concepts of the objectives: overall improvements to public access within agency missions and through partnerships; wildlife-oriented access, education, interpretation and stewardship; providing for a diversity of users and types of recreation; multi-modal linkages with the surrounding communities and the region; and quality visitor experiences. Some additional opportunities have been provided that highlight cultural and historic resources to be included in the planning for restoration and public access and education. Opportunities may overlap and serve to address more than one objective.

- *Provide segments of the Bay Trail Spine and other trail connections to link the South Bay with the surrounding region*. As the project area lands had been in private ownership, new opportunities exist to plan and implement the Bay Trail spine and spur segments within and adjacent to project area lands and complete critical gaps to improve the visitor experience and work towards ultimate completion of this regional asset. Existing, structurally sound levees provide linear corridors that can connect the project area with existing trails and adjacent areas. They also provide the ability to allow pedestrians, cyclists and vehicular access in areas that have been previously closed to the public including open bay areas. Also, as noted below, other trails and links can be made within the existing trail network that exists surrounding the project area including connection with the Bay Ridgeline Trail via the Coyote Creek Trail and other locations and, connection with the Stevens Creek Trail as well as other local and regional trails. .
- *Coordinate the development and management of new facilities and associated infrastructure within the project area and allow for visual and physical connections to adjacent open space and parks.* Many of the adjacent municipalities have strategic recreation and trail plans that can provide links and partnerships to enhance implementation of project area public access and recreation. Some examples include the City of San Jose's Bay Trail Master Plan which augments the work of ABAG and provides a cooperative partnership to implement a series of spine and spur segments, some of which interface with project area lands near the Alviso complex or provide connections to these areas. The East Bay Regional Park District through its holdings along the east shore of the South Bay interface

with CDFG lands as well as with USFWS and are integral to long term management of public access and recreation within the project area. The City of Sunnyvale owns and operates a treatment pond in the Alviso complex as well as the adjacent Sunnyvale Baylands Park. Opportunities exist to foster a partnership between the project area managing agency (USFWS) and the City to pool managerial as well as public access and enforcement efforts. These are a sampling of partnership-related opportunities. More will be identified as the planning process progresses. Additionally, features such as landfills around the project area provide sweeping vistas of the restoration lands that could be used to interpret the types of habitats and scale and scope of the restoration project among other educational topics, provided these lands are in public ownership and partnerships with the landowning agencies are set up to allow for these activities.

- *Provide wildlife-oriented public access opportunities to foster environmental education, interpretation and stewardship.* There is an opportunity to augment the existing educational and interpretive facilities near and adjacent to the project area through the strategic placement of limited access trails, viewing platforms as well as key signage, interpretive displays and docent-led tours (Figure 13). New opportunities should foster cooperation and integration between the many existing and proposed interpretive programs and features. Many interpretive themes can be developed to educate about the history of the land and the restoration effort including the importance of habitats for certain species. Volunteer programs for habitat restoration, invasive species removal and other field activities can provide opportunities for education and can augment implementation of the restoration project.

- *Provide education and/or public access opportunities relative to important South Bay historical and cultural landscape features.* Historic locations such as Rock Island Salt Works, Union City Salt Works and Drawbridge are of public value for their historic character and for the potential interpretation and education of the public about prior use of the adjacent landscape, which can foster a greater appreciation and awareness for the restoration planning effort. Historic land and water use such as waterfowl hunting contribute to the overall understanding of the past and how the landscape has changed over time. Additionally due to the human altered nature of the project area lands in context with surrounding lands as well as other landscape features such as the remains of waterworks structures, cultural landscape values may be high and worthy of protection and interpretation.

- *Diversity of users and types of recreation and multi-modal linkages.* The project area provides opportunities for a diversity of user types from children in school groups to elderly with access limitations to explore and learn about the history of the salt ponds and associated operations as well as the current and future restoration efforts. The ability for guided tours and multi-modal trail opportunities including vehicular trail access for people with limited mobility can provide access for people that otherwise may not have been able to experience this landscape. Given the multi-cultural demographic mosaic of the Bay Area, the project area lands consisting of 15,000 acres provide opportunities for a diverse mix of visitors and facilities to be located and designed with this mosaic in mind. Opportunities also exist to link people to the project area through public transit infrastructure as well as providing connections to existing bicycle trails for recreational as well as commuter cycling connections. The Silicon Valley Bicycle Coalition has identified a variety of cyclist categories including employee recreation, rail-commuters and recreation cyclists that could be served by connecting the project area with certain key links. Other regional transportation planning efforts also provide insight into such opportunities and these will be defined further as the planning process progresses.

- *Ensure quality visitor experiences over the quantity of public access and recreation*. Opportunities exist in and around the project area to ensure that public access and recreation facilities and experiences provide the highest level of quality for the visitor. The placement and type of access and its associated infrastructure or feature should be conducive to allowing the visitor a fulfilled experience. Visitor experience is hard to measure; however, there are some indicators that are known to enhance the visitor experience. In the South Bay, and other water-related landscapes, access to and a visual connection to the open bay may be desirable, for example.
- *Restore recreational boating opportunities.* Opportunities exist to link, enhance and add launch and land sites for watercraft within the South Bay as part of the effort for a San Francisco Bay-wide water trail (Bay Access, I. 2003). Levee breaching, which will increase the tidal prism will likely broaden and deepen slough channels in the surrounding area. This would restore recreational boating access into areas that are currently too shallow for access or have converted to emergent marsh or mudflat habitat. Opportunities exist to link, enhance and add launch and land sites for human-powered and beach-able watercraft within the South Bay as part of the effort for a San Francisco Bay-wide water trail suitable for safe and enjoyable boating on or near San Francisco Bay (Bay Access, I. 2003). Some examples of these opportunities are shown on Figure 13.

6.2 Constraints

Below are the key initial project constraints organized by the five subtopics. They are listed in order of relative importance within each subtopic. The ranking of relative importance reflects the constraints that may present the greatest impediments to achieving the SBSP Restoration Project's detailed objectives.

6.2.1 Biology and Habitats

- *Invasion of newly restored marshes by Spartina alterniflora* [*hybrids*]. Smooth cordgrass (*S. alterniflora*) hybridizes with native Pacific cordgrass (*S. foliosa*) to produce the hybrid *S. alterniflora* x. *foliosa* (*S. alterniflora* [hybrids]). These hybrids have colonized previously unvegetated, tidal mudflats, degrading shorebird foraging habitat. *Spartina alterniflora* [hybrids] also threaten to eradicate the native *S. foliosa* through pollen swamping. *Spartina alterniflora* [hybrids] are able to invade higher elevations, impacting salt marsh harvest mouse and California Clapper Rail habitat, as well as damaging native-plant communities. *Spartina alterniflora* [hybrids] can also invade into lower elevations than the native *S. foliosa*, threatening mudflats and smaller order channels and thus shorebird and California Clapper Rail foraging habitat. Restoration work should be coordinated with the Invasive Spartina Project to assess constraints associated with *S. alterniflora* [hybrids]. It is our current assumption that the Invasive Spartina Project will be able to adequately control *S. alterniflora* [hybrids], and therefore the primary constraint to restoration will be in regards to the timing of restoration activities.
- *Decreased habitat for salt-pond-dependent species.* Several species of shorebirds and other waterbirds use existing salt ponds in large numbers, especially during migration. Some shorebirds, including the Western Snowy Plover, also use existing dry ponds or levees for breeding. There could be some loss of total numbers of some species, especially salt-pond specialized birds without retention of several managed salt ponds. Retention and management of some ponds can provide optimum habitat for these species and will help balance this risk or even enhance these populations.

- *Invasion of restored brackish marshes by perennial pepperweed* (*Lepidium latifolium*). Perennial pepperweed has colonized the marshplain in brackish areas of the South Bay. The project may also increase suitable habitat for other undesirable plant species such as yellow star thistle (*Centaurea solstitialis*), iceplant(s) (*Carpobrotus* sp., *Mesembryanthemum* sp.) and thistle(s) (*Carduus* sp., *Centaurea* sp., *Silybum* sp.), and mustards (*Brassica* sp.).
- *Increased loss of existing outboard mudflats and bayfront marsh.* The increased sediment demand of breached subsided ponds could increase current rates of erosion of offshore mudflats and bayfront marsh. The key to reducing this possibility is to ensure that the project results in a net gain of those habitats and that the timing of losses and new marsh evolution does not leave the system with a deficit of such habitats for a substantial period of time (*e.g.*, existing marshes could erode in ten years and new marsh could take 30 years to sediment in and support vegetation). The loss of existing marsh and mudflat habitat may also occur from levee breaching and pilot channel construction activities.
- *Loss of fringing marsh along existing slough channels.* Increased tidal prism due to restored ponds upstream may erode fringing marsh that has become established within silted up slough channels.
- *Potential of exacerbating mosquito breeding levels.* Increasing the need for vector management could become a constraint, depending on the SBSP Restoration Project design. Marsh areas that do not have vigorous tidal flow are likely to produce habitat for mosquitoes. Among the species involved are mosquitoes that migrate long distances to adjacent communities (*Aedes squamiger*) and vectors of West Nile virus (*Culex tarsalis* and *Culex pipiens*). Designs that minimize the creation of stagnant water areas, and other features that provide breeding habitat for mosquitoes, will help avert this constraint.
- *Colonization of new islands by California Gulls.* Elimination of the dry salt-pond nesting habitat of this species and other larids (terns) could result in increased competition for breeding sites. Such a situation might lead to exclusion of the two tern species from the Bay due to competition with the larger, and dominant California Gull, the most abundant larid now nesting in the salt pond complex. Increases in the population and distribution of California Gulls could also lead to increased predation by California Gulls on other species, potentially including the Snowy Plover and salt marsh harvest mouse. Breaching of pond A-6 in Alviso could displace the California Gull colony that has grown in recent years. Even without such breaching, California Gulls could expand their colony onto newly created islands, effectively limiting the value of these new breeding habitats for other species. The geographic dispersion of created islands would affect the extent of gull interference.
- *Bioaccumulation of toxic substances if mobilized.* The implementation of salinity reduction and habitat restoration measures could result in exposure of wildlife to contaminants such as mercury, PCBs, heavy metals, and chlorinated hydrocarbon pesticides. Some of these contaminants have the potential to directly affect growth and reproduction of these species in the short term, but also are a risk as bioaccumulants in the food chain over time.
- *Wildlife disturbance from increased public access.* Although newly created salt marshes may have less human access than under current conditions, there is the possibility of increased human disturbance in some areas.
- *The presence of a layer of gypsum above marsh-plain elevation.* Gypsum is present in some of the ponds in the project area. Gypsum, a by-product of salt making, forms a relatively insoluble layer. Gypsum can prevent plant establishment, and channel development unless it is dissolved, removed or

buried with sediment. In lower elevation ponds, bay mud's will bury the gypsum layer and effects on restoration efforts will likely be negligible. In higher elevation, ponds gypsum could hinder restoration. The rate of gypsum dissolution depends on a suite of factors, and may take many years. Gypsum dissolution could also potentially serve as a source of additional sulfate to sulfate-reducing bacteria, which could affect mercury methylation (Brown and Caldwell 2004). Higher elevation ponds will be inundated only part of the time, which will further extend the time required to dissolve the gypsum layer. Alternatively, gypsum can be mechanically removed to achieve appropriate elevations for the target habitat(s).

- *Predator access.* Creating extensive habitat corridors in the South Bay may increase predator movement. Extensive interfaces with urban areas, in Ravenswood in particular, allow for numerous predator access points. This risk, for the most part, already exists, and is controlled by active predator management programs at the Refuge and at Eden Landing. Additionally, creating large buffers and expansive insular habitat, and reducing levee connections near areas that are critical for special-status species can reduce risk from predators.

- *Limitations to create new, and enhance existing, freshwater riverine emergent/riparian habitat along primary drainages in the watershed.* There are few opportunities to create this kind of habitat, based on the boundaries of the planning area and the limits of freshwater influence. For example, riparian planting on the most bayward portions of the Lower Coyote Creek Flood Control project grew well initially, but the cottonwoods (*Populus* sp.) planted later died as their roots reached saline groundwater. This section of Coyote Creek is well upstream of any of the habitats that are subject to this type of restoration.

- *Limitations on pond management.* Actively managed ponds as described above can provide extensive new habitat for waterbirds, in addition to the existing managed pond habitat outside of the project area. However, management of ponds within the SBSP Restoration Project area would be required and the Refuge and CDFG would need to provide staff and equipment to provide this level of management. There will be challenges to creating optimal habitat, including managing salinity discharges out of shallow ponds and high salinity "batch" ponds, preventing vegetation from colonizing islands and shallow-water areas. There will also be a need for increased predator control, to the extent that predators focus their efforts on new breeding areas. In addition to limitations of manpower on pond management, weather also introduces limitations because many ponds are not easily accessible when levees are muddy. Another possible constraint is the need to address any potential discharges from the ponds, which would likely exceed RWQCB objectives for salinity and/or other constituents.

- *Cost of monitoring.* Adaptive management of project phasing will be a critical step in insuring overall project success. Monitoring of early phases should be extensive to maximize our understanding of the system's response to specific restoration activities.

- *Nuisance algae / algal blooms.* Nuisance algae have been associated with elevated nitrogen and phosphorus concentrations in ponds with salinity levels below a range of approximately 30 to 50 ppt. Macroalgal mats and heavy algal blooms lead to anoxia and the accumulation of biomass along the shoreline, as well as die-offs of fish and brine shrimp. The decomposition of the biomass causes odor problems caused by releases of hydrogen sulfide.

- *Sediment pH.* Insufficient water inflow can decrease sediment pH due to oxidation rendering the ponds more inhospitable for vegetation colonization. The availability of sufficient funds for water-level management is crucial.
- *Shallow target water depth in managed salt ponds.* Shallow target water depths may pose management challenges to account for wide daily variations in evaporation rates and in water temperature. In particular, shallow water can also lead to increases in botulism outbreaks, especially during warm weather.
- *Wide range of pH and dissolved oxygen concentration in ponds.* Productive algal community in low-salinity ponds indicated by DO and pH characteristics that decrease as salinity increases. Productive algal communities, and algal "blooms" associated with low-salinity ponds can lead to anoxia, fish kills, and odor problems.
- *Presence of California Clapper Rail may impede treatment activities of Spartina alterniflora [hybrids].* Optimal herbicide application timing for the control of non-native tidal-marsh species overlaps with the California Clapper Rail breeding season (summer), which may impose constraints on the timing of herbicide.
- *Potential short-term degradation of water quality.* This degradation could occur with sediment suspension and increased salinity during construction of pilot channels, water-control structures, fill of borrow ditches, and for a short period of time after ponds are opened to tidal action. This impact could affect existing fisheries and invertebrate populations that support native inland and anadramous fishes.
- *Adjacent land use limitations.* Some objectives of the SBSP Restoration Project may be limited by adjacent land uses such as development, pollution sources, and domestic animals. Locations of landfills and developments in particular can be a limitation as they attract predators such as raccoons, cats, and foxes as well as provide forage for many of the predators, including gulls and corvids.

6.2.2 Hydrodynamics and Sediment Dynamics

Hydrodynamics

- *Alterations to the tidal range and tidal asymmetry.* Alterations to MHHW and/or MLLW could affect inundation frequency of existing marsh areas and could result in loss and/or changes to existing habitats. This change may be transitory in nature, as muted tidal conditions may prevail until slough channels erode to equilibrium conditions with the increased tidal prism; or the changes may be permanent
- *Increase in nearshore incident-wave energy due to sea level rise.* Increasing water levels due to sea level rise could result in increased near-shore, incident-wave energy and enhanced erosion potential of offshore mudflats and bayfront marsh.
- *Maintaining shallow water depths in managed ponds.* Shallow water depths in managed ponds can be difficult to achieve/maintain due to variations in evaporation rates, and variability in gravity inflows depending on the strength of the tides. Ponds generally intake more water during strong tides than weak tides, leading to fluctuations in water levels. This fluctuation can be minimized by use of outflow weirs or other hydraulic infrastructure.

- *Decreased passive drainage of managed ponds.* Increasing water levels due to sea level rise can decrease the passive drainage potential of the managed ponds.

Sediment Dynamics

- *Suspended sediment supply limitations to sedimentation.* There may not be enough sediment available in the system to restore ponds to tidal marsh elevations. Many of the existing ponds have experienced subsidence due to groundwater pumping, particularly in the far South Bay (see Figure 9). This subsidence represents a significant sediment demand because pond elevations are below natural marshplain elevations, and in many cases, are too low in the tidal frame for vegetation colonization.
- *Loss of existing mudflats.* Sediment may be eroded from the mudflats to meet sediment demand for tidal-marsh restoration. This erosion may result in the loss of existing mudflats, particularly along the eastern shore, which experiences significant fetch under typical westerly and northwesterly wind conditions.
- *Existing and potential accelerated erosion of bayfront levees and loss of bayfront fringing marsh.* Ongoing erosion of the offshore mudflats may be accelerated, resulting in the erosion and loss of additional existing bayfront fringing marsh, because lower and narrower mudflats have less wave energy dissipation potential. Loss of fringing marsh may increase the erosion potential on bayfront levees due to less wave attenuation.
- *Deepening of the shallow subtidal regions.* Erosion of the mudflats and wave sweep zone would result in deepening of the shallow subtidal zone.
- *Need to handle decant water.* High volumes of decant water associated with hydraulic placement will have to be managed to avoid erosion and/or water-quality problems during placement.

Imported Sediment Supply and Quantity

- *Availability.* Imported sediment may be limited in the quantity and timing, which may not coincide with the needs for sediment supply (Philip Williams & Associates Ltd. and others 2004d).
- *Quality.* The quality of sediments could also limit the quantity of available sediment and/or locations where the sediment could be placed. Data on specific sediment quality, to compare against wetland cover and wetland non-cover criteria, are limited. In addition, the criteria for acceptability and necessary testing protocols will need to be refined to address the specific needs of the SBSP Restoration Project.
- *Transport of imported sediment.* The ability and costs to transport and place sediment where needed on site may also be limiting. Shallow water at site(s) precludes transport of sediment by barge and bottom dumping without dredging access channels to the site(s); landside delivery of dredged sediment could be prohibitively expensive. Other means for sediment transport may need to be developed or refined for application to the SBSP Restoration Project.

6.2.3 Water and Sediment Quality

- *Mobilization of existing contaminants.* The South Bay Salt Ponds and adjacent sloughs and creeks include areas with sediments impacted by legacy pollutants. Restoration could mobilize these contaminants, through erosion and scouring of areas that are currently protected and/or stable (*e.g.*, conversion of a salt pond to a tidal marsh with incised channels). In the case of mercury, deeper sediments in the ponds may be rich in mercury, but this mercury is isolated and not currently in a methylating environment. If this sediment were redistributed into surface sediment and conditions were favorable, the mercury could then potentially drive methylation, with subsequent contamination of biota.
- *Need to evaluate ecological risk associated with mercury in pond sediments.* Existing data on total mercury in pond sediments, generated through recent sampling for the ISP and collected during a 2002 site assessment, indicate that mercury concentrations in most of the Alviso Ponds. The ecological risk associated with ponds that greatly exceed ambient levels of total mercury in sediment will need to be evaluated. If the ecological risk associated with these sediments is deemed significant, the sediments may need to be removed or isolated via capping with clean sediments. In addition, review and evaluation of mercury sediment concentrations in the areas surrounding the ponds is warranted.
- *Increased release of methylmercury*. Tidal wetlands have been shown to be effective sites of methylation of mercury. The creation of large areas of new tidal wetland could increase the net production of methylmercury within the project area, which could increase ecological risk of bioaccumulation, and could also produce a net increase in methylmercury delivered to the Bay. Methylmercury production could be limited through careful selection of habitat mix and location, design features, and management measures, though data needed to support the implementation of such controls are not currently available.
- *Recontamination from outside sources.* Water and sediment quality in the Salt Ponds area could be affected by several potential contaminant sources in the future – the Bay, tributaries (*e.g.*, Guadalupe River and Coyote Creek), urban runoff, wastewater discharges, and imported sediment, and hydraulic interactions between surface and subsurface waters.. Several efforts are underway to reduce pollutant sources, although the time frame may extend over the next 20 years or more. It will be important to understand the relative potential of these various sources to re-contaminate the area during and after restoration and to take steps to limit recontamination, including possibly deferring restoration of some areas until external pollutant sources are controlled.

6.2.4 Flood Management and Infrastructure

The primary constraint for flood management is identified as an exclusionary evaluation criterion in the ADF (Philip Williams & Associates Ltd. and others 2004c): maintain existing levels of flood protection in the South Bay area. Therefore, maximum water depths, frequency and duration must not be exceeded in regions outside of the restoration zone. The primary concern is increased coastal flooding potential due to conversion of the ponds to tidal action and removal of outboard levees.

Flood Management

- *Accommodation of potential sea level rise.* Increasing water levels in the Bay may worsen coastal and fluvial flooding. Rising waters may partially or fully inundate the restoration area, decreasing the storage capacity of the ponds and reducing the flood protection benefits of some levees.
- *Cost of levee reconstruction.* The existing salt ponds were created and are maintained and managed by hundreds of miles of dumped mud levees. These are subject to ongoing deterioration by wave action and levee settlement. Levee retrofit and maintenance will be costly but necessary. Existing salt pond levees do not conform to FEMA flood protection standards. The development of the SBSP Restoration Project plan will include the provision of adequate levees to create the desired types of habitat, as well as provide adequate flood protection to development and infrastructure located landward. FEMA will not eliminate the flood insurance requirement for landward property owners unless levees are built or rebuilt to FEMA standards. This constraint will be accounted for under the Cost Effectiveness objective.
- *Pond levee erosion*. Relocation of tidal boundary from bayside levees to existing (unmodified) internal salt pond levees may result in increased wave energy, overtopping and erosion potential, particularly during large storm events with high winds combined with high tides.
- *Upland tidal flooding*. Introduction of, or increased, tidal action can reduce flood water storage at high tides. Upland tidal flooding may result from an increase in ponded runoff (Figure 14). Gravity drainage of runoff into the creeks and bay may not be effective in some locations due to high water levels in the Bay. Due to subsidence, most stormwater runoff is pumped into creeks via pump stations already. However, as the water districts or municipalities regulate the amount of stormwater pumped into the creeks during high flows, increased pumping may not be allowable in certain locations.
- *Increased flow velocity.* Breaches through slough levees will increase the local flow velocity. The increase in velocity, and resultant channel scour, may lower the bed and induce erosion near the toe of the existing slough levees. The channel may also be subject to head-cutting, which may migrate upstream. While this may provide some beneficial increase in channel capacity and required dredging, it may destabilize adjacent or in-channel infrastructure.
- *Undermining levees along slough channels.* Increased tidal prism will result in increased scour of the slough channels, which may result in erosion and undermining of existing levee systems along the slough channels.
- *Decreased conveyance and flood storage due to marsh establishment.* Flood conveyance and storage may decrease as elevations in restored ponds adjacent to tidal slough channels increase due to sedimentation and vegetation establishment.
- *Impeded drainage due to muted tides.* Increased tidal prism upstream of silted in tidal channels may temporarily cause muted tides until the channel scours. Muted tides may impede passive drainage through the tide gates of adjacent areas.

Infrastructure

- *Integration with existing flood control facilities.* The local flood control agencies throughout the South Bay have constructed a complex flood management system consisting of levees, storm drains, pump stations and open channel systems to reduce flood hazards to the adjacent communities. The proposed restoration plan must be compatible with the existing facilities, not resulting in potential reduction in level of protection provided, potential to damage the facilities, or increase in the long-term maintenance/management of these systems. Infrastructure may, potentially, be relocated or revised for compatibility with the project. This constraint will be accounted for under the Cost Effectiveness objective.
- *Unfavorable levee foundation conditions.* Levees situated on thick deposits of soft bay mud will be difficult to design to a well-defined standard (such as FEMA). If possible, levees that are required for flood protection should be situated on little or no Bay mud. Such conditions likely exist along the inboard (or shoreline) levees. Difficult foundation conditions may be a constraint to the development of certain restoration alternatives.
- *PG&E electrical transmission lines*. Above ground towers require vehicular access, concrete footings and minimum line sag clearance. Below ground lines require minimum depth of cover. The requirements will vary depending on whether the current towers/boardwalks were designed to accommodate the water level fluctuations that will be recommended in the restoration plan. Maintenance access to the transmission lines might be limited if special status species nest or breed in adjacent areas.
- *Sewer force mains and outfall pipes.* The East Bay Dischargers Authority, the South Bayside System Authority, the Union Sanitation District, the City of Palo Alto, the City of Sunnyvale and the City of San Jose manage sewer mains. The mains and outfalls may interfere with tidal exchange. The infrastructure requires minimum depths of cover and vehicular access. Discharge from the outfalls may affect water quality in localized areas.
- *PG&E natural gas pipelines.* Pipelines may lie at elevations that would block tidal exchange. A minimum depth of cover must be maintained on the pipelines and the lines require vehicular access.
- *Existing Cargill facilities*. Cargill has a number of pipelines and pumping facilities that they use in their ongoing operations. While completing their responsibilities, such as reducing pond salinities to an acceptable level, some facilities will be kept in use during the restoration process. In some areas, there may be a layer of halite "pavement" on the bottom of the crystallizer ponds that previously supported equipment and machinery.
- *Unfavorable levee foundation conditions.* Levees situated on thick deposits of soft bay mud will be difficult to design to a well-defined standard (such as FEMA). If possible, levees that are required for flood protection should be situated on little or no bay mud. Such conditions likely exist along the inboard (or shoreline) levees. Difficult foundation conditions may be a constraint to the development of certain restoration alternatives.
- *Sewer force mains and outfall pipes.* The East Bay Dischargers Authority, the South Bayside System Authority, the Union Sanitation District, the City of Palo Alto, the City of Sunnyvale and the City of San Jose manage sewer mains. The mains and outfalls may interfere with tidal exchange. The

infrastructure requires minimum depths of cover and vehicular access. Discharge from the outfalls may affect water quality in localized areas.

- *Roads.* The existing levee road network may interfere with tidal exchange. Roads adjacent to the salt pond complexes may also limit the extent of the proposed tidal boundary. The final restoration configuration will require access for long-term maintenance of the proposed restoration facilities (levees, water control structures, etc).
- *Railways.* Existing and proposed railways may interfere with, or block, tidal exchange. Introduction of an altered hydrologic regime may require additional protection to prevent possible inundation of the tracks, or increased settlement problems.
- *Hetch Hetchy Aqueduct.* The aqueduct crosses the Bay immediately south of the Dumbarton Bridge. Maintenance access to the aqueduct and the structural integrity of the pipeline must be preserved.
- *Storm drain systems*. Drainage systems include pipelines, outfall pipes and pump stations. Local Cities, Counties and Flood Control Districts own this infrastructure. The current locations of the storm drain systems may interfere with tidal exchange and may affect water quality in localized areas. In addition, the restoration project must be designed to accommodate the functions provided by these systems. This may include protecting these facilities or relocating them, and providing access for maintenance.
- *Private petroleum pipelines*. Pipelines may lie at elevations that would fully or partially block tidal exchange. The pipelines require a minimum depth of cover and also require vehicular access.
- *Fiber optic cables.* Cables may lie at elevations that would fully or partially block tidal exchange. The cables require minimum depth of cover and require vehicular access.
- *Historic structures.* Certain structures (*e.g.*, Rock Island Salt Works, Drawbridge, Archimedes screws), located within the vicinity of the restoration area, may require preservation due to historic value.
- *Landfills*. Proximity to landfills may compromise water quality within the restoration area.

6.2.5 Public Access and Recreation

Public access and recreation constraints are categorized by physical, managerial and biological factors. Constraints shown herein are limited and will be more defined when the restoration alternatives are further developed, and therefore are not conclusive.

- *Biological goals and associated factors may limit the ability to provide public access and recreation*. Review of existing research is being conducted, but based on specific species needs associated with nesting, wintering and migration requirements, disturbances by human activities may limit human access. Some of these limitations may be solved through limiting the types and intensity of access through certain habitats, seasonal closures and providing ample buffers.
- *Landowner and managing agencies (CDFG and USFWS) have limitations related to staffing, public access, recreation management and enforcement.* There will be some constraints due to managerial limitations. An example of this is adjacent to the Dumbarton Bridge and pond SF2. The remains of the old bridge were used in the past as a fishing pier and for public access over the water, however due to severe vandalism and inappropriate use this area has been closed. In this case, the inability to

provide staff for enforcement and a continuous presence to prevent illicit behavior forced the USFWS to close this facility. CDFG has severe staffing limitations for the Eden Landing Ecological Reserve making extensive physical presence on site impossible. Throughout the project area, depending on size and complexity of access and connectivity, other managerial limitations will inhibit the managing agencies from providing new access or associated facilities.

- *Physical barriers such as water control structures and existing infrastructure may inhibit the ability to provide public access or recreation in a given area.* There are locations where infrastructure such as PG&E transmission towers may inhibit the ability to create new trails or other connections. Public access near or adjacent to wastewater treatment facilities may need to be controlled for security or operational considerations. Additionally, as the historic town of Drawbridge is only accessible by a rail line that no longer stops there, access to this area may be hampered or more challenging to implement. The full range of limitations due to infrastructure and other physical barriers is not known at this time.

7. DISCUSSION

Restoration of the South Bay Salt Ponds is important within our region, and is also important on a global scale. The San Francisco Bay is the largest estuary on the North American Pacific coast. A large proportion of the wildlife that depend on the Bay are migratory, thus restoration will support species with global distributions during a time when habitats are generally diminishing worldwide. This project is also being followed by a global audience. Developing the framework to assess the balance between opportunities and constraints and formulate meaningful alternatives will provide an important example to restoration practitioners worldwide.

The SBSP Restoration Project presents significant challenges as the opportunities and constraints are numerous and can be formulated at different scales – from the entire South Bay landscape to sets of individual ponds. As indicated by the name, this report is intended to be an initial summary of the opportunities and constraints, and integrates existing opportunities and constraints information from the Science Team, Project Management Team, Stakeholder Forum and other stakeholders. Work on the initial opportunities and constraints was conducted with the existing information and local expertise and experience of all those involved in the restoration project. The topics below present an initial list that identifies those opportunities and constraints that are collectively viewed as the most critical elements driving the initial selection of restoration alternatives. Prioritization of these opportunities and constraints and their relative importance in determining the selection of specific alternatives will continually be developed as the project progresses and new information is obtained.

Central to this restoration project are the opportunities to achieve numerous objectives that have benefits beyond San Francisco Bay. These include:

- Restoration of thousands of acres of historic tidal salt marsh in South San Francisco Bay, which provides habitat for several endangered species (the California Clapper Rail, salt marsh harvest mouse, and California central coast steelhead trout) and CDFG Species of Special Concern (including the Northern Harrier (*Circus cyaneus*), Salt Marsh Common Yellowthroat, and Alameda Song Sparrow), as well as numerous other plant and animal species
- Ability to manage remaining ponds specifically for waterbirds habitat
- Increase flood protection by restoring historic slough-bay connectivity and utilizing natural wetland functioning in this capacity
- Improve water quality in the Bay
- Increase transitional habitat and habitat connectivity throughout the Bay
- Provide additional public use and recreational opportunities
- Support increased abundance and diversity of native species in various South San Francisco Bay aquatic and terrestrial ecosystem components
- Manage the spread of non-native species

Before formulating well-defined restoration alternatives, there are two broadly based, critical issues that present potential levels of constraint to the project that require further analysis. These two issues are:

- Sediment availability and the associated ability to restore tidal marsh, and
- Changes in functions and values for a variety of bird species as a result of those changes

The ADF will evaluate and integrate projected landscape scale changes over the 50-year planning horizon. This step will take into account the anticipated effects of sea level rise, changes in sediment budget, the impacts of tidal restoration itself on the evolution of habitat and bird use throughout the South Bay, and consideration of the goals of other habitat restoration and management projects in the San Francisco Bay such as the Napa Salt Ponds restoration project and management of the Suisun Marsh wetlands. The analysis of the rate and extent of habitat change and bird use response will inform the selection of a preferred landscape scenario that will help define more detailed alternatives. The preferred landscape scenario will address the tradeoff between managed ponds and tidal restoration, net changes in intertidal mudflats, net changes in bird use and preferred locations for tidal restoration within the South Bay to minimize impacts and maximize benefits. Early selection of a preferred landscape scenario will significantly streamline the alternatives development and evaluation process by establishing the target mix of habitats and associated bird use that the project is intended to accomplish at different times within the planning horizon.

Once the landscape-scale approach is more clearly defined the remaining constraints to restoration can be analyzed, prioritized, and developed in pond-specific alternatives. At that time, the interdependence of these initial opportunities and constraints should be re-examined in conjunction with the analysis of the existing conditions on a pond complex basis to help formulate the restoration alternatives. However, based on the current understanding of the project details, the most pressing constraints to the restoration include:

- Mercury and other contaminants present in the salt ponds and in sediments of adjacent sloughs and mudflats
- Invasive plant species such as non-native cordgrass and pepperweed.
- Existing infrastructure
- Mosquito threats to human and wildlife health

The project team is already working closely with the Regional Water Quality Control Board, the Invasive Spartina Project, the Santa Clara Valley Water District, local municipalities, PG&E, and other entities to ensure that the project needs posed by these constraints can be addressed adequately in the planning process. Despite these constraints, the overwhelming beneficial opportunities of this restoration project can be realized. The critical next steps include determining sediment availability, bird use analysis and compilation of existing conditions. Then, alternatives development through a careful and detailed re-examination of the overview of opportunities and constraints presented in this initial report, in conjunction with the knowledge gained in subsequent tasks, can proceed.

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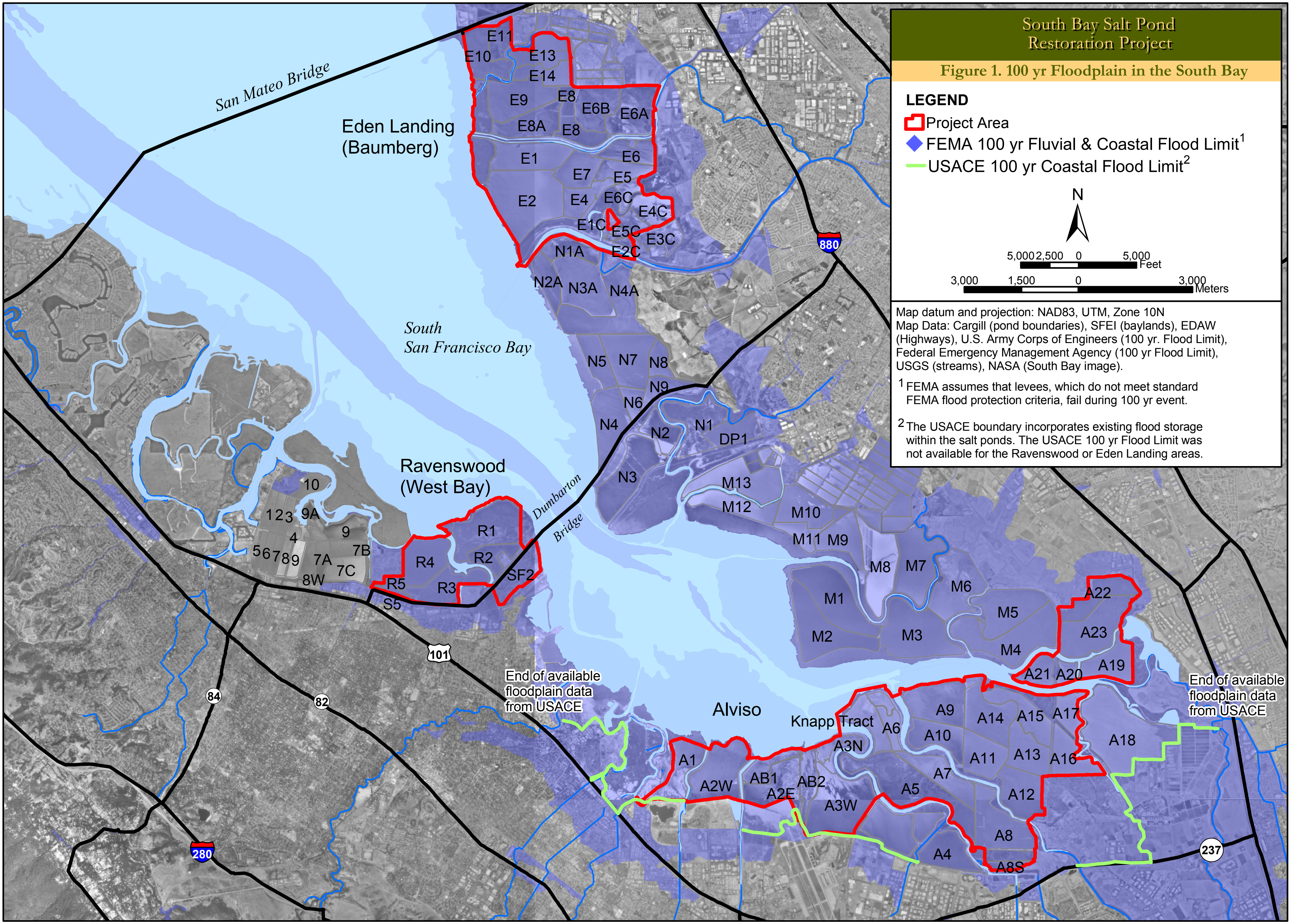

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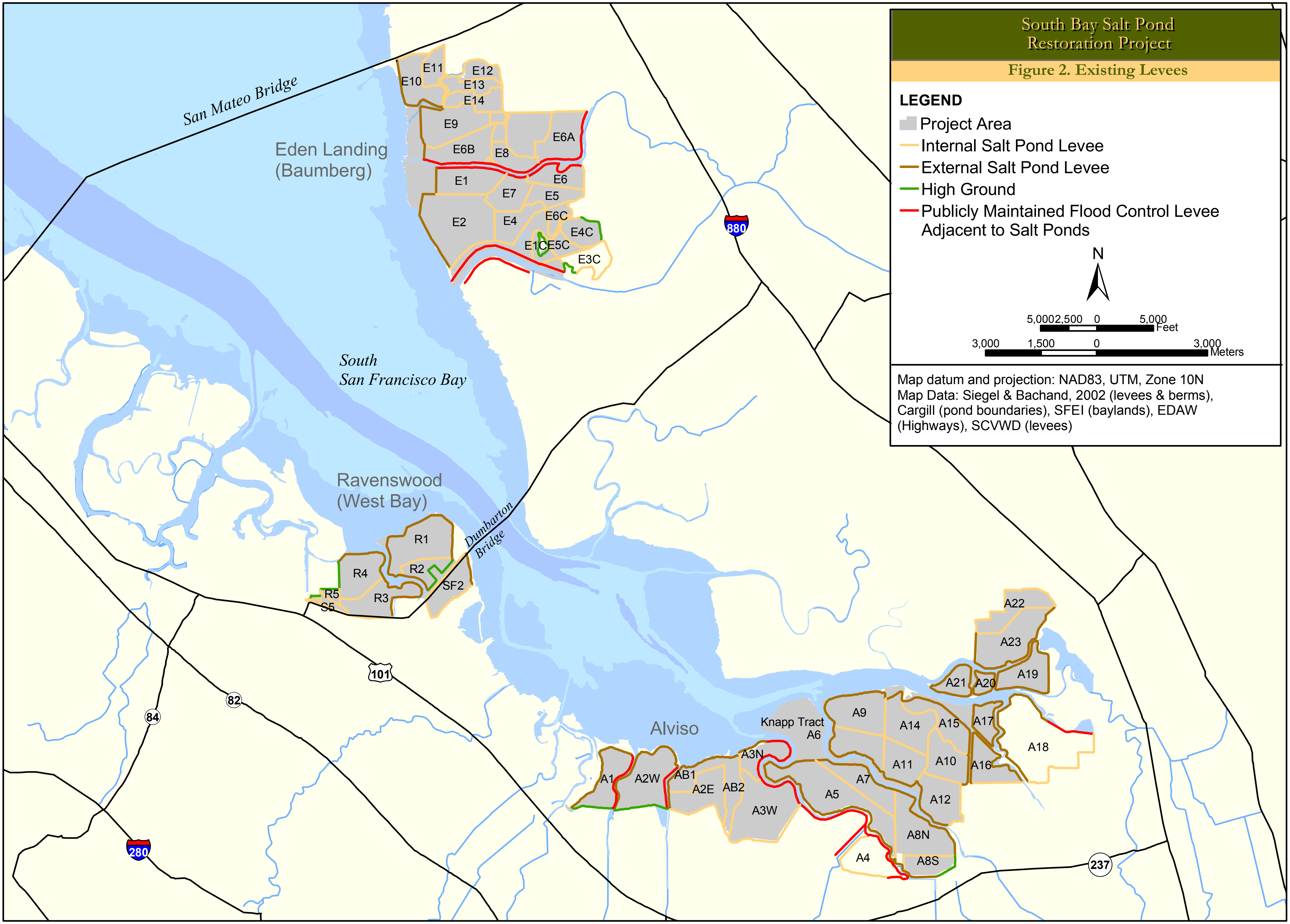

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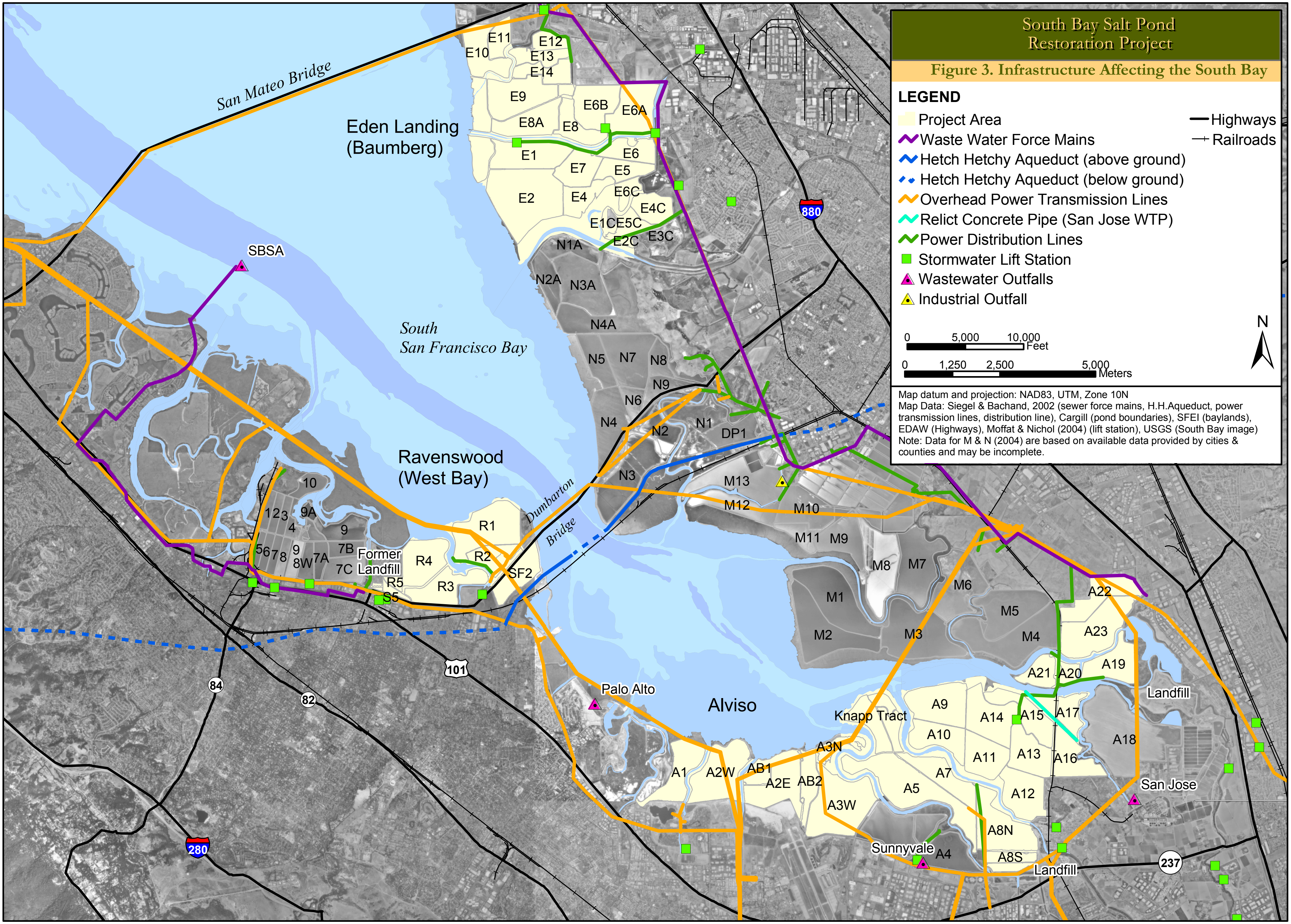

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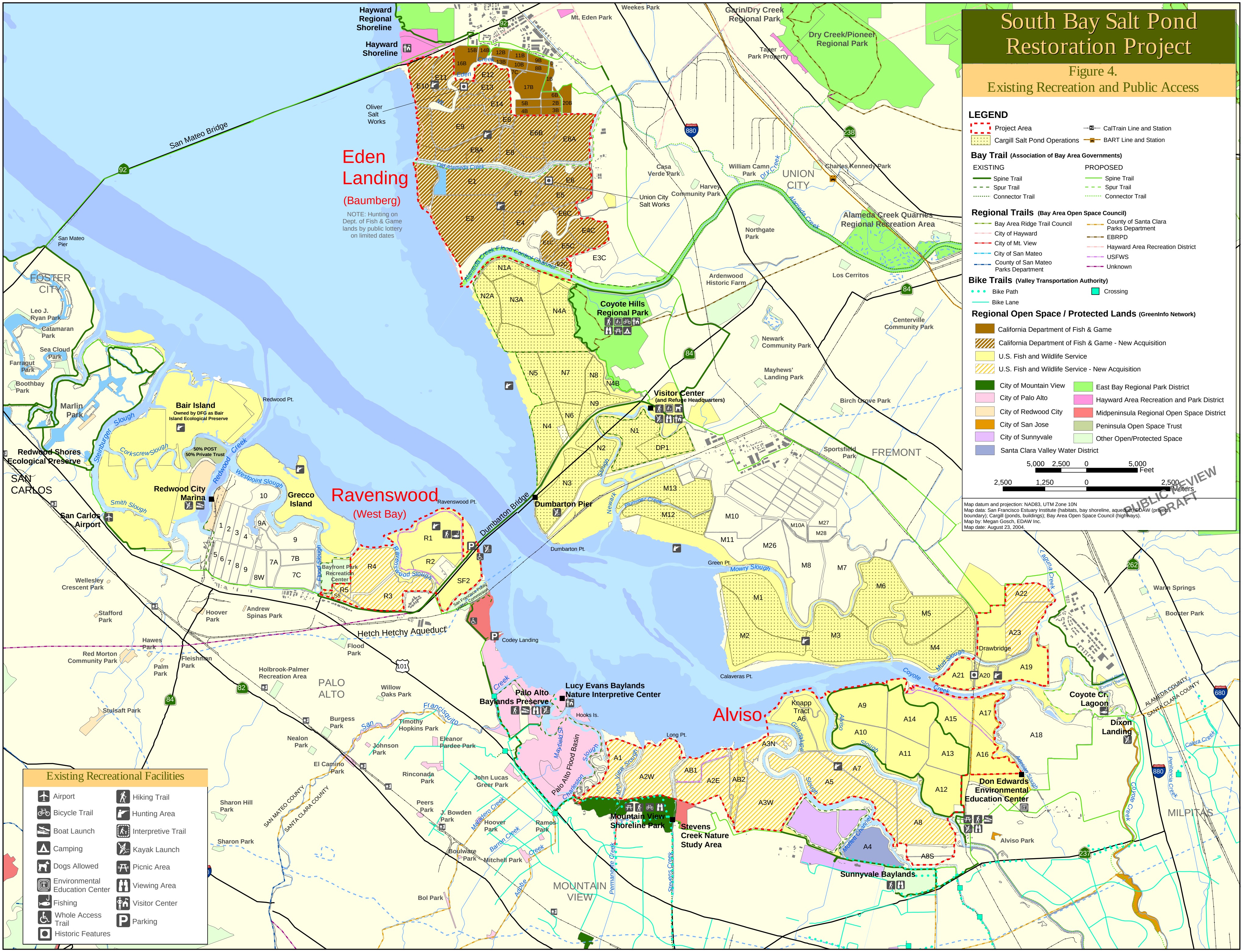
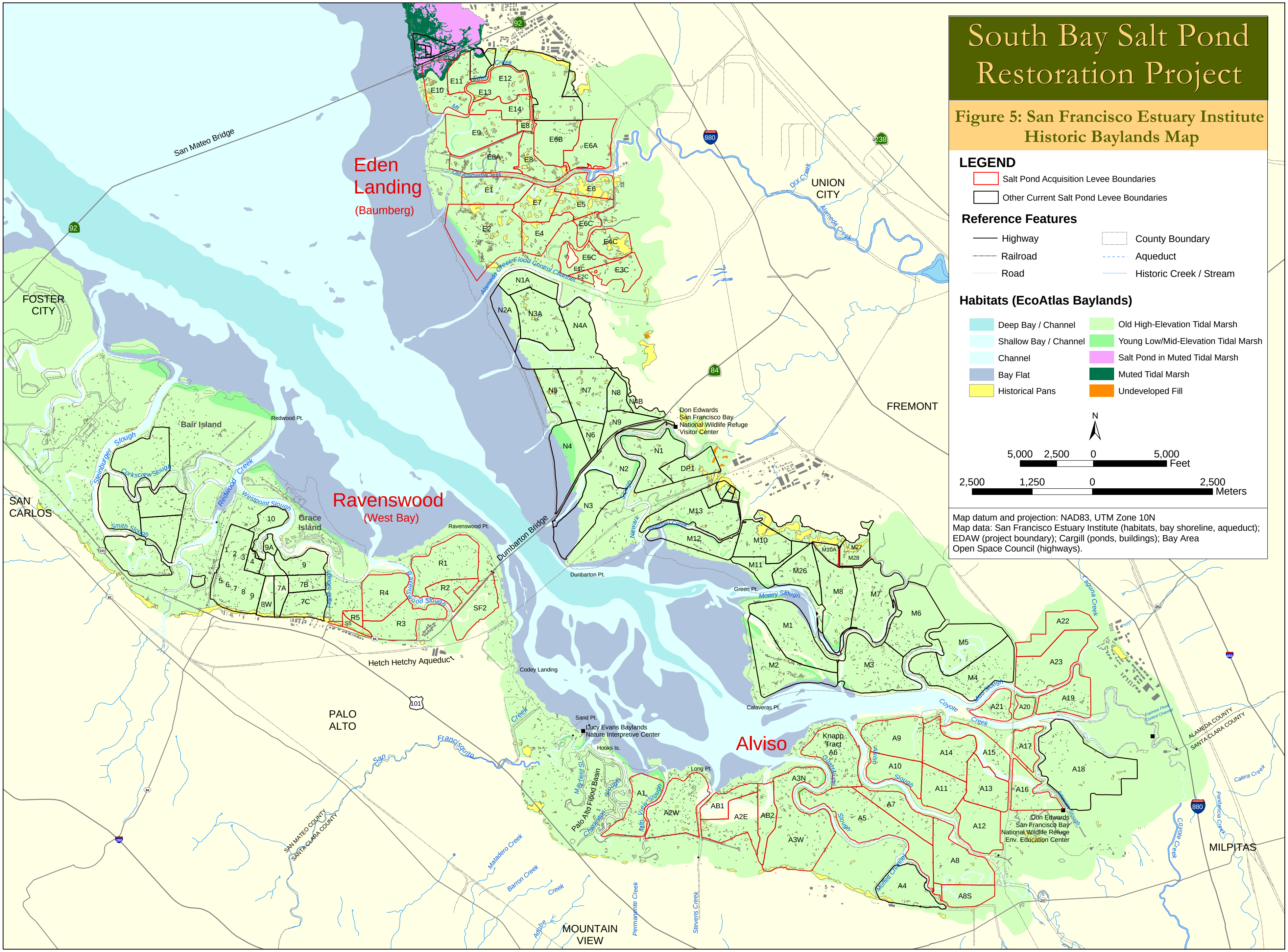
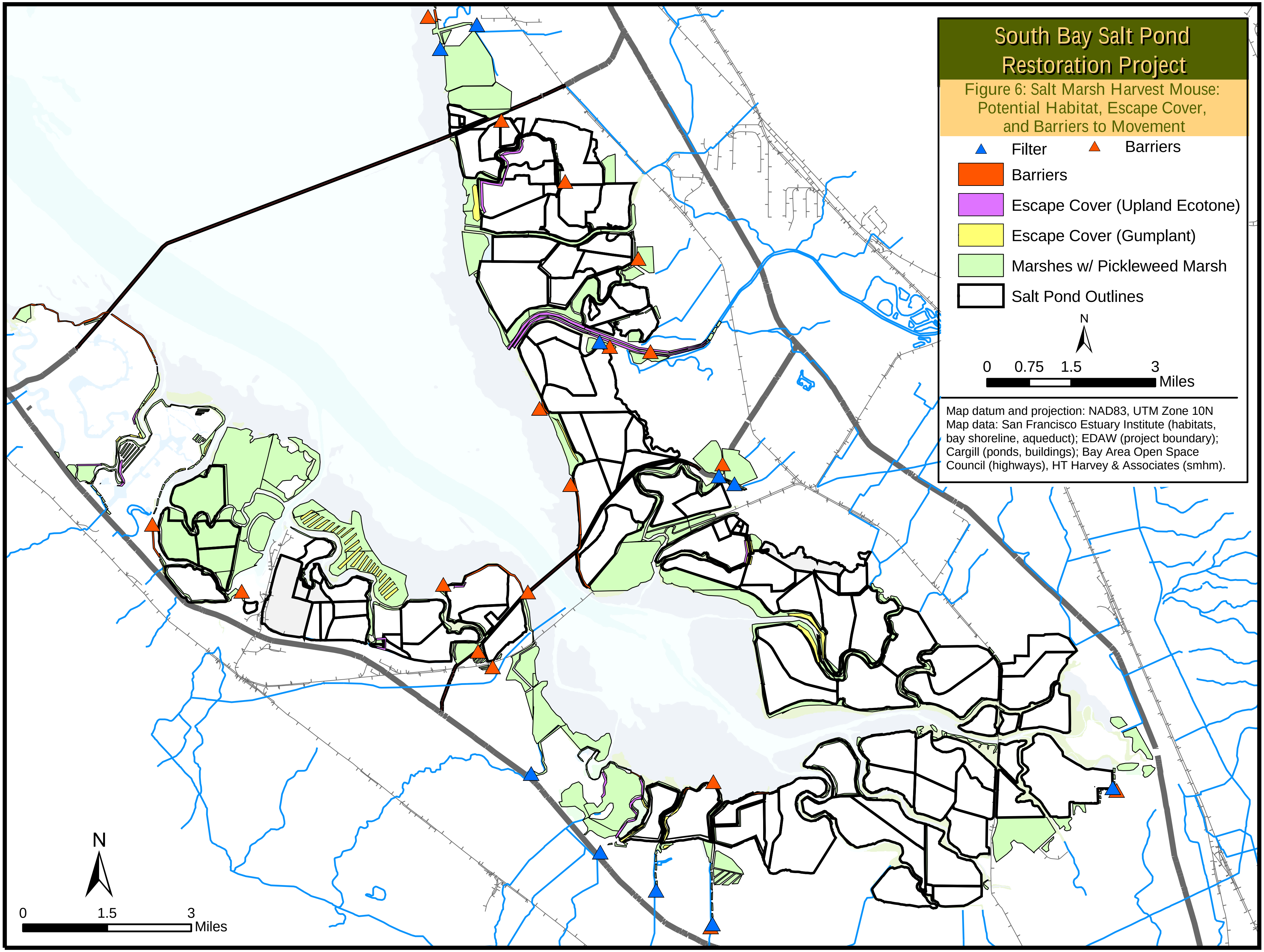


South Bay Salt Pond Restoration Project
Figure 4.
Existing Recreation and Public Access
LEGEND
Project Area
Cargill Salt Pond Operations
CalTrain Line and Station
BART Line and Station
Bay Trail (Association of Bay Area Governments)
EXISTING
Spine Trail
Spur Trail
Connector Trail
PROPOSED
Spine Trail
Spur Trail
Connector Trail
Regional Trails (Bay Area Open Space Council)
Bay Area Ridge Trail Council
City of Hayward
City of Mt. View
City of San Mateo
County of San Mateo Parks Department
County of Santa Clara Parks Department
EBRPD
Hayward Area Recreation District
USFWS
Unknown
Bike Trails (Valley Transportation Authority)
Bike Path
Bike Lane
Crossing
Regional Open Space / Protected Lands (GreenInfo Network)
California Department of Fish & Game
California Department of Fish & Game - New Acquisition
U.S. Fish and Wildlife Service
U.S. Fish and Wildlife Service - New Acquisition
City of Mountain View
City of Palo Alto
City of Redwood City
City of San Jose
City of Sunnyvale
Santa Clara Valley Water District
East Bay Regional Park District
Hayward Area Recreation and Park District
Midpeninsula Regional Open Space District
Peninsula Open Space Trust
Other Open/Protected Space
5,000 2,500 0 5,000 Feet
2,500 1,250 0 2,500 Meters
PUBLIC REVIEW DRAFT
Map datum and projection: NAD83, UTM Zone 10N
Map data: San Francisco Estuary Institute (habitats, bay shoreline, aqueduct); EDAW (project boundary); Cargill (ponds, buildings); Bay Area Open Space Council (highways).
Map by: Megan Gosch, EDAW Inc.
Map date: August 23, 2004
Existing Recreational Facilities
Airport
Bicycle Trail
Boat Launch
Camping
Dogs Allowed
Environmental Education Center
Fishing
Whole Access Trail
Historic Features
Hiking Trail
Hunting Area
Interpretive Trail
Kayak Launch
Picnic Area
Viewing Area
Visitor Center
Parking
Eden Landing
(Baumberg)
NOTE: Hunting on Dept. of Fish & Game lands by public lottery on limited dates
Ravenswood
(West Bay)
Alviso
Hayward Regional Shoreline
Hayward Shoreline
Mt. Eden Park
Weekes Park
Garin/Dry Creek Regional Park
Dry Creek/Pioneer Regional Park
Tyler Park Property
Oliver Salt Works
San Mateo Bridge
San Mateo Pier
Casa Verde Park
Union City Salt Works
Harvey Community Park
William Camm Park
UNION CITY
Charles Kennedy Park
Alameda Creek Quarries Regional Recreation Area
Northgate Park
Ardenwood Historic Farm
Los Cerritos
Coyote Hills Regional Park
Centerville Community Park
Newark Community Park
Mayhews' Landing Park
Visitor Center (and Refuge Headquarters)
Birch Grove Park
Sportsfield Park
FREMONT
Dumbarton Pier
Dumbarton Bridge
Dumbarton Pt.
Green Pt.
FOSTER CITY
Leo J. Ryan Park
Catamaran Park
Sea Cloud Park
Farragut Park
Boothbay Park
Marlin Park
Bair Island
Owned by DFG as Bair Island Ecological Preserve
Redwood Pt.
50% POST 50% Private Trust
Redwood Shores Ecological Preserve
SAN CARLOS
Redwood City Marina
Grecco Island
San Carlos Airport
Ravenswood Pt.
Bayfront Park Recreation Center
Wellesley Crescent Park
Stafford Park
Hoover Park
Andrew Spinas Park
Hetch Hetchy Aqueduct
Codey Landing
Flood Park
Hawes Park
Red Morton Community Park
Fleishman Park
Palm Park
Holbrook-Palmer Recreation Area
PALO ALTO
Willow Oaks Park
Stulsaft Park
Palo Alto Baylands Preserve
Lucy Evans Baylands Nature Interpretive Center
Hooks Is.
Long Pt.
Calaveras Pt.
Burgess Park
Timothy Hopkins Park
Johnson Park
Eleanor Pardee Park
Nealon Park
El Camino Park
Rinconada Park
John Lucas Greer Park
Peers Park
J. Bowden Park
Hoover Park
Ramos Park
Sharon Hill Park
Sharon Park
Boulware Park
Mitchell Park
Bol Park
MOUNTAIN VIEW
Mountain View Shoreline Park
Stevens Creek Nature Study Area
Sunnyvale Baylands
Knapp Tract
Don Edwards Environmental Education Center
Alviso Park
Coyote Cr. Lagoon
Dixon Landing
Drawbridge
Warm Springs
Booster Park
MILPITAS
SAN MATEO COUNTY
SANTA CLARA COUNTY
ALAMEDA COUNTY


South Bay Salt Pond Restoration Project
Figure 5: San Francisco Estuary Institute Historic Baylands Map
LEGEND
Salt Pond Acquisition Levee Boundaries
Other Current Salt Pond Levee Boundaries
Reference Features
Highway
Railroad
Road
County Boundary
Aqueduct
Historic Creek / Stream
Habitats (EcoAtlas Baylands)
Deep Bay / Channel
Shallow Bay / Channel
Channel
Bay Flat
Historical Pans
Old High-Elevation Tidal Marsh
Young Low/Mid-Elevation Tidal Marsh
Salt Pond in Muted Tidal Marsh
Muted Tidal Marsh
Undeveloped Fill
N
5,000 2,500 0 5,000 Feet
2,500 1,250 0 2,500 Meters
Map datum and projection: NAD83, UTM Zone 10N
Map data: San Francisco Estuary Institute (habitats, bay shoreline, aqueduct); EDAW (project boundary); Cargill (ponds, buildings); Bay Area Open Space Council (highways).
Eden Landing
(Baumberg)
Ravenswood
(West Bay)
Alviso
San Mateo Bridge
Dumbarton Bridge
Hetch Hetchy Aqueduct
FOSTER CITY
SAN CARLOS
PALO ALTO
MOUNTAIN VIEW
UNION CITY
FREMONT
MILPITAS
Bair Island
Grace Island
Redwood Pt.
Ravenswood Pt.
Dumbarton Pt.
Green Pt.
Calaveras Pt.
Codey Landing
Sand Pt.
Hooks Is.
Long Pt.
Knapp Tract
Don Edwards San Francisco Bay National Wildlife Refuge Visitor Center
Lucy Evans Baylands Nature Interpretive Center
Don Edwards San Francisco Bay National Wildlife Refuge Env. Education Center
Palo Alto Flood Basin
ALAMEDA COUNTY
SANTA CLARA COUNTY
SAN MATEO COUNTY
SANTA CLARA COUNTY
Alameda Creek Flood Control Channel
Alameda Creek
Old Alameda Creek
Mowry Slough
Coyote Creek
Guadalupe Slough
Alviso Slough
Steinburger Slough
Corkscrew Slough
Redwood Creek
Westpoint Slough
Smith Slough
Ravenswood Slough
Newark Slough
Laguna Creek
Calera Creek
Coyote Creek
Penitencia Creek
Stevens Creek
Permanente Creek
Adobe Creek
Barron Creek
Matadero Creek
San Francisquito Creek
Mallard Slough
Artesian Slough
Mud Slough
Charleston Slough
Mountain View Slough
Stevens Creek
Moffett Channel
E1 E2 E4 E5 E6 E7 E8 E8A E9 E10 E11 E12 E13 E14 E6A E6B E6C E4C E5C E3C E1C E2C
N1 N1A N2 N2A N3 N3A N4 N4A N4B N5 N6 N7 N8 N9 DP1
M1 M2 M3 M4 M5 M6 M7 M8 M10 M10A M11 M12 M13 M26 M27 M28
1 2 3 4 5 6 7 8 9 9A 10 7A 7B 7C 8W
R1 R2 R3 R4 R5 S5 SF2
A1 A2W A2E AB1 AB2 A3N A3W A4 A5 A6 A7 A8 A8S A9 A10 A11 A12 A13 A14 A15 A16 A17 A18 A19 A20 A21 A22 A23
92 880 238 84 101 237



South Bay Salt Pond
Restoration Project
Figure 6: Salt Marsh Harvest Mouse:
Potential Habitat, Escape Cover,
and Barriers to Movement
Filter
Barriers
Barriers
Escape Cover (Upland Ecotone)
Escape Cover (Gumplant)
Marshes w/ Pickleweed Marsh
Salt Pond Outlines
N
0 0.75 1.5 3
Miles
Map datum and projection: NAD83, UTM Zone 10N
Map data: San Francisco Estuary Institute (habitats, bay shoreline, aqueduct); EDAW (project boundary); Cargill (ponds, buildings); Bay Area Open Space Council (highways), HT Harvey & Associates (smhm).
N
0 1.5 3
Miles

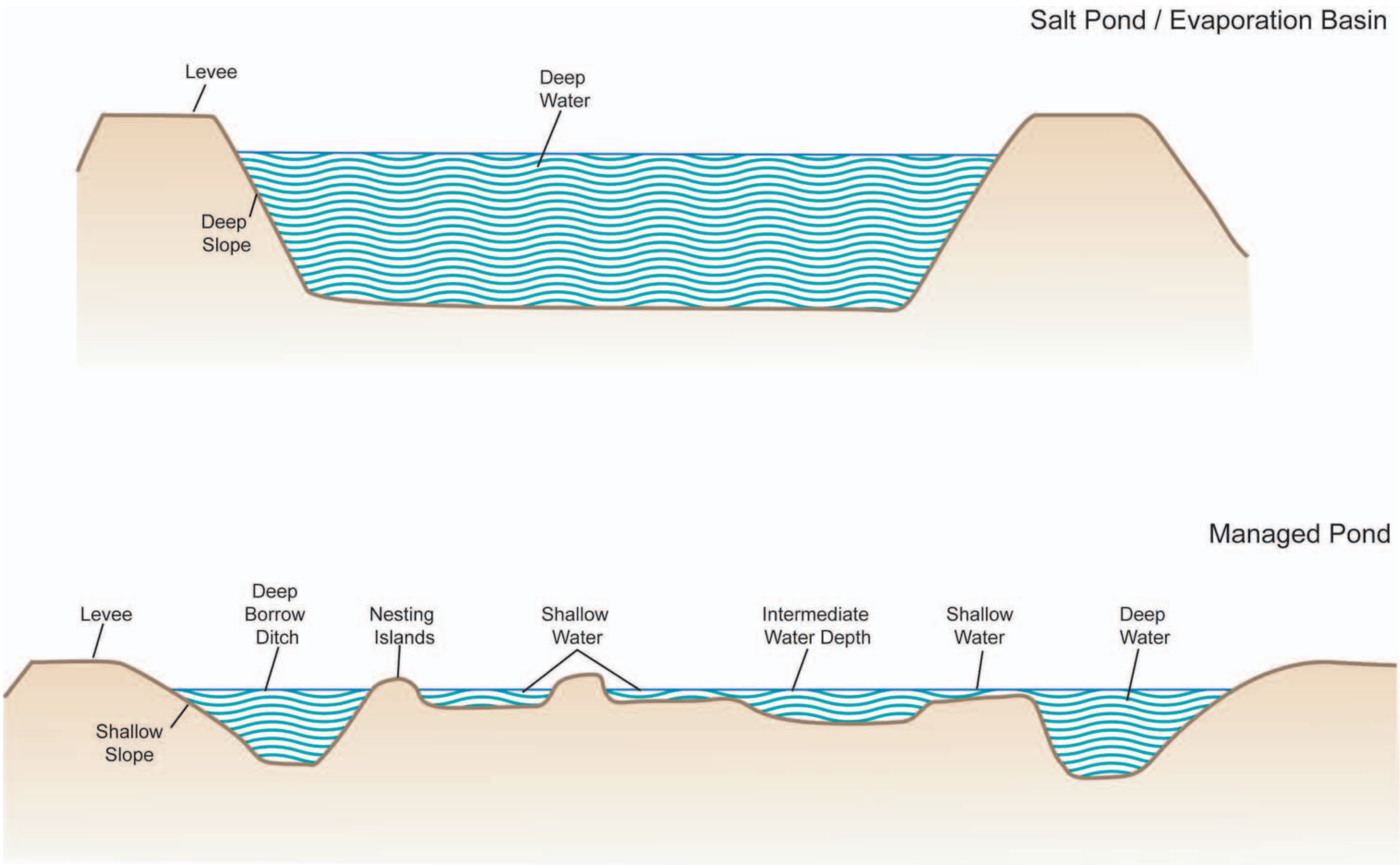


Figure 7: Conceptual Design of a Managed Pond to Maximize Avian Habitat

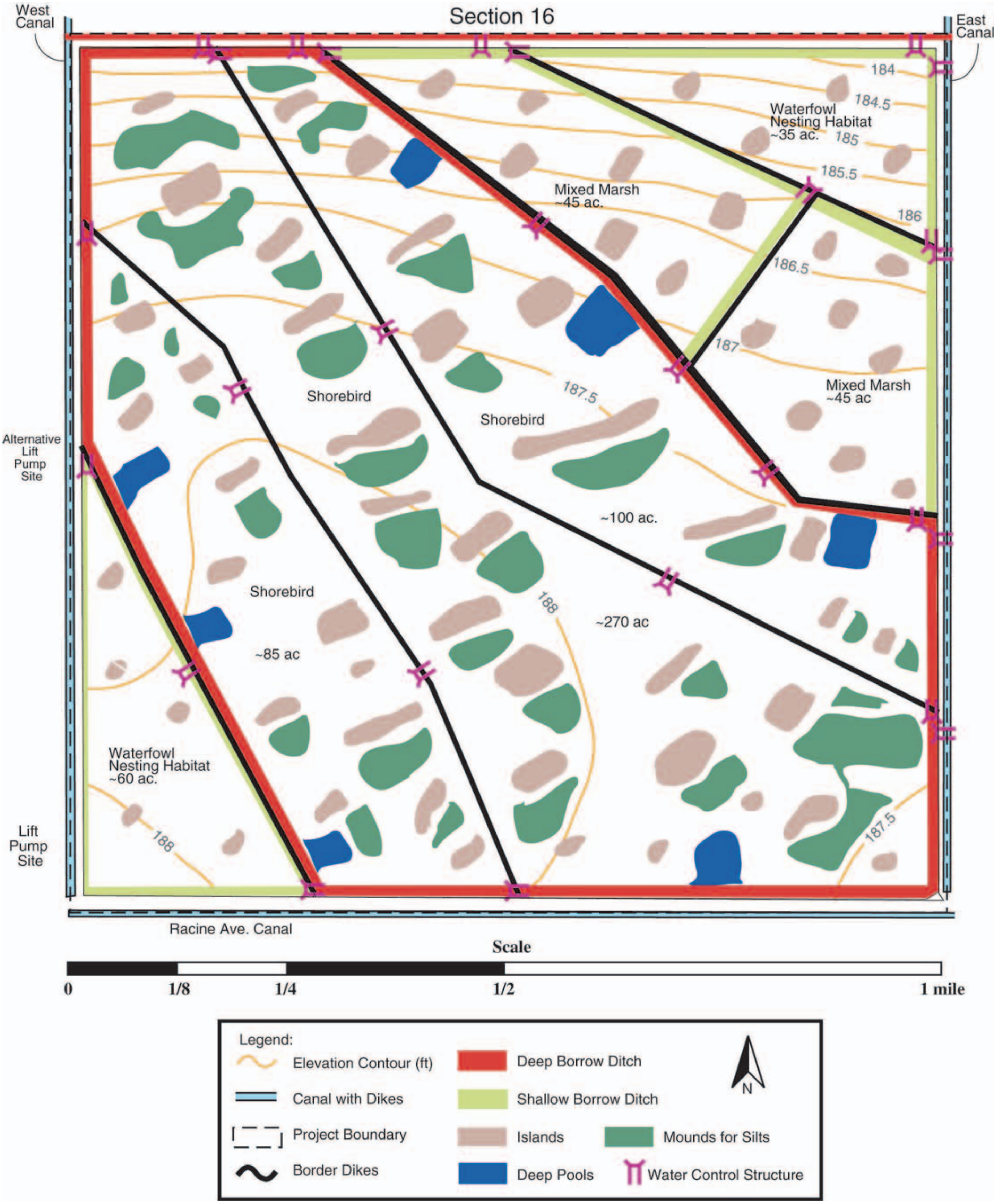
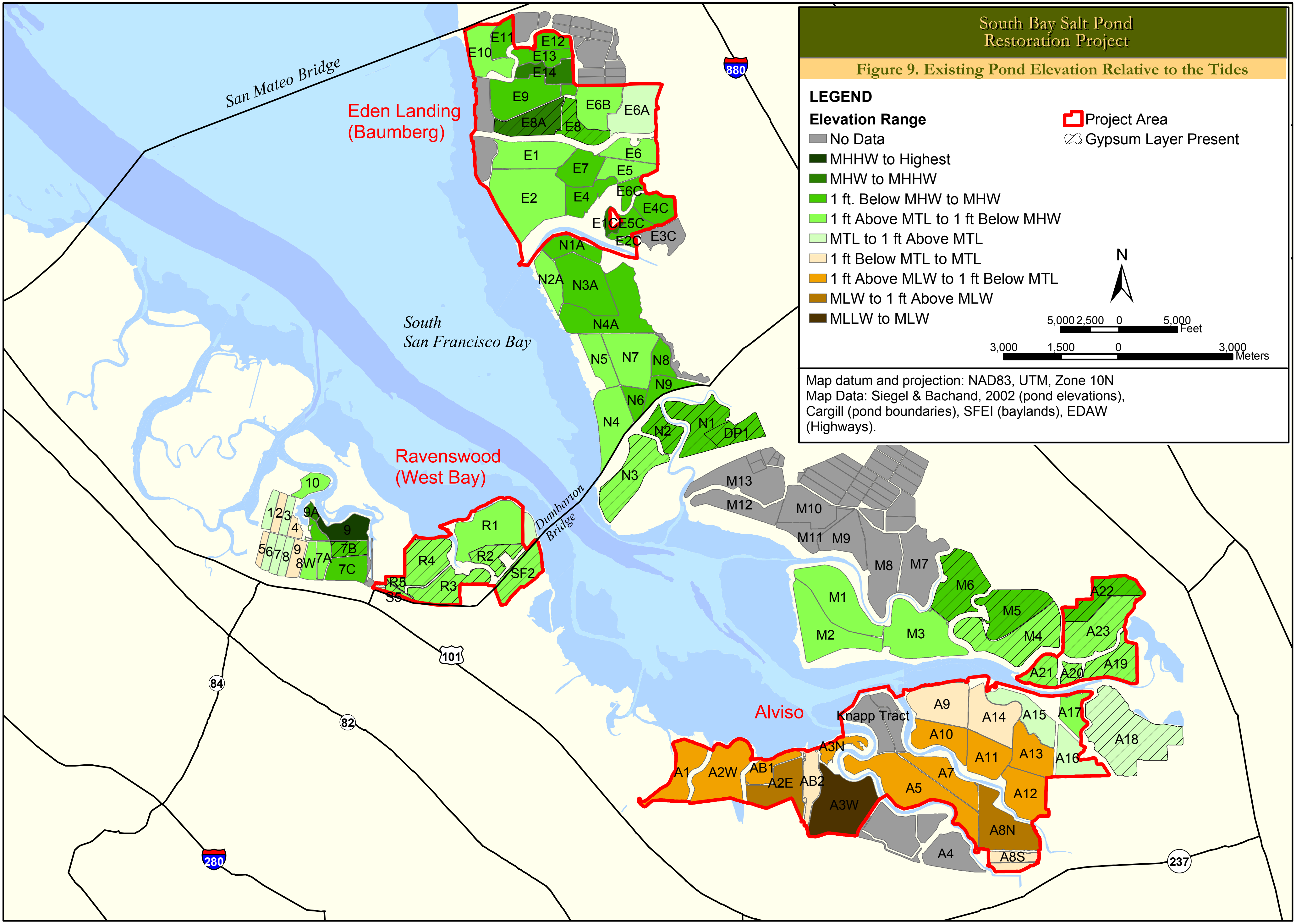
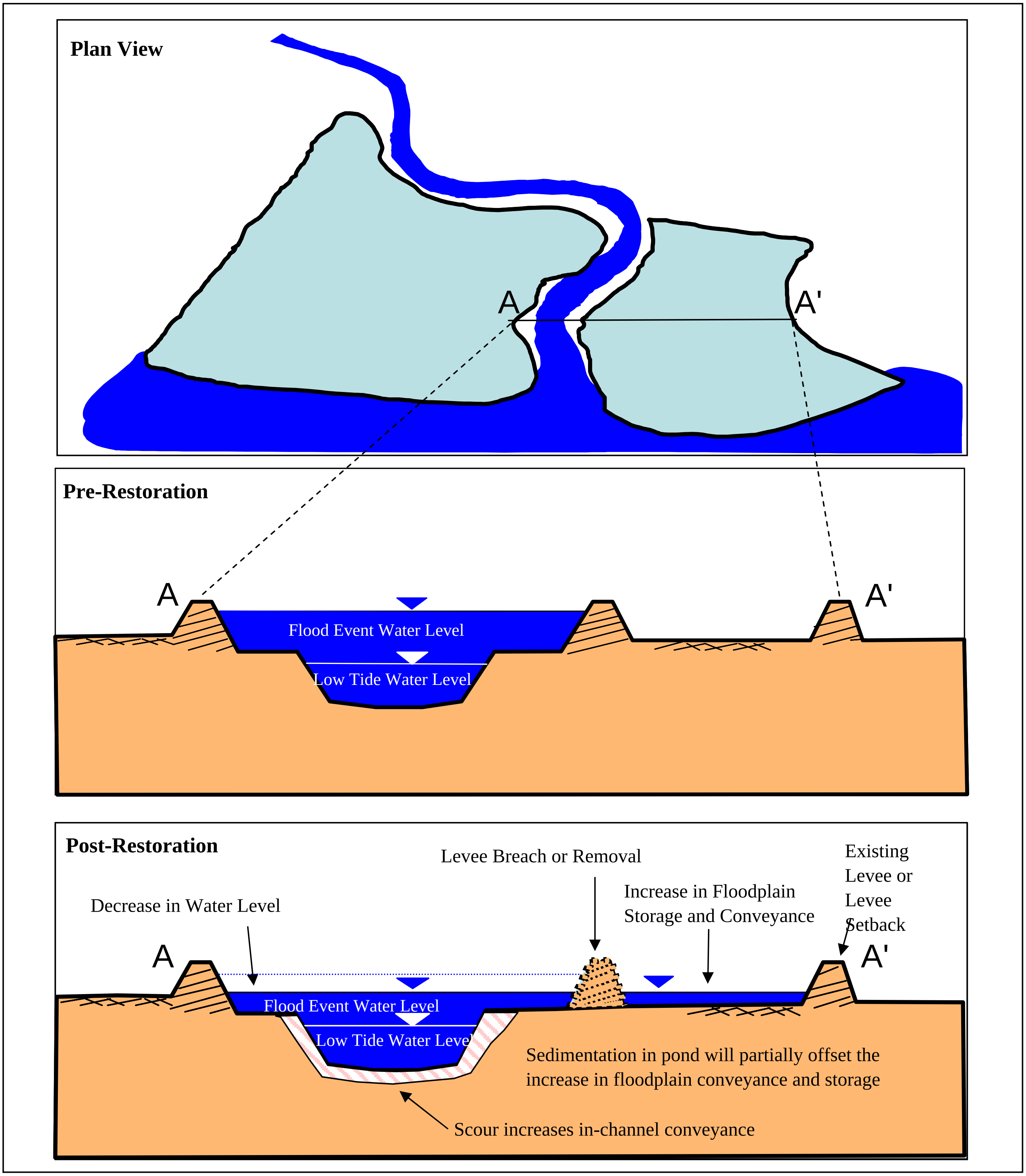


Figure 8: Successful Wetland Demonstration Project Design of a Managed Pond at Westlake Farms

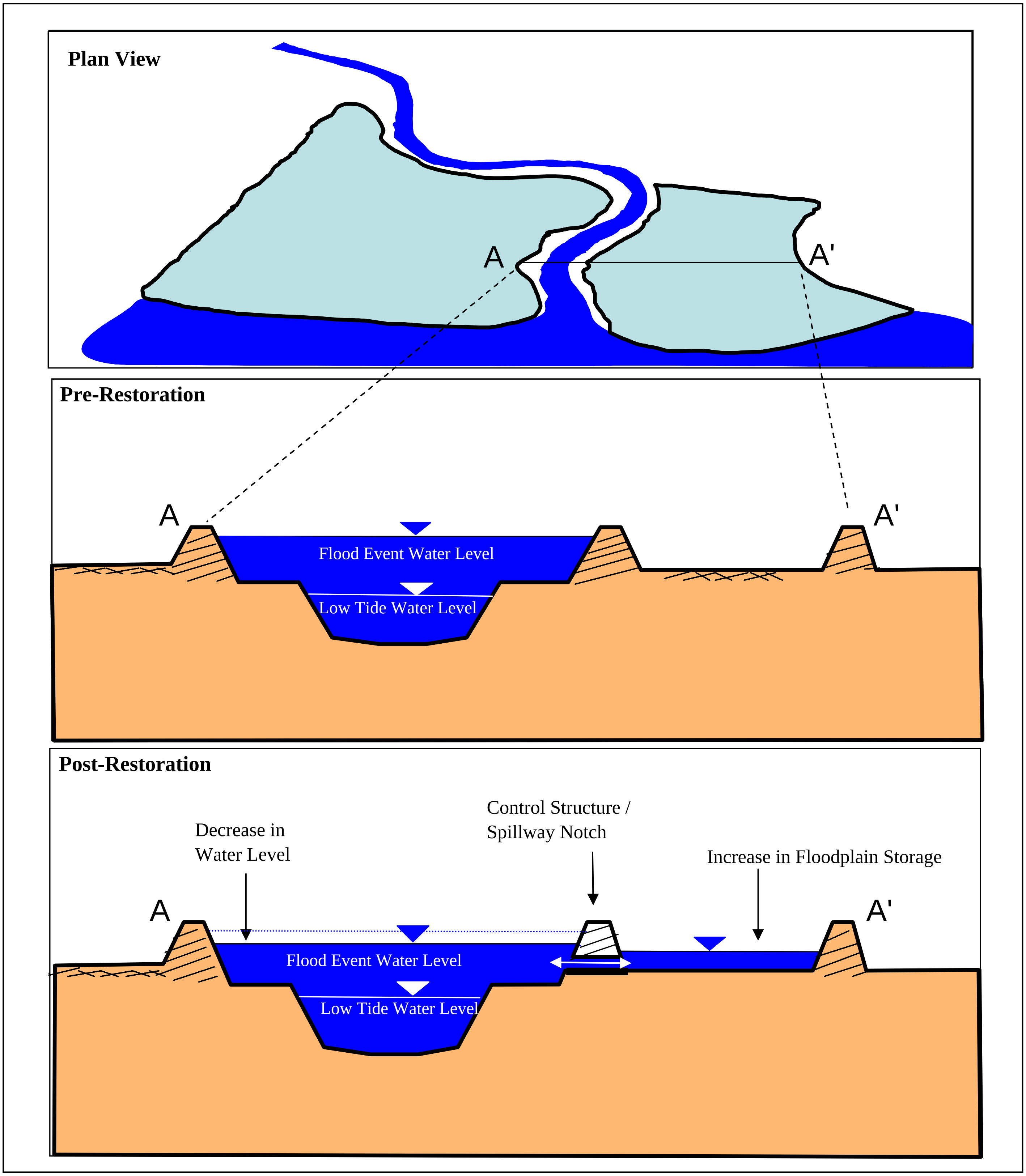


August 16, 2004



Source: PWA (2004)

Figure 10 Salt Pond Conversion to Full Tidal Marsh: Increase in Floodplain Storage and Conveyance



Source: PWA (2004)

Figure 11 Salt Pond Conversion to Managed Pond: Increase in Floodplain Storage

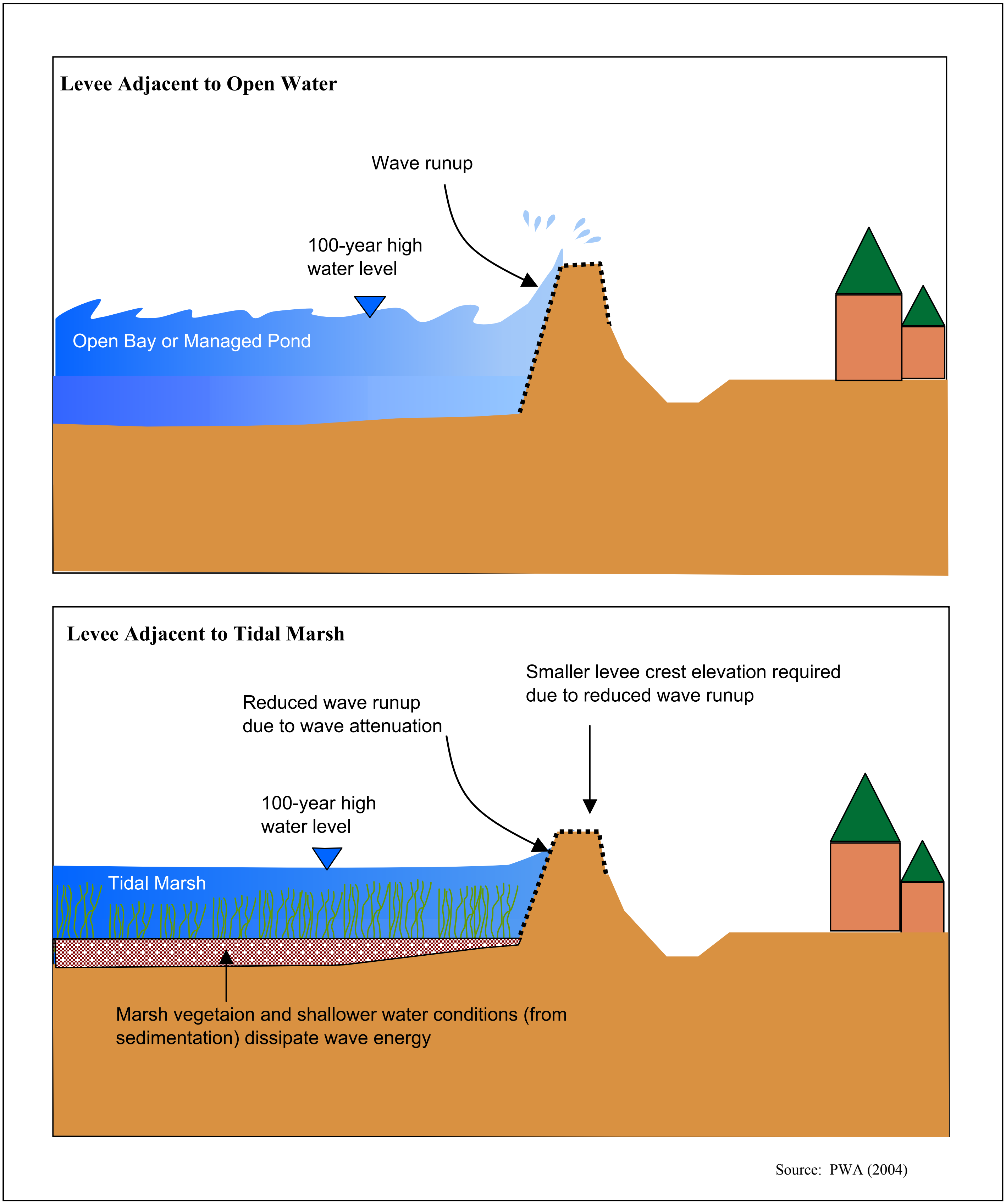
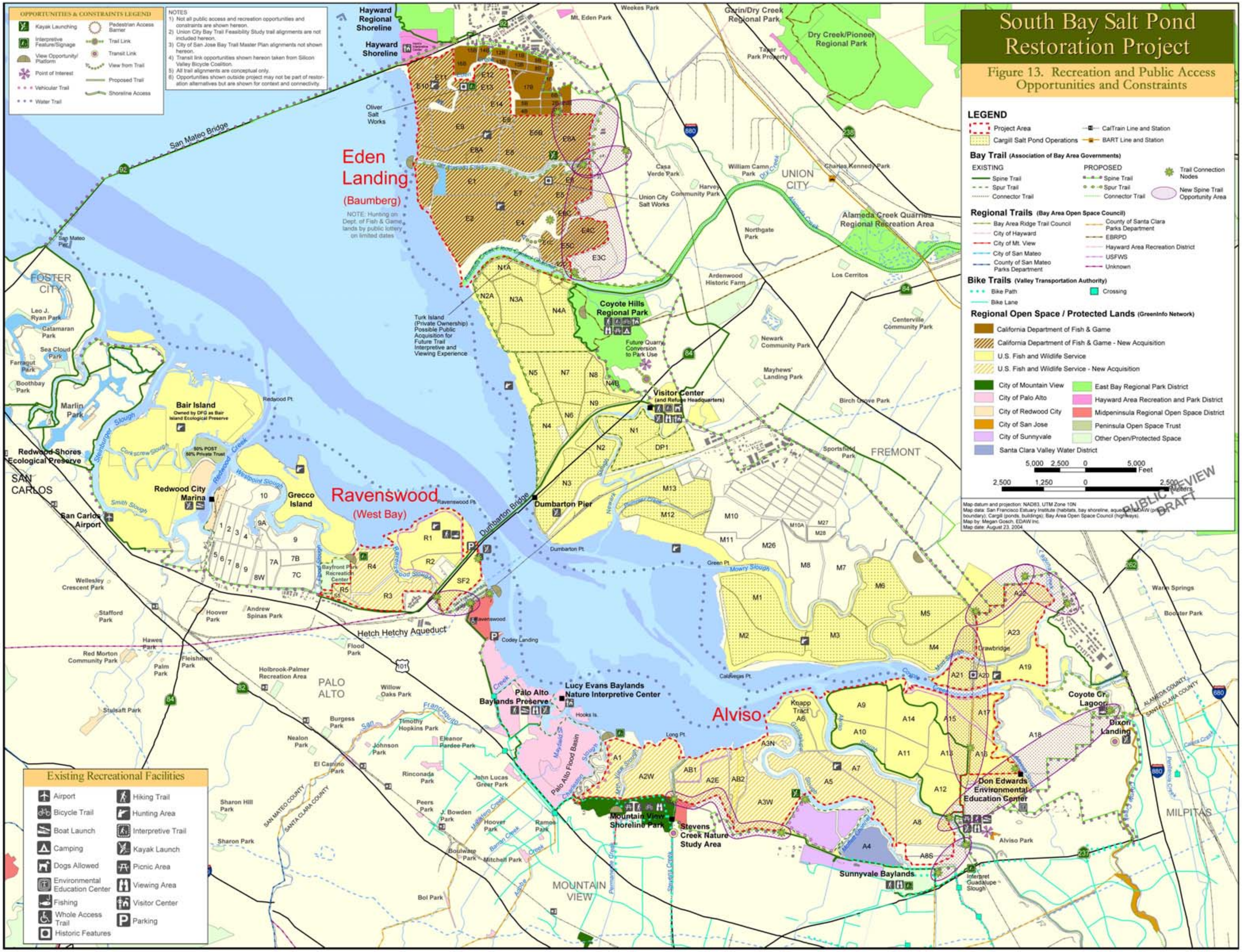
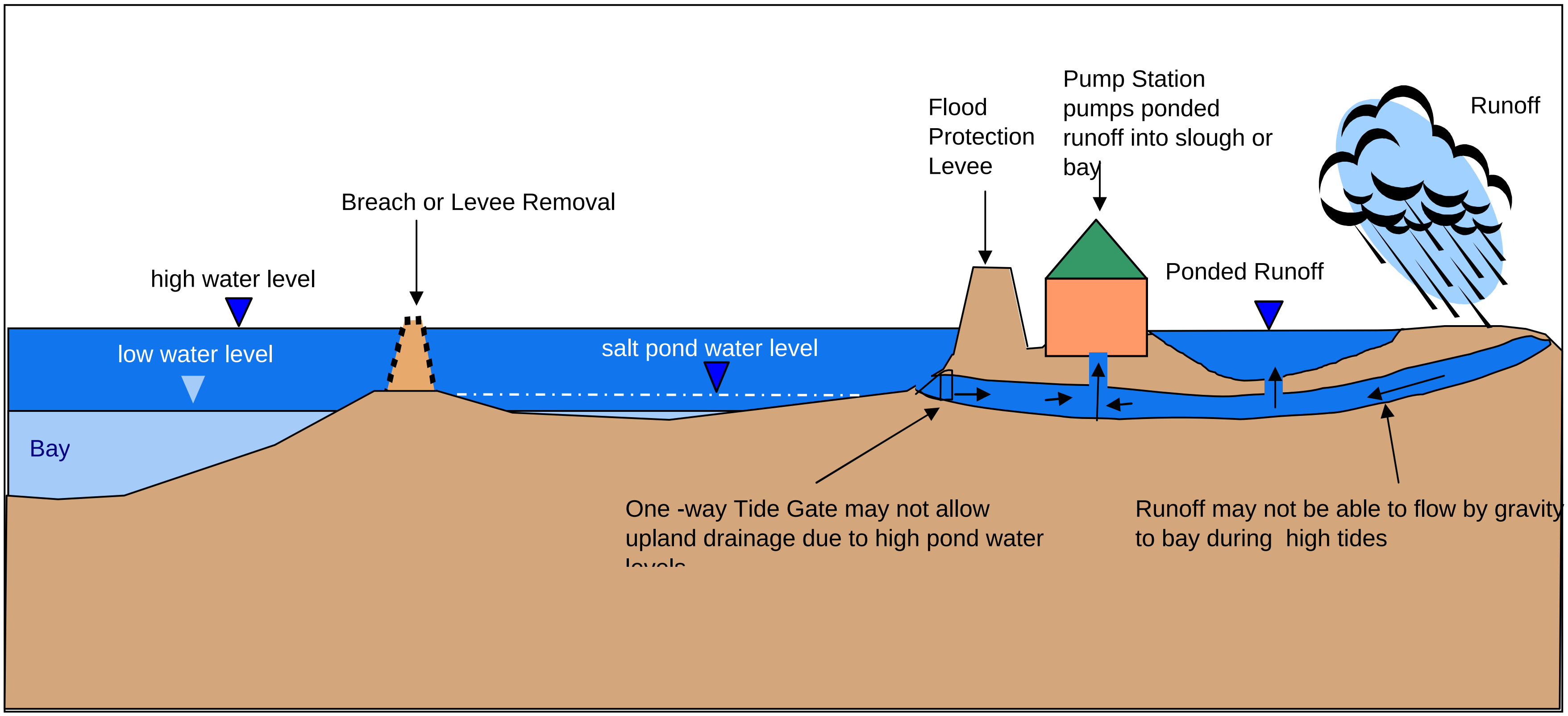


Figure 12 Wave Attenuation by Tidal Wetlands


South Bay Salt Pond Restoration Project
Figure 13. Recreation and Public Access Opportunities and Constraints
LEGEND
Project Area
Cargill Salt Pond Operations
CalTrain Line and Station
BART Line and Station
Bay Trail (Association of Bay Area Governments)
EXISTING
Spine Trail
Spur Trail
Connector Trail
PROPOSED
Spine Trail
Spur Trail
Connector Trail
Trail Connection Nodes
New Spine Trail Opportunity Area
Regional Trails (Bay Area Open Space Council)
Bay Area Ridge Trail Council
City of Hayward
City of Mt. View
City of San Mateo
County of San Mateo Parks Department
County of Santa Clara Parks Department
EBRPD
Hayward Area Recreation District
USFWS
Unknown
Bike Trails (Valley Transportation Authority)
Bike Path
Bike Lane
Crossing
Regional Open Space / Protected Lands (GreenInfo Network)
California Department of Fish & Game
California Department of Fish & Game - New Acquisition
U.S. Fish and Wildlife Service
U.S. Fish and Wildlife Service - New Acquisition
City of Mountain View
City of Palo Alto
City of Redwood City
City of San Jose
City of Sunnyvale
Santa Clara Valley Water District
East Bay Regional Park District
Hayward Area Recreation and Park District
Midpeninsula Regional Open Space District
Peninsula Open Space Trust
Other Open/Protected Space
5,000 2,500 0 5,000 Feet
2,500 1,250 0 2,500 Meters
Map datum and projection: NAD83, UTM Zone 10N
Map by: Megan Gosch, EDAW Inc.
Map date: August 23, 2004
PUBLIC REVIEW DRAFT
OPPORTUNITIES & CONSTRAINTS LEGEND
Kayak Launching
Interpretive Feature/Signage
View Opportunity/ Platform
Point of Interest
Vehicular Trail
Water Trail
Pedestrian Access Barrier
Trail Link
Transit Link
View from Trail
Proposed Trail
Shoreline Access
NOTES
1) Not all public access and recreation opportunities and constraints are shown hereon.
2) Union City Bay Trail Feasibility Study trail alignments are not included hereon.
3) City of San Jose Bay Trail Master Plan alignments not shown hereon.
4) Transit link opportunities shown hereon taken from Silicon Valley Bicycle Coalition.
5) All trail alignments are conceptual only.
6) Opportunities shown outside project may not be part of restoration alternatives but are shown for context and connectivity.
Existing Recreational Facilities
Airport
Bicycle Trail
Boat Launch
Camping
Dogs Allowed
Environmental Education Center
Fishing
Whole Access Trail
Historic Features
Hiking Trail
Hunting Area
Interpretive Trail
Kayak Launch
Picnic Area
Viewing Area
Visitor Center
Parking
Eden Landing
(Baumberg)
NOTE: Hunting on Dept. of Fish & Game lands by public lottery on limited dates
Ravenswood
(West Bay)
Alviso
San Mateo Bridge
Dumbarton Bridge
Hayward Regional Shoreline
Hayward Shoreline
Oliver Salt Works
Union City Salt Works
Coyote Hills Regional Park
Future Quarry Conversion to Park Use
Visitor Center (and Refuge Headquarters)
Turk Island (Private Ownership) Possible Public Acquisition for Future Trail Interpretive and Viewing Experience
Dumbarton Pier
Bair Island
Redwood City Marina
Greco Island
Redwood Shores Ecological Preserve
San Carlos Airport
Bayfront Park Recreation Center
Hetch Hetchy Aqueduct
Lucy Evans Baylands Nature Interpretive Center
Palo Alto Baylands Preserve
Palo Alto Flood Basin
Mountain View Shoreline Park
Stevens Creek Nature Study Area
Sunnyvale Baylands
Don Edwards Environmental Education Center
Coyote Cr. Lagoon
Dixon Landing
Alameda Creek Quarries Regional Recreation Area
Dry Creek/Pioneer Regional Park
Garin/Dry Creek Regional Park
UNION CITY
FREMONT
MILPITAS
PALO ALTO
MOUNTAIN VIEW
FOSTER CITY
SAN CARLOS



Source: PWA (2004)

Figure 14 Upland Tidal Flooding Due to Ponded Runoff