Appendix B
Engineering Appendix

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APPENDIX B - ENGINEERING APPENDIX
HAMILTON ARMY AIRFIELD WETLAND RESTORATION
FEASIBILITY STUDY

1.0 INTRODUCTION

The Hamilton Army Airfield wetland restoration project is located approximately 25 miles north of San Francisco on the southeast edge of the City of Novato, Marin County, California (see Figure 1-1). San Pablo Bay is adjacent to the airfield on the southeast side. Property owned by the St. Vincent Catholic Youth Organization lies to the south while the Hamilton North Antenna Field and property owned by the California Quartet (Bel Marin Keys V) border the airfield to the north. The project would result in 988 acres of tidal marsh and seasonal wetlands and other habitats in the area. The project consists of the engineering, design and construction of a levee (+12 feet NGVD) around the landward periphery of the site which would be tied into an existing levee to replace the existing bay front levee, returning the airfield and adjacent State Lands Commission property to the tidal action of San Pablo Bay. Internal peninsulas would be constructed to reduce wave fetch, protecting the levees from wave action. Weirs would be constructed to control decant water resulting from the placement of dredged material at the site. The project would require the relocation of a waste water dechlorinization facility owned by the Novato Sanitary District and protection of an associated pipeline that runs across the site, discharging to the bay.

2.0 HYDROLOGY AND HYDRAULICS

2.1 Hydrology

2.1.1 Climate and Wind

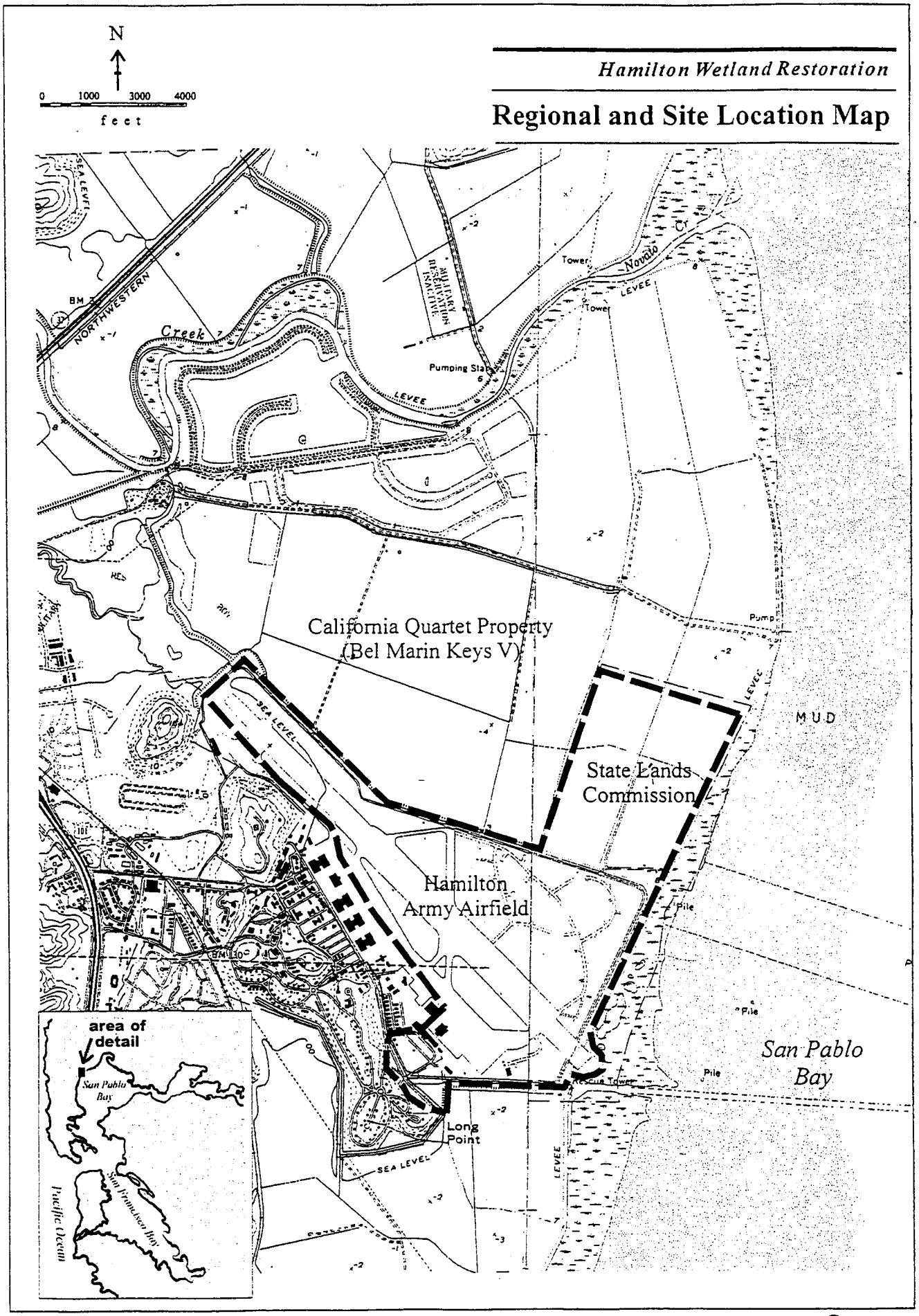
The San Francisco Bay Area has a Mediterranean climate with two primary seasons: warm dry summers which extend from mid-April to late October; and mild cool winters. Average summer (July to September) temperatures range from 52 to 78 degrees F; winter temperatures range from 41 to 55 degrees F (NOAA, 1997).

Rainfall patterns vary throughout the San Francisco Bay estuary as a function of geographic features. Mean annual rainfall at the site is approximately 26 inches per year, with annual precipitation ranging from 14.5 to 37.5 inches in the 1 in 10 dry and wet years respectively (NOAA, 1997). Rainfall is concentrated in the winter season with 90% of the annual rainfall occurring between November and March (See Figure 2-1). Mean marsh evapotranspiration[1] at the site is approximately 49.3 inches per year (Blaney and Muckel 1955). In an average year, direct precipitation exceeds evapotranspiration from November through March and evapotranspiration exceeds direct precipitation from April through October.

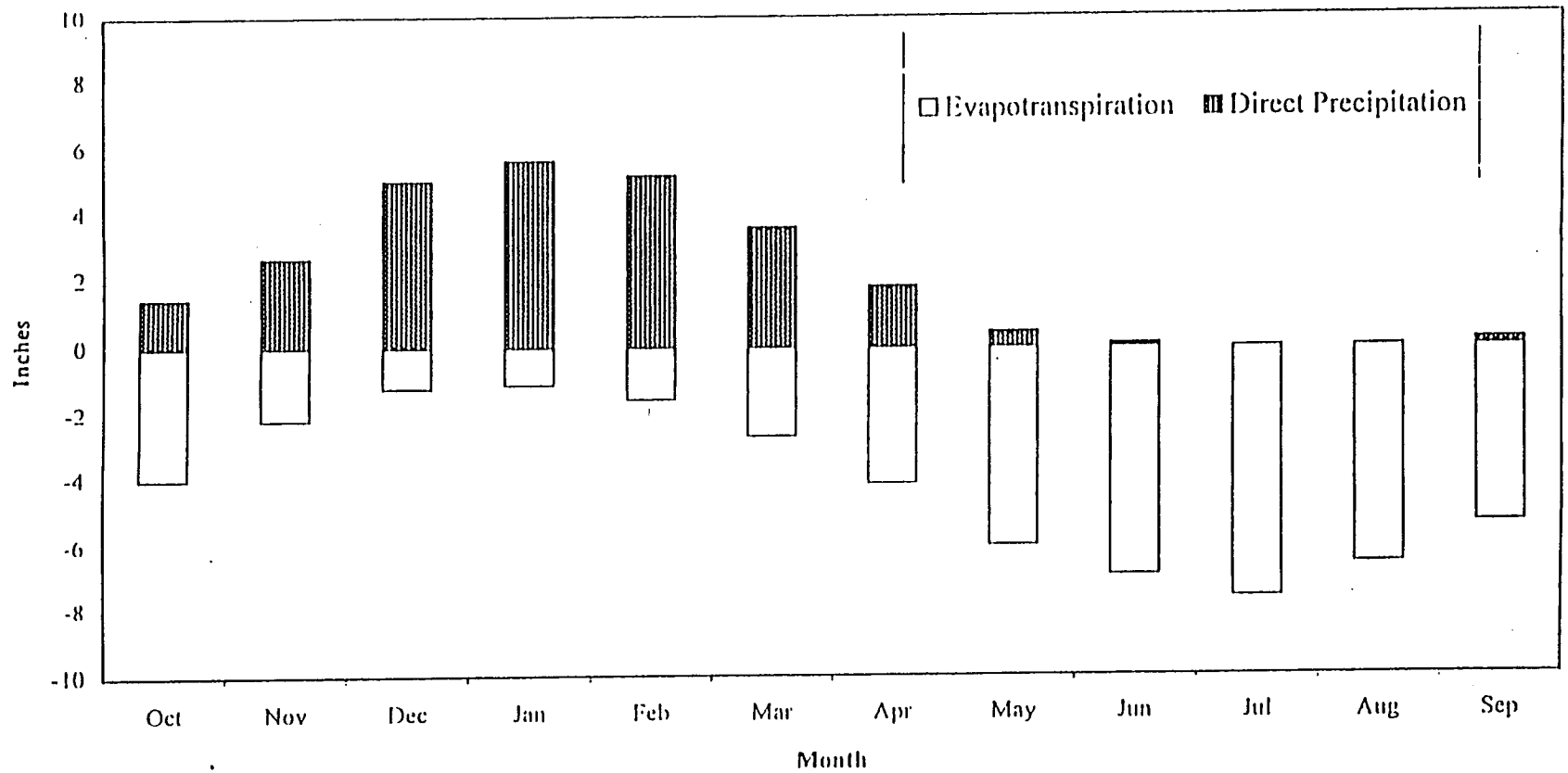
[1] Evapotranspiration is the total water loss due to evaporation from open water and transpiration from plant growth.

Hamilton Wetland Restoration

Regional and Site Location Map



Appendix B Figure 2-1



Notes: Evapotranspiration is the total water loss due to evaporation from open water and transpiration from plant growth. Evapotranspiration presented here is the average of lake evaporation and marsh vegetation evapotranspiration.

Sources: Precipitation from NOAA National Climate Data Center, Hamilton AFB Station, 29-year period of record. Evapotranspiration for Hamilton Field from "Evaporation and Evapotranspiration Investigations in the San Francisco Bay Area," Blaney and Muckel, Transactions American Geophysical Union, Vol. 36., No. 5, October 1955, pages 817-818.

Water Balance for a Mean Rainfall Year

Source: PWA analysis	PWA#: 1224

Philip Williams & Associates, Ltd.

Winds blow predominantly from the northwest and southeast, parallel to the runway. Mean wind speeds are 7.4 knots to the southeast and 7.5 knots to the northwest (DWR, 1978). Table 2-1 presents extreme wind speeds for return periods ranging from 2 to 50 years. The data in Table 2-1 are based on PWA analysis using peak gust data at HAAF over a 24-year period of record (DWR, 1978). Average wind speed and direction are presented in Figure 2-2.

TABLE 2-1 Estimated Wind Speed Frequency at HAAF

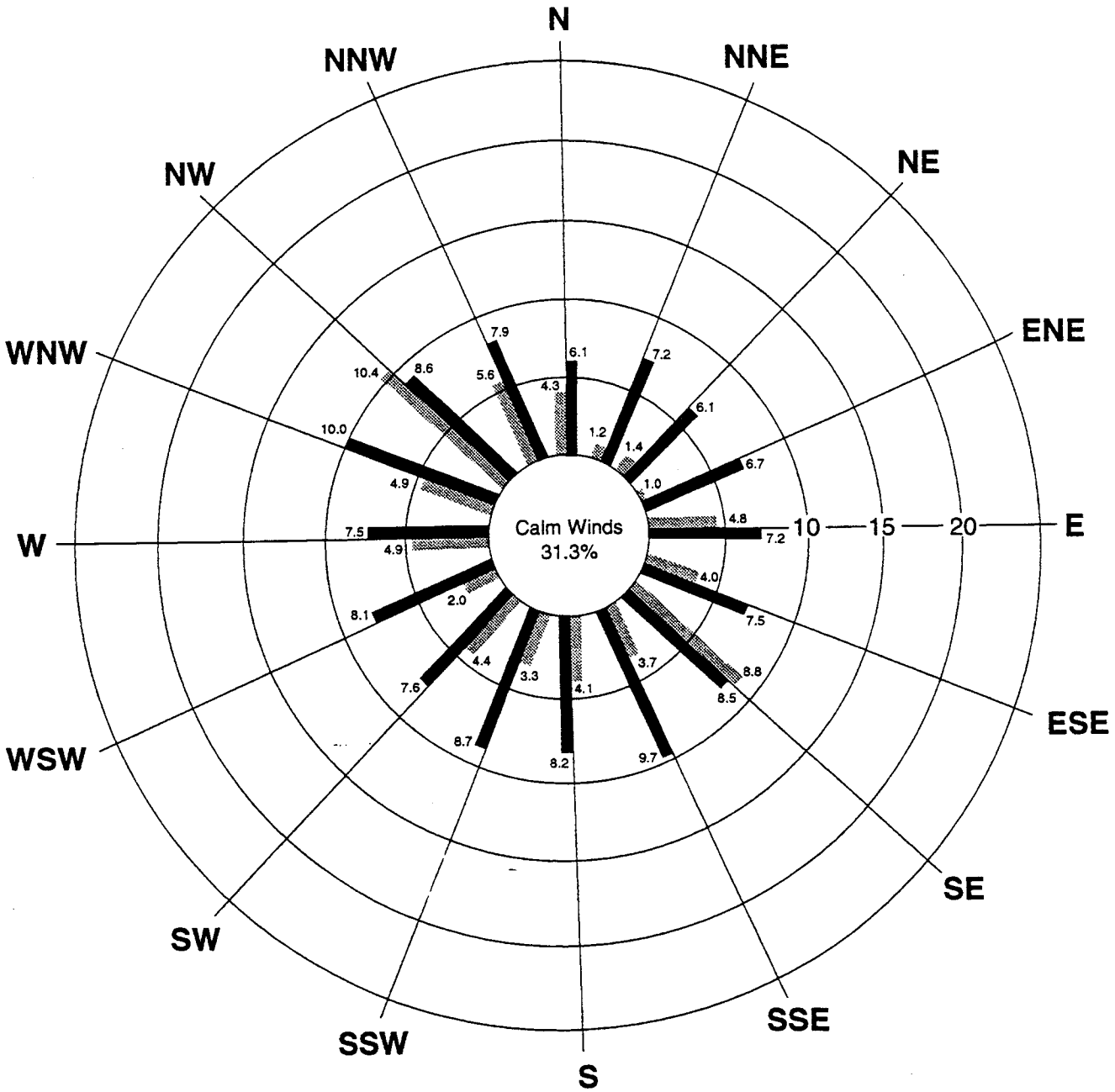
Return Period (years)	Estimated Extreme Wind Speed (mph)
2	55.2
5	63.8
10	69.5
25	76.7
50	82

2.1.2 Regional Hydrology

The San Francisco Bay estuary is one of the largest and most significant estuaries along the U.S. western coast. Over 40 % of California's land area and 60% of the state's runoff drains into the estuary (USEPA 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 1-1).

San Pablo Bay is a large, shallow estuary. Typical water depths in San Pablo Bay are 6 feet at low water. A naturally deeper, and now periodically dredged (to approximately 35 feet), navigational channel 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 approximately a 6-foot range. Tidal characteristics for San Pablo Bay at the mouth of the Petaluma River, approximately 4 miles north of HAAF, are presented in Table 2-2. Monthly variation in tidal fluctuations 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 approximately 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 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 on the adjacent mudflat; flood runoff from the Sacramento-San Joaquin Delta; and uncertainties in the USACE's estimation methods (Knuuti, 1995).



Based on 278,159 hourly observations from 1939 to 1970 at Hamilton Army Force Base

LEGEND

Percent by direction

Mean wind speed (mph)

Source: California Air Resources Board 1984.

Jones & Stokes Associates, Inc.

Appendix B Figure 2-2

Wind Rose Depicting Average Wind Speed and Directional Frequency at Hamilton Army Airfield

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

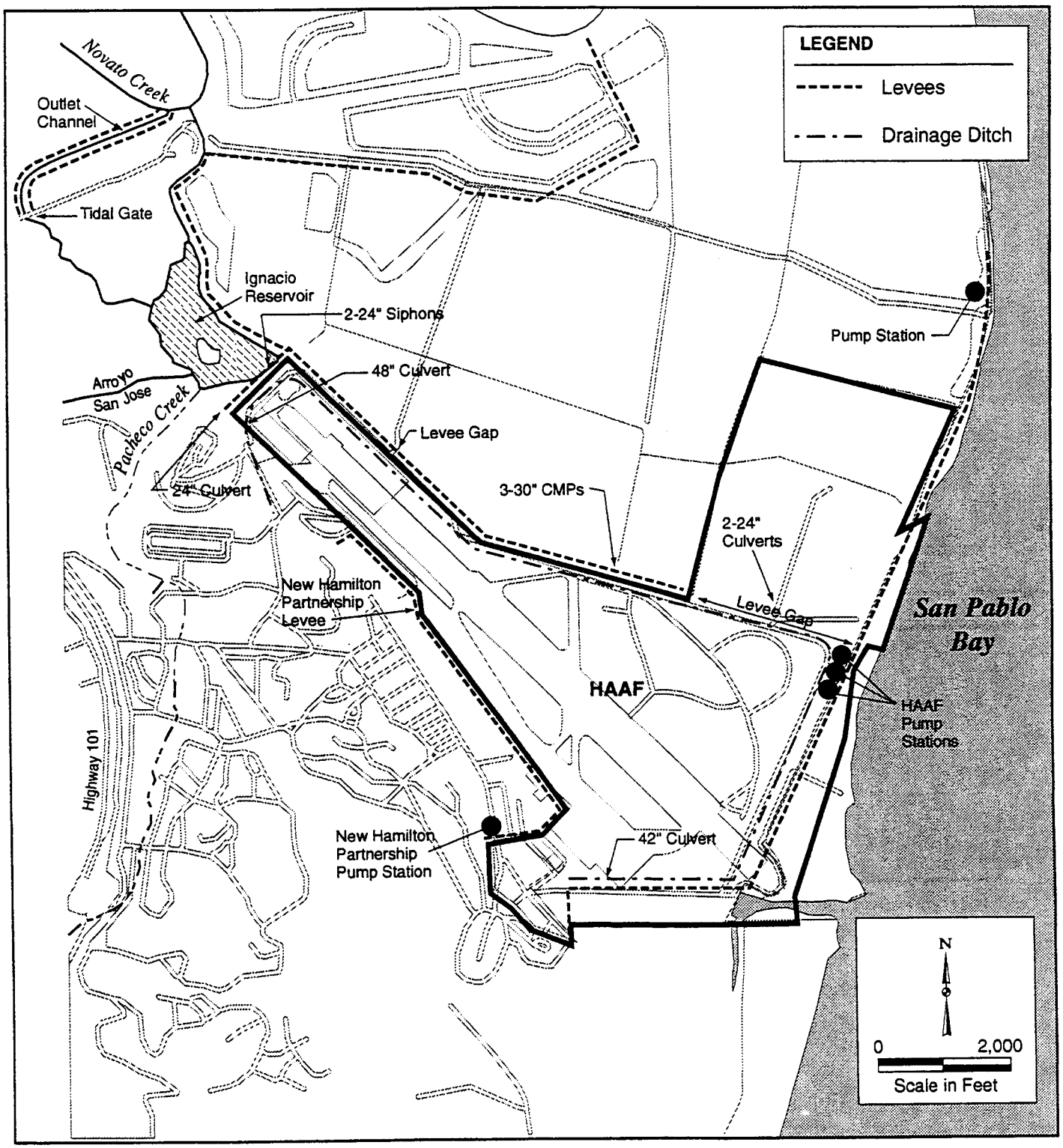
Note: NGVD is mean sea level of 1929. Tidal terms are defined in Appendix B.
Sources: USACE SFD (1984), Tides and Currents tide prediction software, and National Oceanic and Atmospheric Administration (NOAA) tidal benchmark data.

Regional drainage features are shown on Figure 2-3. Pacheco Creek, a small tributary draining a 1.9-square-mile watershed, 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 the 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 below.

2.1.3 Local Hydrology

Mean Runoff Conditions

During an average storm, the HAAF site accepts local surface runoff from approximately 600 acres of adjacent property: the Landfill 26 and Reservoir Hill areas, NHP, and other base property. Storm water from the NHP properties (7a) is lifted onto the HAAF site at two pump stations. Other discharges to the HAAF site occur by gravity flow either over land or in underground storm drains. Figure 2-4 shows the locations of surface inflow to the HAAF site and Table 2-3 shows the mean monthly volume of inflow to the site from offsite areas.



Regional Drainage Features

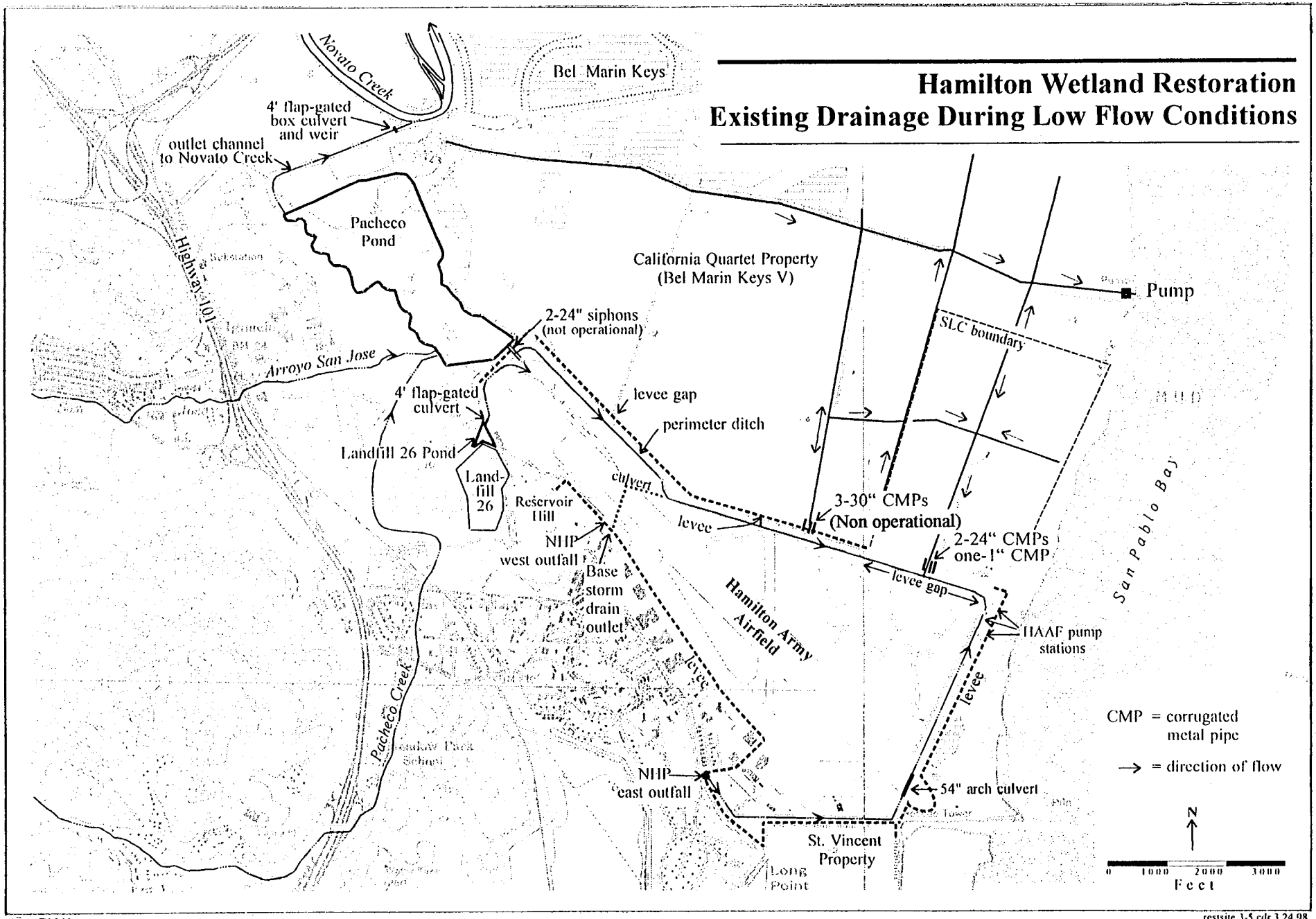


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TABLE 2-3
MEAN MONTHLY SURFACE INFLOW TO THE SITE FROM OFFSITE AREAS

	Landfill 26	North Reservoir Hill	New Hamilton Partners West Outfall	New Hamilton Partners East Outfall	Other Base Property	Total Offsite Areas
Area (acres)	102	38	30	197	216	583
Monthly Surface Inflow (acre-feet)						
Oct	3.85	1.43	1.13	7.43	8.15	21.99
Nov	6.93	2.58	2.04	13.38	14.68	39.61
Dec	13.20	4.92	3.88	25.50	27.96	75.45
Jan	14.78	5.51	4.35	28.55	31.30	84.49
Feb	13.62	5.08	4.01	26.31	28.85	77.86
Mar	9.35	3.48	2.75	18.07	19.81	53.47
Apr	4.77	1.78	1.40	9.21	10.10	27.26
May	1.19	0.44	0.35	2.29	2.51	6.78
Jun	0.26	0.10	0.08	0.51	0.56	1.51
Jul	0.00	0.00	0.00	0.00	0.00	0.00
Aug	0.05	0.02	0.02	0.10	0.11	0.30
Sep	0.53	0.20	0.16	1.02	1.12	3.01
Total	**68.54**	**25.53**	**20.16**	**132.37**	**145.14**	**391.73**

Pacheco Creek and Arroyo San Jose carry surface water runoff from the areas west of the project site. 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 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).

The HAAF, SLC, and BMKV parcels and the St. Vincent's property (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 2-4. Major drainage features and hydrologic resources in the project area are described briefly below.

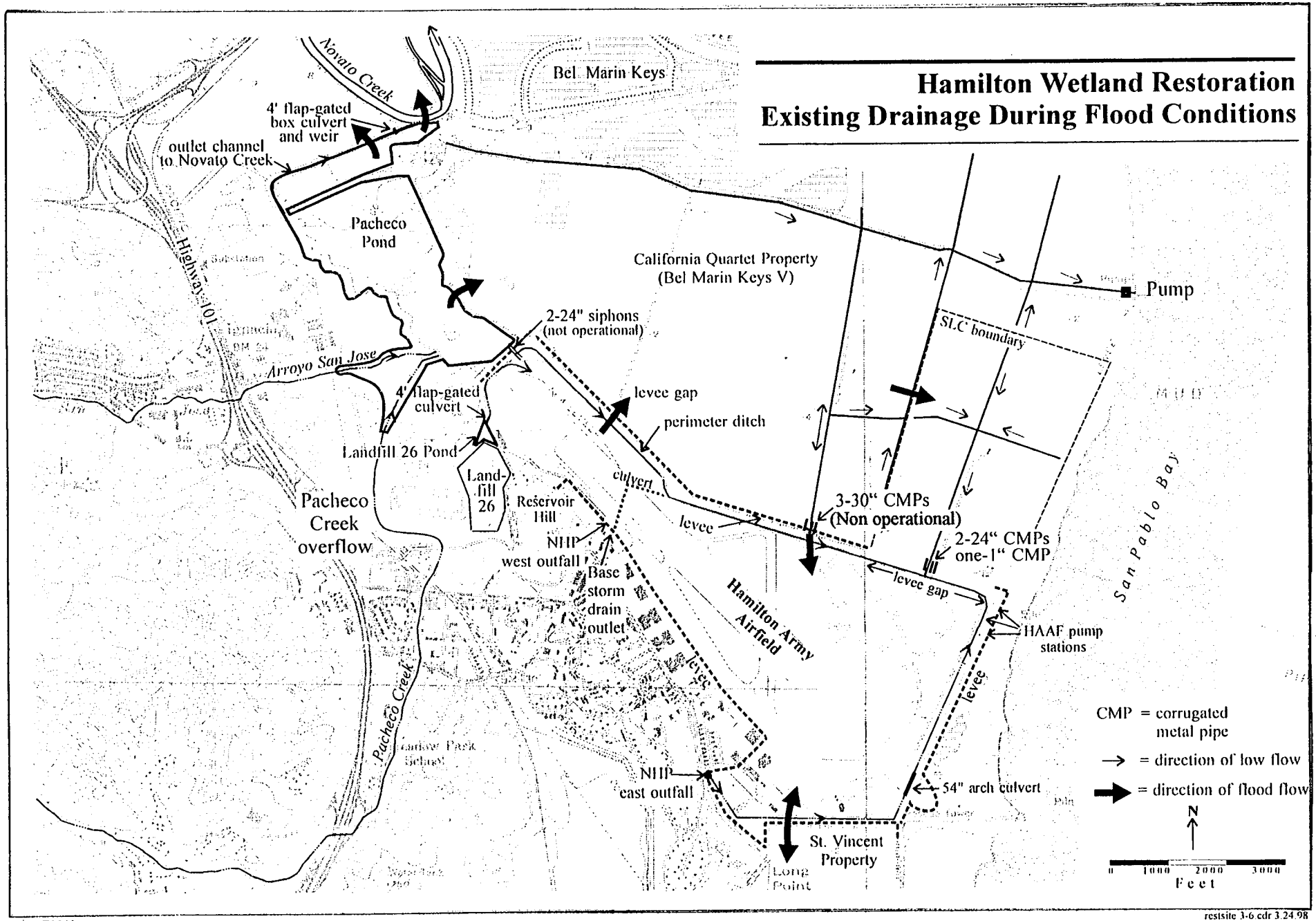
Pacheco Creek: Pacheco Creek originates on Big Rock Ridge 3 miles west of HAAF at an elevation of 1,300 feet. The creek crosses U.S. Highway 101 near the Alameda del Prado/Nave Drive, and crosses Nave Drive, Marin Valley Road, Bolling Drive, Main Entrance Road, and State Access Road in a series of culverts 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. This flood overflow passes around the Landfill 26 area and into the northwestern part of the HAAF parcel. The creek passes between Ammo Hill and Bel Marin Keys Industrial Park before discharging into Ignacio Reservoir (Pacheco Pond). Existing drainage during flood conditions is shown in Figure 2-5.

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.

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



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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 BMKV 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 BMKV 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 BKMV and SLC parcels or through three 30-inch culverts through the HAAF perimeter levee.

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 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 DOD housing and Long Point Peninsula area. 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 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.

HAAF 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).

Three pump stations on the margin of San Pablo Bay serve the perimeter ditch system: Buildings 35, 39, and 41. These three 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 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 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).

2.1.4 Hydraulic Modeling

Existing flood conditions at the Hamilton Army Airfield and adjacent properties have been documented in the draft report "Conceptual Design for Tidal Wetland Restoration for the Hamilton Army Airfield Focused Feasibility Study," prepared for IT Corporation by Philip Williams and Associates with LSA Associates, October 1998 (PWA 1998). This report provides a detailed description of existing flood conditions at the airfield and adjacent properties (including the State Lands) and descriptions of flood assessment methods. The flood assessment methods include rainfall-runoff modeling (HEC-1), hydrologic routing (MPOND), and flood hydraulics modeling (HEC-RAS) for Pacheco Creek. The rainfall runoff model and flood hydraulics model were used to characterize inflows to the site as input to the hydrologic routing model (MPOND).

The current study uses the same analytical approach and modeling tools as were used in the IT study (PWA 1998), with modifications to represent proposed conditions for the natural gradient alternative. The required modifications involved changes to the MPOND input files; changes to the other model simulations (HEC-1 and HEC-RAS) were not necessary.

MPOND is a simple hydrologic routing model which simulates flows and the resulting changes in water surface elevations in a network of ponds connected by one or multiple hydrologic control structures (culverts, weirs, tide gates, and pumps). MPOND was used to simulate the exchange of water between surface runoff (creeks and local drainage), the ponding areas (Ignacio Reservoir and the Landfill 26 pond), and tidal areas (Novato Creek and the proposed HAAF tidal wetland). The model also includes Ignacio Reservoir overflow onto California Quartet property and overflow near the Novato Creek tidegates.

MPOND requires input data describing inflow hydrographs, pond stage-storage curves, starting water surface elevations, pond connections, and specification of hydraulic control structures. Hydrographs and direct rainfall are routed into ponds as specified in the model. The simulated flow between ponds is estimated for each time step as a function of the head difference between ponds and the defined control structures. The model assumes instantaneous changes in water surface elevation over the pond area and does not simulate the hydraulic gradient within a single pond. PWA has used MPOND for over ten years to solve a variety of wetland flooding and design problems.

2.1.5 Sedimentation and Site Evolution

The designs considered for tidal wetland restoration at the Hamilton site rely to varying degrees on estuarine sedimentation processes to fill the site to elevations that can support

colonizing vegetation. The time required for sedimentation is important for predicting restoration time lines, and for the comparison of habitat characteristics between alternatives. The sedimentation rate will depend on the sediment concentration in tidal waters, the deposition rate (as a function of sediment characteristics and wave energy), and the site's initial elevation. The mudflats of San Pablo Bay provide a storage area for estuarine sediments that are continually being resuspended by wave action and then redeposited.

Considerable uncertainty is associated with estimates of long-term sedimentation rates in wetland systems. The effects of large storm events, the natural variability in sediment supply in San Pablo Bay, changes in sedimentation rates as the site fills, and the differential sedimentation anticipated across the large Hamilton Wetlands Restoration site all introduce uncertainty in sedimentation rate estimates. Three information sources are considered in estimating long-term sedimentation rates at the Hamilton site:

- Observed sedimentation rates in San Pablo Bay
- Predicted long-term sedimentation rates
- Hydrodynamic modeling of post-breach flow and sediment transport

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 1.0 foot/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.

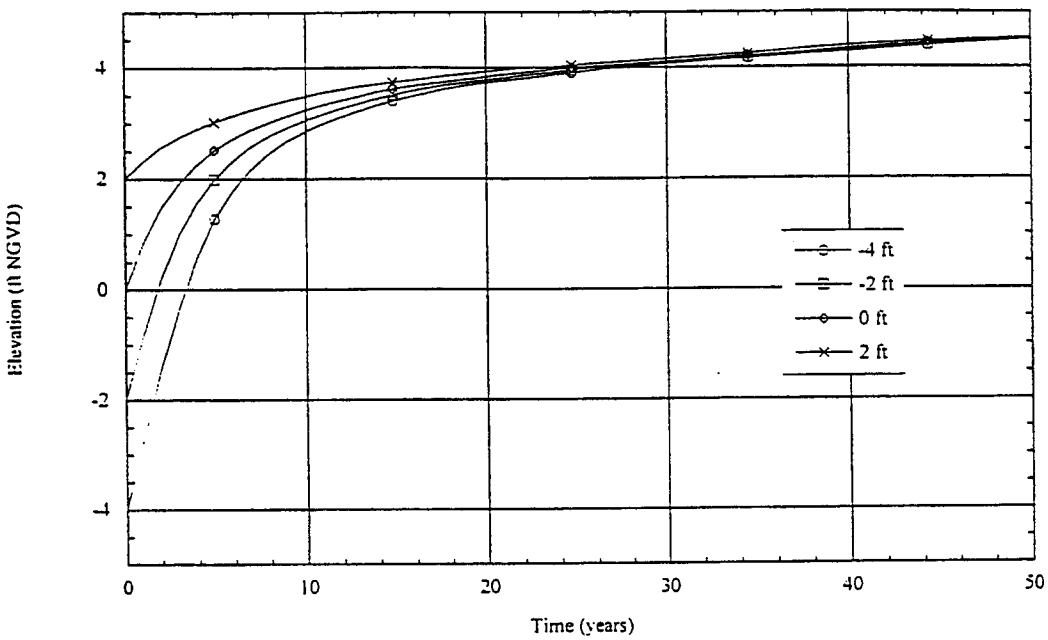
Long-Term Sedimentation Curves

To predict the change in sedimentation rates that can be expected as the site evolves from a subtidal to an intertidal system, sedimentation curves were developed using a one-dimensional, long-term marsh sedimentation model developed after Krone (1987). The model predicts a mean sedimentation rate across the restoration site as a function of the sediment supply and characteristics, the period of inundation (which changes as a function of the tidal range and the bed elevation), and sea-level rise.

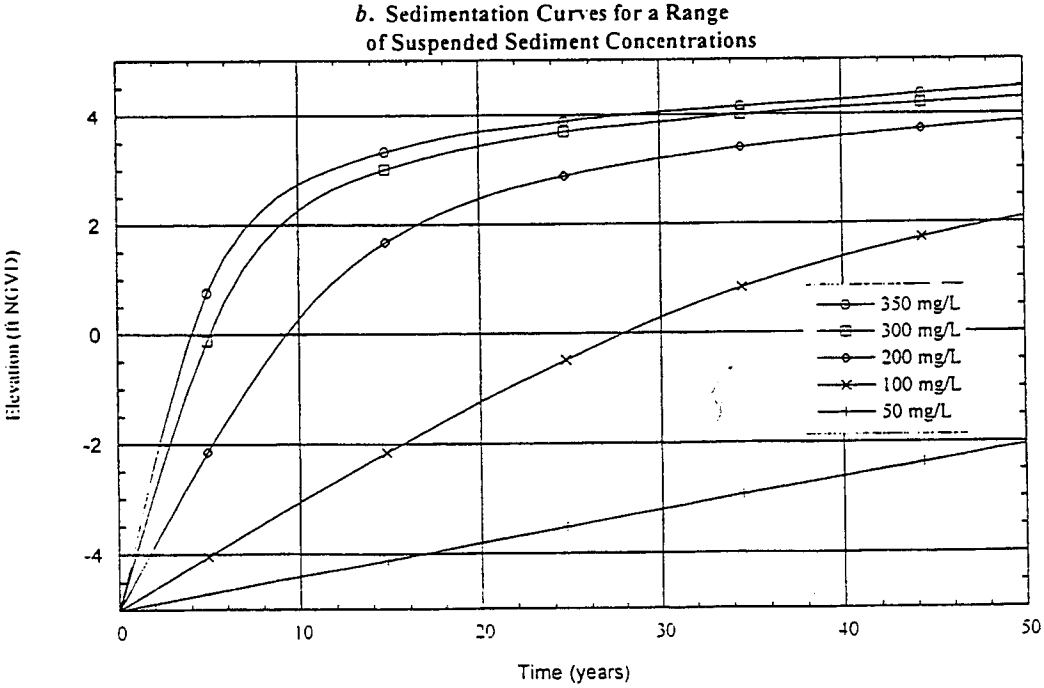
Sedimentation curves generated for a range of suspended sediment concentrations (supply) and initial ground elevations are presented on Figure 2-6. The curves are exponential, indicating the highest sedimentation rates will occur immediately after breaching when the depth of water over the marsh plain and the tidal prism is greatest (marsh plain at the lowest elevation). Sedimentation rates will decrease as the depth of water above the marsh plain decreases (as the marsh plain reaches the elevation of mean high higher water).

Hamilton Wetlands Sedimentation Curves

Hamilton Wetlands
a. Sedimentation Curves for a Range of Bed Elevations (Co = 350 mg/L)



Hamilton Wetlands
b. Sedimentation Curves for a Range of Suspended Sediment Concentrations



The family of curves on Figure 2-6(b) illustrates the effects of initial site elevations on the predicted sedimentation rates. The difference in the time required for site evolution if dredged material is placed in tidal wetland areas will be estimated using pairs of sedimentation curves with initial site elevations of +1 and -5 foot (National Geodetic Vertical Datum), respectively.

Suspended sediments brought into the Hamilton site on flood tides will be at a concentration that reflects some combination of two San Pablo Bay sources, the adjacent mudflats and the San Pablo Bay channel. The family of curves on Figure 2-6(a) illustrates the variability in sedimentation rates associated with the range of long-term average annual suspended sediment concentrations between 50 mg/L and 350 mg/L. The curves presented bracket the expected range of concentrations occurring in tidal waters in San Pablo Bay. The lower (50 mg/L) limit of the range reflects observed suspended sediment concentrations in San Pablo Bay. The upper limit of 350 mg/L is adopted based on the calibration of a comparable long-term sedimentation model using Port Sonoma data (RMA et al., 1996). This range of values illustrates the impacts of uncertainty in defining a representative long-term suspended sediment supply parameter on predicted sedimentation rates. This parameter differs from the measured suspended sediment concentration in that the long-term average supply must incorporate the influences of both average and storm conditions. Figure 2-6(a) shows that approximately 15 years will be required to fill this site to the MHW elevation assuming a 350 mg/L concentration. Assuming a 50 mg/L concentration, sedimentation rates are substantially slower, and more than 50 years of sedimentation is required to fill this site.

Given these uncertainties, the design team's analysis takes a comparative approach to evaluate the proposed design alternatives. For the comparison of alternatives, a suspended sediment concentration range of 200 mg/L and 350 mg/L is assumed. The 200 mg/L values is chosen to reflect a depth-integrated sediment supply dominated by concentrations in the tidal channel in San Pablo Bay (the likely sediment source for the Hamilton Wetlands Restoration site). The upper limit is defined as the 350 mg/L value obtained from calibrations at the Port Sonoma Marina. These higher concentrations are observed on local mudflats (the likely source for the smaller Port Sonoma site) as a result of wind-induced resuspension of sediments. The initial sedimentation rates were estimated using the deep-water curve range from 0.8 to 1.3 feet/year over the first 5 years, and are consistent with observed sedimentation rates noted above.

Spatial Variation in Sedimentation Rates

The sedimentation curves represent average, long-term sedimentation rates across the entire Hamilton Wetlands Restoration site, but do not reflect the spatial distribution of sediments throughout the site. Actual sedimentation rates will not be uniform across this site. Much of the sediment in the water column will be deposited near the inlet at first, and sedimentation will progress inward, becoming more uniform over time. The result is an initial reduction in sediment supply to the 'back marsh' (the area of the restoration site furthest from the inlet) as suspended sediments deposit near the inlet. Preliminary hydrodynamic modeling of a comparable wetland design performed for the U.S. Army (Kamman et al., 1998) indicates that less than 50% of the suspended sediment concentrations near the inlet were predicted to reach the most inland portions of that site during the first year of evolution. Because San Francisco Bay has no restoration sites of

comparable size, little other information is available to characterize differential sedimentation over time.

Given the reduced sedimentation rates observed in the hydrodynamic modeling, sedimentation rates for back-marsh areas are anticipated to be significantly less than those predicted by the long-term sedimentation curves during the early stages of evolution. This lag is illustrated by comparing two of the long-term sedimentation curves presented on Figure 2-6(a). Thus, the placement of dredged material on site will reduce the overall time required for site evolution (Figure 2-6(b)), and will reduce the time lag (or spatial disparity) between evolution of front- and back-marsh areas, for two reasons:

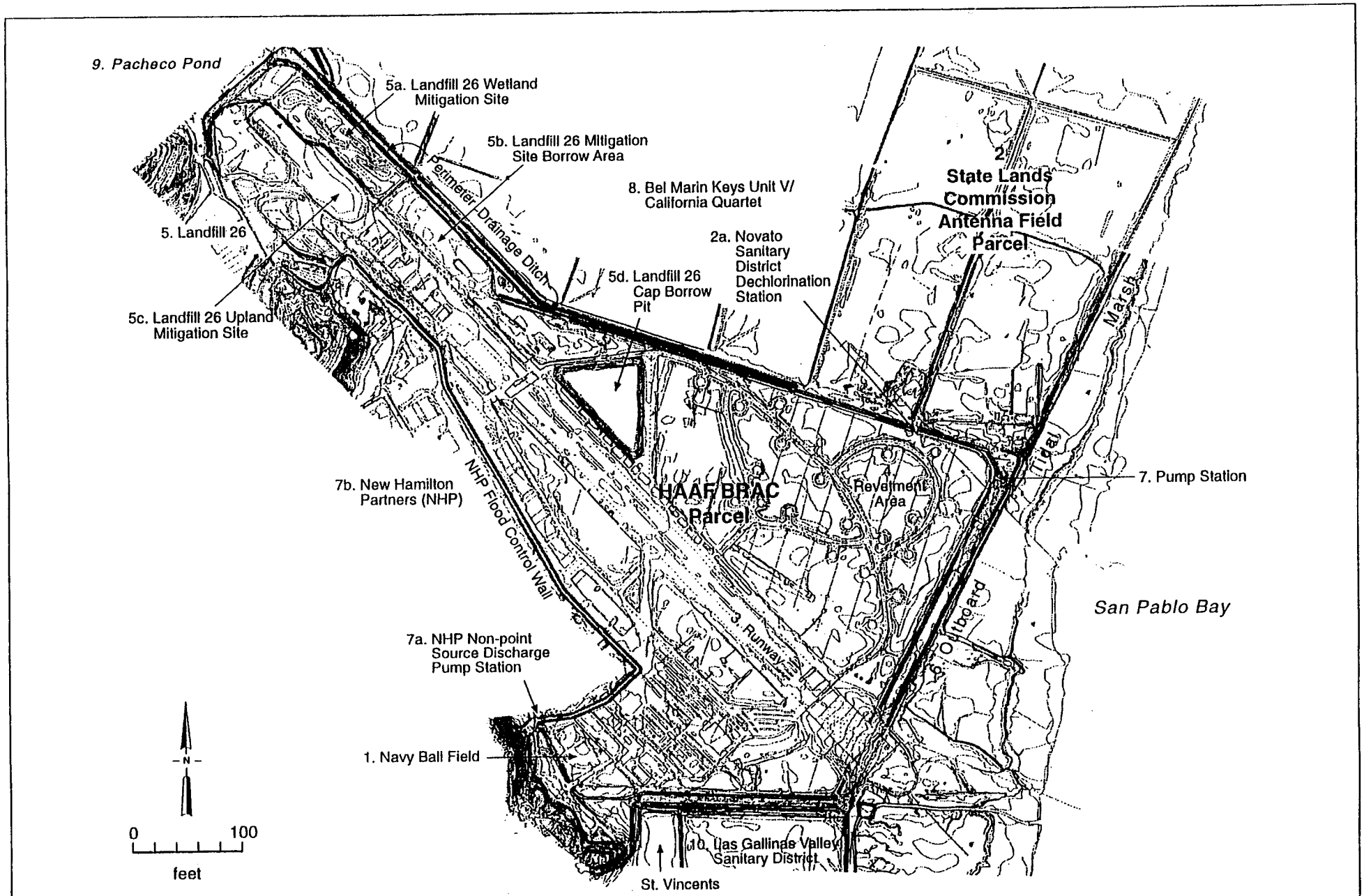
By filling the restoration site with dredged material, the overall sediment deficit for the system is reduced and velocity gradients are more gradual across the site. With less of the supply being deposited near the inlet, more sediments will be available to the back marsh. The sediments will be more uniformly transported and distributed within the system, and sedimentation will progress more rapidly toward the back marsh.

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.

Thus, the advantages of placing dredged material are likely to be even more significant in reducing the time required for evolution of the back marsh.

3.0 SURVEYING AND MAPPING

Existing drawings were utilized in this study. For design, the Corps of Engineers will prepare through a survey contract, a topographic survey of Hamilton Airfield. The area is shown on Figure 3-1. The survey contractor will take aerial photographs of the study area that will be controlled both vertically and horizontally. The aerial photography will be used to plot contours and spot elevations of the area. Cross sections will be plotted of the existing levee, the proposed levee and the proposed pilot channels. The surveying contractor shall locate all above and below ground structures and utilities. The new maps shall be drawn in metric units.



Project No. 971185NA	Hamilton Hamilton Wetlands Conceptual Plan	SITE PLAN
	Woodward-Clyde	

971185NA-22DO/040398/gos

4.0 GEOTECHNICAL

4.1 Regional Geology

The HAAF site lies within the Coast Range physiographic province of California, resting on a large structural block bounded to the west by the San Andreas Fault and by the Hayward Fault to the east. The topography between these fault zones consists of alternating, northwest-trending mountains and hills separated by valleys and lowlands. The bedrock in the region around HAAF consists of the Franciscan Formation, which was deposited during the Jurassic through early Tertiary periods in association with subduction of the oceanic Pacific Plate beneath the continental North American plate. The Franciscan Formation consists of a wide variety of highly deformed rock types that were deposited along the margin of the subducting and overriding plates. Texturally, the Franciscan Formation ranges from large coherent blocks of rock (up to tens of kilometers in length) to a jumbled assemblage of small coherent rock masses floating in a fine-grained matrix of intensely sheared and crushed rock material, commonly referred to as a melange (Rice et al., 1976 and Page, 1979). Typical rock-types found in the Franciscan Formation consist of greenstone, chert, serpentine, schists, meta-volcanics, sandstone, and mudstone. The origin of these rock materials range from oceanic crust and deep marine siliceous oozes to submarine volcanics and well sorted flows of land-born sand, gravel, and clay.

The sediments overlying the Franciscan Formation in the Bay Area are underformed and were deposited during the more recent Holocene and Pleistocene Epochs. In general, these relatively young alluvial (river-born) and estuarine sediments were deposited during cycles of sea-level rise and fall associated with periods of Pleistocene glaciation. The Quaternary sediments in the Bay Area have been referred to by Treasher (1963) as either Younger or Older Bay mud. Trask and Rolston (1951) further subdivide the Older Bay mud into three distinct formations (from youngest to oldest); the Posey Formation, the San Antonio Formation, and the Alameda Formation. In addition, Trask and Rolston identified a localized deposit of aeolian (deposited by wind) sand lying between the Younger and Older Bay mud units.

The Holocene surficial deposits of the Younger bay mud found throughout the Bay Area are considered to be estuarine deposits, formed over the last 10,000 years in association with approximately 100 meters of sea level rise since the end of the Wisconsin glaciation (Atwater, 1977). These estuarine deposits are characterized as soft, organic-rich clay and silt. The older units beneath the Younger Bay mud display a wider range of textural variability, including interbedded clay, sand, and gravel horizons (Trask and Ralston, 1951). Several of these coarser grained Older Bay mud units are considered alluvial fan deposits, characteristic of low stands in sea-level. During the most recent low stand in sea level (Wisconsin glaciation), the aeolian Merrit Sand (observed in borings completed in the central portion of San Francisco Bay) and underlying alluvial Posey Formation were deposited (Atwater, 1977). The period of relatively high sea level between the Illinoian and Wisconsin glaciations was also a period of estuarine sedimentation; sediments correlating to this period consist of the San Antonio Formation clays. Sediments associated with the older glacial and interglacial periods are believed to be contained in the Alameda Formation.

4.2 Geology at Hamilton

The bedrock hills exposed at HAAF consist of the Cretaceous aged Franciscan Formation (Geomatrix, 1994). These rocks include light- to medium-colored, hard, fractured sandstone. It has been suggested by Engineering-Science (ES, 1993) that portions of bedrock underlying Reservoir Hill consist of relatively younger, Tertiary aged interbedded sandstone, siltstone, and shale. Alluvial and colluvial (hillslope) deposits have been identified in borings completed between and along the margins of the bedrock hills at HAAF. Typically, these deposits consist of silts and clays with interbedded lenses of sand and gravel that interfinger bayward with the shallow Bay mud estuarine deposits.

Beneath the proposed Seasonal and Tidal Wetland areas, surface deposits consist primarily of pavement and/or approximately 4 to 5 feet (on average) of subgrade fill material. The fill material, consisting of varying proportions of sand, gravel and Bay mud, is up to 10 feet thick in some areas of the site. Beneath these surficial deposits lays a considerable thickness of Bay mud deposits. Denby (1978) and Bonaparte and Mitchell (1979) have characterized the Younger Bay mud at the site as soft, fine-grained clays, some of which are easily hydrated and expandable. The Younger Bay mud is notorious for its poor engineering properties, mostly a result of its high water content (typically above 90%) and extremely low unconfined compressible strength.

At the HAAF site, Woodward-Clyde (WCC) refers to the upper 5 to 10 feet of Younger Bay mud as Desiccated Bay mud; Bay mud that contains a compositional and structural signature indicative of seasonal wetting and drying . Beneath the Desiccated Bay mud lies what WCC refers to as Soft Bay mud, deposits which are perennially saturated and display lower permeability's than the Desiccated Bay mud (WCC, 1996). The soft Bay mud extends to depths generally varying between 70 feet along San Pablo Bay to around 30 feet in the northwestern portion of the HAAF site.

All investigations at the HAAF site have focused on characterizing and delineating the Younger Bay mud deposits. However, based on logs of relatively deep borings completed along the western margin of the airfield and in the southeast corner of the site, the Younger Bay mud unit appears to be underlain by an equivalent of the Posey Formation, indicating that the Merrit Sand is absent beneath the HAAF site. The overall thickness of the older units beneath the central and southern portions of HAAF is unknown; a geotechnical boring completed in the southeastern corner of the site in 1978 by the USGS extended to 90 feet below ground surface, possibly reaching the San Antonio Formation**,** but not the underlying bedrock.

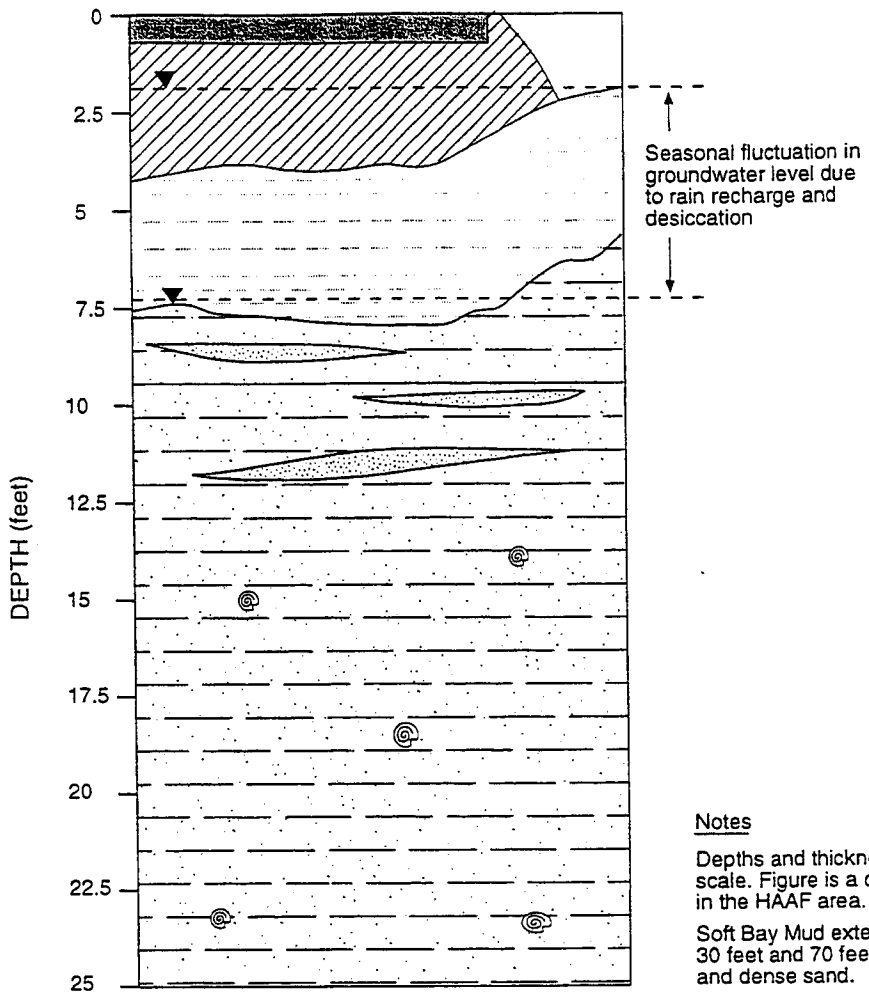
4.3 Geotechnical Conditions

The area of the proposed wetland restoration is presently a few feet 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 varies somewhat seasonally. As shown on Figure 4-1 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.

The Bay Mud is a plastic silty clay, with high compressibility, low shear strength, and generally low permeability. The 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 Bay-Mud-underlain areas cause compression of the Bay Mud, which in turn requires more fill to be placed and 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 4-2 illustrates the anticipated amount and time history of settlements of soft Bay Mud, and distinguishes between large-area loads and more localized loads, such as applied by new levees, which cause somewhat smaller settlements.

In addition, fills applied over limited areas, such as levee fills, cause shear stresses in the Bay Mud that, if they exceed the soil's shear strength, cause stability failures. Therefore, new levees are designed with geometries that provide adequate stability, which may require stabilizing berms.



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

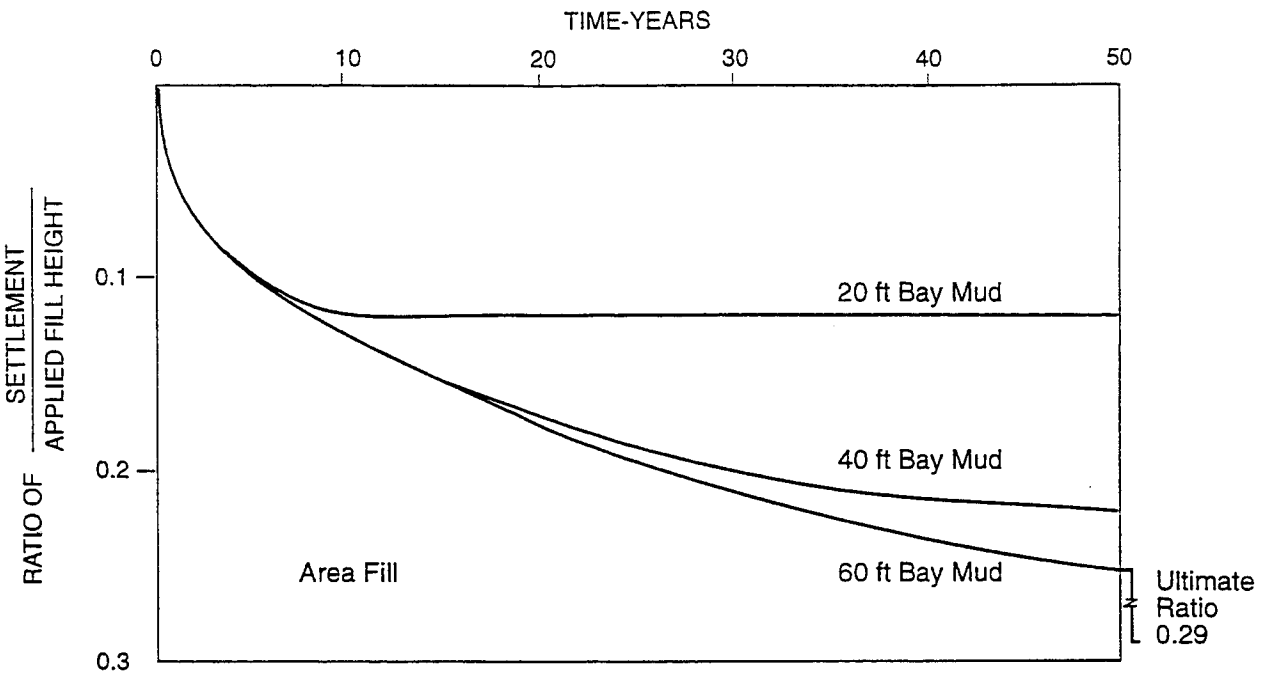
Desiccated Bay Mud
Silty clay, greenish grey (10Y 5/1) to greyish brown (10YR 3/2), strong iron oxide staining on numerous desiccation cracks

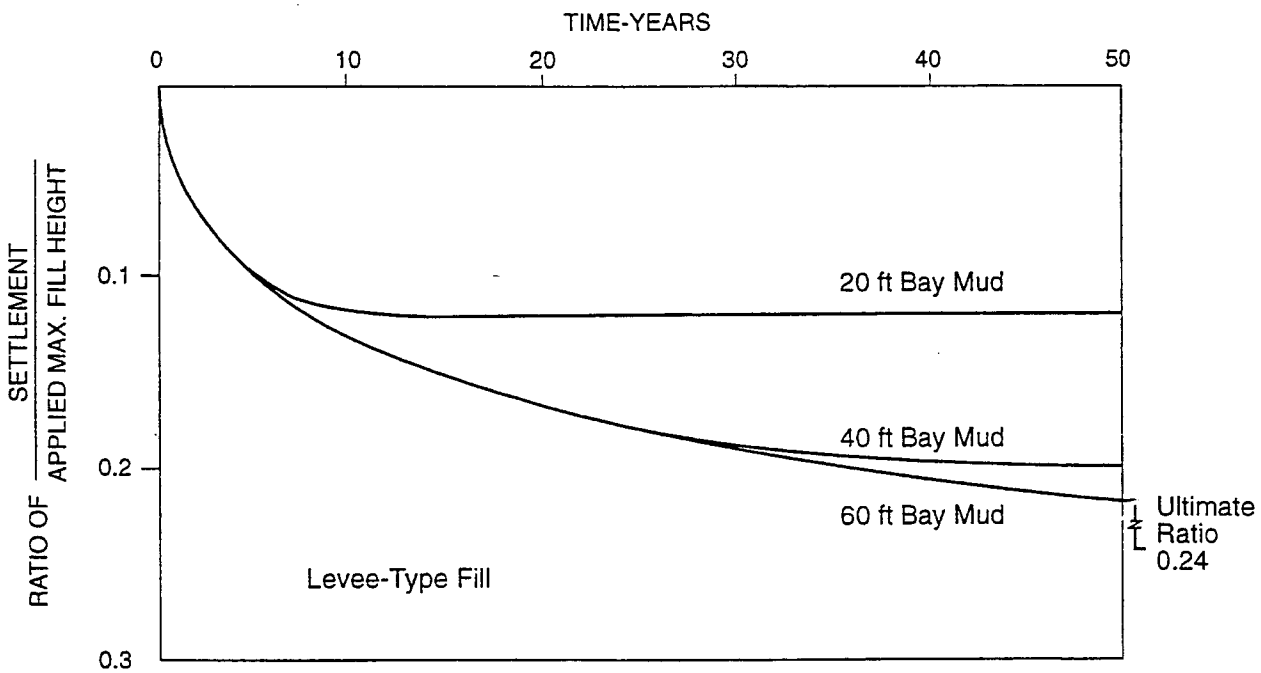
Soft Bay Mud
Silty clay, greenish grey (10Y 5/1) to dark grey (2.5Y 4/1), soft, saturated, shell fragments scattered throughout, rich in organic matter (decayed plant fragments, peat)

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		





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			

971058NA-44F0/033198/gos

5.0 PROJECT DESIGN

In this section the project design and its principal features are discussed. Following a general description of the design, the principal site development engineering aspects and site drainage are addressed. Issues related to existing infrastructure and utilities, and the placement of dredged material are then discussed.

5.1 Introduction

The selected plan is the preferred design based upon its ability to create a natural gradient of habitats, using dredged material, from upland through mudflat, without internal levees and water control structures. The operation and maintenance of this design is simpler since it does not include any water control structures. This design offers the best option for sustaining ecological functions over time and it meets the HRG habitat objective of 80% tidal and 20% non-tidal habitats.

The appearance of the project will evolve over time. Initially, the tidal section of the site will consist of subtidal and intertidal mudflat habitats. The incoming San Pablo Bay waters will introduce invertebrates that will rapidly colonize the intertidal mudflats, providing a food source for shorebirds and waterfowl. Bay waters will also introduce a variety of fish to the site such as chinook salmon, striped bass, green sturgeon, steelhead trout, staghorn sculpin, inland silversides, and Pacific herring. The tidal pannes will be present at the time of the breach as a result of site construction. These areas will provide high tide refugia for shorebirds and gulls. It will take at least one full season to accumulate the salt deposits typical of the pannes and for the growth of vegetation around the fringe of the pannes.

As sediment builds, cordgrass will begin to colonize the site, followed by species such as pickleweed, jaumea, alkali heath, gumplant, and salt grass. The growth of vegetation will be accompanied by the development of the slough channel network. Channels will be broad and undefined at the time of the breach, developing more complexity as the marsh plain elevation increases. Tidal ponds are expected to form in the mature marsh.

The tidal pannes are the transitional habitats between the areas that receive daily tidal action and the non-tidal habitats: the seasonal wetland, grassland, and upland. The seasonal wetlands will shallowly pond precipitation and will have a mixture of areas that have minimal, low-growing vegetation and a drainage channel that will support taller emergent vegetation such as cattail, bulrush, and some willows along the edge. Many of the bird species present in the tidal wetlands will also use the seasonal wetlands. Seasonal wetland invertebrate communities typically include zooplankton, aquatic beetles, bugs, and flies. Fish are not typically found in seasonal wetlands due to their seasonality and shallow depths. As the annual and perennial grassland and upland habitats mature, shrubs will voluntarily colonize the area.

The distribution of habitat is approximately as follows:

Subtidal channel/openwater	= 44 acres
Intertidal channel/mudflat	= 22 acres
Coastal Salt Marsh	= 690 acres
Tidal Pannes	= 41 acres
Tidal Ponds	= 4 acres
Nontidal wetlands	
Seasonal wetland/ponds	= 62 acres
Perennial emergent marsh	= 2 acres
Grassland	= 85 acres
Total*	= 950 acres

*Acreage figures were developed by FWS in preparing the HEP and are not based on real estate acreages calculated by the Corps.

5.2 Principal Site Engineering Aspects

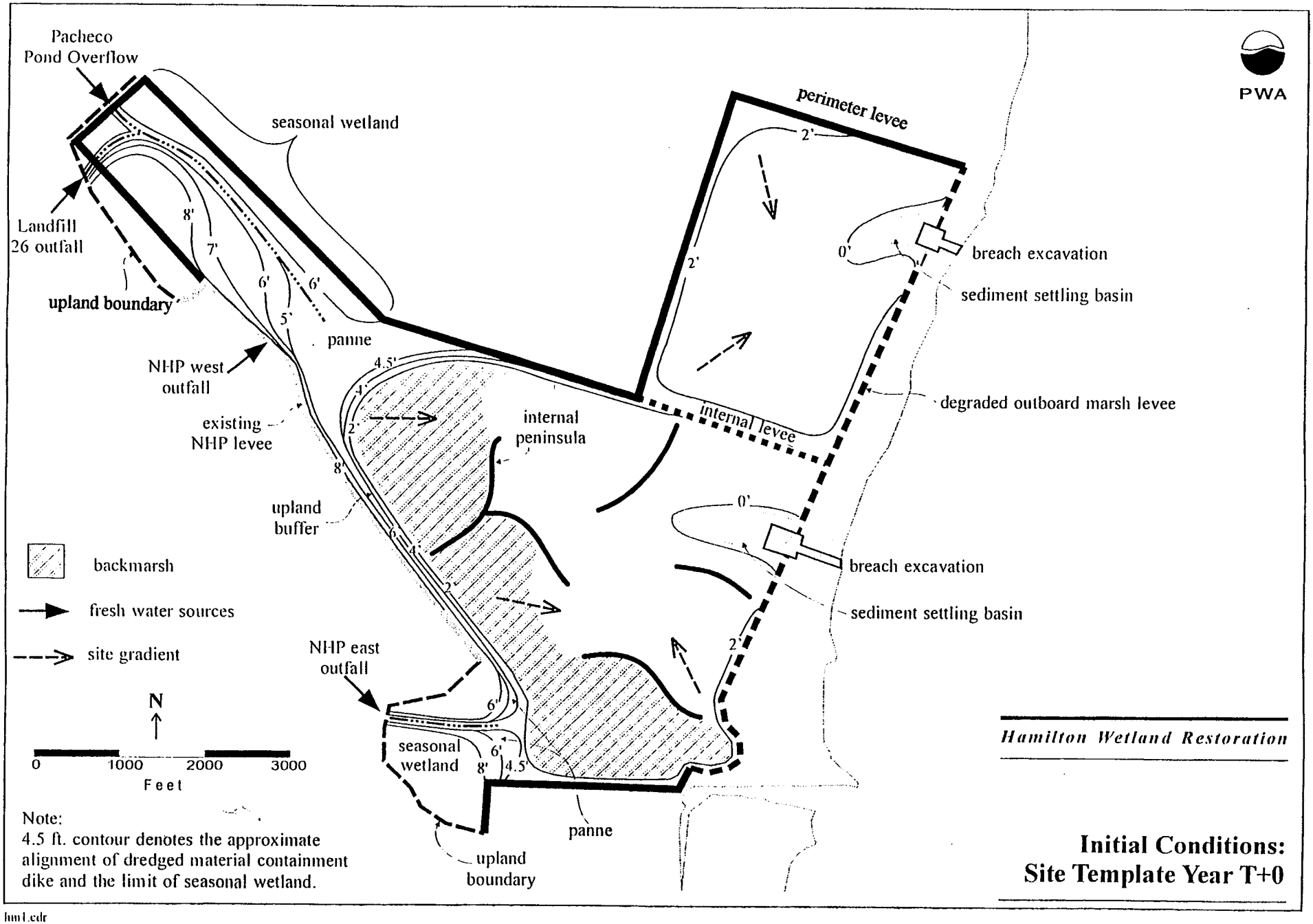
The principal site engineering aspects are addressed in this section. These include design of perimeter levees and internal peninsulas, including borrow material for these levees; design of the levee breaches and associated pilot channels; and design elements that minimize mosquito breeding.

The existing bay front levee is sufficient to retain the dredge material to be placed, and will not be modified except for the addition of two weirs to control process water during dredge material placement. Issues related to site drainage during and after site development, existing infrastructure and utilities including the Novato Sanitary District's outfall facilities, and details of dredged material placement are addressed separately in subsequent sections.

5.2.1 Perimeter Levees

New levees (Figures 5-1, 5-2 cross-section b, and Figure 5-3) are required all around the upland perimeter of the new wetlands except where they abut the recently constructed NHP levee, to protect the adjacent developed and agricultural areas from being flooded once the site is restored to tidal action. The perimeter levees must be designed to provide the existing level of flood protection. The following levee design elevations are conceptual. Final design will require more detailed considerations of the parameters governing necessary levee height.

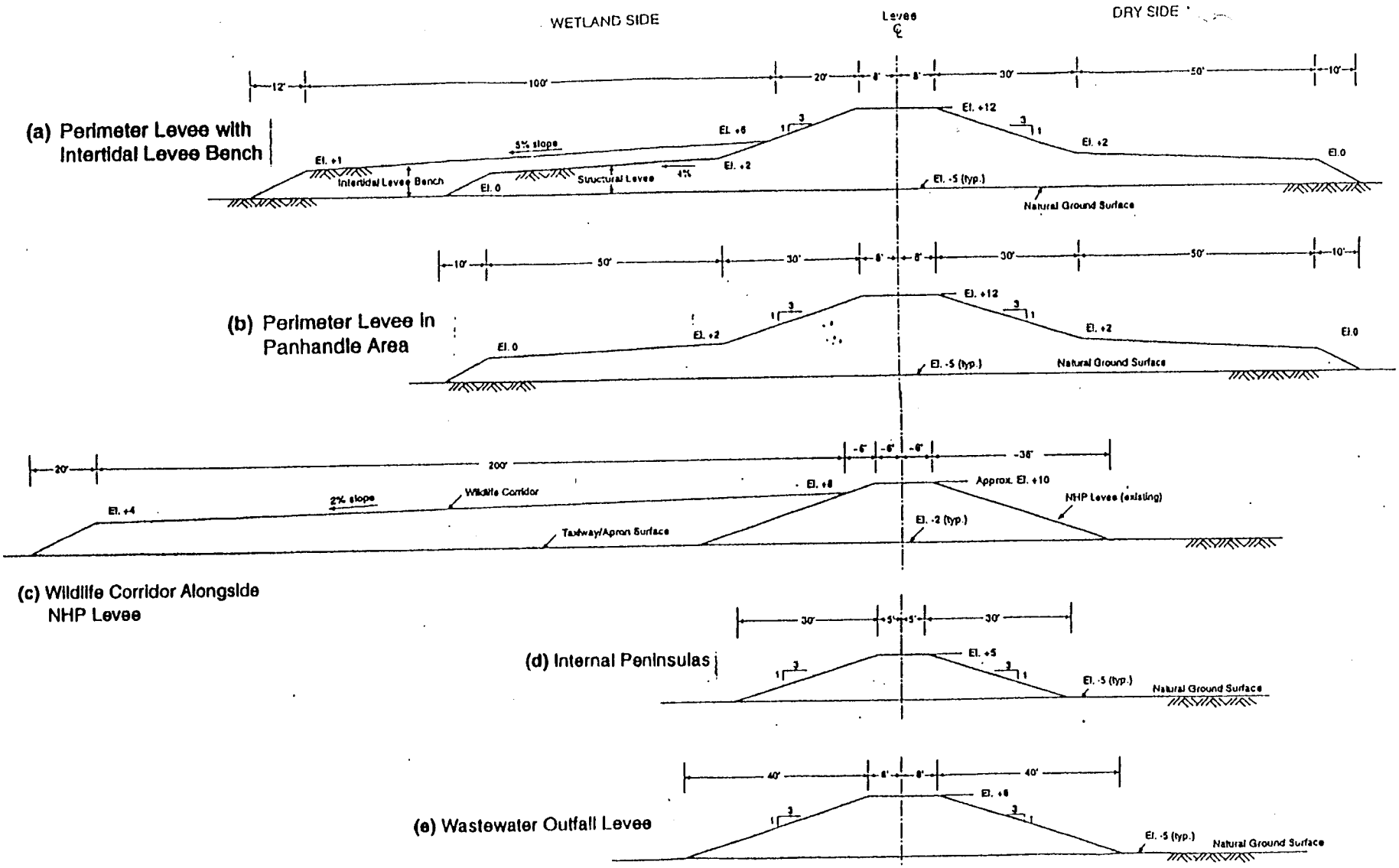
Considering that over most of its lifetime the perimeter levee will not be exposed to deep water and large waves, a levee design elevation of +8.0 feet appears reasonable after 50 years of subsidence to provide the existing level of protection of adjacent agricultural lands and is adopted here for the conceptual design. It is important to note that the levee



Note:
4.5 ft. contour denotes the approximate alignment of dredged material containment dike and the limit of seasonal wetland.

hm1.cdr

DRAFT



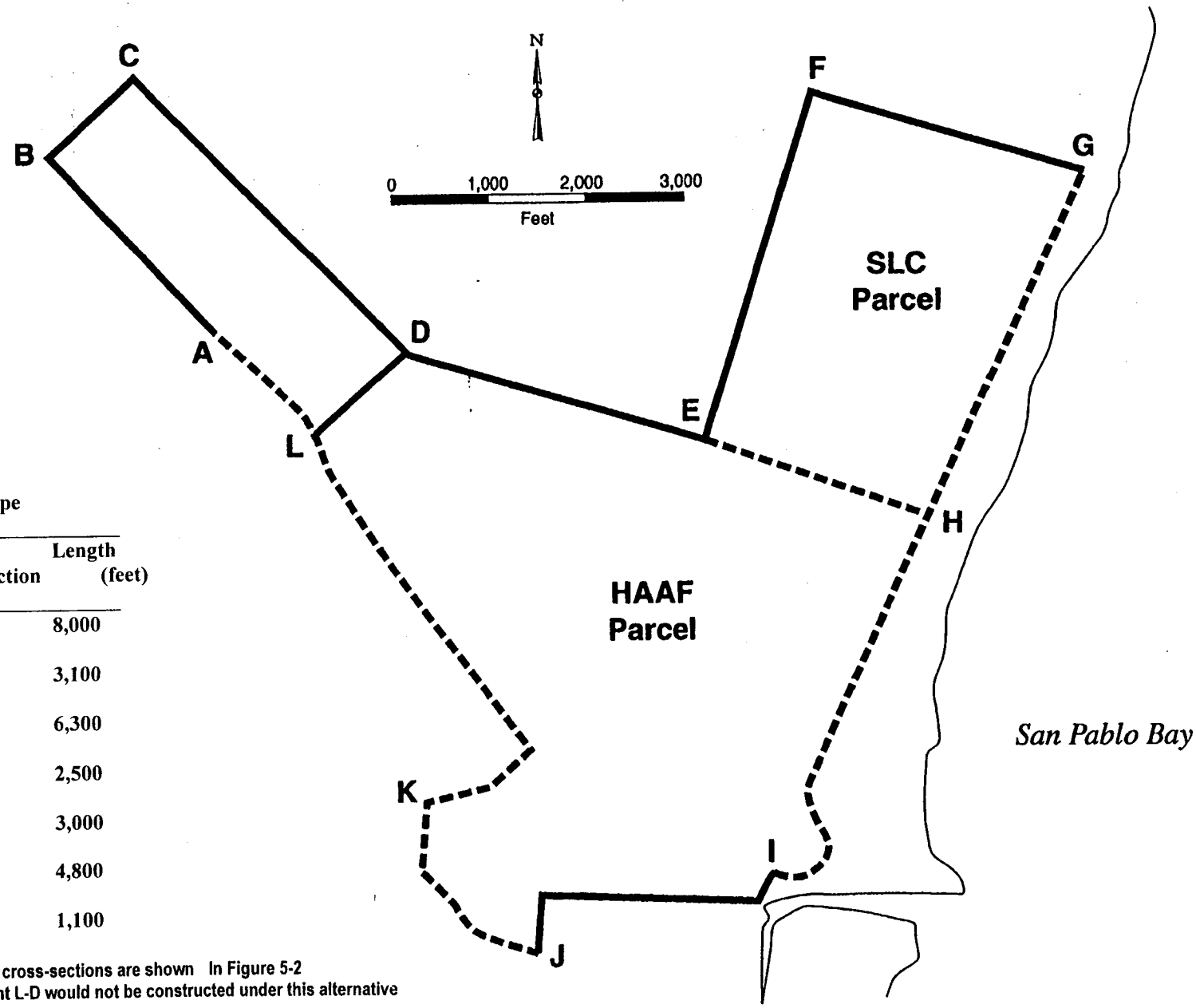
Note: End-of-construction elevations shown; final evevations will be lower.

Source: Woodward - Clyde 1998.

Jones & Stokes Associates, Inc.

Appendix B Figure 5-2

Typical Levee Cross Sections



Segment type

Levee Segment	Cross Section	Length (feet)
A-B-C-D	b	8,000
D-E	a	3,100
E-F-G	a	6,300
E-H	e	2,500
I-J	b	3,000
K-L	c	4,800
L-D	-	1,100

Notes: Levee segment cross-sections are shown In Figure 5-2
- Levee segment L-D would not be constructed under this alternative

Levee Segments for Alternative 5

crest will be initially constructed to an elevation +12 feet, and will subside to the 8 foot elevation toward the end of the 50 year design life, after mature wetlands have formed.

The perimeter levees must satisfy 5 types of performance criteria: settlement, stability, seepage, scour/erosion, and sea-level rise. These criteria, especially stability and settlement, are a challenge for levees constructed on the soils encountered at the Hamilton Wetlands Restoration site because of the thick soft clay layer underlying the site.

Settlement - The settlements expected under the loads imposed by the levee and adjacent fill must be considered in the design of the levees, by either constructing the levee to a greater height initially or planning future levee raising to account for the settlements, or a combination of the two.

Stability - The levees must be constructed to have adequate short-term and long-term stability; i.e., they must not fail under expected imposed operating conditions including earthquakes.

Seepage - The perimeter levees must control seepage both through and under the levee.

Scour/Erosion - Levee slopes in contact with areas of open water must be designed to resist scour and erosion damage due to water currents and waves.

Sea-Level Rise - Approximately 0.5 foot of sea-level rise is anticipated over the design life of the structure.

Investigations of subsurface conditions and levee construction in the area were conducted by IT Corporation (1997a, 1996) and Miller-Pacific (1995). The conceptual information on levee design and expected performance presented here is based primarily on site-specific information and designs presented in these references, as well as information published by California Division of Mines and Geology (1969) and information in Woodward-Clyde files. No new site investigations or laboratory tests have been performed for this study. Therefore, the concepts developed here are conceptual and must be refined based on additional site-specific information obtained during final design.

The perimeter levee will be constructed using on-site desiccated clay from the Bay Mud "crust." Borrow material is further discussed in Section 5.2.3. The clay will be well compacted. Satisfaction of the performance criteria is discussed below.

Settlement. To achieve a long-term (defined here as 50 years) levee crest elevation of +8 feet, the levee should be constructed to an elevation of +12 feet initially, to accommodate an estimated 4 feet of long-term settlement. The estimate of 4 feet of settlement is reasonable rather than conservative, because each foot of additional initial levee crest height makes initial construction more onerous due to stability concerns. The capability exists to make moderate adjustments to levee crest height in the future if the levee should settle more than 4 feet. The 4 feet of settlement also includes a 0.5-foot allowance for sea-level rise.

Stability. To satisfy stability criteria for end-of-construction conditions (required minimum stability factor of safety of 1.3), the levee with a crest elevation of +l2 feet will

require side slopes of 3 horizontal to 1 vertical (3H:1V) or flatter, and toe berms on both sides of average 6-foot height and 50-foot width, as shown in Figure 5-2. This levee has a 200-foot wide footprint. Over time, as the levee settles and the underlying Bay Mud consolidates and gains strength, the factor of safety will increase to well in excess of 1.5. Placement of dredged material and sediment on the wetland side of the levee and inundation of the wetland area by breaching the outboard levee will not significantly affect stability, but will increase the expected long-term settlement. With a static factor of safety exceeding 1.5, the levee is also expected to survive earthquakes to which it might be subjected.

Seepage. Seepage through or under the levee is of concern for the perimeter levee, because it will have a combination of water and dredged material on its "wet" side. It is expected that the levee will be constructed of either dried Bay Mud or imported clayey fill. Hence, through-levee seepage will not be of concern. Existing granular near-surface fill from below the main body of the levee (but not below the toe berms) should be excavated, and a keyway (trench filled with new levee fill), about 20 feet wide, should be constructed through the natural clay crust.

Scour/Erosion. Scouring of the levee face on the bayward side due to wave action and water currents is of concern. The concern is mostly short-term, since after the first few years marsh vegetation will establish on the levee and tidal berms such that water depths adjacent to the levee will be shallow and the wind fetch will be shortened by internal peninsulas and increasing dredged material and sediment depth. Nevertheless, levee slopes expected to be exposed to wave and current action for extended periods of time (i.e., exceeding a few months), should have scour protection. Because scour protection consisting of rock riprap is not acceptable for this project, the tidal berm placed alongside the levee will serve as a sacrificial earth berm. This berm will consist of compacted soil, probably on-site desiccated clay, and will also be compacted to provide optimal scour resistance. No scour protection is needed where dredged material is placed against the levee to at least elevation +5.0 feet prior to breaching of the outboard levee along San Pablo Bay, because any waves above this level will be rare and will have low energy due to the shallow depth of water. Any scour damage should be repaired as a part of levee maintenance.

5.2.2 Internal Peninsulas

A system of internal peninsulas is proposed as part of the site template to: (1) reduce levee erosion by decreasing internal wave heights, thereby reducing wave runup; (2) promote rapid sedimentation by limiting internal wave energy; and (3) constrain the location of tidal slough channels in order to minimize the impacts of the runway on wetland evolution. A gap of at least 200 feet will be established between the peninsulas and the site perimeter to limit predator access. Internal peninsulas will be constructed to provide a maximum fetch length of 3,000 feet on the HAAF site. A pre-breach peninsula crest elevation of +5 feet and crest width of 10 feet are needed to reduce internal wave energy during both typical and extreme storm conditions. The crest height specified provides wave energy dissipation during storm conditions assuming 2-3 feet of inundation and waves. The resulting peninsula cross section is shown on Figure 5-2, cross-section d. The peninsulas will be constructed using on-site desiccated clay borrow

material. If the amount of borrow is insufficient, then dredged material will be used for peninsula construction.

Settlement. At the end of construction an internal peninsula crest elevation of 5 feet will be needed to accommodate consolidation on the HAAF site. After 50 years of settlement, the crest elevation will drop to about 3 feet.

Stability. Side slopes of 3H:1V and a crest width of 10 feet will provide adequate levee stability. Final design may be able to reduce this based on further analysis.

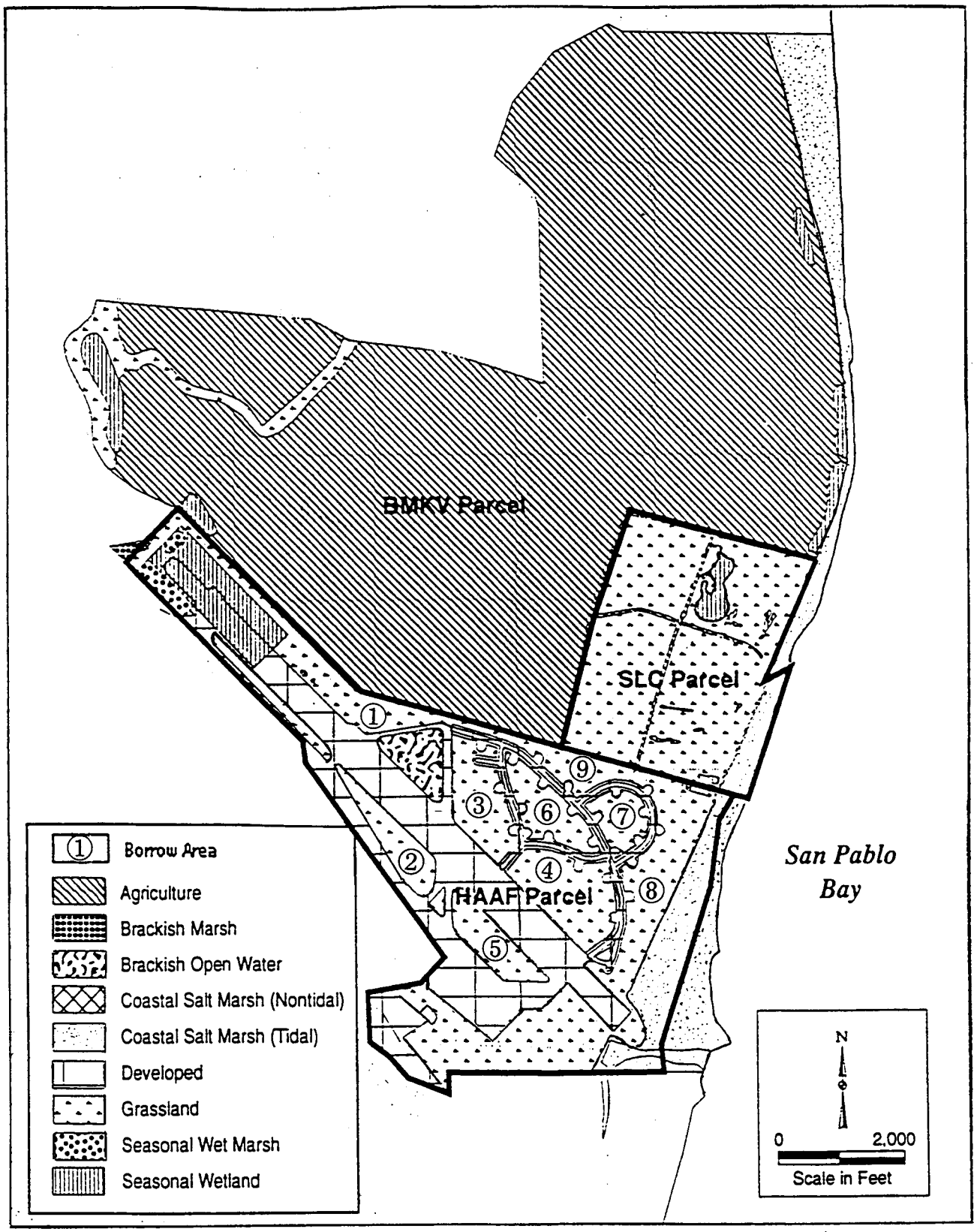
Seepage. Seepage, either through or underneath the levee, is not of concern for the internal levees, because water pressures acting on both sides will be essentially equal.

Scour/Erosion. The internal peninsulas will be subject to scouring action due to tidal flows and waves. A slow deterioration of the peninsula's shape is acceptable and desirable because they have a limited design life on the order of 10 years, beyond which time they should blend into the marsh plain. Because of the intent for these levees to blend into their surrounding, any "artificial" slope protection that might otherwise be recommended for the prevailing scouring conditions is undesirable. The recommended solution is to use relatively erosion resistant well-compacted soil for the construction of the peninsulas, and to seed them with grasses before the outboard levee is breached. Well-compacted desiccated Bay Mud appears suitable as construction material. Peninsula compaction is specified based on experience from the Sonoma Baylands Marsh Restoration site, where uncompacted peninsulas initially eroded quickly when subjected to storm wind-wave conditions. Removal of peninsula remnants may be necessary if they are still evident as discontinuities in the newly established marsh plain.

5.2.3 Borrow Materials and Volume Needs

The preferred source of borrow material to construct levees and internal peninsulas at this site is desiccated (dried-out) Bay Mud. Naturally desiccated Bay Mud is found to several feet of depth throughout the future wetland sites, both in the HAAF and SLC sites. The borrow sites are shown in Figure 5-4, while Fig. 4-1 presents a soil schematic. Because of the long-term use of the HAAF site, part of the near-surface soils could be chemically contaminated to some degree. Therefore, the near-surface soils in the SLC site are the preferred borrow source until adequate testing is done for material from HAAF. Testing and cleanup of contaminated soils is being conducted by the Army under the BRAC process. Final design should use Army data to determine acceptable borrow areas.

An estimate has been made of the required fill quantity to construct the perimeter levee, internal peninsulas, and outfall pipeline protection levee. For flood protection, erosion protection, and habitat reasons, the perimeter levee cross section has been modified to include a tidal berm on the wetland side having a width of 100 feet and end-of-construction elevations of +6 feet at the levee and +2 feet on its outboard side (see Figure 5-2, cross-section a). This tidal berm would be used wherever the flood control levee was not located along a seasonal wetland and would serve as a site for the vegetation



Jones & Stokes Associates, Inc.

Habitat Types and Borrow Sites At HAAF Wetland Restoration Project Site

colonization around the site perimeter. The estimated total required borrow volumes for the levees are:

Perimeter levee with tidal berm: 9,400 feet @ 85 cu yd/foot = 799,000 cubic yard (cu yd)

Perimeter levee without berm: 11,000 feet @ 64 cu yd/foot = 704,000 cu yd

Internal peninsulas: 5,800 feet @ 16 cu yds/foot = 93,000 cu yd

Novato Sanitary District discharge outfall protection levee: 2,500 feet @ 29 cu yd/foot = 73,000 cu yd

Total = 1,669,000 cu yd

The potentially available borrow volume from the SLC site, estimating a practical excavation depth of 3 feet, is estimated at about 1,000,000 cu yd. Compared with the borrow material need of over 1.7 million cu yd, this estimate suggests that there may be a shortfall of the preferred borrow material. Measures to cover the shortfall are considered to be, in order of preference:

Using adjacent or nearby clean borrow material for the internal peninsulas in the HAAF site would "save" 93,000 cu yd

Using dredged material for the tidal berms on the wetland side of the flood control levees except for a small toe berm constructed of adjacent borrow material (needed to place the dredged material) would save 260,000 cu yd

Reusing material from existing levees along the new levee alignments and elsewhere is estimated to replace up to 100,000 cu yd of borrow material

Constructing the levees to less than full design height initially, and then using material gained from excavation of the pilot channels, levee breaches, and lowering of the remainder of the outboard levee along San Pablo Bay would displace about 140,000 cu yd of borrow material that would otherwise be needed

Using additional crust material from the HAAF site, both desiccated Bay Mud and overlying gravel fill, all demonstrated as clean by closely spaced tests, as borrow material

Importing construction fill

Use of most or all of these alternatives could eliminate the apparent shortfall of borrow material.

In summary, it appears that suitable borrow material in adequate quantities will be available to construct the planned levees. The quantities of material from the primary source, the desiccated shallow Bay Mud in the SLC site, and from the preferred alternate sources should be maximized by judicious planning and implementation, to minimize the need to use the less desirable, more costly alternate sources.

The excavation of one to one-and-a-half million cu yd of fill from the SLC and HAAF sites to construct levees has been factored into the dredged material volume and site development calculations.

5.2.4 Levee Breaches and Pilot Channels

A single inlet channel will be excavated in the existing outboard levee and salt marsh for each of the sites. The breach locations are identified on Figure 5-1. Use of a single inlet channel maximizes persistent subtidal habitat in the mature marsh system by focusing the tidal prism within the tidal channel network. The inlets consist of two parts: the levee breach cut through the existing outboard levee; and a narrower, but equally deep, pilot channel cut through the outboard marsh. This narrower pilot channel reduces the impacts of excavation to the outboard tidal marsh; however, the pilot channel is expected to scour rapidly due to tidal exchanges after breaching. The breach dimensions will provide full tidal action to the restoration sites and maximize intertidal circulation and sedimentation.

The proposed dimensions of the levee breaches and pilot channels are summarized below in Table 5-1. They are based on an extrapolation of hydraulic geometry relationships for large North Bay marshes.

TABLE 5-1
INITIAL TIDAL WETLAND INLET DIMENSIONS

	HAAF Site Inlet Dimensions		**SLC Site Inlet Dimensions**	
	Levee Breach	**Outboard Marsh Pilot Channel**	**Levee Breach**	**Outboard Marsh Pilot Channel**
Cross-Sectional Area (ft^2)	2,500	1,600	1,200	800
Channel Depth (ft, bottom elevation)	- 8.5	-8.5	-5.5	-5.5
Channel Top Width (ft)	280	165	220	100
Channel Bottom Width (ft)	155	40	120	20
Channel Side Slope (H:L)	1:4	1:5 - 1:10	1:4	1:5 - 1:10
Channel Length (ft)	200	800	50	200
Channel Excavation Volume (yd^3)	25,500	24,900	7,900	3,400
Channel Surface Area (acres)	1.3	3.0	0.5	0.6

The breach dimensions are based on the expected equilibrium channel dimensions for the site. The levee breaches are designed to remove compacted levee material so the remaining portions of the levee will not impede tidal flows in the mature marsh system.

The inlet channel is anticipated to scour rapidly in response to the large initial tidal prism and then fill as sediment deposition reduces the tidal prism and tidal exchange. A channel across the mudflat connecting the restoration area to San Pablo Bay is expected to form naturally as a result of tidal flows into and out of each site.

Construction of the outboard marsh pilot channels would be the first step toward introducing tidal action and the levee breaches would follow. Construction of the outboard marsh pilot channels could be accomplished by excavating with standard heavy land-based equipment or by dredging with a small dredge. The excavated material would be placed into the project site or used for levee construction.

Excavation methods would typically use medium to large track mounted excavators. This equipment would enter the marsh from the levee placing timber mats ahead of itself if necessary to avoid sinking into the marsh plain. Excavation would begin at the bayside extent of the channel and proceed back toward the site. The main disadvantages of this method are the continual re-handling of material as excavation proceeds towards the site and the difficulty in spreading the excavated material within the project site.

The dredging method would likely use a small hydraulic cutterhead suction dredge (6- to 10-inch diameter pipeline). This dredge would be floated into the exterior portion of the channel during a spring high tide and excavate towards the site. Dredged material would be pumped into the site. This operation would likely be more efficient than the excavation method and the relatively small amounts of dredged material could easily be blended into the adjacent tidal marsh restoration areas. The possible disadvantage of this method is that the dredge might only be able to operate during high tides, since the mudflats outboard of the marsh may prevent the dredge from having a source of water to work with during low tides. Alternatively, a very small tidal water channel could be temporarily excavated across the mudflats as the dredge was approaching the site.

Prior to the levee breach excavation, the existing outboard levees will be degraded to an elevation similar to that of the outboard marsh plain (approximately +3.5 feet). Portions of the outboard levee would remain at higher elevations to function as high tide refugia for marsh biota, such at the salt marsh harvest mouse. The material removed from the levees could be spread on the inboard levee slope or hauled to other on-site locations. Appropriate reuses for the excavated material could be along the flood control levee near the breach to provide added erosion protection, or it may be used for the new flood control levees or tidal berms.

Levee breaches would be the final operation to restore tidal action into the sites. This excavation would likely be accomplished with medium to large track mounted excavators. The excavated material could be placed and spread nearby or hauled to other on-site locations. Typically, a small plug of levee would be left in place and the final breach would be cut at an appropriate tide level.

5.2.5 Design Elements that Minimize Mosquito Breeding

The early, open-water stages of the project will likely provide minimal habitat for mosquito breeding and larval development. The levee breaches and pilot channels that will be cut through the outboard marsh introduce a large volume of tidal water to the site. The tidal marshes planned for the site are likely to produce fewer mosquitoes than the seasonal wetlands, thus the goal of having a 4:1 ratio of tidal to seasonal wetlands may also minimize opportunities for mosquito breeding. Non-tidal wetlands that maintain a seasonal nature and dry out in late spring or early summer are potentially less of a problem than non-tidal wetlands that have standing water all year. Thus, the low channel that will help to drain the seasonal wetlands will decrease the size of the potential area of mosquito breeding habitat. Consolidating the seasonal wetlands into one area is preferable from a mosquito management perspective. Areas such as tidal ponds and pannes that will develop over time may be mosquito breeding habitat if they do not receive daily tidal flushing. The dynamic processes of settlement and sea-level rise may

contribute to creating elevations that increase the frequency of tidal flushing in the tidal ponds.

The width of the flood control levee crest is adequate for vehicle access in order to provide for long-term operation and maintenance requirements of mosquito abatement district personnel and equipment, as well as other wetland managers. Larval controls used by the mosquito abatement district include methoprene and BTI, a bacterial agent, and mosquito fish.

5.3 Channel Characteristics and Site Drainage

5.3.1 Channel and Inlet Features

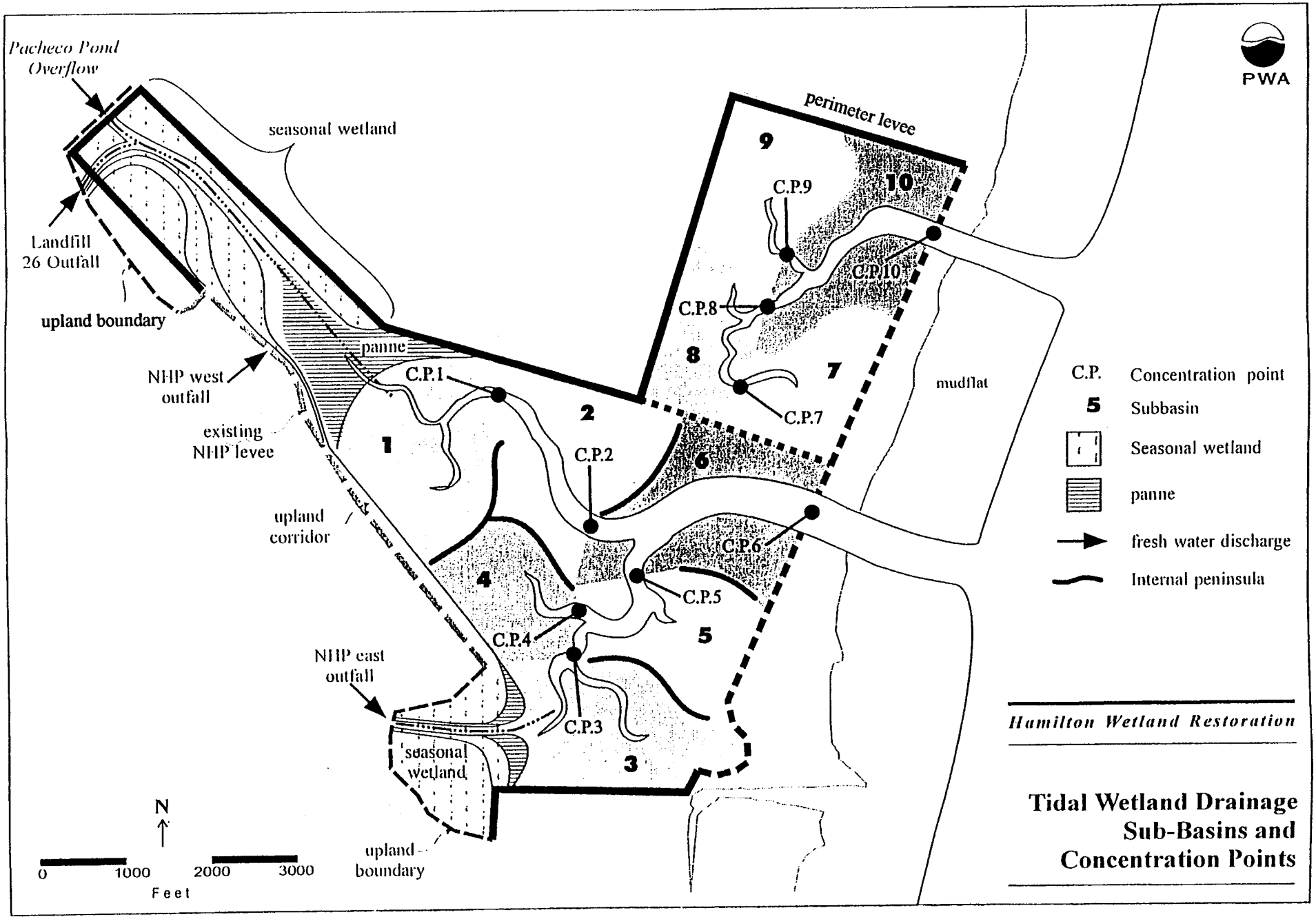
This section describes the configuration and density of internal channels expected to form in the mature wetland system, expected tidal wetland slough channel habitats, and the levee breaches and pilot channels.

Internal Channels

When it reaches a state of dynamic equilibrium, the Hamilton Wetlands Restoration site tidal wetland will be a combination of marsh plain areas and slough channels. The size of the slough channel that will form on any given part of the site depends on the amount of tidal flow through the channel. Tidal prism, the volume of water in a marsh system contained between MLLW and MHHW, is the characteristic measure for this flow. Tidal hydraulic geometry relationships between slough channel dimensions and tidal prism for equilibrium (long-term) conditions for large North Bay wetlands were used to estimate the size of the slough channels that are expected to form for the preferred alternative. Table 5-2 shows the estimated equilibrium dimensions of slough channels at the points depicted on Figure 5-5. The shaded regions denote the areas draining to the respective channel at these points. The equilibrium tidal prism draining to each concentration point (location) was calculated using these shaded areas.

Placing internal peninsulas that direct flow can influence the general location and size of major slough channels. The anticipated configuration of these major channels is shown on Figure 5-6. As much as possible, the internal peninsulas were sited to direct the development of the largest channels to minimize the impacts of the runway on channel evolution. The former runway and other paved surfaces may influence the configuration of internal slough channels at the site by limiting the extent of channel down cutting. Table 5-2 provides a comparison of equilibrium channel depths and local runway or paved surface elevations at each concentration point. Although the concrete runway is high in elevation relative to the adjacent airfield, it does not appear to be a significant constraint on channel formation with the proposed configuration. Table 5-2 shows that local runway elevations would limit the evolution of the channel at concentration point 4 only and that other paved surfaces would limit the evolution of channels at concentration points 1, 2, and 5. However, for concentration point 4 on the runway, the depth reduction is one foot or less and is unlikely to seriously hinder site drainage or affect general wetland morphology. For the limitations at concentration points 1, 2, and 5, it is

Appendix B Figure 5-5



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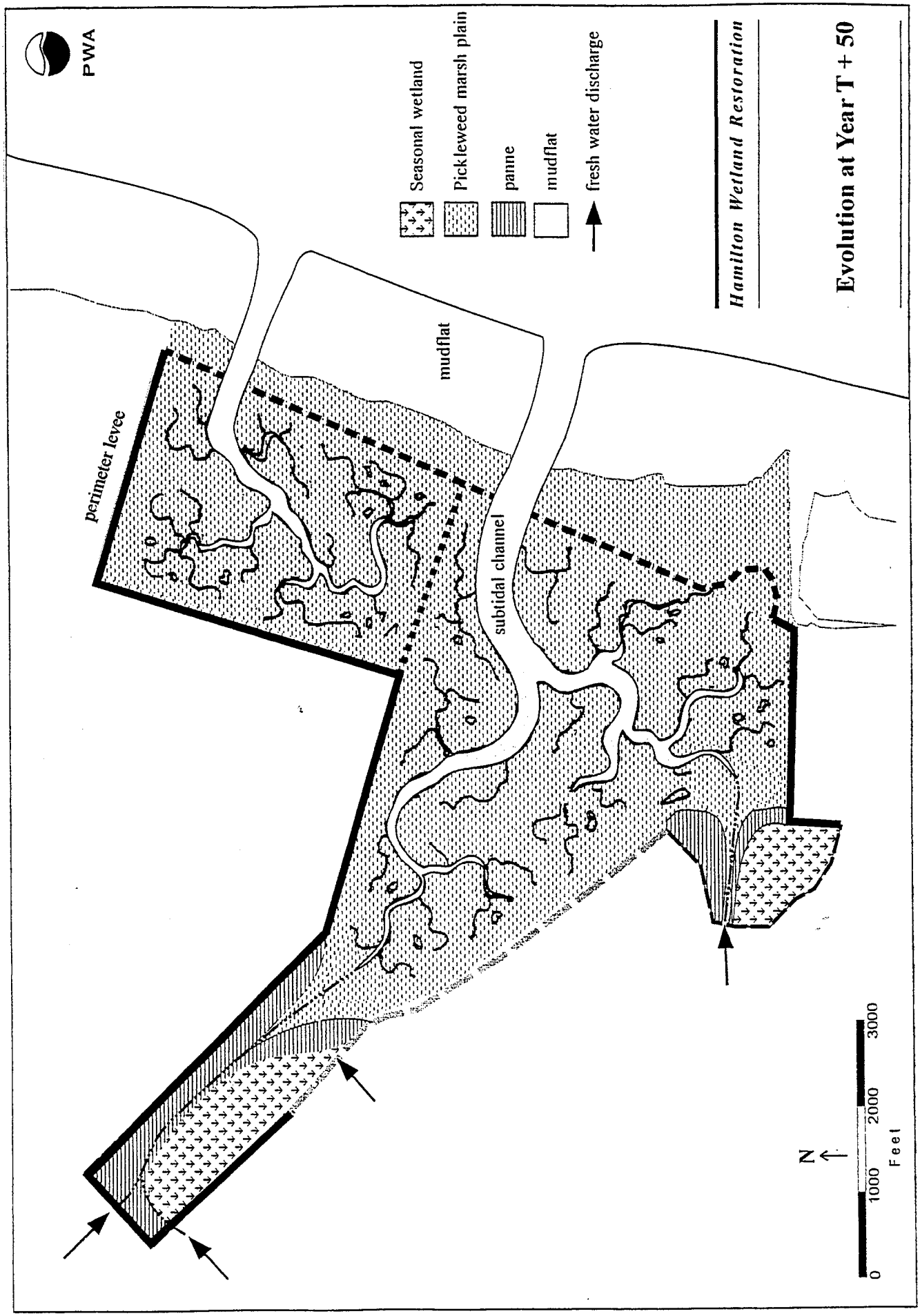

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recommended that the paved surfaces be removed. Other impacts associated with the runway may include the formation of scour holes in the path of the channel on either side of the runway and temporary ponding of water on the landward side of the surface during the ebb portion of spring tides.

TABLE 5-2
APPROXIMATE EQUILIBRIUM DIMENSIONS OF INTERNAL SLOUGH CHANNELS

Concentration Point	Marsh Zones ** Drained	Estimated Tidal Prism (acre-feet)	Channel Top-width at MHHW (feet)	Channel Cross-Section Area below MHHW (sq. feet)	Maximum Channel Depth below MHHW (feet)	Channel Thalweg Elevation (feet)	Local Runway/ Paved Elevation (feet)
1	1	55	138	270	7.90	-4.47	-2.3 to -3.2*
2	1, 2	103	182	400	9.30	-5.87	-4.0 to -2.7*
3	3	29	103	180	6.64	-3.21	-3.8 to -4.1
4	3, 4	63	146	300	8.17	-4.74	-4.0 to -3.6***
5	3, 4, 5	94	175	370	9.09	-5.66	-3.8 to -4.5*
6	1, 2, 3, 4, 5, 6	250	269	700	11.75	-8.32	n/a
7	7	24	95	170	6.30	-2.87	n/a
8	7, 8	49	131	265	7.66	-4.23	n/a
9	9	35	113	208	7.02	-3.59	n/a
10	7, 8, 9, 10	129	200	450	9.86	-6.43	n/a

* Runway or other paved surface elevation will inhibit the equilibrium channel thalweg elevation for this concentration point.

** See Figure 5-4

*** Runway surface elevations will inhibit the equilibrium channel thalweg elevation for this concentration point. Since less than 1 foot, no action recommended.

Shortly after breaching, it is likely that deep subtidal channels will form near the inlet and where flow is constricted between internal peninsulas. If the width is sufficiently constrained, scour will occur in response to the large initial tidal prism, which is approximately four times larger than equilibrium values throughout the site. Scour is anticipated near concentration points 2, 4, and 5 during the first 1 to 2 years of site evolution. It is advisable to remove or break up the concrete and asphalt areas near concentration points 1, 2, and 5. These areas should be targeted as borrow sites creating excavations which will eliminate any impacts and facilitate channel development. In areas where paved surfaces do impact channel formation, the channels will likely be wider than equilibrium top-widths to maintain adequate cross-sectional flow areas.

Expected Tidal Wetland Slough Channel Habitat

Initially, the tidal wetland portion of the site will be almost exclusively intertidal habitat, with site grades between 0 and 2 feet. Over time, sediments carried with each tide will build the marsh plain upward and concentrated flow will cut drainage channels into the fill material. At equilibrium, the site will provide a combination of tidal channel and

marsh plain habitat. Table 5-3 shows the expected distribution of subtidal channel (below MLLW), intertidal channel (between MLLW and MHHW), and high marsh plain habitat (approximately MHHW) at equilibrium conditions. These estimates are based on channel geometry relationships for existing and historic systems in northern San Francisco Bay.

The habitat estimates in Table 5-3 are derived from an analysis of channel order relationships. A tidal wetland is drained by a network of small (lower order) channels joining to form successively larger (higher order) channels. The order of the channel is specified based on the number of channels that contribute flow to that channel. Based on the sizes of the HAAF and SLC sites, it is estimated that fifth-order channel systems will form in each of these areas. Channel geometry relationships derived from other San Francisco Bay marshes were used to estimate the expected distribution of first through fifth order channels at the site. For each channel order, average channel length and cross-sectional geometry (top width, depth, and shape) were estimated. This information was used to estimate expected habitat distributions.

TABLE 5-3
ESTIMATED EQUILIBRIUM TIDAL WETLAND HABITAT TYPES

Channel Characteristics	Channel Order					Total
	1	2	3	4	5	
HAAF Site						
Total Length of Channels (ft)	141,109	46,046	13,148	4,597	1,300	206,200
Average top width at MHHW (ft)	2	6	22	80	269	--
Average Depth below MHHW (ft)	1.0	3.2	8.0	10.5	11.8	--
Subtidal Habitat (acres)	-	-	5.8	8.2	7.9	21.9
Intertidal Habitat (acres)	6.5	6.3	0.8	0.3	0.1	14.0
Marsh plain (acres)	--	--	--	--	--	485.0
SLC Site						
Total Length of Channels (ft)	65,974	26,035	8,990	3,801	1,300	106,100
Average top width at MHHW (ft)	2	6	22	80	200	--
Average Depth below MHHW (ft)	1.0	3.2	8.0	10.5	9.9	--
Subtidal Habitat (acres)	-	-	4.0	6.7	5.9	16.6
Intertidal Habitat (acres)	3.0	3.6	0.6	0.2	0.1	7.5
Marsh plain (acres)	--	--	--	--	--	213.0

Notes: Calculations assume a total drainage density of 500 feet/acre and constant bifurcation ratio. The inlet channel length is not included in the subtidal channel acreage.

First and second order channels generally drain completely at MLLW and are thus intertidal habitat. Third, fourth, and fifth order channels are deeper and generally extend below MLLW. Channel portions above MLLW are included in the estimate of intertidal habitat; the portions below MLLW are included in the subtidal estimate. For the estimates of intertidal area, it was assumed that the larger channels would have steep, 4.5V:1H side-slopes between MHHW and MLLW.

5.3.2 Site Drainage During Construction

Existing on-site drainage routes will be disrupted during site preparation. On the HAAF site, the perimeter drainage ditch will be closed during site preparation. On the SLC site, drainage to the HAAF site will be blocked and existing ditches will be altered or blocked. On both sites, interim drainage will be required to remove standing water and maintain access during site construction. The project will also need to provide interim drainage during site construction for Landfill 26, other portions of HAAF and the NHP outfalls which will ultimately discharge directly into either the tidal or the seasonal wetlands. The conceptual plan assumes that alternate drainage systems will have to be established for the Las Gallinas Valley Sanitary District property and California Quartet Property by the Army as part of base closure and prior to the transfer of the property to the State Coastal Conservancy. Alternative discharge points will be required for these adjacent properties.

One of the first steps in site preparation will be to establish an interim drainage system consisting of a series of surface ditches and a lift station within each of the restoration sites. Within the HAAF parcel, a primary drainage ditch will be cut into the existing site grades along the northern side of the runway. A drainage network consisting of surface channels will be established, and linked with the existing drainage network where possible, to provide site drainage. Surface connections and small capacity pumps will be placed as needed to remove excess water. The interim drainage system will terminate at the lift station. A series of pumps will be installed, creating a lift station adjacent to the proposed new perimeter levee ditch to remove accumulating water from the site. After excavation is complete no effort will be made to remove water which accumulates in borrow areas across the site. Drainage from the NHP outfalls and Landfill 26 will be maintained during dredged material placement and routed to the interim drainage network.

A similar approach will be taken on the SLC site during site preparation. Existing drainage ditches will be utilized and/or regraded toward the future breach location as necessary. In areas where borrow sites obstruct channel drainage, new surface channels will be cut or pumps will be utilized to route water to the collection point. Water will be routed to a borrow area near the future levee breach and pumped from the site into the existing outboard marsh channel.

Large quantities of water will be generated during filling of the tidal and seasonal wetlands with dredged material.

5.3.3 Surface Drainage Changes

Under existing conditions, storm runoff from the Hamilton Wetlands Restoration site and adjacent areas drains through the perimeter drainage ditch to the northeastern end of the airfield, where pumps transport runoff into San Pablo Bay.

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 Bel Marin Keys Unit V (BMKV) development parcel, Landfill 26, Pacheco Pond, and the

SLC parcel. The Coastal Conservancy has indicated that before its acceptance of the HAAF parcel, existing flood control and drainage issues between the Army and surrounding landowners would be resolved.

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. The Army has agreed to implement the following solutions.

- Permanently close the slide gate on the canal that currently drains the St. Vincent's, Las Gallinas Sanitary District, and U.S. Navy properties. The drainage will be redirected to a pump station managed by the Sanitary District. The pump station is currently being upgraded to be able to accommodate any increase in drainage caused by closing the slide gate.
- Construct a pump station to convey water from Landfill 26 and the surrounding area to the HAAF parcel.
- Permanently block the three 30 inch corrugated steel pipes that run through the levee separating the HAAF and BMKV parcels. These pipes are currently non-operational. The property owner is willing to let the Army block these pipes without making any further modifications to the BMKV parcel drainage system.

In addition to the Army's modifications, the restoration project will incorporate two flap gated culverts to accept overflow from Pacheco Pond into the panhandle during flood conditions.

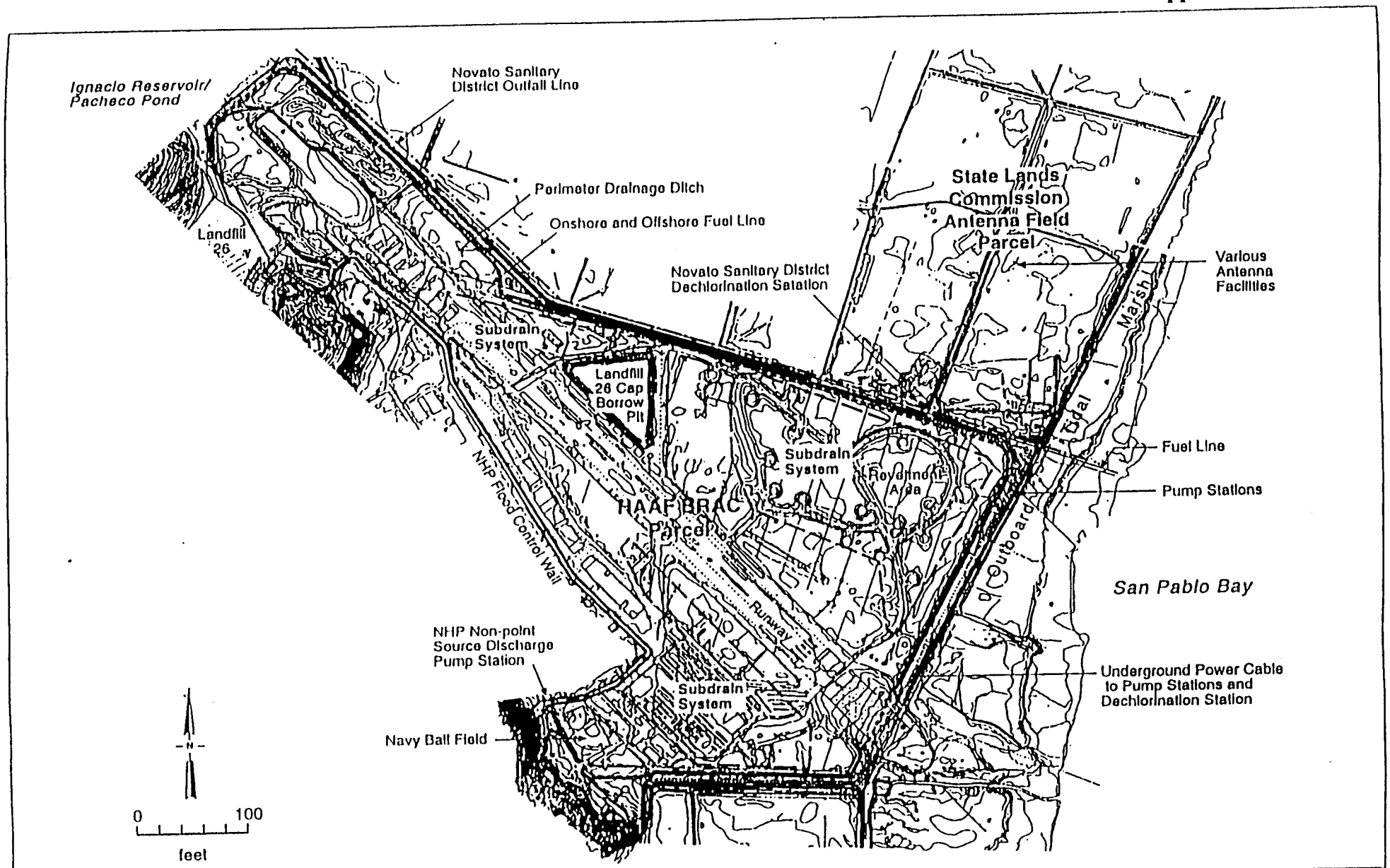
With the proposed restoration, airfield pumping would be discontinued and the outboard levee will be breached in each site, allowing tides to inundate much of the site. Perimeter levees will be constructed or improved around the site, tying into existing flood control levees and upland areas. Portions of the site (in the airfield panhandle and in the southeast portion of the airfield) will be filled to create uplands, seasonal wetlands, and pannes above the high-tide elevation. These activities will alter the existing drainage characteristics within the site. Runoff would enter the site at the NHP east and west outfalls, the new Landfill 26 outfall, and through the flap gated culverts from Pacheco Pond. Some water would pond in the seasonal wetland areas and the rest would enter the bay through the natural system of channels that the restoration project would create.

5.4 Existing Infrastructure and Utilities

The two principal facilities of concern are the existing sewer outfall facilities and the existing drainage system facilities. Other existing facilities that are believed to have less significant impacts on the planned wetland development are also addressed. The existing facilities are shown on Figure 5-7.

5.4.1 Novato Sanitary District Facilities

The Novato Sanitary District outfall facility includes the outfall pipeline itself, a dechlorination station located next to the pipeline about 1,300 feet west of the present



Project No. 971185NA	Hamilton Hamilton Wetlands Conceptual Plan	FACILITIES
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outboard levee, utility connections to the dechlorination station, and an access road for inspection and maintenance along the length of the pipeline.

Discussions with the Novato Sanitary District have indicated that it may be possible to move the dechlorination facility off of the SLC site. This issue needs further study to determine if the move is feasible and would allow the District to meet its discharge requirements.

An equally significant issue regarding the District's facilities concerns the section of the pipeline between the two main wetland sites, the HAAF and SLC sites. The new flood control levee along the west side of the SLC site will cross the pipeline, and new fill will be placed on the section of the pipeline along the south side of the SLC site to develop the wetland. Also, the section of the pipeline through the wetland must remain accessible for inspection and maintenance, which requires construction of a new levee alongside the pipeline in the SLC site.

The new outfall access levee will be constructed immediately south of the pipeline, leaving a distance of at least 20 feet between the pipeline and the toe of the levee. The preliminary cross section of the new levee is shown on Figure 5-2, cross-section e. Analysis of this cross-section by the five previously discussed criteria shows:

Settlement. This levee's height has been selected to allow access to the outfall under all except extreme high tide conditions. A long-term crest elevation of +5 it has been tentatively selected for this levee, requiring an end-of-construction elevation of +8 ft. A crest width of 16 feet has been adopted for ease of access including heavy equipment. A sea-level rise of 0.5 foot is included in the 3 feet of settlement.

Stability. With these crest conditions, satisfaction of the end-of-construction stability criterion requires 3H:1V side slopes. The resulting levee geometry is shown on Figure 5-2. During final design any expected displacements due to seismic events should be estimated and their effects on the levee and the outfall considered.

Seepage. Seepage through or under this levee is of potential concern only during a possible period when the Bay levee is breached on one but not the other side of the levee. Even then, only seepage that might affect stability would be of concern. Use of appropriate levee construction material and appropriate levee foundation preparation, as discussed for the perimeter levees, would obviate any seepage concerns.

Scour/Erosion. The outfall levee will have to be protected from scour in a similar manner as the flood control levee, but in this case, protection will have to be provided on both sides. Only levee slopes not protected by dredged material at the time of levee breaching would need scour protection. Use of sacrificial fill for scour protection would be acceptable.

The outfall, by nature of its construction (54-inch reinforced concrete pipe, with bell-and-spigot joints) is susceptible to leaks due to differential rotation of joints. Construction of the adjacent levee must prevent damage to the pipeline.

The outfall pipeline will be crossed by the new perimeter levee located west of the SLC site, and will receive 8 to 10 feet of new fill over it as a result of the Hamilton Wetlands Restoration project activities. Because the pipeline is underlain by about 60 feet of soft

Bay Mud, the newly applied fills will cause pipeline settlement, and will make the pipeline more difficult to maintain.

At the pipeline crossing of the new flood control levee, approximately 17 feet of new fill is expected to cause a sag in the pipeline of 4 to 5 feet over a length of about 200 feet. In the developing wetland, with 8 to 10 feet of new fill, the expected total pipeline settlement will be about 2 feet. This total settlement will be accompanied by differential settlement, due to unequal fill heights and unit weights and random differences in subsoil properties, estimated at about +/- 3 inches.

These conditions of overburden depths and differential settlement will require the approval of the Novato Sanitary District. The location of the pipeline under the wetlands may be acceptable, but it is unlikely that the severe sag at the levee crossing would be approved.

Alternatives for the pipeline crossing may include:

- Sliplining the pipeline over the length of the levee crossing to prevent leakage at the joints
- Reconstructing the pipeline through the crossing zone, possibly with a positive initial camber (i.e., built higher) of up to 2 feet, with flexible joints
- Minimizing Bay Mud settlement by in-situ soil treatment in the crossing area by surcharging combined with use of wick drains at close spacing to speed occurrence of settlement, or use of stone columns or deep-soil-mixing columns to reduce the soil's compressibility
- A combination of in-situ soil treatment and sliplining of the pipeline, or reconstructing the pipeline with flexible couplings, appears most promising. The District may accept the increased depth of overburden over the short distance of the levee crossing.

If the conditions resulting from development of wetlands in the SLC site should be found unacceptable by the District, alternatives may include:

- Constructing a second sewer outfall levee north of the pipeline to prevent deposition of new dredged material or sediment over the pipeline
- Sliplining the entire pipeline across the SLC site
- Constructing a berm of either compacted soil or sandy dredged material adjacent to the north slope of the new outfall levee to an elevation of approximately +5 ft, and reconstructing the pipeline within the berm, possibly with sliplining or flexible couplings (since +/- 3 inches of differential settlement would still be expected)

If pipeline maintenance is not an issue, sliplining alone may be an acceptable solution. If maintenance is an issue, reconstructing the pipeline at a higher elevation (in a berm) and with improved tolerance for differential settlements may be the preferred solution.

In summary, solutions are available for the outfall pipeline issues, but it is likely that significant construction effort and additional costs may be involved. In light of the problems associated with the current alignment of the discharge pipeline, the alternative

of discharging the highly treated effluent into the Hamilton site, as discussed in Section 4.1, would resolve the engineering problems associated with the pipeline while allowing a single tidal breach for the entire project site.

5.4.2 Drainage System Facilities

Facilities that are currently in operation to drain the HAAF site (see also Figure 5-7) include subdrain pipes underlying part of the HAAF site, a perimeter drainage ditch, and three pump stations along the Bay levee located near the northeast corner of the HAAF site. Utility connections to the pump stations (power and water) are located between the perimeter ditch and the present outboard levee along San Pablo Bay, although the water line has been abandoned.

All these facilities except for the pump stations and associated piping can be abandoned in place once dewatering of the area is taken over by the wetland site development contractor. The pump stations and piping will need to be demolished and removed from the site.

5.4.3 Other Facilities

Other facilities in the HAAF site include:

- Shallow gravel fills in many areas
- Asphalt and concrete pavements at roads, revetment pads, runway and taxiways, and aircraft maintenance areas
- Abandoned wharf and landing lights
- Abandoned fuel pipelines including a 6-inch diameter steel fuel supply pipeline extending from offshore of the northeast corner of HAAF in San Pablo Bay to the hangar area, as shown in Figure 5-7
- One hangar, Building 86, with associated power and other utilities, and twelve small buildings

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 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.

The remaining facilities pose no significant hindrance to wetlands development. The settlement-reducing effect of existing fills and pavements may be considered in setting initial levee and fill elevations. The potential impact of pavements on development of channels in the tidal wetlands is discussed in Section 5.3.1.

Other facilities in the SLC site area include abandoned antenna installations and associated cables, etc. Any abandoned structures will be demolished as part of site preparation. In both areas, the existing outboard levee along San Pablo Bay will be lowered to about elevation +3.5 feet. Portions of this levee will remain at elevation 5 feet to function as high-tide refugia. Any structures (former wharf, outfalls, pipes, and timber piles) encountered would be properly disposed of. Any structures remaining in the outboard tidal marsh (e.g., landing lights) will be left in place to avoid unnecessary impacts to the marsh.

5.4.4 Real Estate

The sponsor shall provide all lands, easements, rights of way, and relocations (LERRDS) for the construction, operation, and maintenance of the Hamilton Army Airfield Wetland Restoration Project. This is in accordance with the provisions of the terms of Water Resources Development Act of 1986 (WRDA '86) and the Project Cooperation Agreement (PCA). The real estate requirements for this project are a total of 988 acres to be acquired for various project features. This includes the airfield parcel consisting of 644 acres to be conveyed in fee to the sponsor through the BRAC process, 319 acres known as the antennae field to be obtained from the State Lands Commission, 18 acres from to be acquired in fee from the U.S. Navy, 6 acres of a levee easement to be acquired from the City of Novato, and 0.76 acre for pipeline placement to be provided through the Navigation Servitude. The total value of these land rights has been estimated at $241,600.00 including contingencies. (The real estate requirements are described in more detail in the Real Estate Plan, Appendix C.)

5.4.5 Relocations

There are no Public Law 91-646 Relocations in this project. There are no utilities being affected by the project that are considered to be relocations as defined in WRDA '86 and the PCA. There is one facility that is affected by the project which is the Novato Sanitation District's Dechlorination Station. This facility is considered to be a facility relocation as defined in WRDA '86 and the PCA.

5.5 Dredged Material Placement, Phasing, and Site Elevations

The intent of this section is to build on the information contained in other sections of this report and Appendix C to further define the plan, constraints, and details for construction of the project design. As introduced in the initial description of this alternative, the seasonal wetland and upland corridor areas will be the priority location for placement of sandy dredged materials due to their specific elevation and permeability requirements. The tidal wetland areas are able to accommodate sandy or fine-grained dredged materials and are flexible in regards to the quantity of material placed (up to a maximum amount) prior to the introduction of tidal action and natural sedimentation.

5.5.1 Seasonal Wetlands and Upland Corridor

Containment Berms

The seasonal wetland and upland corridor areas are separated from the tidal wetland portions of the site by a containment dike. For settlement considerations this dike would be constructed to crest elevations ranging from 5.7 feet to 5.0 feet to allow for an average crest elevation of 4.5 feet after 10 years of foundation consolidation. This dike would be constructed with a 10 foot top width to allow vehicular, equipment, and dredged material pipeline access during construction. The proposed side slopes are 3H:1V. Construction of this dike would require approximately 70,000 cubic yards of fill material. As with the other levees and peninsulas constructed for this project, it is assumed it would be constructed from on-site material prior to placing any dredged material in the site.

The design elevations stated above are sufficient to allow the containment dike to persist for a 10 year design goal. This will allow for the construction of all project features and the possible breaching for the tidal wetlands prior to completion of the seasonal wetlands. However, these elevations may not be sufficient for the hydraulic placement of fill materials under all potential project conditions. Additionally, during the early years of tidal action this dike would be slightly above the representative spring high tide level and would limit the required tidal inundation of the panne areas. Therefore, in the final design this dike should be designed to accommodate hydraulic placement of the specific fill proposed for the area and construction access. After construction and prior to tidal inundation the dike should be degraded to the appropriate level to assure proper tidal inundation of the panne areas.

New Hamilton Partnership Levee

The hydraulic placement of fill materials onto the side slope of the New Hamilton Partnership (NHP) levee to the required levels (up to +8 feet NGVD) for construction of upland corridor and southeastern seasonal wetland areas will require further geotechnical analysis. This analysis is underway and the results will be incorporated into the final conceptual plan for this project.

Dredged Material Discharge Pipeline

The dredged material discharge pipeline will enter the site from San Pablo Bay. To effectively fill the seasonal wetland sites with sandy dredged materials, the pipeline will be placed at many locations around the site perimeter and within the site. To allow the most efficient and cost effective filling of this site the project design and specifications should not constrain the ability of the construction contractor to place the pipeline on the site unless absolutely necessary. One area that may pose a constraint for the pipeline is the NHP levee. Use of this levee for the pipeline may be limited by many factors including: ownership/right-of-way, geotechnical considerations, and the masonry wall located on the top of the levee.

Construction Process Water Control

During construction, allowances will need to be made for controlling the process water associated with hydraulic dredged material placement, rain water, and the off-site

discharges entering the site. The off-site discharges into the seasonal wetland areas include the Landfill 26 outfall and New Hamilton Partners west and east outfalls.

The containment dike would keep the process water from spreading onto the tidal wetland areas of the site. It would likely be preferable to construct temporary ditches to channelize process water, rain water, and offsite discharges to convey them to the eastern edge of the site for discharge into the Bay. Construction of temporary ditches would also prevent the process water from spreading over large areas of the seasonal wetland site, limiting or eliminating equipment access.

For the seasonal wetland areas, the three primary methods for handling the process water are:

- Discharge the water into the tidal wetland area and allow it to spread
- Discharge the water into a confined basin in the tidal wetland for subsequent discharge into the Bay via pumps or weirs
- Pump the water directly from the seasonal wetland area into the Bay

Discharging the process water into the tidal wetland area and allowing it to spread may be unacceptable for many reasons including limiting access to large areas of the site and potential disturbance of concurrent construction activities on the site. However, if this method was acceptable it would likely be the least expensive. The water would have to be pumped from the tidal wetland area unless the area was allowed to pond up to the intertidal levels required for gravity discharge through weirs.

If the process water was discharged into a confined basin in the tidal wetland it would allow for greater control of the site than the previous option. The water could be ponded against the existing outboard levee to intertidal levels and be discharged through weirs. However, this would also require ponding the seasonal wetland area to intertidal levels which may be unacceptable for a variety of reasons including material movement and site access. Therefore, dewatering this basin with pumps is likely the preferable option.

Pumping the water directly from the seasonal wetland area into the Bay would require the construction of an 1,800-foot long pipeline to connect the pumps to the outboard marsh tidal channels. It would be difficult to completely fill this site and maintain discharge water quality without having an off-site water storage area.

At this level of analysis, the second alternative presented above appears to be preferable. Therefore, it is assumed that pumps will be required to dewater the seasonal wetlands site. These pumps should be specified, supplied, operated, and maintained by the contractor filling the site. The construction contract should clearly indicate the nature and variability of rain and off-site discharges into the site and make the management of those waters the contractor's responsibility.

Water quality control is not expected to be a major problem on these sites since the primary materials are clean sands with only limited quantities of fine-grained material. The water quality standards will be specified in the Waste Discharge Requirements from the RWQCB. Meeting the standards of the Waste Discharge Requirements should be the contractor's responsibility and these requirements should be clearly defined in the project

specifications. Potentially complicating factors are the discharges into the site from Landfill 26 and the NHP outfalls. These factors can and should be addressed in the final design.

The quantity of process water is dependent on many operational factors specific to the type of off-loading equipment, material type, and pumping distance. For estimating purposes, it is assumed that the off-loader is similar to the 24-inch off-loader used for Sonoma Baylands. If this type of off-loader was operated continuously, the discharge from the site could be up to 80 cfs. A more typical discharge for this type operation would be 20 to 50 cfs based on non-continuous operations.

Fill Placement in Non-tidal Areas

The non-tidal areas will be constructed in the following sequence: panhandle seasonal wetland, the upland corridor, and the southeast corner seasonal wetland. Many filling sequences are possible and the most desirable sequence will depend on the type and timing of dredged material availability. In general, the project specifications should be performance specifications indicating the final elevations and other necessary requirements. These specifications will require careful design to ensure that biological and hydrological functions are the controlling factors, not ease of construction. Due to differences in equipment, material supplies, and operational techniques, the construction contractor should be allowed the maximum flexibility possible in placing materials. This type of specification will generally result in lower project costs and fewer claims and disagreements.

The panhandle seasonal wetland would be the first of the seasonal wetland areas to be filled. Filling would typically begin in the northwest and proceed towards the southeast. The northeast corner is the deepest part of the site (-8 ft) and will pond substantial quantities of water until filled. The envisioned material placement scenario for all three areas is to fill the entire site with sandy material to approximately 1 to 2 feet below the design grades and then add a final layer of fine-grained dredged material to bring the site to design grade. Alternatively, in the upland corridor, capping could be accomplished with the materials excavated from the degrading of the outboard levees just prior to breaching the levees. Filling in the southeast corner seasonal wetland would be expected to begin in the north and west areas and proceed towards the Bay in a continuous fashion.

The estimated fill quantities for this area are presented in Table 5-4 below. These fill depths and quantities are based on average expected short-term foundation and fill material consolidation conditions for a sand base fill and 1 to 2 foot fine-grained cap fill. One of the constraints on filling this site is that the Landfill 26 and NHP's west outfalls will continue to discharge during site filling and must be accommodated during site preparation, construction (filling), and between the end of construction and the introduction of tidal action.

The quantities in Table 5-4 represent in situ (in the dredge cut) dredged material quantities. The calculations account for a conservative level of foundation consolidation. The calculations for fine-grained material account for material expansion during dredging

and off-loading and shrinkage during drying. These quantities assume project fills on only the presently identified portion of the HAAF property to be restored to wetland. If the real estate and drainage issues related to filling areas on the GSA property up to the toe of Landfill 26 can be resolved, the filling of this area would save the construction of a containment dike and add to the area of seasonal and upland habitat.

TABLE 5-4
SEASONAL WETLAND QUANTITY SUMMARY

Site	Site Area (acres)	Average Fill Depth (ft)	Fill Volume (cubic yards)
Panhandle Area	93	8.5	1,200,000
Upland Corridor	16	8.5	200,000
Southeast Area	45	9.3	700,000
TOTAL	152	8.8	2,100,000
Total Sand Material			1,800,000
Total Fine-grained Material			300,000

Site Grading

Due to the nature of hydraulically placed sand fills a substantial amount of grading work will likely be required to finish placing the sand materials at the design grades. The final grading of the sand fills prior to placing the cap layer of fine-grained materials will likely reduce the initial effects of differential settlement due to hydraulic placement, differential fill elevations, and foundation conditions. However, future site grading may be required to maintain appropriate wetland functions in the seasonal wetlands.

The purpose of the fine-grained cap layer is to reduce surface permeability to levels compatible with desirable ponding periods for rain-fed seasonal wetlands. The potential problem of desiccation cracking in the fine-grained cap layer and resulting adverse impacts to permeability would be mitigated by mixing the surface layers of fine-grained and sand materials and then finish grading and flat rolling the mixture. This operation will need to be designed for the specific materials placed on the site and done at the proper soil moisture levels and, therefore, is a final design issue.

As briefly discussed in previous sections, the large areas (150+ acres) filled with sand have a significant potential to cause on-site and/or off-site problems due to wind-blown sand. Substantial problems of this type have been encountered with dredged sands in the North Bay area and in the Sacramento-San Joaquin Delta. Some of these problems have been very expensive to remediate. This problem can be avoided by keeping the material wet and vegetated; however, this issue needs to be addressed in the final design and project specifications.

5.5.2 Tidal Wetlands Site

Containment Levees and Berms
The containment of dredged material on the HAAF site during construction is provided by the existing outboard levee on the eastern perimeter, the new perimeter and Novato Sanitary District outfall pipeline levees on the northern perimeter, the containment berm for the seasonal wetland on the western perimeter, and high ground, the NHP levee and the new perimeter levee on the southern perimeter. Dredged material will be contained on the SLC site by the existing outboard levee on the eastern perimeter, the perimeter levee on the northern and western perimeters, and the new Novato Sanitary District outfall levee on the southern perimeter. Since dredged material placement in these tidal wetland areas will be to a maximum elevation of +2 feet around the site perimeter, all these levees and dikes have sufficient freeboard at the designed elevations.

Depending on the types of dredged materials placed in the tidal wetlands, the construction contractor may choose to construct temporary low berms within the tidal areas to control material or process water movement. These berms would typically be constructed from on-site material and the details should be left to final design.

Dredged Material Discharge Pipeline
The dredged material discharge pipeline will enter this site from San Pablo Bay. To fill these tidal wetland areas with sandy dredged materials the pipeline will be moved around the site perimeter and within the site. Moving the pipeline within the site will require that the site remain dewatered (not ponded). As discussed in other sections of this report, placing fine-grained material in the site will require pipeline access primarily to the site perimeter and will not require frequent pipeline movement. The plans and specifications should not constrain the ability of the construction contractor to place and move pipeline. No specific areas or features appear as significant constraints for the pipeline on the tidal wetland sites.

Construction Process Water Control
During construction, allowances will need to be made for controlling the process water associated with hydraulic dredged material placement, rain water, and off-site discharges entering the sites. The off-site discharges into the seasonal wetland areas include the Landfill 26 outfall and New Hamilton Partners west and east outfalls.

The process water control required on these sites could vary substantially depending on the type of materials placed in the site (sand vs. fine-grained) and if the site is de-watered with pumps or allowed to pond to intertidal levels and drained through weirs. If large quantities of sandy materials are to be placed on interior portions of the site, it would be preferable to keep the site dewatered with temporary ditches and pumps during these activities to allow site access. If predominantly fine-grained materials are placed into the site, interior site access may not be required and ponding to intertidal levels and dewatering with weirs would be the cost effective option. Ponding to intertidal levels may also be preferable to keep the material in a saturated condition. Water quality

control is not expected to be a problem on these sites for sandy or fine-grained fills and the dewatering considerations will be similar to those described in Section 5.5.1.

If pumping is the required or preferred method to dewater the site, the pumps should be specified, supplied, operated, and maintained by the contractor filling the site. The construction contract should clearly indicate the nature and variability of rain and off-site discharges into the site and make the management of those waters the contractor's responsibility.

If significant quantities of fine-grained materials are placed and the site is dewatered by pumps it may be desirable to have a sediment settling basin to control turbidity and provide temporary storage for process water or other waters. For both sites, a sediment settling basin could be placed near the future levee breach area (see Figure 5-5), a location where no fill is required. These basins would typically be constructed with a low dike of native materials with a crest elevation 1 to 2 feet above the preferred water ponding elevation. Water would enter these areas through weirs in the dike.

If the site is to be drained by weirs they should be designed to accommodate significant storm water flows as well as the expected process water quantities. It must be noted that storm conditions in this area are frequently accompanied by high tides, storm surges, and wind wave conditions that may severely limit or preclude dewatering the site by gravity. Recently, conditions of this type have persisted for a week or more. If weirs are used to dewater the site the sediment settling basins would not be a necessary project feature and would be expensive to construct due to the cost of building a dike for this basin to above intertidal elevations.

As stated in Section 4.5.1, the dredged material process water discharge from the site could be up to 80 cfs. A more typical discharge for this type of operation would be 20 to 50 cfs. Due to the size of this project and the three distinct areas to be constructed (seasonal wetlands and two tidal wetland areas), it is possible that more than one off-loader be used concurrently on the project. Therefore, it is recommended that the project Waste Discharge Requirements be developed to allow for the discharge quantities from multiple off-loaders.

When fine-grained fill is hydraulically placed into the tidal wetland restoration areas on the HAAF and SLC sites, it will be low-density fluid mud. Prior to breaching the levees and restoring tidal action to these sites, the material will require time to consolidate. Similar projects have allowed approximately 6-12 months for this consolidation. During this consolidation period, the material typically remains inundated to preclude chemistry changes that could be detrimental to wetland habitat. The dredged material is placed to a maximum elevation of +2 feet NGVD in these areas and the water level during consolidation should remain slightly above the material surface. Therefore, assuming the template is fully constructed, the maximum water elevation in the site during the consolidation period would be approximately +2.2 feet NGVD.

Dredged Material Placement Elevations and Sequence

The post construction elevations within the tidal wetlands at the HAAF and SLC sites are not critical as long as they remain below elevation +2 feet. If the dredged material supply allows these areas to be filled completely from +2 feet at the perimeter to +0 feet

near the levee breach it will shorten the time to re-establish tidal wetland habitat. If the dredged material supply is not sufficient to completely fill the site, natural sedimentation will fill the site over a longer time frame. Therefore, the complete filling of these areas is less critical than for the seasonal wetland areas.

The tidal wetland final fill elevations will likely be below process water ponding levels and cannot be visually monitored. To monitor and control the tidal wetland filling sequence (and possibly to monitor the tidal marsh sedimentation after levee breaching) some type of monitoring system will be required. The options for a monitoring system include: physical monitoring by frequent surveys from a small shallow draft boat, and electronic monitoring by electronic measurement of resistivity gages placed within the fill areas.

Daily physical monitoring surveys during construction are problematic due to the large site area. Additionally, water depths over the material may not always be sufficient to navigate a small boat over the site and the material is typically not solid enough to support foot or vehicle traffic. Due to these difficulties, the cost of frequent surveys during construction by this method may be significantly higher than other monitoring methods.

The project sites could be monitored with an electronic monitoring system similar to the system used at the Sonoma Baylands project. This program would include resistivity probes placed strategically across the Hamilton and SLC sites with frequent measurements and occasional truthing surveys during material placement. The resistivity probes yield sediment surface elevation and sediment density profile data. After material placement, monthly monitoring could assist in determining the appropriate point to restore tidal action to the site. This system could also be used after restoration of tidal action to monitor natural sedimentation processes. The cost for a monitoring program of this type for this site would be approximately $300,000.

Since the filling sequence for the tidal wetland sites may be limited by the supply of dredged materials, it is important to prioritize site filling to enhance tidal marsh evolution. Since the areas furthest from the tidal source will typically have the lowest natural sedimentation rates, these areas will receive priority for dredged materials.

For the tidal wetland sites, the filling sequence can be described by referring to the tidal wetland drainage sub-basins shown on Figure 5-4. For the HAAF site, the filling sequence should begin with sub-basin 1 and proceed through sub-basins 3, 4, 2, 5, and 6. For the SLC site the filling sequence should begin with sub-basin 7 and proceed through sub-basins 8, 9, and 10.

If sand and fine-grained materials are both available for the tidal wetland areas, the sand materials can be placed around the site perimeter and the fine-grained materials can be discharged over the top of these materials and will flow into the central areas of the site. If the fine-grained materials are placed first, the sandy materials will displace them towards the center of the site due to the greater density of sand.

Tidal Wetland Fill Quantities

The maximum dredged material fill quantities required to completely fill the tidal wetland sites to design grades were calculated for sandy and fined-grained fills and are

presented in Table 5-5 below. These quantities represent in situ (cut) dredged material quantities. Both calculations account for a conservative level of initial foundation consolidation. The calculations for fine-grained material account for material expansion during dredging and off-loading and for self-weight consolidation after placement. It is assumed that the fine-grained material remains inundated for at least 12 months between placement and introduction of tidal action. This assumption is consistent with the site management for the Sonoma Baylands project.

TABLE 5-5
TIDAL WETLAND RESTORATION - MAXIMUM SAND AND FINE-GRAINED QUANTITIES

Site	Site Area (acres)	Max Sand Average Fill Depth (ft.)	Max Sand Fill Volume (cu yd)	Max Fine-Grained Average Fill Depth (ft.)	Max Fine-Grained Fill Volume (cu yd)
HAAF Site Tidal Wetland	400	6.7	4,400,000	9.8	5,000,000
SLC Site Tidal Wetland	210	6.8	3,300,000	10.1	3,500, 000
TOTAL	610	6.75	7,700,000	9.95	8,500,000

6.0 CONCEPTUAL MAINTENANCE, MONITORING, AND ADAPTIVE MANAGEMENT PLAN

6.1 Introduction

This plan provides a general framework for maintaining and monitoring the success of the Hamilton Wetlands Restoration Project. Included is guidance for monitoring levee performance, site hydraulics, biological success, and water quality. This conceptual plan will be greatly expanded and quantified in the detailed design phase of the study.

This plan covers the period after the completion of construction. At the beginning of this period, dredged material will have been placed and the bayward levee breached. Maintenance and monitoring during construction will be described in the plans and specifications for construction. Monitoring of sediments for contaminants will be completed prior to levee breaching.

The Corps of Engineers will participate in the monitoring program for 13 years after the end of construction. Subsequent monitoring under the detailed plan will be the responsibility of the non-federal sponsor.

Monitoring of biological, hydrological, topographic, bathymetric, and chemical conditions will track the evolution of the site after breaching of the bayward levee. Periodic comparisons of measured conditions with expected conditions will determine whether the development of the site is progressing as planned.

Restoration goals and objectives for the project are qualitative statements in the EIR/EIS regarding expected future conditions. Quantitative standards intended to measure progress towards these goals and objectives will be developed later for the detailed maintenance, monitoring, and adaptive management plan.

6.2 Levees

6.2.1 Monitoring

Settlement

Monitoring of settlement of the levees due to foundation consolidation should be performed annually by means of precision level surveys of settlement monuments installed during construction. The greatest rate of settlement is expected to occur during the first ten years after the levees are constructed. The data should be reduced, plotted, and compared with the expected design rate. Settlement monitoring of the levees should continue annually until the analyses of the survey data shows that the rate and amount of settlement are within design expectations. At that time the frequency of settlement monitoring may be adjusted to longer intervals of time. If the rates and amount of settlement are unacceptable, then corrective measures should be recommended and action taken.

Annual Inspections
During the first few years after breaching of the bayward levee, a walkover inspection of the levees should be performed twice annually for pre- and post-winter conditions. Subsequently, the frequency of inspection can be reduced to one annual post-winter inspection. The reduced frequency would be based upon determining that the performance of the levee features, and of the site in general, are in accordance with design expectations.

The inspection should look for erosion problems such as rills, gullies, and other evidence of erosion on the newly constructed levees, and for evidence of burrowing mammals. Burrowing mammals, when present in large enough numbers, are detrimental to the overall stability of a levee. Burrowing mammals should be eradicated when infestations endanger the perimeter levee system, and the damage repaired. The breach openings should also be inspected for any obstructions or debris that would limit tidal flows. The walk over inspection should document the implementation of previously recommended corrective actions (or the lack thereof) and the effectiveness of that action.

The annual inspections may be supplemented as necessary following a major storm event or an earthquake of magnitude 5 or greater located within 50 miles of the project, or a smaller magnitude event if specific reports of local damage are received.

Cross Sections
Surveyed cross-sections of the perimeter levees and any water-side, wave-erosion protection berms should be performed annually until they have stabilized, but no less than five years after the breaching of the bayward levee. Supplemental surveys should be made after a severe storm event or a major El NiZo winter.

Inspection Report
An inspection report should be written for each inspection documenting the observations and finding, recommended maintenance action items, and actions taken. In general, the monitoring and inspection report should include but not be limited to the following:

A. A site map indicating the areas of significant findings and/or observations.

B. Condition of the breaches, once they are created, noting obstructions and debris.

C. Condition of the levees and any recent repairs, noting any unusual, abnormal, or unexpected conditions or occurrences that could bear on the effectiveness of the structure.

D. Results of the settlement monitoring and interpretation of the data.

E. Condition of hard structures, culverts, and pipelines.

F. Condition of access and service roads, especially areas where problems are likely to develop.

G. Availability of emergency supplies necessary for immediate repairs of major storm related damages.

H. An emergency action plan that includes phone numbers and means of contacting operating personnel.

I. Maintenance measures taken (date, temporary measures taken, permanent repairs, etc.) and the cost of maintenance an operations for the report period.

J. A summary of findings, proposed corrective actions, and a maintenance plan to implement those actions.

6.2.2 Maintenance

Maintenance will consist of corrective action in response to problems identified when monitoring levee conditions as described in the section on monitoring above. Actions could include adding material to compensate for excessive settling or erosion, repair of earthquake damage, reinforcing the levee surface to withstand erosion in problem areas (to the minimum extent necessary), repair of drainage structures, or control of burrowing rodents. Any rodent-control efforts will need to be carefully planned and executed to avoid negative impacts on adjacent habitats and wildlife. Such efforts would be confined to levees; rodent populations in other habitat areas including berms would not be controlled except under unusual conditions.

6.3 Hydraulics

6.3.1 Monitoring

Dredged Material Fill Elevation and Tidal Sedimentation

The surface elevation of the dredged material fill after consolidation will be an important determinant of the success of the project. Proper development of the tidal marsh requires that the fill elevation be low enough to allow additional sedimentation and development of tidal channels on the site after breaching of the bayward levee. If significant portions of the fill are above the intended elevation, formation of small marsh channels will be inhibited and the eventual quality of the marsh habitat will be reduced. In contrast, if the fill elevation is lower than intended, the only negative impact would be a delay in marsh development while additional sedimentation raises the grade level to the intended elevation.

Dredged material deposited on the site will consolidate over time, with the fastest consolidation occurring initially. The degree of consolidation and its duration will depend upon the texture and depth of the dredged material. By the time that the bayward levee is breached, most consolidation will have already occurred. During the next several years, some additional consolidation may occur and could counteract tidal sediment deposition during that period.

While monitoring the surface elevation of the fill material during and immediately after completion of disposal is important, this is part of the construction process and is not part of post-construction monitoring. Measurement of the fill elevation as part of the post-construction monitoring of the site will commence upon the breaching of the bayward levee, and will continue thereafter primarily to measure ongoing sedimentation on the site. These elevation data will also provide the baseline for measuring the physical development of the marsh plain and channels following the introduction of tidal action.

Monitoring of sediment deposition rates and patterns will provide useful information regarding the accuracy of predictive sedimentation models and will help to quantify the acceleration of marsh restoration achieved by using dredged material. This information will be important in future decisions regarding the use of dredged material in marsh restoration projects. Information regarding sediment deposition patterns will also assist in understanding changes in vegetation patterns as the marsh develops and will provide a basis for evaluating the effectiveness of the interior peninsulas in accelerating sediment deposition. The techniques to be used in monitoring site elevations will be determined during the detailed design stage, but could include transects across the site and/or resistivity staffs as used at the Sonoma Baylands project.

Exterior Tidal Channels

To provide initial tidal access to the site, channels will be excavated to connect the site to the waters of San Pablo Bay. These channels will be large enough to provide substantial tidal circulation, but will be smaller than the initial equilibrium size. As the tidal hydrology of the site and its connecting channels evolves, the channels are expected to increase in size until they are in equilibrium with the tidal prism of the site. As the tidal prism eventually decreases due to sedimentation on the site, the channels will decrease in size in response.

To ensure that the site is developing properly, the geometry of these channels will be monitored periodically and will be compared to expected conditions.

Tidal Regime

The intent of the project is to create a tidal marsh with physical and biological conditions similar to natural marshes in the general area. The creation and maintenance of a normal tidal regime is a very important component of restoration, as tidal action and suspended sediment circulation are essential to the creation and maintenance of tidal marsh topography and vegetation.

The progress of the site's tidal regime towards reference conditions will be monitored using appropriate recording equipment. Measurements of tide elevations will be recorded periodically or continuously at locations within the site and at a nearby reference location. The tidal regime and tidal prism will be determined from these measurements.

Peninsula Crest Elevations

The peninsulas are intended as temporary features to reduce wind and wave fetch, direct tidal flows away from levees, and encourage sedimentation. They are expected to

gradually erode away and eventually disappear. The elevation of the peninsula crests will be periodically measured to monitor their progress towards specified standards.

Internal Channel Development
Tidal channels are the most important physical feature of a tidal salt marsh. The extent, pattern, and density of the channel system determines many other attributes of the marsh, including hydrology, vegetation distribution, and habitat values. It is therefore important to document these attributes of channel development in the Hamilton restoration project for use in the design of future wetland restoration projects.

Channel development will be mapped from aerial photographs taken during appropriate tidal conditions. Transects may also be useful in measuring the development of these channels.

6.3.2 Maintenance

Maintenance will consist of removal of any debris that obstructs tidal flows, and maintenance of any monitoring equipment in the area. Corrective action to ensure the proper physical development of tidal habitats is covered under *Adaptive Management*, below.

6.4 Water Quality

6.4.1 Monitoring and Maintenance

Water quality parameters to be monitored will include salinity, temperature, and dissolved oxygen. Measurements will be taken at several locations within the site and in the connecting channels. Due to the substantial tidal exchange that should exist immediately after breaching, water quality should be comparable to that in adjacent parts of the bay. If water quality deficiencies are substantial and persistent, remedial actions will be developed and implemented if practicable.

6.5 Biological Resources

6.5.1 Monitoring

Marsh Development
Marsh development will be determined by measuring physical parameters (hydrology and topography/bathymetry) and biological parameters (plant and animal life). Monitoring of physical parameters is discussed under hydraulics, above.

Monitoring of vegetation will include periodic measurements of the extent, location, composition, and density of marsh vegetation. Measurement techniques are expected to include aerial photography and field surveys. Actual conditions will be compared to predicted conditions. Monitoring data will be analyzed to identify possible reasons for differences between observed and predicted conditions.

After five years of monitoring, the development rate of tidal marsh will be analyzed to determine whether the standard of 6 acres of new tidal marsh within the first 10 years is likely to be achieved. Similar reviews of tidal marsh development will be conducted in years 10 and 15 if it appears that further action is needed to meet tidal marsh restoration standards.

Use by Birds

As intertidal mudflat and marsh habitats develop along with associated invertebrate fauna, use of these habitats by birds should gradually become similar to usage occurring on nearby intertidal habitats. As seasonal wetlands develop, winter use by waterfowl and shorebirds should become similar to such use on nearby seasonal wetlands. Periodic bird surveys will document trends in use of the site by birds in comparison to a nearby reference site and will provide an indication of the success of habitat restoration.

Use by Fishes

Fish surveys early in the restoration process will document the initial suitability of the site for fishes. Ongoing surveys will document continued use of the site by fishes as marsh and channel formation occur.

Use by Endangered Species (California Clapper Rail and Salt Marsh Harvest Mouse)

As marsh and channel development progress, habitats for the California clapper rail and the salt marsh harvest mouse are expected to gradually develop. After suitable habitat has developed over a portion of the site, periodic surveys will document the extent of these habitats and the presence of these species. Surveys will be coordinated with the U.S. Fish and Wildlife Service and the California Department of Fish and Game to ensure compliance with endangered species laws and regulations.

Benthic Macroinvertebrates

Development of a benthic macroinvertebrate community should occur rapidly after the initial establishment of tidal action on the site. The presence of a thriving benthic macroinvertebrate community (together with abundant fish and bird populations) will indicate that the site is ecologically healthy even if it has not yet developed substantial tidal marsh habitat. However, the composition of this community can be expected to change rapidly and unpredictably due to normal natural fluctuations, which would lessen the value of monitoring trends in these species.

Surveys of benthic macroinvertebrates will be conducted during the first year after breaching to document the colonization of the site by these species. Additional surveys may be conducted later if site deficiencies arise.

Vegetation in Seasonal Wetland and Upland Areas

Development of appropriate vegetation in these areas will be monitored through field surveys. Success criteria will be based upon the establishment of appropriate native species and vegetative cover.

6.5.2 Maintenance

Maintenance in non-tidal areas will be directed towards encouraging appropriate native plant species and minimizing the presence of exotic plant species of particular concern such as pampas grass, broom, and yellow star thistle. Management techniques may include mowing, burning, manual removal of unwanted plants, and herbicides if needed. Mowing and manual removal have been effective so far at suppressing unwanted upland plant species at the Sonoma Baylands project, and herbicides have not been necessary. Control of non-native predators (feral cats and/or red foxes) may also be needed.

Biological maintenance in tidal areas will primarily be passive, with natural processes allowed to gradually restore habitats. However, tidal areas (and uplands) may be invaded by the non-native perennial pepperweed *Lepidium latifolium*. Control of this plant is uncertain and can not be guaranteed. Herbicides would most likely be required in any attempt to control this species, should it invade the site.

6.6 Adaptive Management

Adaptive management is a term which has been used to mean various things. As used here, it is an approach to resource management in which management goals remain the same, but management objectives and techniques may be modified in response to feedback (such as monitoring results) from the system being managed. Adaptive management recognizes that human knowledge regarding biological and physical systems is limited and that these systems may not always behave as expected. When a management or restoration project is to be implemented but there is some uncertainty regarding the response of the system to particular actions, adaptive management provides a way for management actions to respond to feedback from the system being managed.

Adaptive management will be implemented if specific restoration standards are not met or if it appears that actual conditions will diverge sufficiently far from intended conditions to threaten the achievement of overall project goals. Funding for adaptive management will be included in the project cost estimates so that this option will be available in the future if needed.

Should the development of the site fail to meet quantitative standards to be stated in the detailed monitoring plan, action to correct these shortfalls will be undertaken if such action could reasonably be expected to assist in the achievement of these standards. Corrective action could include vegetation management, predator management, topographic modifications such as creation of or enlargement of channels, or levee repairs or modifications.

7.0 ACCESS ROAD

Access to the wetland restoration site would be provided by an easement over existing and new roads through the General Services Administration (GSA) Sale Parcel at HAAF. The road would connect Nave Drive and Perimeter Road and would serve as the primary access route to the restoration site during the construction phase and for monitoring and caretaking purposes once the construction phase is completed. The road would also serve as access to the NSD outfall pipeline and SLC parcel. The proposed alignment for the access route is shown in Figure 7-1. The road will be reconstructed to standards to withstand the traffic of the construction equipment. The road will be reconstructed by funding provided by the US Army.

8.0 PRELIMINARY COST ESTIMATES

8.1 Basis of Cost

This estimate is based on Woodward-Clyde concept plan, reference "Hamilton Wetlands Conceptual Restoration Plan" and "Technical Appendices", prepared by Woodward-Clyde for the State Coastal Conservancy, the City of Novato, April 24, 1998. The project consists of site improvements at Hamilton Army Airfield (HAAF) and the State Lands Commission (SLC) areas to create a disposal site for dredged materials and eventually to create wetlands. Improvements would include perimeter levees, peninsula levees, containment levee, and Novato Sanitary District (NSD) pipe protection levee. Other features of the project include AC pavement removal, constructing weir structures, lowering the bayward levee, breaching the bayward levee, hydroseeding levees, NSD outfall pipe protection, dechlorination plant relocation, constructing outboard marsh pilot channels, monitoring, maintenance, finish grading of dredged material, and incremental dredged placement costs. This project is expected to be constructed with all land based equipment. Table 8-1, below, shows a summary of fully funded costs.

Table 8-1, Fully Funded Summary of Costs

U.S. Army Corps of Engineers 20-Oct-98
HAMILTON WETLAND PROJECT ALT 5
Preliminary Government Planning Estimate FULLY FUNDED SUMMARY

COA		QUANTY UOM	CONTRACT	CONTINGN	TOTAL COST	FULLY FUNDED COST TO MIDPT CONST. ESC. TO FY 2001 ESC.	TOTAL
01	LANDS & DAMAGES	1 JB	$305,400	$64,700	$370,100	$29,608	$399,708
02	RELOCATIONS	1 JB	$1,583,842	$554,345	$2,138,187	$171,055	$2,309,242
11	LEVEES AND FLOODWALLS	1 JB	$17,333,149	$3,522,676	$20,855,825	$1,668,466	$22,524,291
12	NAVIGATION PORTS & HARBORS	1 JB	$25,424,100	$2,385,000	$27,809,100	$2,224,728	$30,033,828
30	PLANNING, ENGINEERING & DESIGN	1 JB	$1,210,000	$0	$1,210,000	$96,800	$1,306,800
31	CONSTRUCTION MANAGEMENT	1 JB	$2,900,000	$0	$2,900,000	$232,000	$3,132,000
	TOTAL PROJECT COST	1 JB	$48,756,491	$6,526,721	$55,283,212	$4,422,657	$59,705,869

Appendix B Figure 7-1

4000 0 4000 Feet

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Proposed Right-of-Way

Jones & Stokes Associates, Inc.

Proposed Access Route to the Hamilton Wetland Restoration Project Site

8.2 Assumptions

1. Pricing: Estimated costs are based on a July 1998 price level. Plant and equipment costs are from EP 1110-1-8 "Construction Equipment Ownership and Operating Expense Schedule, Region 7" 1997 database, "Unit Price Book" (UPB) 1997 database, and "National Labor Rates" 1997 database supplied with the MCACES program. The national labor rates are adjusted to State of California Wage Rate Determination sheets by adjusting the national rates upwards by 20%. The material prices from the UPB are adjusted upwards 20% to account for California (San Rafael) locality. Material costs are from the MCACES databases, publications and previous studies. Cost estimates from the Woodward-Clyde concept plan are also used in the MCACES estimate.

2. Contract Work: It was assumed that the prime contractor will perform all features of work, 5 days a week, 8 hours per day.

Major Construction Features Include:

3. Levee Construction:

Perimeter Levee w/tidal berm:	9,400'
Perimeter Levee:	11,000'
Peninsula Levees:	5,800'
Containment Levee:	2,500'
NSD Protection Levee	2,500'

Material for levee construction would be obtained by excavating borrow material at a depth of 2 feet from designated areas within the HAAF site. Material would be placed, compacted and shaped to form levees at the designated footprints. Lengths of levees and cross-sections used in this estimate were from Woodward-Clyde concept plan. The quantity of borrow material identified is not sufficient to construct the levees. The estimated quantity of borrow material identified is from BRAC estimates at 2' depth. Project manager will recommend excavating up to 8' depth to make up for any shortfall in borrow quantity. Dredged material may possibly be used also as borrow. Levee construction is expected to take 2 years.

4. Lowering the Bayward levee consists of cutting the levee top to elevation +3.5 ft; Breaching the Bayward Levee, and; Constructing the outboard marsh pilot channels allows tidal flow into the site for wetlands creation.

5. Weir structures cost is from the Sonoma Baylands wetlands restoration project done in 1994. The Sonoma Baylands project is similar in size and scope.

6. Taxiway/apron AC pavement removal consists of demolition and removal of three sections of taxiway/apron AC pavement for the creation of the subtidal channel. The length of the sections are 269', 175' and 182'. The assumed widths are 50' and assumed depths are 5'.

7. NSD outfall pipeline modifications consists of flood control levee crossing, sliplining, foundation treatment, SLC site crossing, and temporary bridge for construction traffic as described in the concept plan. The estimated cost used is from the Woodward-Clyde concept plan.

8. Dechlorination plant relocation would consist of relocating the plant to either the Ignacio Treatment Plant or the Novato Treatment Plant. The estimated cost used is from the Woodward-Clyde concept plan.

9. Building Demolition would consists of demolition, removal and disposal of buildings composed of various materials (wood, masonry, metal, concrete). Buildings range from 150 square feet to 15,000 square feet. Costs were determined using R.S. Means, Heavy Construction Cost Data. Design and costs were developed by Eric Polson, P.E., consultant for the Sponsor.

10. Mobilization and demobilization: Assume all land based plant and equipment is available locally and mobilization would take 8 hours and demobilization would take 8 hours.

11. Monitoring consists of monitoring initial and final fill elevations for dredged material placement using resistivity staffs and remote monitoring equipment similar to Sonoma Baylands project. The cost is from Woodward-Clyde concept report.

12. Finish Grading consists of mixing the top 2' of dredged material placement to prevent complete desiccation and cracking of the top layer. It is assumed that the dredging contractors will deposit 1' of sand 1' below the final elevation and 1' of fine-grained material at the final elevation.

13. Dredged Material Placement Incremental Cost is the difference in cost of dredging and disposal of O&M or new work dredged material to Hamilton as compared to dredging and disposal of O&M dredged material to in-bay disposal sites. The incremental cost is from Woodward-Clyde report and LTMS COE studies. This cost includes all pipe and off-loader costs for pumpout to the site. This cost is included in code of accounts 12, Navigation Ports & Harbors.

14. Long Term Monitoring Costs consists of monitoring and maintenance of the levees, water control structures, tidal channel depth; aerial photos, transects monitoring, biological monitoring, water quality, and sedimentation surveys for a period of 13 years.

15. Adaptive Management Monitoring Costs for development of the wetland are estimated at 2% of total project cost. This estimate is 1% higher than is customary due to the 13 year period of monitoring necessary to accurately assess the long term development of the marsh.

16. Real Estate Costs: Real Estate Costs are based on gross appraisal.

17. Planning, Engineering and Design (PED) and Construction Management (S&A) costs are developed by Scott Nicholson, project manager and Specifications and Cost Engineering Section, SPN.

18. MCACES Assumptions: 10% overhead, 8% profit, 1% bond, 20% locality and varying contingencies based on the work item. Work items that occur in future years were escalated at the rate of approximately 3% per year.

19. Federal/Non-Federal Costs: This MCACES cost has not been broken out into Federal and Non-Federal costs since the cost-sharing percentages have not been identified and the Federal and local sponsor responsibilities have not been identified.

20. Project Phasing:

Phase 1: The majority of work for this project is the levee construction which will take approximately 2 years to construct. The project start date is scheduled in the spring, year 2000 (FY 2000).

Phase 2 (Alternates 3,5 only): Placement of dredged material to created wetland would take approximately 5 years (Only the incremental cost of this work is covered under this project).

Phase 3: Lowering levee, beaching levee, construction of the outboard marsh channels, weir structures removal, hydroseeding levees, finish grading, monitoring, and maintenance would occur during this phase.

8.3 Contingency Percentages

1. Mobilization and Demobilization 15% percentage was determined using an average percentage for similar type work. Cost could differ depending on transfer distances, plant availability, amount of plant required, type of plant used by the Contractor, road conditions, weather and traffic.

2. Levee Construction, Lower & Breach Bayward Levee, 15% percentage was determined using an average percentage for similar type work. Construction is relatively straight forward. Cost may change since it is based on a concept plan. Revision to the concept plan, i.e., levee lengths, cross-section, breach dimensions, and cut elevations would affect quantities assumed for this estimate. Haul roads, weather and traffic are also factors.

3. Borrow Material 35% percentage was based on the availability of the borrow material. BRAC estimates approximately 550,000 cubic yards available at 2’ depth. Project manager will recommend excavation up to 8’ depth to makeup for any shortfall in borrow quantity. Unknown factors such as contamination, groundwater and slope stability are factors.

4. Outboard Marsh Channels 20% percentage was based on using land-based equipment for constructing the channels. Cost may increase if the dredged material is unable to support the construction equipment which would slow production and add support costs, or if dredging equipment is brought in. Affect of tides, and weather are factors.

5. Hydroseeding Levees 10% percentage was determined using an average percentage for similar type work. Construction is relatively straight forward. Concept plan did not identify mix design. Material price is a factor.

6. Weir Structures, Remove Weir Structures 20% percentage was based on the concept plan which did not identify weir structures in the design. Cost is from Sonoma Baylands wetlands restoration project weir structures and cost would differ if design is not the same.

7. Taxiway/Apron AC Removal 20% percentage was based on the assumed removal quantities. Quantities are preliminary, and AC pavement width and depth has not been established. Pavement may be asphalt or asphalt concrete according to concept plan.

8. NSD Outfall Pipeline Modifications 35% consists of flood control levee crossing, sliplining, foundation treatment, SLC site crossing, and temporary bridge for construction traffic as described in the concept plan. Cost may change since it is based on the concept plan.

9. Dechlorination Plant Relocation 35% percentage was based on the concept plan which only identified this work item and description. Cost is from concept plan report.

10. Building Demolition 25% percentage was based on design and estimates by Eric Polson, P.E., consultant for the Sponsor. Building to be demolished were identified, square footage and volumes were determined for demolition, removal and disposal costs. Costs were determined using R.S. Means, Heavy Construction Cost Data. Data is consistent with MCACES database which is developed by R.S. Means Company.

11. Monitoring 15% percentage was based on the concept plan. This monitoring design for initial and final dredged material elevations is based on the Sonoma Bayland project which was successfully used. The cost is from Woodward-Clyde concept report.

12. Finish Grading 15% percentage was based on concept plan and BCDC input. Work is fairly straight forward. Factors include the type of dredged material that would be placed on the top 2’, dryness and workability of the material, and bearing support for the equipment.

13. Dredged Material Placement Incremental Cost 10% percentage is based on the concept plan. Cost is from the concept plan and COE LTMS studies. Factors would include the dredging process (availability of equipment, type, size, fuel costs, production, material type, haul distances, etc.). COE has dredging costs from previous studies, historical data and CEDEP (dredging computer programs) to verify this cost.

14. Long Term Monitoring Costs 15% percentage is based on the concept plan, BCDC input, and COE. Work has been done before on Sonoma Baylands project and costs were determined from Sonoma Baylands project.

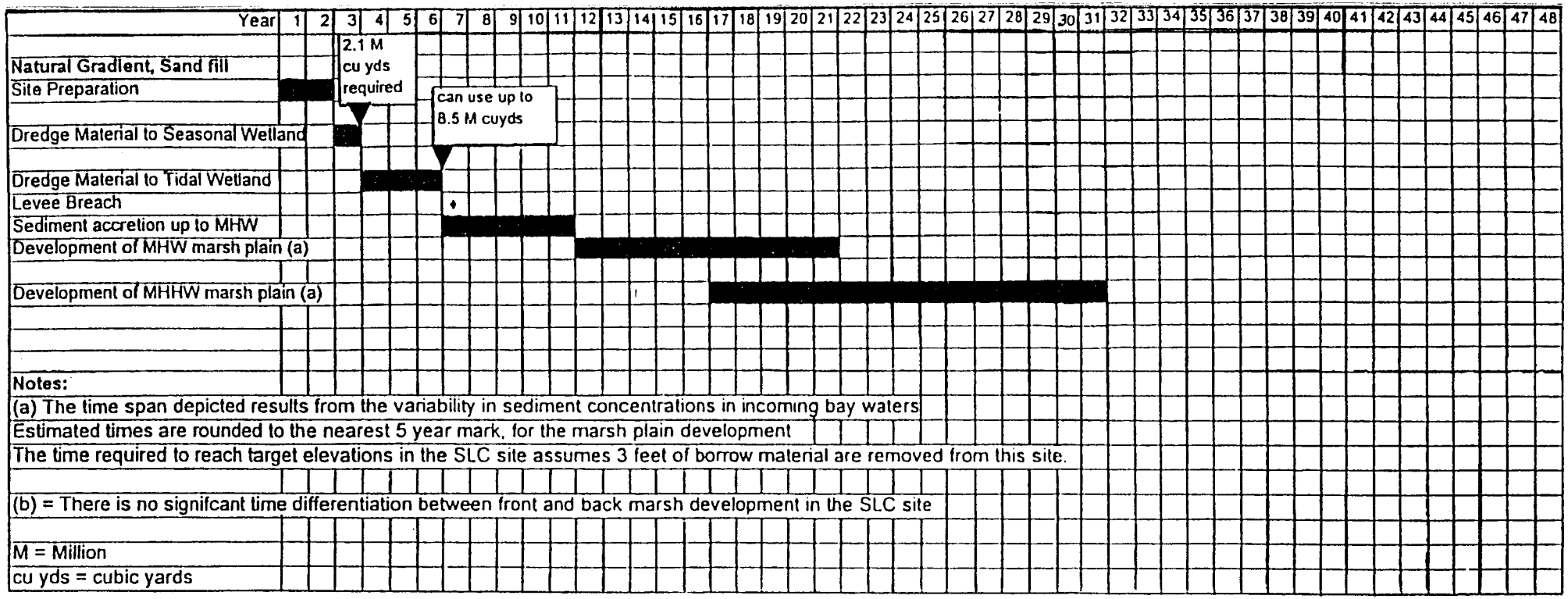
15. Adaptive Management Monitoring Costs 15% percentage for development of the wetland is estimated at 2% of total project cost. This estimate is 1% higher than is customary due to the extended period of monitoring necessary to accurately assess the long term development of the marsh, which will occur over a period of 31 years. long term development of the marsh, which will occur over a period of 31 years.

9.0 SCHEDULE FOR DESIGN AND CONSTRUCTION

Figure 9.1 shows the proposed Design and Construction schedule.

Appendix B Figure 9-1

Proposed Design and Construction Schedule



Notes:

(a) The time span depicted results from the variability in sediment concentrations in incoming bay waters

Estimated times are rounded to the nearest 5 year mark, for the marsh plain development

The time required to reach target elevations in the SLC site assumes 3 feet of borrow material are removed from this site.

(b) = There is no signifcant time differentiation between front and back marsh development in the SLC site

M = Million

cu yds = cubic yards