HAMILTON ARMY AIRFIELD WETLAND RESTORATION
FEASIBILITY STUDY
NOVATO, CALIFORNIA

1.0 INTRODUCTION

1.1 Purpose and Scope

This report summarizes the study process and results of the Hamilton Army Airfield Wetland Restoration Feasibility Study. The purpose of the study is to evaluate potential Federal interest in habitat restoration at the Hamilton Army Airfield and the adjacent properties along San Pablo Bay in Marin County, California, and to identify a feasible project which fulfills the Federal interest requirements and meets the needs of the non-Federal sponsor. Project feasibility is assessed in terms of physical, environmental, and economic considerations.

The study area extends over 988 acres along San Pablo Bay. Federal interest requires that a proposed project be in accordance with Federal principles and guidance, comply with applicable environmental laws and statutes, and have the support of a non-Federal sponsor who is willing and able to participate in the cost-sharing requirements for project implementation.

1.2 Study Authority

This Feasibility Study is authorized by a resolution adopted by the United States Senate Committee on Environment and Public Works Resolution, October 29, 1997, that states "*that the Secretary of the Army is hereby requested to review the report of the Chief of Engineers on San Francisco Bay and Tributaries, California, dated December 21, 1976, and any other pertinent reports, with a view to determining whether any modification of the recommendations contained therein are advisable at this time, in the interest of ecosystem protection and restoration, including restoring tidal and seasonal wetlands, and related purposes at the Hamilton Army Airfield and adjacent properties on San Pablo Bay, Marin County, California*."

1.3 Prior Studies and Reports

There have been numerous prior studies and reports relating to this project. Those most relevant are listed below. The remainder of the prior studies and reports are listed in Appendix A. Additional prior studies and reports are listed in the Hamilton Wetland Restoration Plan EIS/EIR.

a. *Final Environmental Impact Statement Hamilton Army Airfield Disposal and Reuse Vol. 1 and Vol. 2.* February 1996. Sacramento District, Army Corps of Engineers, Sacramento, CA. Technical assistance from Jones & Stokes Associates, Inc. The potential environmental effects of reuse including the effects of the proposed disposal action, are described in volume one of this report. A description of the affected environment, environmental consequences and mitigation measures are provided for thirteen resources. The abstract provided in the beginning

of the document states that the disposal action would result in the loss of federally protected wildlife and sensitive plant communities, historic structures, and risk of flooding from reduced maintenance of flood protection facilities. The abstract also states that reuse could result in a range of impacts including loss of wetlands and destruction of cultural resources. Section 4. 11 of this report provides an overview of the biological resources at HAAF. Table E-1 and E-2 are lists of plants and wildlife observed at HAAF. Volume 2 includes Responses to Comments.

b. A Section 204 *Initial Appraisal of the Hamilton Army Airfield Wetland Restoration Project,* prepared in accordance with the Water Resources Development Act of 1992, was submitted to the Commander, U.S. Army Corps of Engineers, in December 1997. The appraisal, which contained the information necessary to enter into Project Study Plan (PSP) negotiations for a cost shared feasibility study, was submitted with the recommendation that it be considered as an Expedited Reconnaissance Study 905(b)(WRDA 1996) Preliminary Analysis. In that same month, Headquarters approved the appraisal as the reconnaissance level document providing the basis for proceeding into the feasibility phase of planning under the General Investigations program. The reconnaissance phase resulted in the execution of a feasibility cost sharing agreement (FCSA) on April 8, 1998.

c. Draft document, *Hamilton Wetlands Conceptual Restoration Plan,* April, 1998. Woodward Clyde, Inc. in collaboration with H.T. Harvey and Associates, Eric Polson, Philip Williams and Associates, Ltd., SCC, the City of Novato and BCDC. This document presents the physical and biological design for the tidal marsh recommended by this study. Portions of this document are incorporated herein.

d. *The Long Term Management Strategy for Bay Area Dredged Material Final EIS/EIR* was published in October 1998. It was a joint effort by the U.S. Army Corps of Engineers (Corps), the Environmental Protection Agency (EPA), the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB), the Bay Conservation and Development Commission (BCDC) and the state Water Resources Control Board (SWRCB). These agencies joined together with navigation interests, fishing groups, environmental organizations, and the public in a cooperative effort to establish a comprehensive Long-Term Management Strategy (LTMS) for Bay Area dredged material. Three alternative long-term approaches were evaluated in this EIS/EIR. Each of these alternatives includes a more balanced distribution of dredged material disposal in a combination of all three of the potential placement environments; at existing sites within the Estuary, offshore in the Pacific ocean, and at a variety of upland or wetland disposal or reuse sites. The goal is to conduct necessary dredging and dredged material disposal in an environmentally sound and economically prudent manner, to maximize the beneficial reuse of dredged material and to develop a coordinated permit review process for dredging projects. HAAF was evaluated as part of a comprehensive review by the LTMS agencies of potential sites for reuse and was found to be a very suitable site for wetland restoration using dredged material.

1.4 Planning Process and Report Organization

The Hamilton Wetland Restoration Plan was developed jointly by the SCC and BCDC. Coordination with other agencies was performed throughout this study to ensure that problems, concerns, and opportunities that could be addressed through water and related land resources

planning received the broadest possible attention. The Hamilton Restoration Group (HRG) met regularly to identify and resolve issues related to wetland restoration at Hamilton Field. Input from the HRG was solicited by the SCC's consultant team and was incorporated into the design. The team completed the *Draft Hamilton Wetlands Conceptual Restoration Plan* in April of 1998.

The Corps of Engineers planning process consists of six steps, which are repeated throughout a study as new and more detailed information is developed. Chapter 2, Problem Identification, provides a description of the study area, and describes the problems and needs which are the focus of this study. In Chapter 3 the steps to the formulation of alternative plans to address the identified problems and needs are discussed. Chapter 4 evaluates and compares the alternative plans and concludes with plan selection. Chapter 5 presents the selected plan. Coordination and public involvement are discussed in Chapter 6 and the study conclusions and recommendations are presented in Chapter 7.

2.0 PROBLEM IDENTIFICATION

2.1 General

This section presents the results of the first and second major steps in the planning process, the specification of water and related land resources problems and opportunities, and the forecast and analysis of water and related land resources in the study area. Presented is a description of the affected environment, problems and opportunities, and planning constraints. The problems this project addresses are the regional decline in tidal marsh habitat and constraints on dredged material disposal capacity in the Bay Area due to environmental and navigation concerns. Opportunities that the project would realize include endangered species habitat restoration, reuse and closure of the airfield, and beneficial reuse of dredged material. The section concludes by presenting the planning objectives developed for this study.

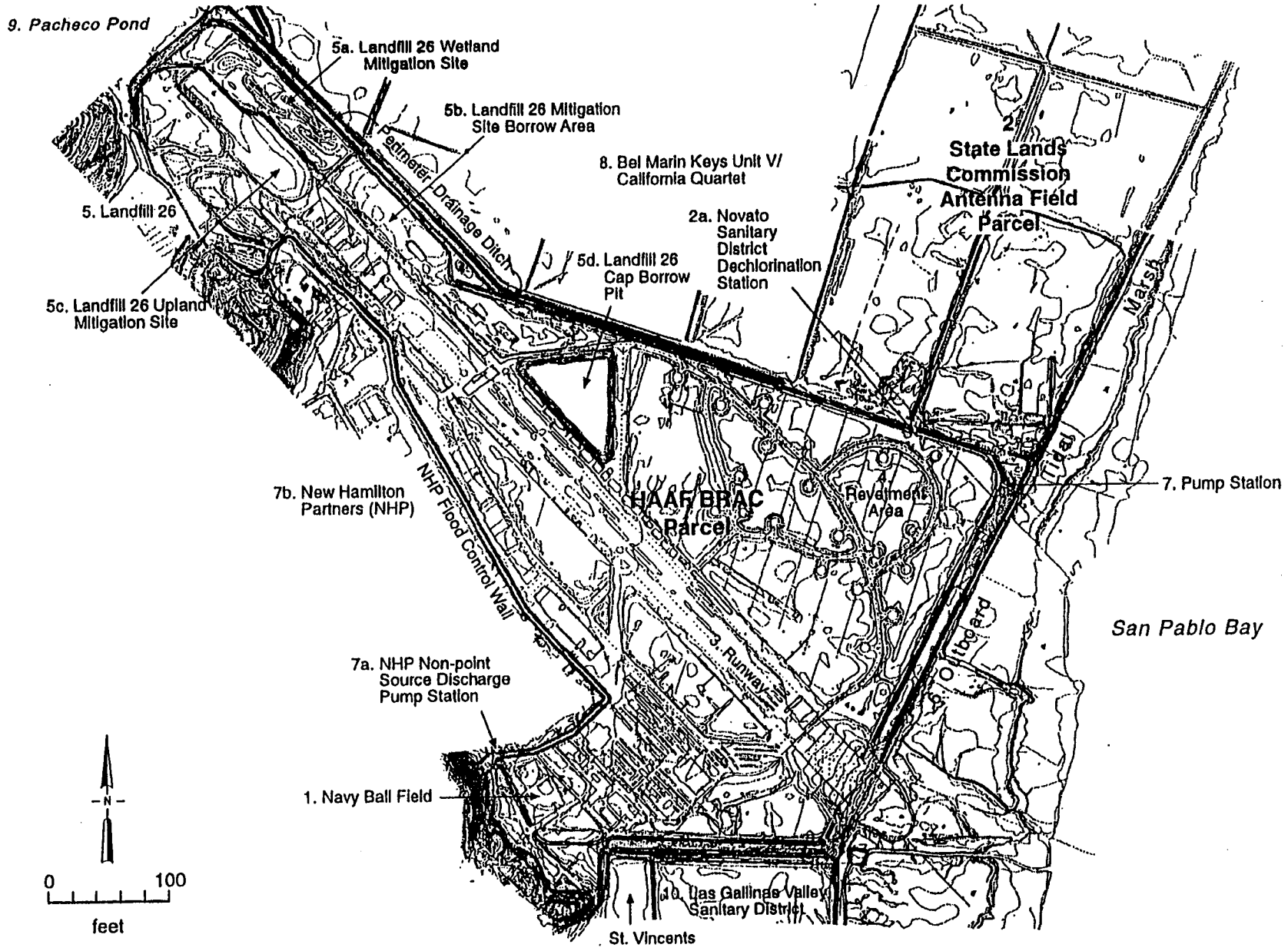
2.2 Study Area Description

The term study area refers to the area that would be affected to a significant degree by implementation of any of the alternative plans considered in this study. The study area consists of three parcels of land; the 644 acre airfield parcel, the 18 acre Navy ballfields to the southwest, and the 314 acre State Lands Commission property (former Hamilton Antenna Field) to the Northeast. (See Figure 2.1) These three parcels occupy 988 acres, which includes 6 acres of levee easment from the city of Novato. This comprises the project site. The remainder of the original 2,184-acre air base is outside the project footprint, and is being developed as residential, light industrial, and open space areas.

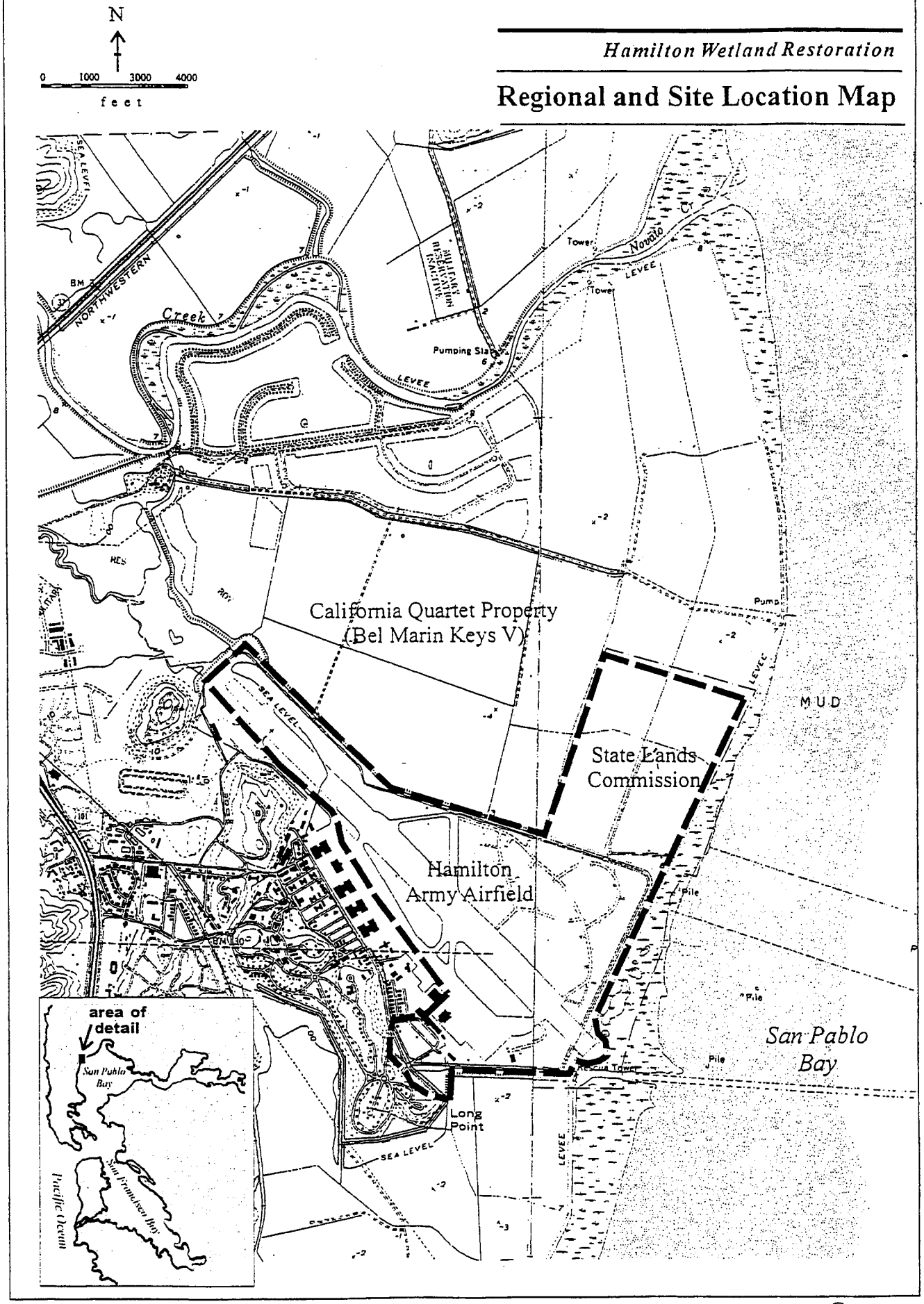
The Hamilton Army Airfield (HAAF) is located 25 miles north of San Francisco on the southeast edge of the City of Novato, Marin County, California. San Pablo Bay is adjacent to the airfield on the southeast side. Properties owned by the St. Vincent Catholic Youth Organization and Las Gallinas Valley Sanitary District lie to the south, while property owned by the California Quartet (Bel Marine Keys V) borders the airfield to the north. (See Figure 2.2) The Novato Sanitary District's sewer outfall pipeline runs along the entire northern boundary of the HAAF site, and the District operates a dechlorination station next to the pipeline about 1,300 feet west of the bayfront levee on the California State Lands Commission (SLC) property. A power supply line extends from HAAF's pump stations to the dechlorination station. The water supply line along the same route has been abandoned.

Antenna installations and associated cables are on the SLC site. Other facilities also on that site include aboveground fuel tanks, transformers, target practice ranges, and burn pits. These facilities are presently being investigated under the Formerly Utilized Defense Sites (FUDS) program prior to the wetland restoration project, and any needed remediation would be implemented.

These properties historically supported tidal salt marsh habitat, but levee construction separated the area from the tidal influence of San Pablo Bay. Subsequent natural and artificial processes have resulted in lowered surface elevations.



Project No. 971185NA	Hamilton Hamilton Wetlands Conceptual Plan	SITE PLAN
Woodward-Clyde		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feet
Hamilton Wetland Restoration
Regional and Site Location Map
California Quartet Property
(Bel Marin Keys V)
State Lands
Commission
Hamilton
Army Airfield
San Pablo
Bay
Long
Point
area of
detail
San Pablo
Bay
Pacific Ocean
San Francisco Bay
NORTHWESTERN
Creek
Novato
LEVEE
SEA LEVEL
MUD
Pile
Tower
Pumping Sta.
BM 30
Rescue Tower

2.2.1 Existing Conditions

Land Use

The airfield parcel includes a 6,000-foot runway, aprons, taxiways, an aircraft dispersal area, and twelve associated small outbuildings. The hangar is being removed as part of the Base Realignment Closure Act (BRAC) process, while the remaining buildings will be demolished and removed by this project prior to restoration.

A six-inch diameter fuel pipeline, formerly used to supply storage tanks that were present on the site, transects the airfield and extends 18,000 feet into the bay. This pipeline has been closed. The pipeline portion lying on upland area has been removed and the remaining portion lying in the bay has been abandoned in place.

A perimeter drainage ditch runs along much of the property line of the HAAF site, but not along the New Hamilton Partnership (NHP) levee. The ditch is classified as a jurisdictional water of the United States. Subdrainage pipes in three areas of the HAAF site discharge to the perimeter drainage ditch and were installed to assist in lowering the water table, as shown on Figure 2.1. Three pump stations (buildings housing pumps, associated equipment, and water conveyance piping) near the northeastern corner of the HAAF site discharge drainage from the perimeter ditch to a channel in the outboard tidal marsh. Power supply lines to the pump stations run along the outboard levee from the south. Drainage outlets from adjacent properties also lead into HAAF's perimeter drainage system.

A wetland mitigation site exists at the northern end of the runway. The 12.4-acre mitigation site was constructed to replace seasonal wetland losses resulting from Landfill 26 closure activities. The mitigation wetland is predominantly emergent marsh dominated by cattail, tules and shallow open water.

Natural Environment

The Hamilton Wetlands Restoration project site was historically dominated by tidal salt marsh habitat but was converted in the late 1800s to agricultural land. In 1931 funds were appropriated for the construction of Hamilton Army Airfield, which was in operation until 1974. Currently the site is mostly grasslands, seasonal wetlands, and developed areas. The only remaining salt marsh in the project area is outboard of the dike that defines the developed portions of both the HAAF and SLC sites. Although the habitats present throughout most of the project site area are structurally simple (i.e., lacking the vertical structure that would be provided by trees and shrubs), a moderately large number of vertebrate species are present in this area, including some special-status species; however, relatively few species of reptiles and amphibians are present. Bird diversity is quite high, but the number of birds using the project site is limited. Species present include ducks, shorebirds, wading birds, passerines (perching, mainly song birds), and many species of raptors (birds of prey) that forage across the entire site.

A U.S. Army Corps of Engineers (USACE) certified wetland jurisdictional delineation of 87 acres on the HAAF site is in effect until February 23, 1999. A wetland delineation, identifying 16 acres of jurisdictional waters of the United States, was performed in January 1998 on the interior portions of the SLC site, and currently is in the process of being certified by the Corps.

A delineation defines the area of wetlands and waters of the U.S. that are subject to the USACE's jurisdiction, pursuant to Section 10 of the Rivers and Harbors Act of 1899, and Section 404 of the Clean Water Act (33 USC 1344). A delineation does not define the functions and values of the wetlands, waters, or other non-delineated areas that may provide value to wetland-associated species. The functions and values of the site are being identified as part of a Habitat Evaluation Procedure conducted by the U.S. Fish and Wildlife Service (FWS).

Tidal marsh habitat: The project site includes 120 acres of high pickleweed marsh. There are 88 acres outboard of the developed portion of the HAAF site. Of this acreage, 66.3 acres are within the HAAF site boundary and the additional 32 acres are outboard of the SLC site. The pickleweed dominated tidal salt marsh along San Pablo Bay provides habitat for a number of bird species, including several special status species, dependent on such habitats, such as the California clapper rail. Shorebirds, generally present during winter as well as spring and fall migration, feed on mudflats at low tide or around the marshes adjacent to ponds and sloughs. Some water birds occur in both fresh water and saline wetlands, including dabbling ducks and wading birds. Although no surveys for the salt marsh harvest mouse have been conducted, it is likely that the tidal marsh supports a population of the mouse, and this study assumes that the species is present.

Seasonal Wetland: The recent SLC site wetland delineation marked the boundaries of the wetlands, but did not quantify the acreage of the site. There are 35.5 acres of seasonal wetland on the project site. A total of 19.5 acres are on the HAAF site (including the 12.4-acre Landfill 26 wetland mitigation site) and 16 acres are on the SLC site. The dominant seasonal wetland species at the HAAF site are salt grass and alkali heath (*Frankenia salina)*. Common wetland plant species on the SLC site include cattail (*Typha* spp.), salt marsh bulrush (*Scirpus maritimus*), and curly dock (*Rumex crispus*). Seasonal wetlands commonly provide high tide refugia (resting areas during high tide) for shorebirds. In addition, the aquatic invertebrates that inhabit the seasonal wetland pools provide forage for shorebirds.

Brackish marsh: Cattail and bulrush colonize a total of 4 acres of marshy sections along the perimeter drainage ditch. Common species in the perimeter drainage ditch include threespine stickleback (*Gasterosteus aculeatus*), mosquito fish (*Gambusia affinis)*, and red-winged blackbirds.

Grassland: 259 acres of the HAAF site (mostly in the revetment area) and nearly the entire SLC site are grassland. This habitat is dominated by ruderal (weedy) upland plants such as bristly ox-tongue (*Picris echioides*), yellow star thistle (*Centaurea solstitialis*), wild radish (*Raphanus sativa*), and curly dock (*Rumex crispus*). Additionally, non-native grasses such as Mediterranean barley (*Hordeum marinum*) and perennial ryegrass (*Lolium perenne*) are common throughout the project site. Grassland and ruderal vegetation around the project site supports relatively few bird species except where coyote bush (*Baccaris pilularis consanguinea*), blackberry (*Rubus* spp.), or patches of dense, tall herbaceous vegetation are present.

Developed Areas: 284 acres of the project site are developed areas consisting of concrete, asphalt, buildings, and bare ground. These areas provide minimal habitat for wildlife. The buildings were surveyed in 1997 for use by special-status bat species and none were present.

Special-Status Species: The following Table (2.1) lists the special-status wildlife species known to occur within the project site. A complete list of potential special-status species is contained in the EIS. Four of the seven species utilize wetland habitat and two of the raptors forage in wetlands and grassland. A survey was conducted for special-status plant species and none were identified (USACE, 1996). No trapping has been conducted to determine the presence of the salt marsh harvest mouse; however, this study assumes that the mouse is present in the existing pickleweed marsh.

TABLE 2.1
SPECIAL-STATUS SPECIES OBSERVED AT HAMILTON ARMY AIRFIELD

Common and Latin Name	Status	Habitat
California clapper rail (*Rallus longirostris obsoletus*)	State and federal endangered	Cordgrass marsh, tidal sloughs
California black rail (*Laterallus jamicensis coturniculus*)	State threatened	Pickleweed marsh and grasses at edge of marsh
San Pablo song sparrow (*Melospiza melodia samuelis*)	State species of special concern	Tidal marsh
Salt marsh common yellowthroat (*Geothlypis trichas sinuosa*)	State species of special concern	Salt marsh and fresh water emergent marsh
Northern harrier (*Circus cyaneus*)	State species of special concern	Marshes and grasslands for foraging
Short-eared owl (*Asio flammeus*)	State species of special concern	Marshes and grasslands for foraging
Burrowing owl (*Spermophilus beecheyi*)	State species of special concern	Grassland with ground squirrel burrows

Hazardous, Toxic, and Radiological Wastes (HTRW)
The Hamilton Army Airfield has been in the Base closure process since 1974. Twenty acres of the airfield are considered contaminated with relatively low levels of petroleum hydrocarbons, volatile and semi-volatile compounds, polychlorinated biphenyls, herbicides, pesticides and metals. Soils contaminated by Army activities on the HAAF parcel are concentrated around underground storage tanks (UST's), above ground storage tanks (AST's), an aircraft maintenance facility, transformer and generator sites, a former sewage treatment plant, two burn pits, perimeter drainage ditch sediments, and coastal marsh sediments. A more detailed discussion of site contamination is provided in Chapter 10 of the restoration plan EIS.

The SLC parcel was also part of the military complex in the past and has more recently been used by the Novato Police Department for target practice. Assessment and investigation of the potential contamination in the SLC parcel has yet to be performed. Potentially contaminated sites include a rifle range, a former firefighting facility, a pistol range, a night firing range,

transformers, and miscellaneous UST's and AST's. Several unexploded grenades (expected to be practice grenades) were recently found on this parcel.

The U.S. Army is implementing a remediation program under the BRAC 1988 process to restore the airfield to a condition protective of human health and the environment for reuse as a wetland area, and is further coordinating its remediation technical studies with the State's efforts to restore a valuable wetlands ecosystem. The State Lands property is being remediated under the Formerly Used Defense Sites (FUDS) program. All contaminants on these properties will be remediated to support reuse prior to site transfer. A combination of confirmatory sampling, toxicity testing, and ecological and human health risk assessments will provide information used to determine final cleanup goals in a focused feasibility study during 1999. The Army intends to have the site remediated and available for reuse by January 2000.

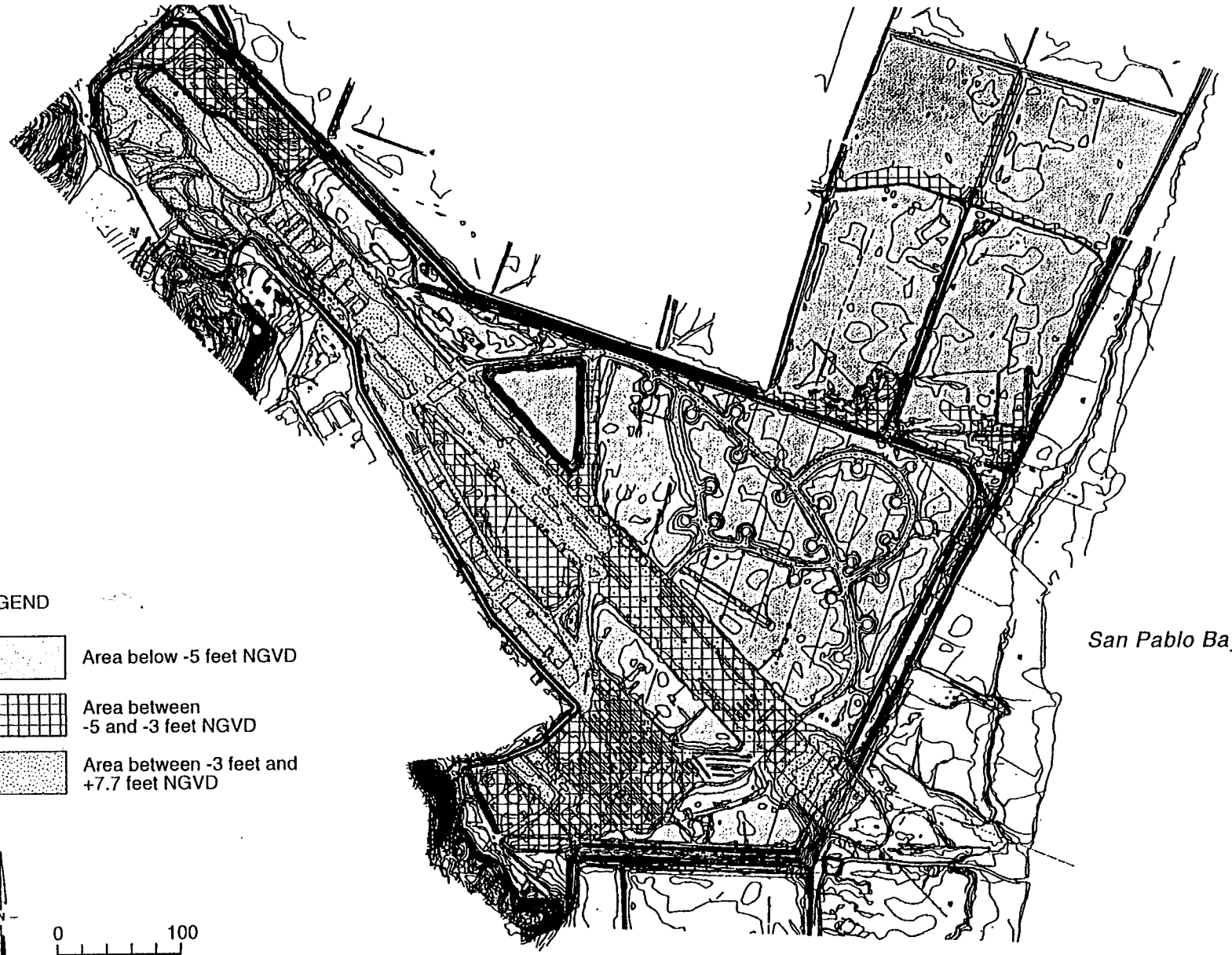
The site has been the property of the military since 1930. Prior to that time it was farmed. Pre-WWII farming did not involve the use of significant contaminants and therefore there is no reason to believe that there are any potential concerns other than those resulting from the military use of the site, which is being addressed as part of the BRAC and FUDS efforts described previously. Soil samples taken by the Army to establish background levels at Hamilton for heavy metals are consistent with this analysis. Finally, the project site is a diked historic bayland similar to other diked areas that have been restored to tidal action, such as the nearby Sonoma Baylands Project, and therefore it can be concluded that the site substrate is compatible with the wetlands restoration project

Regional Hydrology

The San Francisco Bay estuary is one of the largest and most significant estuaries along the western coast of the United States. Over 40 % of California's land area and 60% of the volume of the state's runoff, drains into the estuary (EPA et al., 1996). The Hamilton Wetlands Restoration site is located along the northwestern shore of San Pablo Bay, in the northern reach of the estuary (Figure 2.2).

San Pablo Bay is a large, shallow estuary. Typical water depths in San Pablo Bay are 6 feet at low water. A naturally deeper, periodically dredged, navigational channel of 35 feet extends over the length of the Bay between Point San Pedro and Carquinez Strait. A 3,500-foot-wide expanse of mudflat in San Pablo Bay, adjacent to the project site, is exposed at low tide.

San Pablo Bay is subject to semidiurnal tides with a 6-foot range. Tidal characteristics for San Pablo Bay at the mouth of the Petaluma River 4 miles north of HAAF are presented in Table 2.2 and Figure 2.3. Monthly variation in tidal fluctuations (not shown in Table 2.2) create cycles of extreme high and low tides, called spring tides, and less pronounced tides, called neap tides. The values in Table 2.2 are for current mean sea level elevations for San Francisco Bay. Mean sea level is expected to rise by 1-foot per 100 years as a result of global warming trends, including the "greenhouse effect" (IPCC, 1996). The 100-year tide is based on an estimate of 6.5 feet National Geodetic Vertical Datum (NGVD) by the USACE (1984). Phillip Williams and Associates, Ltd. (PWA) has adjusted this value upward to 7 feet to account for the effects of a number of factors: mean sea level rise; wind-induced set-up within San Pablo Bay; wave runup



Project No. 971185NA	Hamilton Hamilton Wetlands Conceptual Plan	EXISTING ELEVATIONS ON THE PROJECT SITE
Woodward-Clyde		

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on the adjacent mudflat; flood runoff from the Sacramento-San Joaquin Delta; and uncertainties in the USACE's estimation methods (Knuuti, 1995).

Regional drainage features are shown on Figure 2.4. Pacheco Creek traverses the southwestern side of the overall Hamilton area. Pacheco Creek drains into Pacheco Pond, located adjacent to the base's northwestern boundary. Arroyo San Jose, a slightly larger stream draining a 5.4-square-mile area, also drains into Pacheco Pond, but does not cross base property. Pacheco Pond provides temporary storage prior to draining through flap-gates to Novato Creek, which is fully tidal at its confluence with the Pacheco Pond outflow. Although Pacheco Creek, Arroyo San Jose, Novato Creek, and Pacheco Pond are not connected to the HAAF site drainage during average runoff conditions, they become important sources of flow to the site during flood conditions. This issue is discussed further in the following local hydrology section.

TABLE 2.2
TIDAL CHARACTERISTICS AT HAMILTON ARMY AIRFIELD
(based on Petaluma River Entrance Tide Gauge #941-5252)

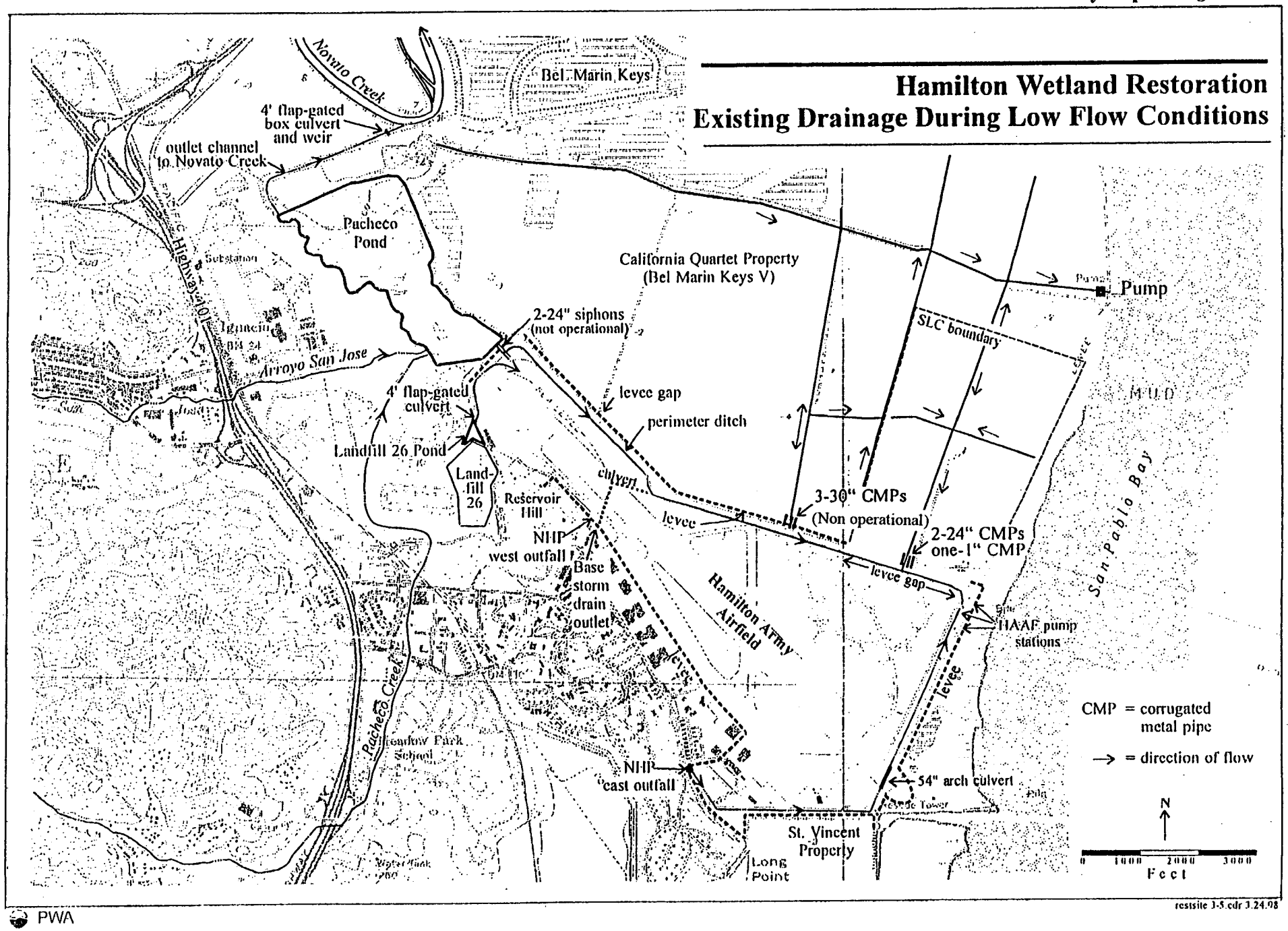
	NGVD Datum (feet)	MLLW Datum (feet)
100-year high tide	7.00	9.63
10-year high tide	6.00	8.63
Mean highest annual tide	4.68	7.31
Mean Higher High Water (MHHW)	3.43	6.06
Mean High Water (MHW)	2.86	5.49
Mean Tide Level (MTL)	0.61	3.24
Mean Low Water (MLW)	-1.63	1.00
Mean Lower Low Water (MLLW)	-2.63	0.00

Note: NGVD is mean sea level of 1929. Tidal terms are defined in Appendix B.

Sources: USACE SFD (1984), Tides and Currents tide prediction software, and National Oceanic and Atmospheric Administration (NOAA) tidal benchmark data.

Local Hydrology

Surface water runoff from the areas west of the project site is carried by Pacheco Creek and Arroyo San Jose. Historically, these streams were part of a network of natural channels that drained through the low-lying area, where Ignacio Reservoir is now located, to Novato Creek. Pacheco Creek and Arroyo San Jose both have their headwaters on Big Rock Ridge, at elevations of 1,300–1,600 feet NGVD. Pacheco Creek has a watershed area of 1.9 square miles and Arroyo San Jose has a watershed area of 5.4 square miles, which is a tributary to Ignacio Reservoir. Ignacio Reservoir drains to Novato Creek through a leveed channel with a flap gate outlet (Bissell & Karn/Greiner 1993 and unpublished Corps data). Figure 2.4 shows regional drainage features in the area.


Hamilton Wetland Restoration
Existing Drainage During Low Flow Conditions
Novato Creek
Bel Marin Keys
4' flap-gated box culvert and weir
outlet channel to Novato Creek
Pacheco Pond
California Quartet Property (Bel Marin Keys V)
Pump
2-24" siphons (not operational)
SLC boundary
Arroyo San Jose
4' flap-gated culvert
levee gap
perimeter ditch
Landfill 26 Pond
Land-fill 26
Reservoir Hill
culvert
3-30" CMPs (Non operational)
2-24" CMPs one-1" CMP
levee
NHP west outfall
Base storm drain outlet
Hamilton Army Airfield
HAAF pump stations
San Pablo Bay
Pacheco Creek
NHP east outfall
54" arch culvert
St. Vincent Property
Long Point
CMP = corrugated metal pipe
→ = direction of flow
N
0 1000 2000 3000
Feet
resisite 3-5.cdr 3.24.08

PWA

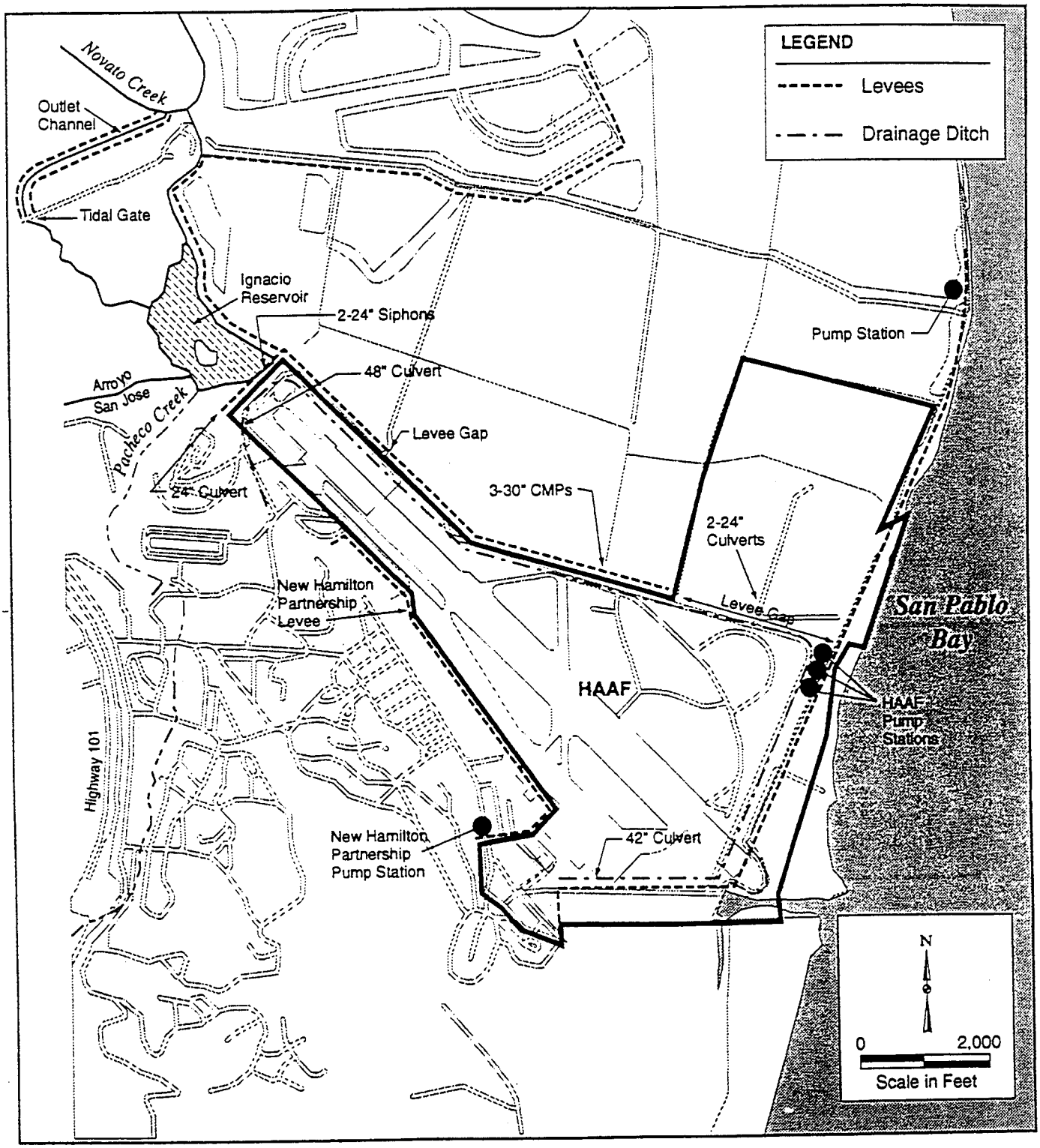
The HAAF, SLC, and California Quartet (Bel Marin Keys V) parcels and the St. Vincent's and Las Gallinas properties (located south of the HAAF parcel) are all served by local drainage facilities, including drains, channels, culverts, and pump stations with outfalls into San Pablo Bay. Ground elevations in these areas are generally from 0 to -4 feet NGVD, several feet below the mean higher high water elevation of 3.4 feet. The general pattern of drainage on and near the project site is shown in Figure 2.5. Major drainage features and hydrologic resources in the project area are described briefly below.

Pacheco Creek: Pacheco Creek originates on Big Rock Ridge 3 miles west of HAAF at an elevation of 1,300 feet. The creek crosses U.S. Highway 101 near the Alameda del Prado/Nave Drive, and crosses Nave Drive, Marin Valley Road, Bolling Drive, Main Entrance Road, and State Access Road in a series of culverts. The computed 10-year and 100-year peak discharges for Pacheco Creek are 470 and 770 cubic feet per second (cfs), respectively (Bissell & Karn/Greiner 1993). With the exception of low-lying areas near Ammo Hill, the 10-year peak discharge is contained within the creek banks, culverts, and road crossings in the vicinity of the project site. The capacity of Pacheco Creek is substantially lower near the southern and western sides of Ammo Hill than it is upstream, resulting in overflow of the banks during even low flows near Ammo Hill.

The peak 100-year discharge exceeds the channel and culvert capacities in several locations, including Bolling Road, Main Entrance Road, and the area near Ammo Hill. The 100-year peak discharge would also flood the areas between Bunker Hill and Ammo Hill that are at elevations less than 10 feet. The creek passes between Ammo Hill and Bel Marin Keys Industrial Park before discharging into Ignacio Reservoir (Pacheco Pond).

The Army recently completed construction of a berm around a portion of Landfill 26. The purpose of the berm is to protect the landfill from overflow from Pacheco Creek up to the 100-year flood.

Arroyo San Jose: Arroyo San Jose also originates on Big Rock Ridge 5 miles west of the HAAF parcel at an elevation of 1,600 feet. The creek crosses U.S. Highway 101 near the Ignacio Boulevard/Bel Marin Keys Boulevard interchange and discharges into Ignacio Reservoir. Arroyo San Jose has a watershed of 5.4 square miles, and the computed 10-year and 100-year peak discharges are 1,200 and 2,300 cfs, respectively (Bissell & Karn/Greiner 1993). The 10-year peak discharge is contained within the channel banks and road crossings between U.S. Highway 101 and Ignacio Reservoir. High tides on San Pablo Bay raise the water surface elevation in Ignacio Reservoir and affect water surface elevations in the lower portion of Arroyo San Jose and Pacheco Creek. The 100-year peak discharge would cause flooding in the Los Robles Mobile Home Park and the Bel Marin Keys Industrial Park if accompanied by a high tide on San Pablo Bay (Bissell & Karn/Greiner 1993). At lower tides, the 100-year peak discharge is not expected to cause flooding in these areas.



Jones & Stokes Associates, Inc.

Figure 2.5
Regional Drainage Features

Ignacio Reservoir: Both Pacheco Creek and Arroyo San Jose discharge into Ignacio Reservoir (also called Pacheco Pond). This reservoir was built by the Marin County Flood Control and Water Conservation District (MCFCWCD) and is operated jointly by MCFCWCD and the California Department of Fish and Game. The reservoir occupies 120 acres and has a storage capacity of 480 acre-feet (unpublished Corps data). The reservoir discharges to Novato Creek through a leveed channel with a flap gate at the outlet. The outlet is located at the Bel Marin Keys Boulevard bridge. High tides in San Pablo Bay prevent outflow from Ignacio Reservoir and may cause flow reversal in the outlet channel if the flap gates do not operate properly (Bissell & Karn/Greiner 1993). Ground elevations near the reservoir are near mean sea level.

The reservoir was constructed to provide flood protection by providing storage for discharges from Pacheco Creek and Arroyo San Jose. However, the storage capacity of the reservoir is not always adequate to provide 100-year flood protection and prevent overflow of the reservoir. For example, during a high tide of 7 feet, the reservoir would need a capacity of 600 acre-feet to accommodate 100-year inflows from Pacheco Creek and Arroyo San Jose (unpublished Corps data). The reservoir is also operated to provide freshwater wetland and wildlife habitat. Flashboards are used at the outlet to control water levels during nonflood periods.

Two 24-inch siphons were installed by the U.S. Air Force to provide an overflow from the reservoir onto the HAAF parcel (Bissell & Karn/Greiner 1993). The siphons were designed to prevent overtopping and damage to the airfield levee, but they are no longer operational. According to the draft restoration plan, the reservoir instead overtops levees to flow into agricultural fields north of the reservoir, into Novato Creek, and into the California Quartet (Bel Marin Keys V) parcel. Low points in the levees between Ignacio Reservoir and Novato Creek, and between the reservoir and agricultural lands to the northeast, are 6.2 feet and 8.0 feet, respectively.

California Quartet (Bel Marin Keys V): The California Quartet (Bel Marin Keys V) (BMKV) parcel is currently in agricultural use and is drained by a system of channels. Under normal runoff conditions, most of the runoff from the parcel drains to a pump station at the northeast corner of the property that discharges to San Pablo Bay. 100 acres drain to the channel system on the SLC parcel to the east, and these flows are conveyed by gravity to the HAAF perimeter ditch system through two 24-inch culverts (described above).

Under flood conditions (greater than 10-year events, according to the draft restoration plan), the California Quartet (Bel Marin Keys V) parcel receives overflows from Ignacio Reservoir and from the HAAF parcel through a levee gap 2,000 feet southeast of the northwest corner of the HAAF property. Flood overflows cause ponding on the BMKV parcel under current conditions and leave the property either by overflowing the drainage divide between the BMKV and SLC parcels or through three 30-inch culverts through the HAAF perimeter levee.

California State Lands Commission (SLC) Parcel: The SLC parcel presently drains to the HAAF perimeter ditch system through a network of channels on the SLC parcel. Flows in the channel system are conveyed to the HAAF perimeter ditch system near the Novato Sanitary district (NSD) dechlorination facility in two 24-inch pipes. The HAAF perimeter ditch system conveys these flows to HAAF pump stations that discharge to San Pablo Bay.

St. Vincent's Property: The St. Vincent's property south of HAAF is served by a system of drainage channels that discharge through a pump station to San Pablo Bay. In general, ground elevations on the St. Vincent's property drain away from HAAF, and most of this property does not contribute flows to the perimeter ditch system. However, a channel along the northern boundary of the St. Vincent's property intercepts flows from the western portion of the former DOD housing and Long Point peninsula area. The former DOD housing remains in use, but has been converted to non-military housing. A portion of the St. Vincent's property also drains to this channel. In addition, overflows from the drainage system on the St. Vincent's property may flow to this channel during periods of high runoff. The channel carries flows to a culvert crossing of the HAAF perimeter levee near the southwestern corner of the airfield and then into the perimeter ditch (unpublished Corps data). The channel carrying flows from the former DOD housing area may also overtop onto the St. Vincent's property, where these flows are intercepted by the St. Vincent's property drainage system and conveyed to the associated pump station.

Hamilton Army Airfield Drainage: Drainage from the HAAF parcel is collected in a perimeter ditch system and conveyed to three pump stations on the margin of San Pablo Bay. The drainage system is described in detail in an engineering evaluation of the ditch system prepared by International Technology Corporation for the Corps (U.S. Army Corps of Engineers 1997). Drainage subareas for the HAAF parcel are delineated in the Flood and Drainage Baseline Study (unpublished Corps data).

The perimeter ditch system is served by three pump stations on the margin of San Pablo Bay: Buildings 35, 39, and 41. These pump stations have a combined capacity of 230 cfs and are equipped with both diesel-powered and electric motor-driven pumps (unpublished Corps data).

In addition to the HAAF parcel, the perimeter ditch system receives drainage from several adjacent areas:

- drainage flows through a 42-inch gated culvert through the perimeter levee near the southwest corner of HAAF on the St. Vincent's property, which carries flows from the western portion of the former DOD housing and Long Point peninsula upland areas adjacent to the airfield, and from a portion of the St. Vincent's property;

- drainage from the New Hamilton Partnership development, the eastern portion of the former DOD housing area, and other areas adjacent to the west side of the airfield that are conveyed to the ditch in two outfalls, one near Reservoir Hill (west outfall) and one near the southwest corner of the airfield (east outfall);

- drainage from the area of Landfill 26 and Ammo Hill that is conveyed to the ditch system through a 48-inch flap-gated culvert;

- flood overflow (under some conditions) from Ignacio Reservoir and the BMKV parcel through a levee gap 2,000 feet southeast of the northwest corner of the HAAF parcel;

- flood overflow and normal drainage through two 24-inch gated culverts on the SLC parcel.

In addition, flood overflow from Ignacio Reservoir could be conveyed from the reservoir to HAAF through the two 24-inch siphons (these siphons are currently not operational).

Conditions of Property Transfer Relating to Flood Control and Drainage

The flood control and drainage facilities in the HAAF parcel affect the hydrologic characteristics of surrounding properties, including the New Hamilton Partnership development, the St. Vincent's and Las Gallinas Sanitary District properties, the California Quartet (Bel Marin Keys Unit V) development parcel, Landfill 26, Ignacio Reservoir, and the SLC parcel (Figure 2.6). The SCC has indicated that before its acceptance of the HAAF parcel, existing flood control and drainage issues between the Army and surrounding landowners must be resolved.

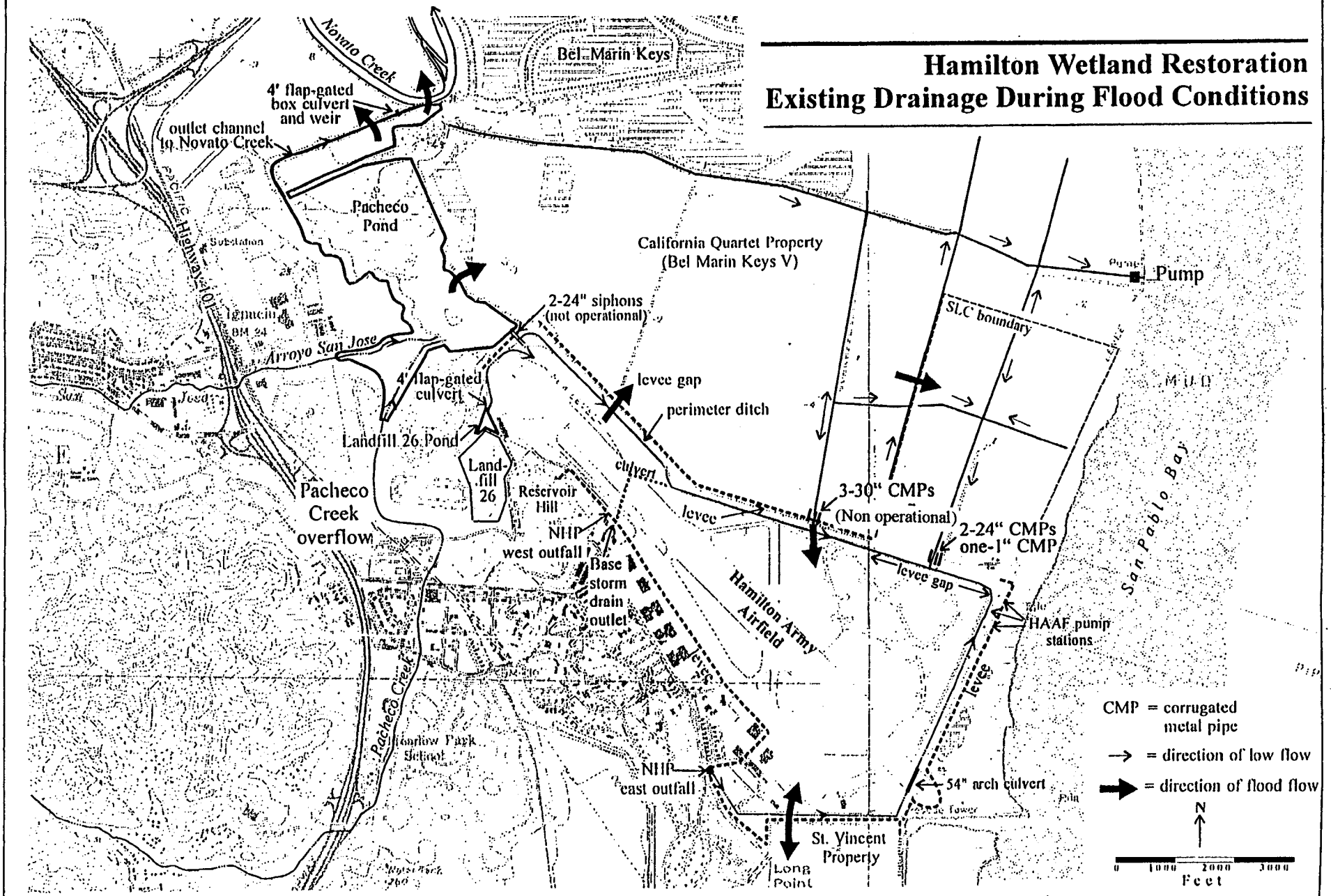
The Army's goal is to resolve flooding and drainage issues with surrounding properties so that flooding and drainage characteristics of parcels surrounding the HAAF parcel are not adversely affected as a result of base closure. To ensure that closure of the HAAF parcel would not affect the flooding and drainage characteristics, the Army has committed to making modifications to the drainage facilities of the surrounding parcels: the St. Vincent's, Las Gallinas Sanitary District, and U.S. Navy properties; Landfill 26; the SLC parcel; and the BMKV development parcel.

The Army has agreed to address these drainage issues as part of the closure of HAAF. It has indicated that it will undertake any additional environmental impact analysis that may be required to implement these solutions before transfer of the HAAF parcel. A copy of a recent letter to the SCC from the Army describing these commitments is included in Appendix C of the Hamilton Wetland Restoration Plan EIS/R.

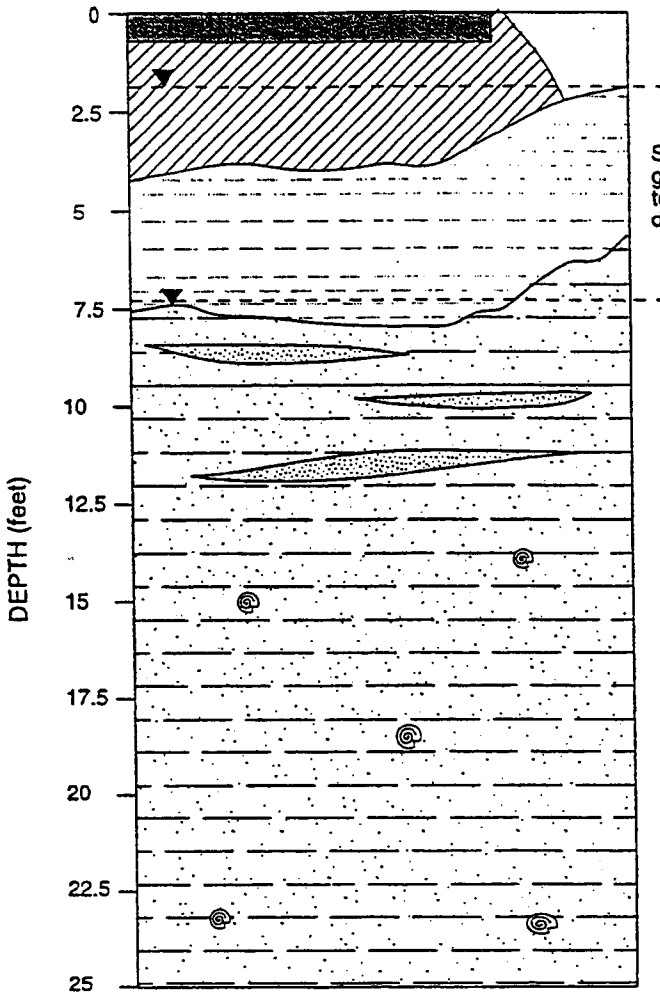
Geotechnical Conditions

The area of the proposed wetland restoration is presently below sea level (typical elevation -5 feet) and is protected from tidal inundation by flood control levees along San Pablo Bay and a system of drainage trenches and pumps. The water table is typically located several feet below the surface, and is seasonally variable. As shown on Figure 2.7, the area is underlain, below a thin near-surface "crust", by soft marine clays known as Bay Mud to depths which vary from up to 70 feet near San Pablo Bay to 30 feet and less in the northwestern end of the site. The crust is composed of desiccated Bay Mud over the entire area and, in many locations, especially on the HAAF site, by a few feet of granular fill and, in the runway and taxiway areas, pavement.

Bay Mud is a plastic silty clay, with high compressibility, low shear strength, and generally low permeability. Bay Mud is underlain by much stronger and less compressible, competent soils. Due primarily to its high compressibility and low strength, the soft Bay Mud poses considerable challenges to development of the site as a wetland. New fill loads placed on top of areas underlain with Bay Mud cause compression of the mud, which in turn requires more fill to be placed. This compression also causes uneven settlement of the surface. Depending on the depth of the soft Bay Mud, the settlement may take from 10 to as much as 50 years to develop. Figure 2.8 illustrates the anticipated settlement estimates based on past Bay Mud settlement history. It also distinguishes between large-area loads and more localized loads, such as applied by newly built and modified levees, which cause somewhat smaller settlements.


Hamilton Wetland Restoration
Existing Drainage During Flood Conditions
Novato Creek
Bel Marin Keys
4' flap-gated box culvert and weir
outlet channel to Novato Creek
Pacheco Pond
California Quartet Property (Bel Marin Keys V)
Pump
2-24" siphons (not operational)
SLC boundary
Arroyo San Jose
4' flap-gated culvert
levee gap
perimeter ditch
Landfill 26 Pond
Land-fill 26
Reservoir Hill
culvert
levee
3-30" CMPs (Non operational)
2-24" CMPs one-1" CMP
Pacheco Creek overflow
NHP west outfall
Base storm drain outlet
Hamilton Army Airfield
levee gap
HAAF pump stations
San Pablo Bay
Pacheco Creek
NHP east outfall
54" arch culvert
St. Vincent Property
Long Point
CMP = corrugated metal pipe
= direction of low flow
= direction of flood flow
N
0 1000 2000 3000
Feet
restsite 3-6.cdr 3.24.98

PWA



Notes

Depths and thicknesses approximate, no horizontal scale. Figure is a compilation of field and boring logs in the HAAF area.

Soft Bay Mud extends to depth varying between 30 feet and 70 feet, and is underlain by stiff clay and dense sand.

LEGEND

Pavement
concrete or asphalt

Fill
Yellowish-brown (10YR 5/4) to greenish grey (10Y 5/1) gravelly sand to reworked Bay Mud

Desiccated Bay Mud
Silty clay, greenish grey (10Y 5/1) to greyish brown (10YR 3/2), strong iron oxide staining on numerous desiccation cracks

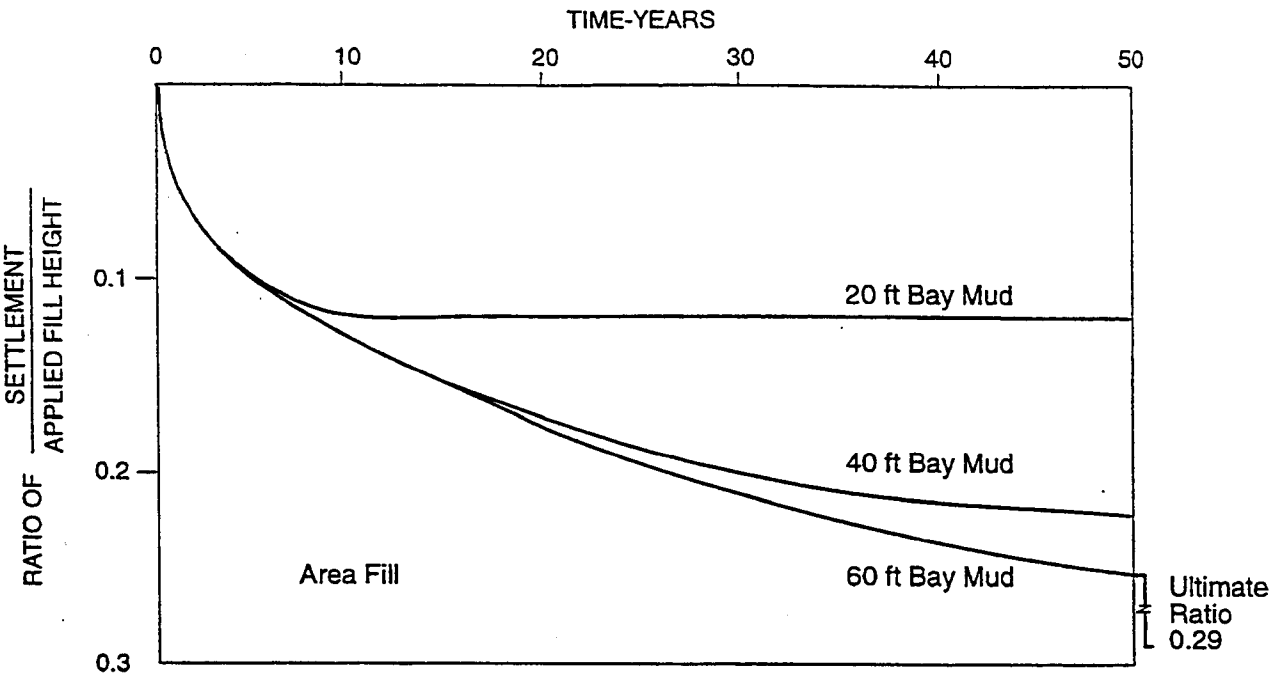
Soft Bay Mud
Silty clay, greenish grey (10Y 5/1) to dark grey (2.5Y 4/1), soft, saturated, shell fragments scattered throughout, rich in organic matter (decayed plant fragments, peat)

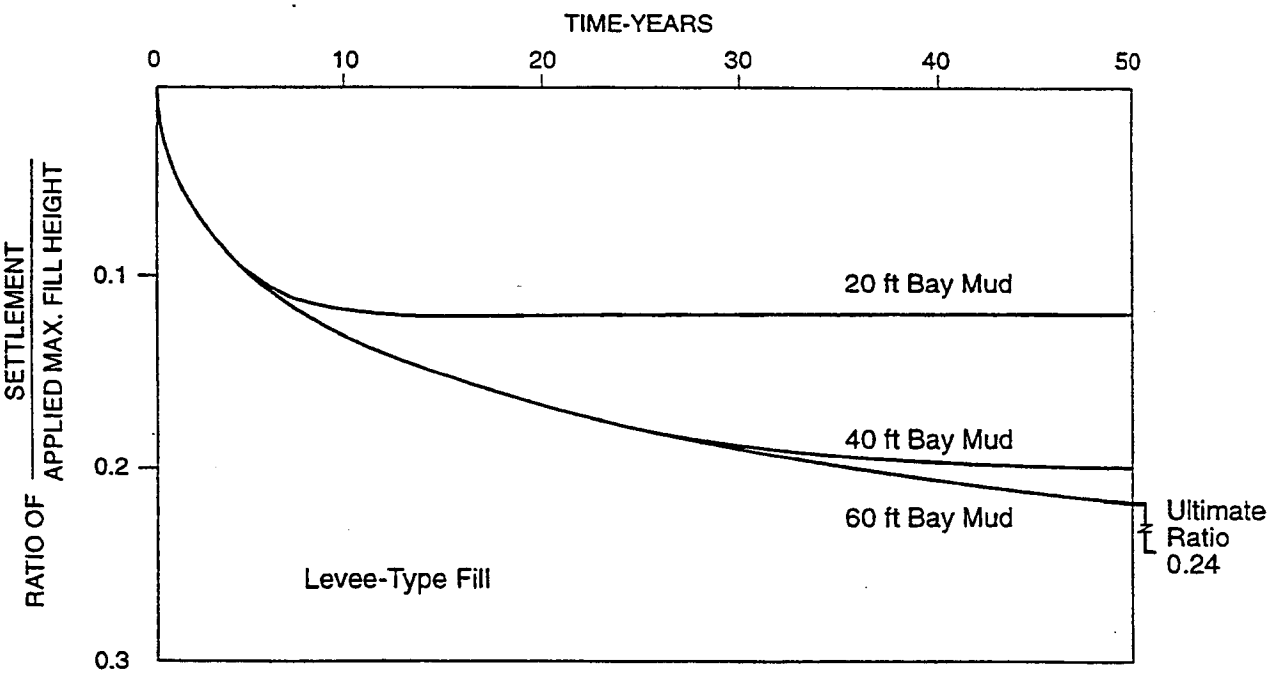
Sand lenses
Discontinuous lenses, 1-inch to 3-feet thick, fine to coarse grained, dark greenish grey (10G 3/1) to brown (7.5YR 4/3), clayey, generally found along the hill range

Shells and shell fragments

Project No. 971185NA	Hamilton Hamilton Wetlands Conceptual Plan	SCHEMATIC STRATIGRAPHIC COLUMN IN SHALLOW SOIL ON RUNWAY AT HAAF	
Woodward-Clyde			

971058NA-44F0/033198/gos





Note:
The figure depicts settlements as a fraction of the applied fill height. For instance, for an area fill, at a location with 60 feet of Bay Mud, the expected settlement after 30 years is 20% of the applied fill depth.

Project No. 971185NA	Hamilton Hamilton Wetlands Conceptual Plan	CONCEPTUAL SETTLEMENT ESTIMATES	
Woodward-Clyde			

Fills applied over limited areas, such as levee fills, cause shear stresses in the Bay Mud that, should they exceed the soil's shear strength, will cause stability failures. Therefore, new levees need to be designed with geometries that provide adequate stability, which may require stabilizing berms.

Observed Sedimentation Rates: Observed sedimentation rates adjacent to San Pablo Bay at Port Sonoma Marina, Bel Marin Keys, and the Petaluma Marsh range from 0.5 to 1.3 feet/year, and suggest an average initial rate of one foot per year. These estimates are based on measurements of bed elevation changes in these maintenance dredging and wetland restoration sites. However, the observed sedimentation rates are representative of subtidal or subsided systems. As the site fills and becomes intertidal, water depths, inundation periods, tidal exchange, and sedimentation rates will decrease exponentially. Therefore, the one foot per year rate should be considered representative of the initial phases of evolution in subsided San Pablo Bay systems. A more detailed discussion of spatial and temporal effects on sedimentation rate is provided in the Engineering Appendix.

2.2.2. Future Conditions without a Project

If the restoration project were not constructed, the reuse plan currently developed for the property would not be implemented. The Army would continue to operate and maintain the site until an alternative method of disposal was developed. Operations and maintenance of the site currently consists of pump operations and repair, fire protection, levee maintenance, storm watch, and police protection. The cost of operations and maintenance is significant, averaging $400,000 per year. The Army would continue to incur these costs for an unforeseen amount of time. In addition, without the project the San Francisco Bay would not receive the environmental benefits resulting from the restoration of nearly 700 acres of continuous endangered species habitat.

2.3 Problems and Opportunities

2.3.1 Problems

Historical Decline of Wetlands
This project is being proposed to restore important tidal salt marsh habitat to San Francisco Bay. Diking or filling them for purposes such as agriculture, housing, and salt production has destroyed approximately 90% of the original tidal wetlands of San Francisco Bay. This loss of tidal wetlands has greatly reduced the amount of habitat available to many species of fish and wildlife. Several local animal and plant species, including the salt marsh harvest mouse and the California clapper rail, have been listed as endangered due to the reduction of their wetland habitats.

Dredged Material Disposal Constraints
Three designated in-bay disposal sites are currently available for use by various dredgers and projects. Two additional aquatic disposal sites are restricted to disposal of clean sand from Corps maintenance projects only. By far the most heavily used of these sites is the Alcatraz disposal site (SF-11). An average of 4 million cubic yards of dredged material from various

projects are disposed of annually at SF-11. In 1982 it was discovered that mounding was occuring at SF-11. It has become apparent since then that the site does not have the capacity to accept the disposal volumes that it has in the past. Realization of the need for disposal volume limitations, mounting scientific and public concerns about the health of the Estuary overall, and increasing controversy about the effects of dredging and disposal of dredged material in the Bay have led regulatory agencies to tighten their dredging regulatory requirements.

The Long-Term Management Strategy Objectives
The Long-Term Management Strategy (LTMS) for dredging and dredged material disposal in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, California is being conducted to address the dredging and dredged material disposal needs of Congressionally authorized and Federally permitted projects in the estuary over the next fifty years. LTMS is being jointly conducted by the Corps of Engineers, U.S. Environmental Protection Agency, San Francisco Bay Conservation and Development Commission, State Water Resources Control Board, and San Francisco Bay Regional Water Quality Control Board. The goals of LTMS are to:

- Maintain in an economically and environmentally sound manner those channels necessary for navigation in San Francisco Bay and Estuary and eliminate unnecessary dredging activities in the Bay and Estuary.

- Conduct dredged material disposal in the most environmentally sound manner.

- Maximize the use of dredged material as a resource.

- Establish a cooperative permitting framework for dredging and dredged material disposal applications.

The long-term goal of the preferred plan presented in the Final LTMS EIS/EIR released in October 1998 is that 20% of dredged material would be disposed of in the Bay, 40% would be reused beneficially, and 40% will be disposed of at an ocean disposal site.

The Hamilton site has been identified as a site for beneficial reuse of dredged material by the LTMS team.

2.3.2 Opportunities

Wetland Restoration
Restoration of tidal wetlands on subsided diked lands provides an opportunity to offset historic habitat losses. The Hamilton site is an ideal location for such a restoration project. The site could easily be restored to the tidal action of the bay by breaching the existing bayfront levee providing 988 acres of tidal marsh, seasonal wetlands, transitional, and upland habitat.

Beneficial Reuse of Dredged Material
This project would provide the opportunity to beneficially reuse a large quantity of dredged material and would help begin implementation of LTMS goals. The site has subsided to an

average elevation of -5 feet NGVD, and would accommodate up to 10.6 million cubic yards of dredged material in bringing the site up to marsh plain elevations. Use of dredged material would accelerate the rate of marsh development, making habitat available to fish, wildlife, and particularly the endangered species that depend on tidal marsh for survival. In addition reusing the material would alleviate to an extent the environmental effects of aquatic disposal. Dredged material would be available from a variety of sources.

Maintenance Project Sources of Dredged Material

Investigation of the potential sources of dredged materials for the Hamilton Wetland Restoration project included a review of the information in the Moffatt & Nichol Study (Moffatt & Nichol, 1997) and information obtained from the San Francisco District Corps project management staff (Chatfield, 1998) and operations & maintenance staff (McGovern, 1998; Bruch, 1998), the Port of Oakland staff (Amdur, 1998), and numerous other contacts for smaller dredging projects. Of the 58 maintenance dredging projects considered in the Moffatt & Nichol study, 45 are possible sources of dredged material for the Hamilton Wetland Restoration project. The average annual dredging volume of these 45 projects is 2.7 million cubic yards. Of these 45 projects, 18 should be considered probable dredged material sources for this project due to their location, probable timing, dredging methods, material type, and material history (see Table 2.3, following page). The average annual dredging volume of these 18 projects is 2.2 million cubic yards. Assuming a 3 to 5 year construction period for this project, a probable maximum of 6.6 to 11 million cubic yards of maintenance dredging material could be available for the project. This volume would include 5.1 to 8.5 million cubic yards of fine-grained material and 1.5 to 2.5 million cubic yards of sand.

New Work Project Sources of Dredged Material

In addition to maintenance dredging projects there are several new work (deepening) projects that are potential large sources of dredged material for the Hamilton Wetland Restoration project. These are: the Port of Oakland 50-foot Project; Concord Naval Weapons Station Deepening; Southhampton Shoal Deepening; Richmond Harbor 38-foot Project; and Redwood City Harbor Deepening

Port of Oakland 50-foot Project: The Port of Oakland is currently planning a major dredging project to deepen the Port's channels and berths to -50 feet MLLW. The Hamilton Wetland Restoration project is one of the disposal alternatives being evaluated in this project's EIR/EIS and is part of the preferred alternative. This project will generate 10 to 12 million cubic yards of dredged material.

Contact with the Port (Amdur, 1998) indicated that 3 to 4 million cubic yards of Merritt sands from this project may be available for the Hamilton Wetland Restoration project and will likely be dredged in 2002 (Cardoza, 1998). This material is considered very clean and will likely be suitable for use in the tidal or seasonal wetlands areas.

TABLE 2.3
POTENTIAL SOURCES OF MAINTENANCE DREDGING MATERIAL
(FROM THE MOFFATT & NICHOL STUDY)

Project	Average Annual Volume (cubic yards)	Material Type	Dredging Frequency (years)
Larkspur	75,000	Fine	6
Mare Island	400,000	Fine	1
Oakland Harbor	400,000	Fine	1
Petaluma River (across the flats)	54,000	Fine	8
Pinole Shoal	200,000	Sand	2
Richmond Harbor	430,000	Fine	1
San Rafael Creek (across the flats)	30,400	Fine	7
Suisun Bay Channel	70,000	Sand	2
Benicia Industries	33,500	Fine	1.5
Benicia Marina	20,000	Fine	1
Larkspur Ferry - berths & basin	15,000	Fine	2
Port of Oakland - berths	150,000	Fine	1
Port of Richmond - berths	30,000	Fine	1.7
Port of San Francisco - berths	50,000	Fine	1
Exxon	40,000	Fine	1
Unocal	20,000	fine sand	2-3
Chevron - Richmond Long Wharf	130,000	Mixed	2
Other Small Projects (30% of total)	67,000	Mixed	1
TOTAL	2.2 million		
Total fine material	1.7 million		
Total sand and mixed material	0.5 million		

Concord Naval Weapons Station Deepening: This is a proposed Department of Defense project that would be designed and constructed by the Corps. The project would deepen the existing channels from the west Richmond channel through San Pablo Bay/Pinole Shoal and Suisun Bay to Concord Naval Weapons Station. The project depth would be -40 to -42 feet NGVD. Construction is envisioned in 2003 or 2004. The project would dredge 5 to 7 million

cubic yards of material, the majority of which would be in the Pinole Shoal area, near the Hamilton site. The material would likely be sands and hard clays. Due to project location and timing, the sandy material from this project is considered a promising source of dredged material for the Hamilton Wetland Restoration project.

Southhampton Shoal Deepening: This proposed federal project is locally sponsored by Contra Costa County. This project would deepen existing channels, including Southhampton Shoal channel, to a minimum of -50 feet NGVD and may include deepening of the Chevron Long Wharf maneuvering area. The project would dredge 6 million cubic yards (2 to 2.5 million cubic yards without the Chevron Long Wharf maneuvering area). The material would likely be hard clays and sands. This project has strong local support and will likely be constructed in 2001. Due to the project location, timing, and material type, it is considered a promising source of sandy dredged material for the Hamilton Wetland Restoration project.

Redwood City Harbor Deepening: While this source may be considered in the future**,** due to distance it was not considered the most promising source of dredged material for the Hamilton Wetland Restoration project.

Table 2.4 summarizes the material quantities potentially available for the Hamilton Wetland Restoration project from the new work dredging projects described above.

Other Potential Sources of Dredged Material

There are three small sources of dredged material near the Hamilton Wetlands Restoration project site that were not addressed to the extent appropriate for this project in the Moffatt & Nichol Study:

Port Sonoma Marina Maintenance Dredging

Bel Marin Keys Community Service District Maintenance Dredging

Bahia Community Lagoon Maintenance Dredging

TABLE 2.4
POTENTIAL NEW WORK PROJECT MATERIAL VOLUMES

Project	Quantity of Sand (cubic yards)	Quantity of Fines (cubic yards)	Potential for Use at Hamilton Project
Port of Oakland	1.8 million	3 to 4 million	High
Concord NWS	Est. 3 to 5 million	Est. 0 to 2 million	Medium
Southhampton Shoal	Est. 1 to 3 million	Est. 1-3 million	High
Port of Redwood City	Assumed low	Unknown	Low
TOTAL	6 to 10 million	4 to 10 million	

Port Sonoma Marina (Port Sonoma): Port Sonoma is located 4 miles northeast of the Hamilton Wetland Restoration project site at the mouth of the Petaluma River and adjacent to Highway 37. Future maintenance dredging material from Port Sonoma is a potential source for small quantities of material for the Hamilton Wetlands Restoration project. However, the cost of pumping the material to the Hamilton site could be prohibitive. It would likely be more feasible to barge material from Port Sonoma to the off-loading location, if combined with off-loading of material from other projects.

Bel Marin Keys Community Service District Maintenance Dredging: The community of Bel Marin Keys is located within two miles of the Hamilton Wetlands Restoration project site. The Bel Marin Keys Community Service District is currently planning a 250,000 cubic yard maintenance dredging project in Novato Creek and the North Lagoon. The Bel Marin Keys project may occur prior to the Hamilton Wetlands Restoration project. However, the material from this project could be placed and dried on the HAAF or SLC sites and used for levee construction or other project uses. This material is primarily fine-grained Bay Mud. The suitability of the Bel Marin Keys material for this project would be based on project timing and further material testing.

Bahia Lagoon Maintenance Dredging: The Bahia Lagoon Maintenance Dredging Project is 250,000 cubic yards of fine-grained material. Obtaining material from this project is not likely to be cost effective because of the long pumping distance (5 to 7 miles) and the inability to transport the material to the Hamilton site by barge.

2.4 Planning Constraints

Planning constraints are those concerns that must be considered in developing alternative plans. Both environmental and technical constraints were identified for this study.

2.4.1 Threatened and Endangered Species in Existing Wetlands

Cutting channels through the outboard marshes to restore tidal action to the HAAF and SLC sites will directly impact some salt marsh habitat (5.4 acres). Two endangered wildlife species, California clapper rail and salt marsh harvest mouse, may be present in the marsh. In addition, winter-run chinook salmon, Central California coast steelhead, and delta smelt could be present in the marsh channels. Impacts will be minimized during construction. By creating a significantly larger tidal salt marsh, major new habitat areas will be created for these species.

2.4.2 Novato Sanitary District Facilities

The Novato Sanitary District (NSD) outfall pipeline runs between the HAAF and SLC property. A dechlorination facility is located 1300 feet west of the outboard levee. The outfall extends into San Pablo Bay, discharging into shallow water. The outfall, pipeline and associated facilities must be protected from construction impacts, settling, offshore activities, and changes in elevation as the airfield is filled in to form a wetland. The section of the pipeline through the wetland must remain accessible for inspection and maintenance. A levee would be constructed along the length of the pipeline that runs through the marsh to allow access. This levee would

create a hydrological separation between the SLC and HAAF parcels, requiring the need for more than one connection to the Bay.

2.4.3 Dredged Material Suitability

Only dredged materials that have chemical concentrations and sediment toxicity below levels that could harm wetland biota will be accepted for this project. Regional dredged material testing guidelines are provided by the LTMS agencies in the Corps San Francisco District, Public Notice 93-2, *Testing Guidelines for Dredged Material Disposal at San Francisco Bay Sites*. The current regional guidance specific to the chemical suitability criteria for dredged material use in tidal and seasonal wetland restoration projects, upland habitat creation, and other upland uses is contained in *Interim Sediment Screening Criteria and Testing Requirements for Wetland Creation and Upland Beneficial Reuse, Interim Final* (Wolfenden & Carlin, 1992). The LTMS agencies are currently writing a management plan that will integrate the suitability testing framework for all dredged material disposal and end use options including beneficial reuse such as wetland restoration projects. As part of this effort, the RWQCB staff is currently rewriting the Wolfenden & Carlin document and the updated version will likely be completed prior to the final design of the Hamilton Wetland Restoration project. The LTMS management plan will specify the main guidance documents to be used for dredged material suitability in the final design and construction specifications for this project.

2.5 Planning Objectives

Planning of wetland restoration has been in progress since 1996 when the National Marine Fisheries Service (NMFS) convened a group of federal and state agencies to explore possibilities. This group was expanded to form the Hamilton Restoration Group (HRG). The HRG defined project purposes and developed a project goal and objectives, which are discussed in chapter 2 of the accompanying EIS/R. These purposes, goals, and objectives have been condensed to the following planning objectives.

2.5.1 Wetland Restoration

The Main Federal planning objective for the Hamilton wetland restoration study is to create and maintain a diverse array wetland and associated habitats that sustain viable wildlife populations, particularly for Bay Area special status species.

2.5.2 Elimination of Disposal Impacts Through Reuse of Dredged Material

The disposal of dredged material from San Francisco Bay is currently constrained by physical, environmental, and regulatory limits on the use of existing disposal sites. To the extent that dredged material is used beneficially, the need for unconfined aquatic disposal and other disposal methods, and the impacts associated with those methods, will be reduced.

2.5.3 Facilitate Base Closure

The Army has the authority to transfer property through base closure by a public benefit conveyance for the purpose of environmental restoration. The wetland restoration project would allow the Army to transfer the property to the non-federal sponsor by this means. Base closure has been in progress since 1974. Creation of wetlands at the site would help finalize this long arduous process and implement the adopted reuse plan.

2.5.4 Public Access

Public access was also evaluated as a planning objective of the project. Pedestrian access will be provided offsite along the crest of the New Hamilton Partners levee, which borders the southwest edge of the proposed wetland. Since access would already exist offsite, measures for access were not developed further.

3.0 PLAN FORMULATION

3.1 Introduction

Plan formulation is an iterative process that establishes planning objectives, evaluates management measures that address these objectives, develops potential alternatives that meet the objectives, screens out plans based on comparison criteria, and identifies plans for implementation. This process is consistent with the planning requirements of the Water Resources Council Principles and Guidelines, the National Environmental Policy Act of 1969, and the U.S. Army Corps of Engineers Planning Guidance Notebook. The process requires systematic development and evaluation of alternatives for alleviating problems and realizing potential opportunities.

This section has two purposes. First, it describes the formulation, evaluation and screening of management measures that address the planning objectives. Second, it describes the formulation of a final array of plans, which display trade-offs between different combinations of management measures. The plans in this final array are candidates for possible recommendation for implementation.

3.2 Management Measures

3.2.1 No Action

The No Action plan is the "without-project" condition that serves as the basis for developing and comparing the impacts of preliminary and candidate plans. Under the No Action Plan, it is assumed that a Federal project would not be constructed to restore habitat in the study area boundaries. Thus, the environmental benefits of the proposed project would not be realized within the study area. The Army would continue to operate and maintain the site until an alternative method of land transfer was developed. The average annual cost to the Army for operations and maintenance is $400,000.00.

3.2.2 Real Estate Parcels Considered

A) Hamilton Army Air Field. The 644 acre airfield parcel lies on what was historically tidal marsh. Since being diked off in the early 20th century, the site has subsided to an average elevation of -5 feet NGVD. The airfield is protected from tidal inundation by a bayfront levee. The parcel would be acquired by the sponsor from the Army through the BRAC process. This parcel is an ideal candidate for tidal wetland restoration and is being considered further.

B) Navy Ball Fields. The 18 acre Navy ballfield parcel abuts the airfield parcel at its southwestern corner. The parcel lies directly adjacent to a hillside (Long Point). Incorporation of this parcel in the restoration project would allow the use of the existing topography in the design. The levee would be tied into the hill, reducing the length of the levee required, thereby reducing the cost of the project. In addition, use of a natural border for the wetland would enhance the restoration by providing transitional habitat, and high tide refugia for marsh species that levee

slopes do not provide. This parcel currently drains to the airfield. If this parcel were not included in the project, and a levee were to separate it from the airfield, it would be necessary to pump runoff over the levee in order to prevent ponding. This would incur an additional cost to the project. The sponsor would acquire this parcel via a public benefit conveyance from the Navy. Incorporation of this parcel is being considered further.

C) State Land Commission Property. Formerly the Hamilton Antenna Field, this 319 acre parcel abuts the northeastern portion of the airfield and lies along the bayfront. Like the airfield, this area is historic tidal marsh. This parcel also has subsided significantly since being diked off. This parcel was transferred to the SLC during base closure. The non-federal sponsor would obtain the use of this property by a 49 year lease from its fellow State agency. This parcel is being considered further.

D) California Quartet (Bel Marin Keys Unit V) Property. The 1,610 acre Bel Marin Keys Unit V parcel lies on the northern border of the airfield and to the west of the SLC parcel. This parcel was also historical tidal marsh. The property is currently in agricultural use (hay production). Incorporation of this parcel would substantially increase the amount of wetlands that would be restored, increase the amount of area that could be used for disposal of dredged material, and reduce the number of levees that would need to be constructed. The property owners intend to develop this parcel as a residential community and golf course. The County of Marin has a permit application pending for development of the site that is currently in litigation. Due to the uncertainty of potential land acquisition and lack of engineering information available, this parcel is not considered further. The non-federal sponsor is actively attempting to acquire this parcel for future restoration. Including this parcel in the restoration project would require supplemental CEQA/NEPA documentation.

E) The "Bulge". A 14 acre parcel known as the "bulge" lies in the area between the panhandle seasonal wetland and Landfill 26. The Army owns this property and could include it in the public benefit conveyance to the non-federal sponsor. Adding this area would enlarge the seasonal wetland and could save over 2,000 feet of flood control levee construction, because the wetland fill could directly abut higher ground. The addition would increase the amount of dredged material to bring the area up to seasonal wetland grade by about 300,000 cubic yards. Insufficient engineering information is currently available to evaluate the inclusion of this parcel. Therefore it has not been considered further in this report, but will be considered in the design phase as value engineering.

3.2.3 Modification of Site Elevation

The majority of the project site has subsided significantly from its historic elevation since being diked off. Typical elevation at the site is -5 feet NGVD. An elevation of +2 feet NGVD is necessary for the establishment of tidal marsh. This report considers both the use of suitable dredged material and natural sedimentation processes to bring the site to the desired elevation.

A) Natural Sedimentation. If the project area were returned to the tidal action of San Pablo Bay, sediment would accrete by natural processes, and marsh plain elevations would eventually be reached. Complete restoration of tidal wetlands by natural sedimentation is estimated to take up to 50 years. The proposed restoration of tidal wetlands in the HAAF parcel is characterized by the following steps, including the estimated time necessary for the restored wetlands to become fully functional:

- sediment accretion to mean high water level (year 3 through year 12),
- development of mean high water marsh plain near breach (year 13 through year 27),
- development of mean high water marsh plain in back marsh (year 18 through year 32),
- development of mean higher high water marsh plain near braech (year 18 through year 42), and
- development of mean higher high water marsh plain in back marsh (year 23 through year 48).

Restoration of tidal wetlands by natural sedimentation is effective and is being considered further.

B) Use of Dredged Material. The use of dredged material for wetland restoration projects is a beneficial reuse of sediment resources with a net positive environmental effect. Reuse of dredged materials reduces the cumulative environmental impacts associated with aquatic dredged material disposal and is consistent with the goals and objectives of the federal and state resource agencies in the region.

Complete restoration of wetlands using dredged material is estimated to take 30 years (See Figure 5-1). The restoration of wetlands using dredged material, including the estimated time necessary for the restored wetlands to become fully functional, is characterized by the following steps:

- sediment accretion to mean high water level (year 7 through year 10),
- development of mean high water marsh plain (year 12 through year 21), and
- development of mean higher high water marsh plain (year 17 through year 31).

One important advantage of using dredged material is the reduction in the amount of time necessary for restored wetlands to become fully functional. This is especially true in the back marsh. By filling the restoration site with dredged material, the overall sediment deficit for the system is reduced and velocity gradients are more gradual across the site. With less of the supply being deposited near the inlet, more sediment will be available to the back marsh. The sediments will be more uniformly transported and distributed within the system, and sedimentation will progress more rapidly toward the back marsh. In addition, by filling the

restoration site with dredged material, a local sediment supply is established for the back marsh. During tidal channel formation, sediments placed within the system will be redistributed as sediments are scoured from higher-order tidal channels and redeposited in marsh plain areas throughout the site.

The period over which the mean high water marsh plain is expected to be completely developed would be 6 years shorter using dredged material, and the period over which the mean higher high water marsh plain is expected to develop would be 10 years shorter compared to natural sedimentation.

Another advantage in using dredged material is that it would allow the creation of design features such as a wildlife corridor connecting habitats to the north and south, tidal pannes, and transitional habitat along the edge of the marsh. The addition of these features would provide a more diverse tidal marsh habitat than would be restored with natural sedimentation alone.

If dredged material were used to restore habitat, a more natural system would result, requiring less maintenance. Use of dredged material would allow seasonal wetland areas to transition to the tidal marsh along a gradient with a natural drainage pattern. This is an advantage over natural sedimentation which would require the construction of a levee between the panhandle seasonal wetland area and the tidal marsh. This levee would be equipped with flap gated culverts to allow exchange between the two areas. The outfall from the seasonal wetland area would discharge to a sediment retention basin which would require periodic maintenance dredging. This maintenance would not be required by the project if dredged material were used.

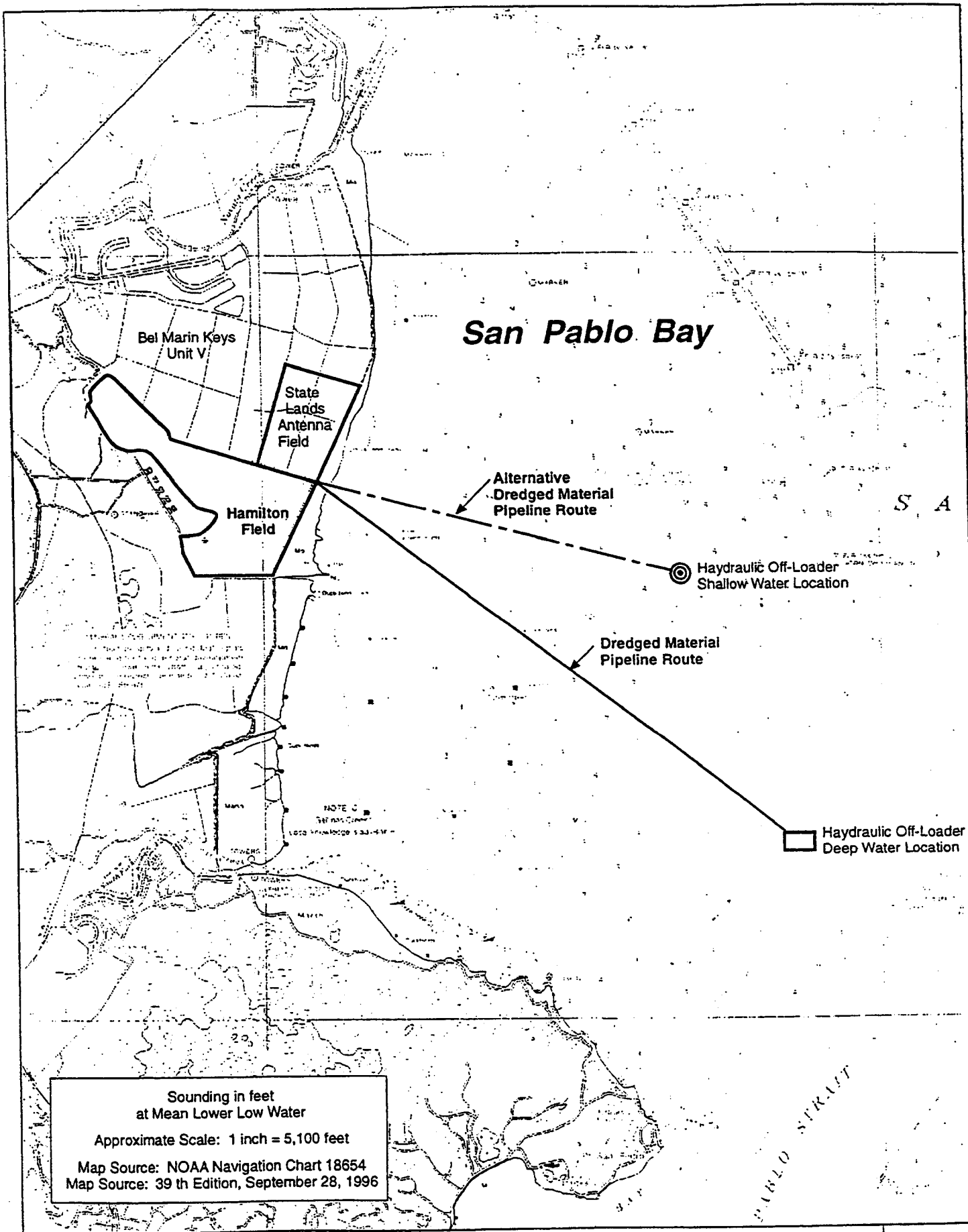
Use of dredged material was considered further because it is consistent with LTMS guidelines, it restores endangered species habitat much sooner than natural sedimentation, and it allows for the restoration of a more diverse tidal marsh ecosystem that would be more efficient to maintain.

3.2.4 Dredged Material Off-Loading Alternatives

Dredged material would typically be delivered by barge to the Hamilton Wetlands Restoration project site. These barges usually require a draft of 8 to 16 feet of water when fully loaded. The areas of San Pablo Bay adjacent to the Hamilton Wetlands Restoration project are primarily shallow mudflats that do not allow access for loaded dredged material barges.

Offloading operations would be part of each dredging project supplying material to the site. A hydraulic off-loader is the preferred method of transporting dredged materials from positioned dredged material barges (scows) in an off-loading area located in San Pablo Bay to the HAAF and SLC sites. A hydraulic off-loader is used to remove dredged materials from a scow and transport them through a pipeline in a water slurry.

See Figure 3.1 for potential off-loader locations and pipeline routes. The following options were considered.



Project No. 971185NA	Hamilton Wetlands Restoration Project	DREDGED MATERIAL OFF-LOADER AND PIPELINE ROUTES
Woodward-Clyde		

971185NA-22DO/021198/wcc/graphics/mci

A) A deep water (-16 ft MLLW) location in western San Pablo Bay. A deep water (-16 ft MLLW) off-loader could be located in existing deep water areas in western San Pablo Bay, 24,000 feet from the Hamilton Wetlands Restoration project site. The main advantage of a deep water off-loading location is unlimited access for fully loaded scows. This allows dredging and off-loading operations to be continuous and eliminates the need to light load scows or to wait for high tides in order to move the scows. The disadvantage of this deep water off-loading site is the long distance to the site (24,000 feet, 4.5 miles). This requires the purchase, placement, and maintenance of a large amount of pipe and the use of booster pumps. This option is preferable for large dredging projects (typically 1 million cubic yards or larger), using large scows that draw 15 feet of water or more when fully loaded. This option has been carried forward for further consideration.

B) A shallow water (-6 to -8 ft MLLW) location in western San Pablo Bay. A shallow water (-6 to -8 ft MLLW) off-loader could be located in western San Pablo Bay, 15,000 feet (or 2 ¾ miles) from the Hamilton Wetlands Restoration project site. The main advantage of a shallow water off-loading location in San Pablo Bay is a shorter pipeline and pumping distance. The distinct disadvantage of this location is that the shallow water depth will require the light loading of large scows and/or coordinating large scow movements with high tide levels. This constrains both the dredging and off-loading operations and increases project costs. However, this alternative would work well for most small dredging projects and for large volume shallow draft (-6 to -8 ft MLLW) dredging projects that must use shallow draft scows. This option has been carried forward for further consideration.

C) Dredging a deep water (-16 ft MLLW) temporary access channel near the site. A -16 ft MLLW temporary access channel for dredged material scows across the flats of western San Pablo Bay could be dredged to within 1,000 to 3,000 feet of the Hamilton Wetlands Restoration project site. This option would allow a short pumping distance and access for fully loaded scows. To dredge a temporary access channel closer to the site would likely have unacceptable impacts to the existing tidal marshes from dredging and off-loader operations. Dredging this temporary channel across the mudflats close to the site would reduce the pumping distance substantially. However, the channel would require dredging 1.4 million cubic yards of material. Additionally, a channel this deep in the mudflats might not be technically feasible due to sediment stability problems. Due to the dynamic sediment transport in this area, the channel would likely silt in very rapidly and require frequent, expensive maintenance dredging. This option has been removed from further consideration due to these environmental, cost and maintenance issues.

D) Dredging a shallow water (-6 to -8 ft MLLW) temporary access channel near the site. Dredging an -8 ft MLLW temporary access channel for dredged material scows across the mudflats of western San Pablo Bay to within 1,000 to 3,000 feet of the Hamilton Wetlands Restoration project site is possible (more feasible than a -16 foot channel). However, this option would allow only limited (tidal) access for fully loaded large scows. This channel would require dredging 300,000 cubic yards of material. Due to the dynamic sediment transport in this area, this channel would likely silt in very rapidly and require frequent maintenance dredging. Maintenance dredging costs would be highly dependent on Hamilton Wetlands Restoration

project length, construction frequency, and weather conditions. Like Option C, this option has been removed from further consideration due to environmental, cost and maintenance issues.

3.2.5 Novato Sanitary District Facilities

A Novato Sanitary District treated wastewater pipeline runs along HAAF's northern boundary extending between the HAAF and SLC sites to an outfall in San Pablo Bay. The Novato Sanitary District (NSD) serves 60,000 people with two connected treatment plants. During the dry season, treated wastewater is used for spray irrigation on a 1000-acre reclamation facility along Highway 37. During the wet season, treated wastewater is discharged into San Pablo Bay through a pipeline and outfall that passes through the SLC parcel.

The NSD outfall pipeline runs through a 20-foot wide easement for two miles along the north boundary of the airfield and south boundary of the State Lands Commission (SLC) property. A dechlorination facility is located 1300 feet west of the outboard levee. The outfall extends past the outboard levee into San Pablo Bay, discharging into shallow water. The dechlorination facilty lies in an area that will be inundated by sediment and tidal action.

The following measures were considered in protecting the facilities.

A) Modification of Outfall. One option is to terminate the outfall at the upper end of the new wetland, and discharge into the wetland instead of the bay, eliminating the need to construct a levee for maintenance access. However, NSD and the San Francisco Bay RWQCB are concerned about this proposal for two reasons: (1) Presently NSD's outfall discharge into shallow bay water just meets discharge dilution requirements. Discharging into a confined wetland channel would be very unlikely to meet Regional Board discharge dilution requirements. (2) Water quality requirements could be more stringent if the receiving water is a wetland rather than San Pablo Bay. Due to these water quality constraints, this option was removed from further consideration.

B) Relocation of Dechlorination Facility. Another option is to move the dechlorination facility off the SLC site. NSD, in partnership with the SCC, has contracted with Kennedy/Jencks Consultants to evaluate sites for relocation of the dechlorination facilities out of the project area. This would be the most promising solution and it was carried forward for further consideration.

C) Protection of the Dechlorination Facility at the Existing Location. Protection of the facility in place was considered as an alternative to relocation. This would require either the construction of a protective levee around the facility or raising it to the elevation of the projected marsh plain. In addition, access to the facility would have to be provided across the marsh to allow NSD to operate and maintain the plant. Operations at the plant would require the transportation of chlorine across the marsh creating an ecological risk. This option would be more costly than relocation, would make less acreage available for restoration, would be less environmentally sound, and has been removed from further consideration.

3.2.6 Levees

The project site is neighbored by several properties currently in a variety of uses such as residential, agricultural, recreational, light industrial and wildlife habitat. Measures must be taken to prevent flooding of these properties.The following measures were considered.

A) Perimeter Levees. The project would require levee construction all around the upland perimeter of the new wetlands except where they would abut the recently constructed NHP levee or higher ground, to protect the adjacent developed and agricultural areas from being flooded once the site was restored to tidal action. The perimeter levee would be designed to replace the level of protection provided by the existing bayfront levee, which would be graded down to high marsh plain elevation by the restoration project.

As the site consists of bay mud, which is highly compressible, the design must account for settlement of the levees that will occur over time. Staged construction of the levees was considered to recognize the time value of the project investment cost and result in much lower total present value and average annual costs. However, if staged construction were employed, imported levee material would have to be utilized instead of on-site borrow material after the initial construction, as the restored habitat would cover the borrow sites. This would result in a significant cost increase over using on-site borrow. In addition, staged construction would have adverse impacts to restored habitats, to the endangered species, and to other fish and wildlife that would reside there. For these reasons staged construction was removed from further consideration.

B) Acquisition of Property. Acquisition of adjacent properties was considered as an alternative to construction of a perimeter levee system. Due to uncertainty of cost, this option was removed from further consideration at this time. However, should the property become available for wetland restoration in the future, the California Quartet (Bel Marin Keys V) parcel could be incorporated.

3.2.7 Internal Peninsulas

Internal peninsulas would be constructed to reduce fetch length on the HAAF site. These peninsulas are needed to reduce internal wave energy during both typical and extreme storm conditions. The crest height must provide wave energy dissipation to protect from inundation and waves during storm conditions. These peninsulas would also direct the formation of the main tidal channels and thus would protect the perimeter levee system from head cutting by these channels. Use of peninsulas has been carried forward for further consideration. Due to the smaller size of the SLC parcel it was determined that internal peninsulas were not necessary for protection from wave energy and head cutting, and instead a sacrificial berm constructed from dredged material would be employed.

3.2.8 Breach Alternatives Considered

Breaching the outboard levee that separates the SLC and HAAF sites from San Pablo Bay tidal waters is necessary to re-introduce tidal action. Two breach options have been considered in this report.

A) Single Channel Cuts. The option of single channel cuts to each parcel has been continued through the evaluation process: one cut to the SLC site and one cut to the HAAF site. The option of one main channel cut was rejected because of the need to protect Novato Sanitary District's sewage outfall line by maintaining a levee between the two portions of the restoration site.

B) Many Small Channels. The option of using many small channels to introduce tidal action to the project site was rejected because it results in the maximum impact on the outboard marsh and is less efficient for providing tidal exchange. In addition, a single breach to each site is desired to promote formation of large subtidal channels that increase wetland complexity and provide habitat for special status species.

3.2.9 Additional Measures

With the management measures described above, there are design requirements that must be included for the formulation of complete alternative plans. These measures include provision of an access road for construction equipment and site maintenance, breaching and removal of the bayfront levee, and demolition of remaining outbuildings.

3.3 Array of Final Alternatives

3.3.1 Basis for Final Alternatives

With those management measures that survived the screening described above, a final array of alternatives was formulated. This array of plans demonstrates the trade-offs between restoring wetlands to the HAAF and Navy ballfield parcels alone, incorporating the SLC parcel, using dredged material to raise elevations, and relying on natural sedimentation to raise elevations. The array of final alternatives is assessed in the following chapter of this report.

3.3.2 Plan Alternatives

Five plans were developed during the Feasibility Phase and were retained for final consideration. These plans are referred to as the candidate plans, and are shown in Figures 3.2 - 3.5.

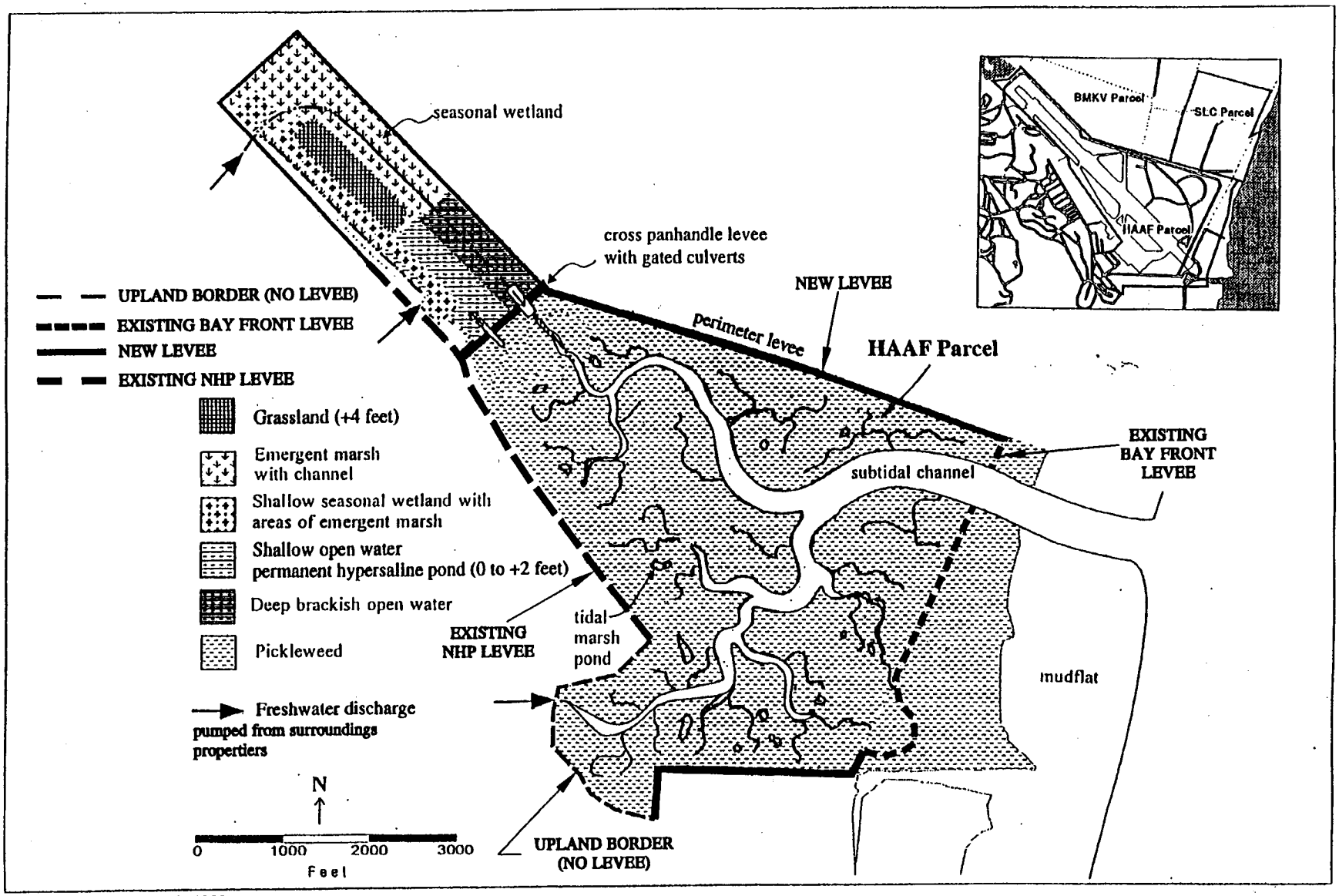
Alternative 1 - No Action Plan
The No Action plan is the "without-project" condition that serves as the basis for developing and comparing the impacts of preliminary and candidate plans. Under the No Action Plan, it is assumed that a Federal project would not be constructed to restore habitat in the study area boundaries. Thus, the environmental benefits of the proposed project would not be realized within the study area. The Army would continue to fund and perform operation and maintenance of the airfield until another method of base closure and transfer was developed.

Alternative 2 - Wetland Restoration at the Airfield and Navy Ballfields Via Natural Sedimentation
Habitats would be restored at the Airfield and Navy ballfields without the use of dredged material. This alternative would result in 668 acres of habitats, relying on tidal sedimentation to fill the tidal portions of the project. Seventy acres of non-tidal and seasonal wetlands would be created in the northwestern portion of the airfield. This area would be separated from the tidal wetland by a levee connecting the NHP levee to the flood control levee on the north side of the airfield.

Alternative 3 - Wetland Restoration at the Airfield and Navy Ballfields Via Beneficial Reuse of Dredged Material
Habitats would be restored at the Airfield and Navy ballfields using dredged material to accelerate marsh establishment and raise elevations for seasonal wetlands. This alternative would result in 668 acres of habitat. 7,100,000 cubic yards of dredged material from various bay area projects would be used. This alternative would create a gradient of transitional habitat between the tidal and seasonal wetlands instead of an internal levee.

Alternative 4 - Wetland Restoration at the Airfield, Navy Ballfields and SLC Property Via Natural Sedimentation
Habitats would be restored at the Airfield and adjacent properties at the site without the use of dredged material. This alternative would result in 988 acres of habitat. This project differs from the first natural sedimentation alternative in that the flood control levee on the northern edge of the site would encompass the SLC property, providing an additional 319 acres of habitat.

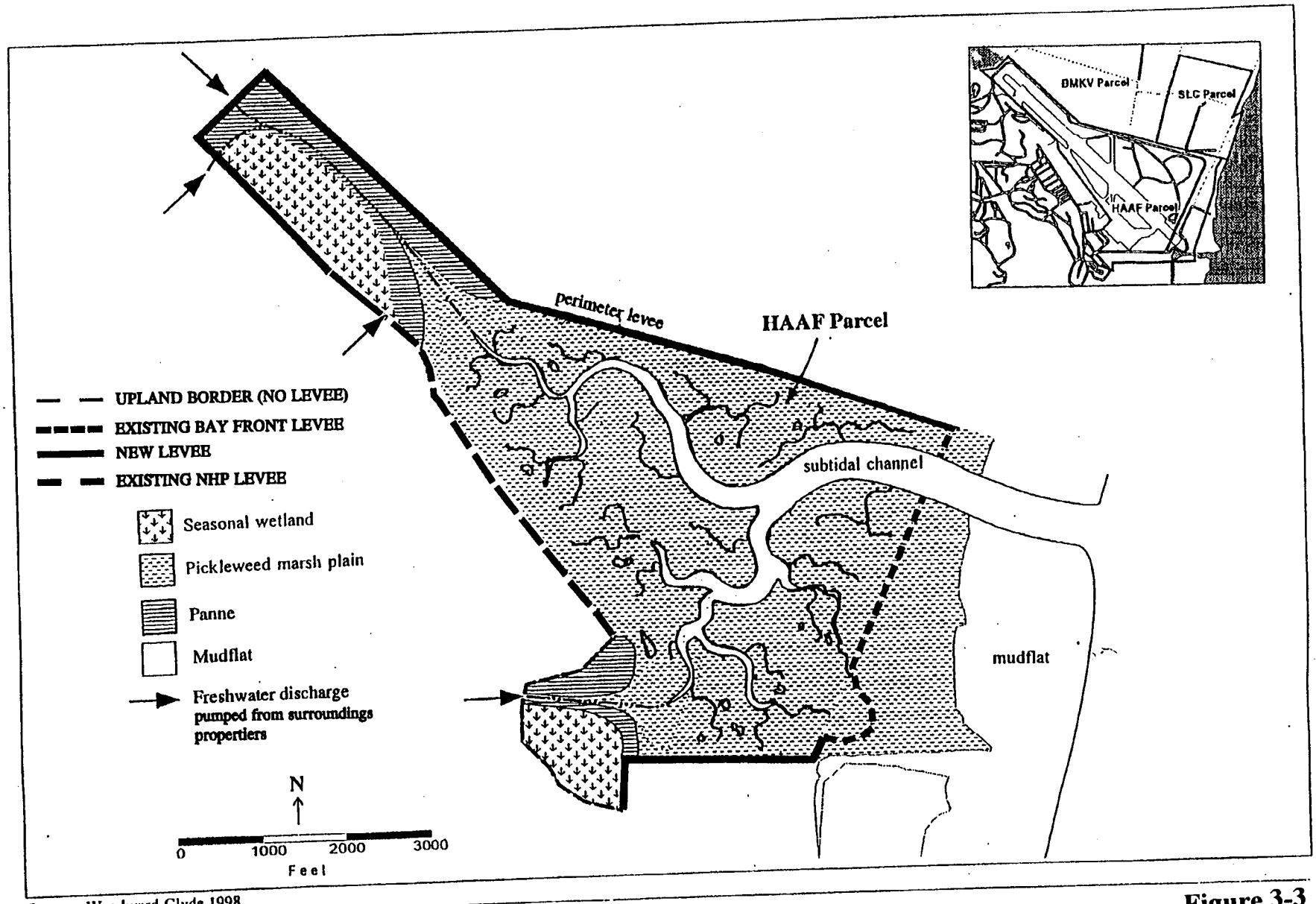
Alternative 5 - Wetland Restoration at the Airfield, Navy Ballfields and SLC Property Via Beneficial Reuse of Dredged Material.
Habitats would be restored at the Airfield and adjacent properties at the site using dredged material to accelerate marsh establishment and raise elevations for seasonal wetlands. This alternative would result in 988 acres of habitat. 10,600,000 cubic yards of dredged material from various bay area projects would be used. This project differs from the first dredged material reuse alternative in that the flood control levee on the northern edge of the site would encompass the SLC property, providing an additional 319 acres of habitat.



Source: Woodward-Clyde 1998.

Jones & Stokes Associates, Inc.

Figure 3-2
Alternative 2: Restoration of Wetlands in the HAAF Parcel through Natural Sedimentation at Maturity

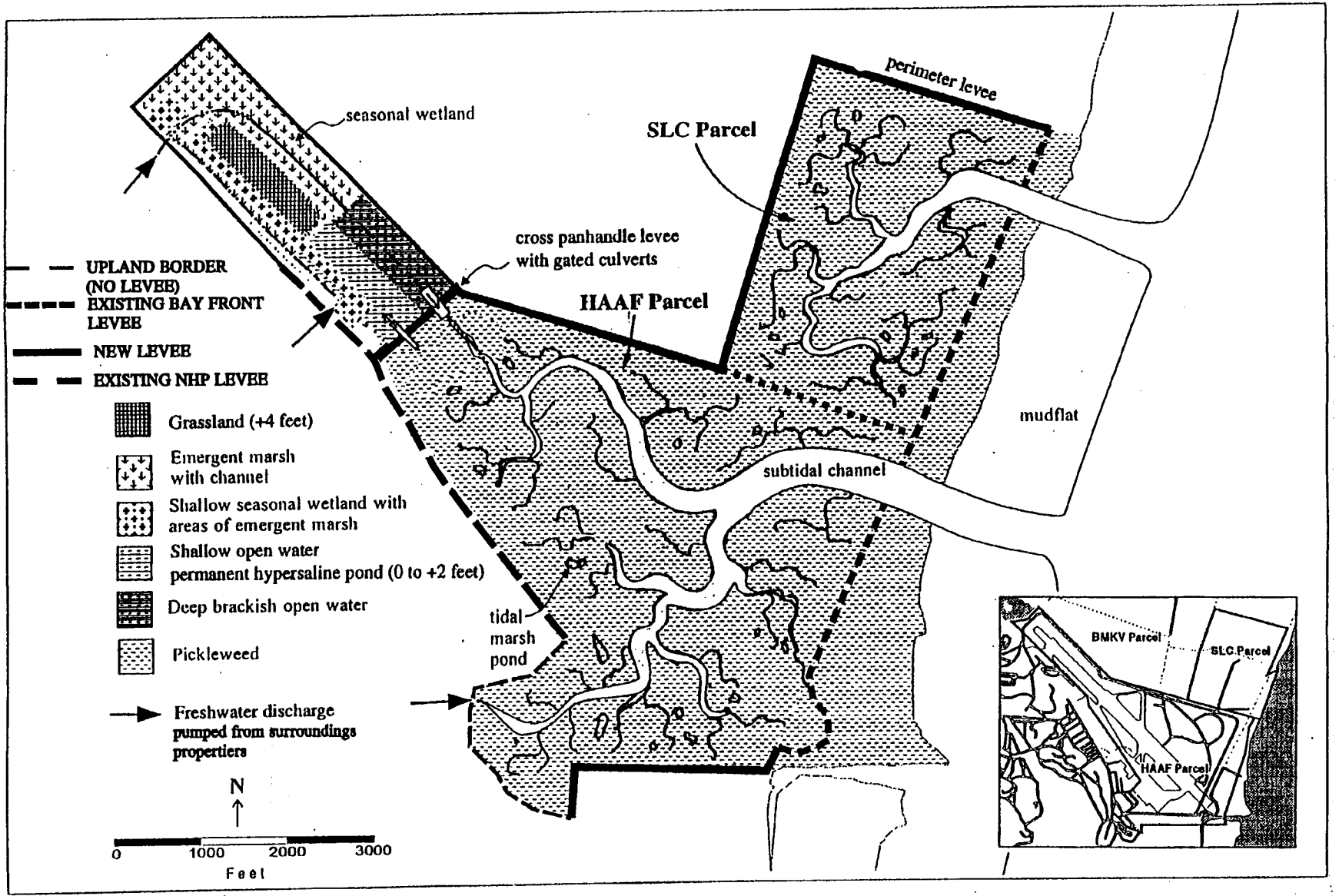


Source: Woodward-Clyde 1998.

Jones & Stokes Associates, Inc.

Figure 3-3

Alternative 3: Restoration of Wetlands in the HAAF Parcel Using Dredged Material at Maturity

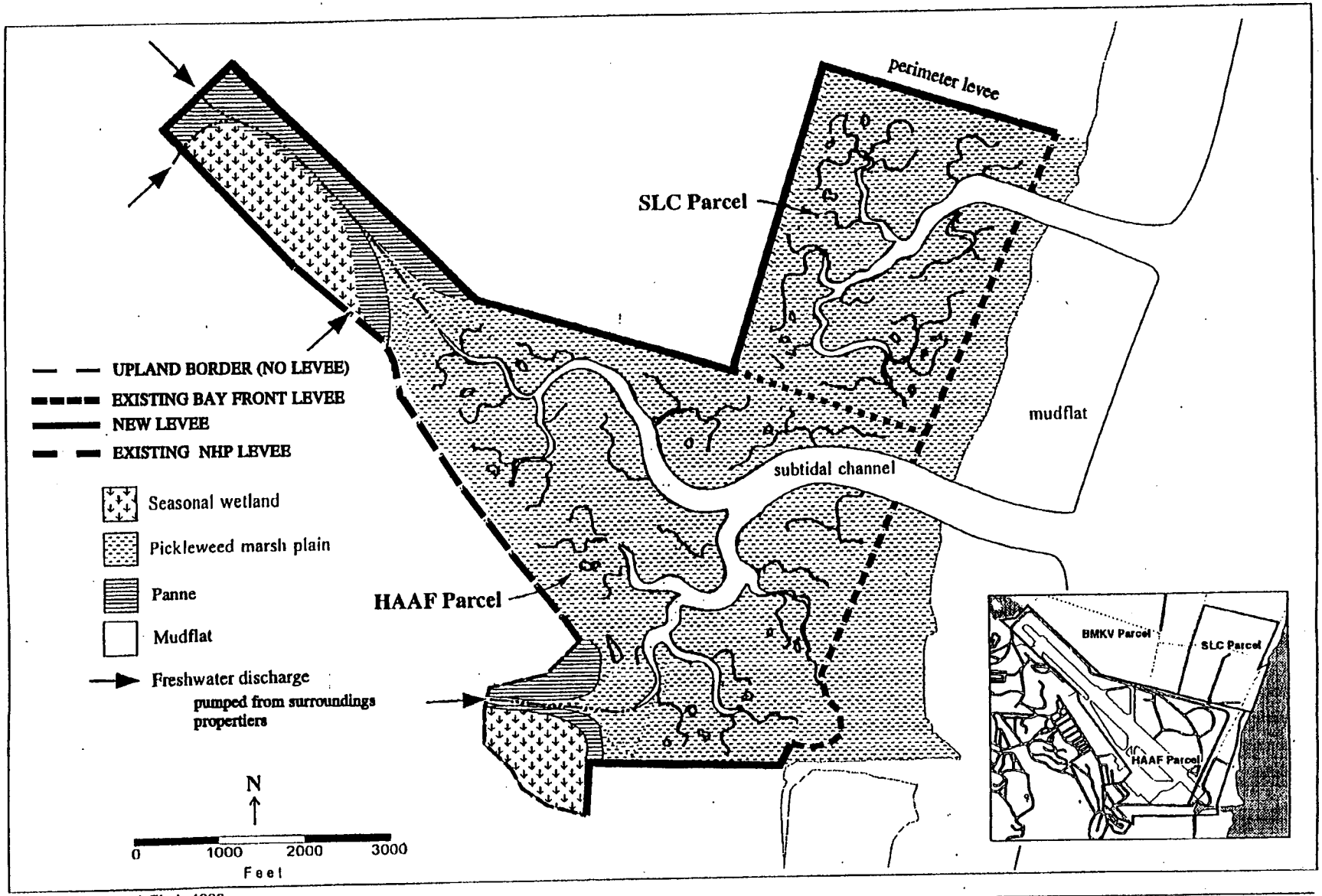


Source: Woodward-Clyde 1998.

Jones & Stokes Associates, Inc.

Figure 3-4

Alternative 4: Restoration of Wetlands in the HAAF and SLC Parcels through Natural Sedimentation at Maturity



Source: Woodward-Clyde 1998.

Jones & Stokes Associates, Inc.

Figure 3-5

Alternative 5: Restoration of Wetlands in the HAAF and SLC Parcels Using Dredged Material at Maturity