

Figure 3.2-11. Net Bathymetric Changes in San Francisco Bay from 1955 to 1990 — North Bay, Section B (Plate 7)

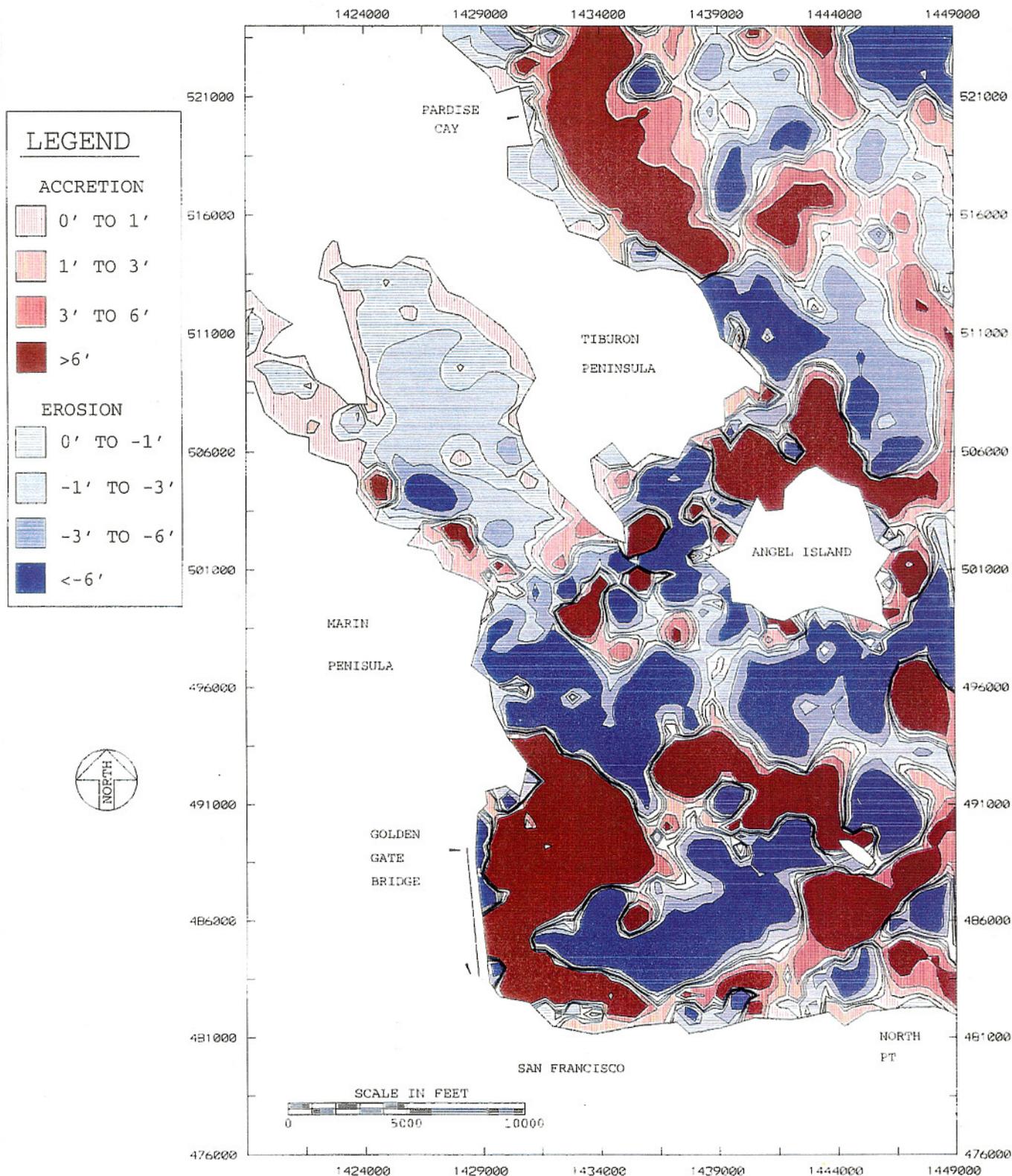


Figure 3.2-12. Net Bathymetric Changes in San Francisco Bay from 1955 to 1990 — North Bay, Section C (Plate 8)

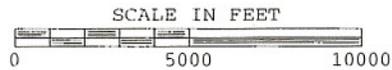
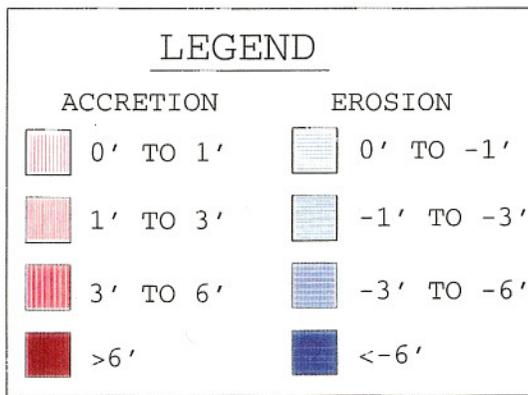
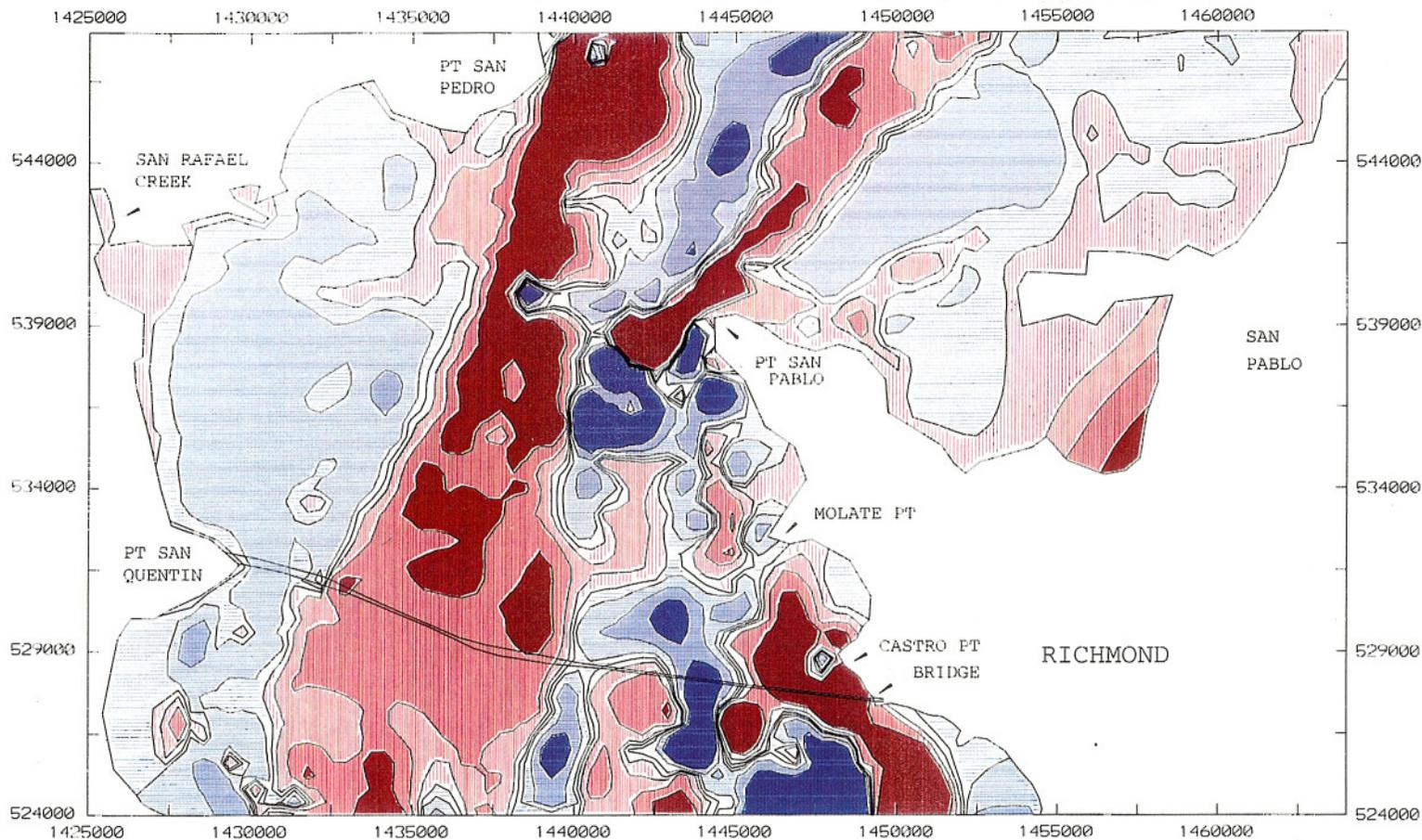


Figure 3.2-13. Net Bathymetric Changes in San Francisco Bay from 1955 to 1990 — North Bay, Section D (Plate 9)

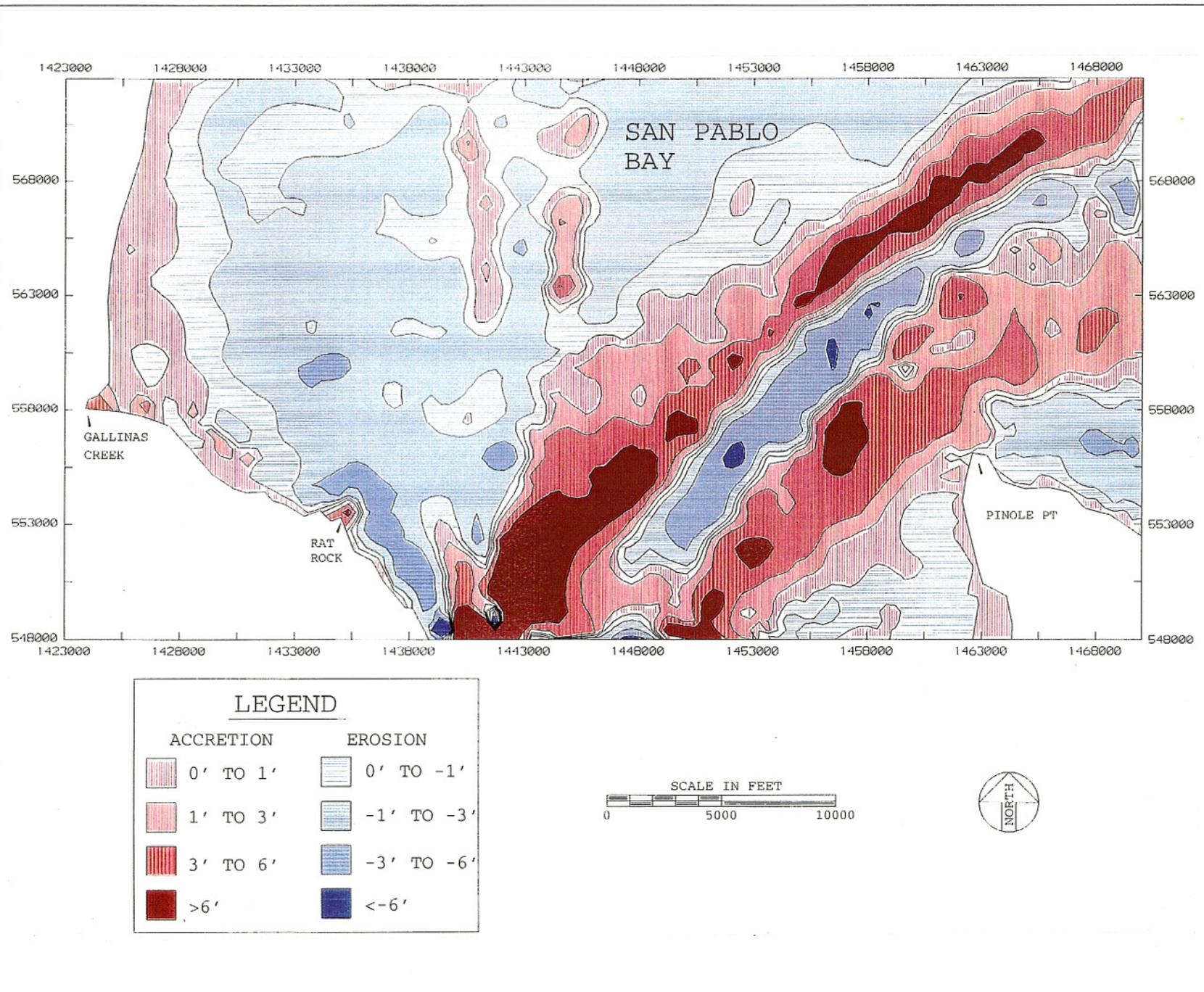


Figure 3.2-14. Net Bathymetric Changes in San Francisco Bay from 1955 to 1990 — San Pablo Bay, Section A (Plate 10)

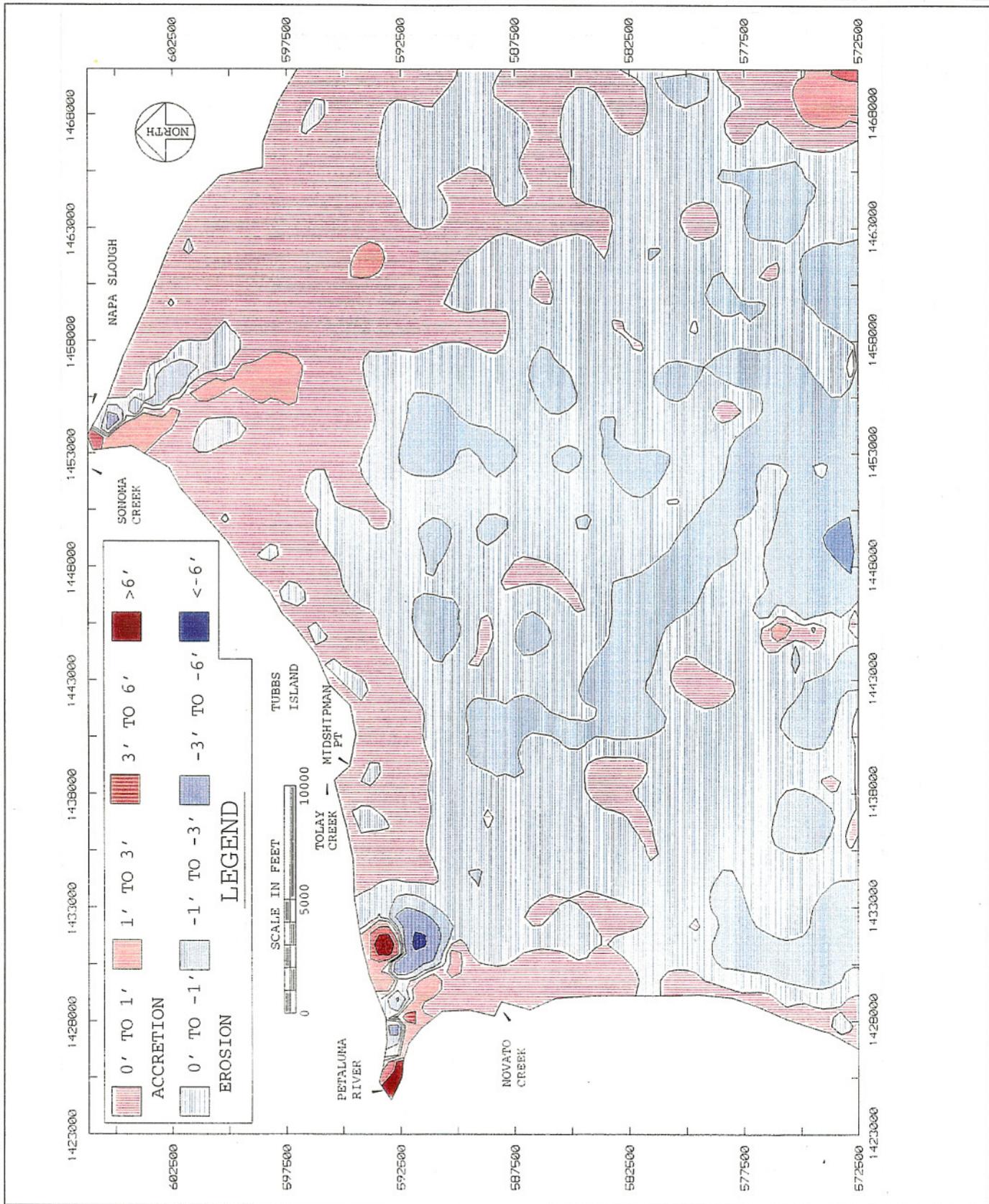


Figure 3.2-15. Net Bathymetric Changes in San Francisco Bay from 1955 to 1990 — San Pablo Bay, Section B (Plate 11)

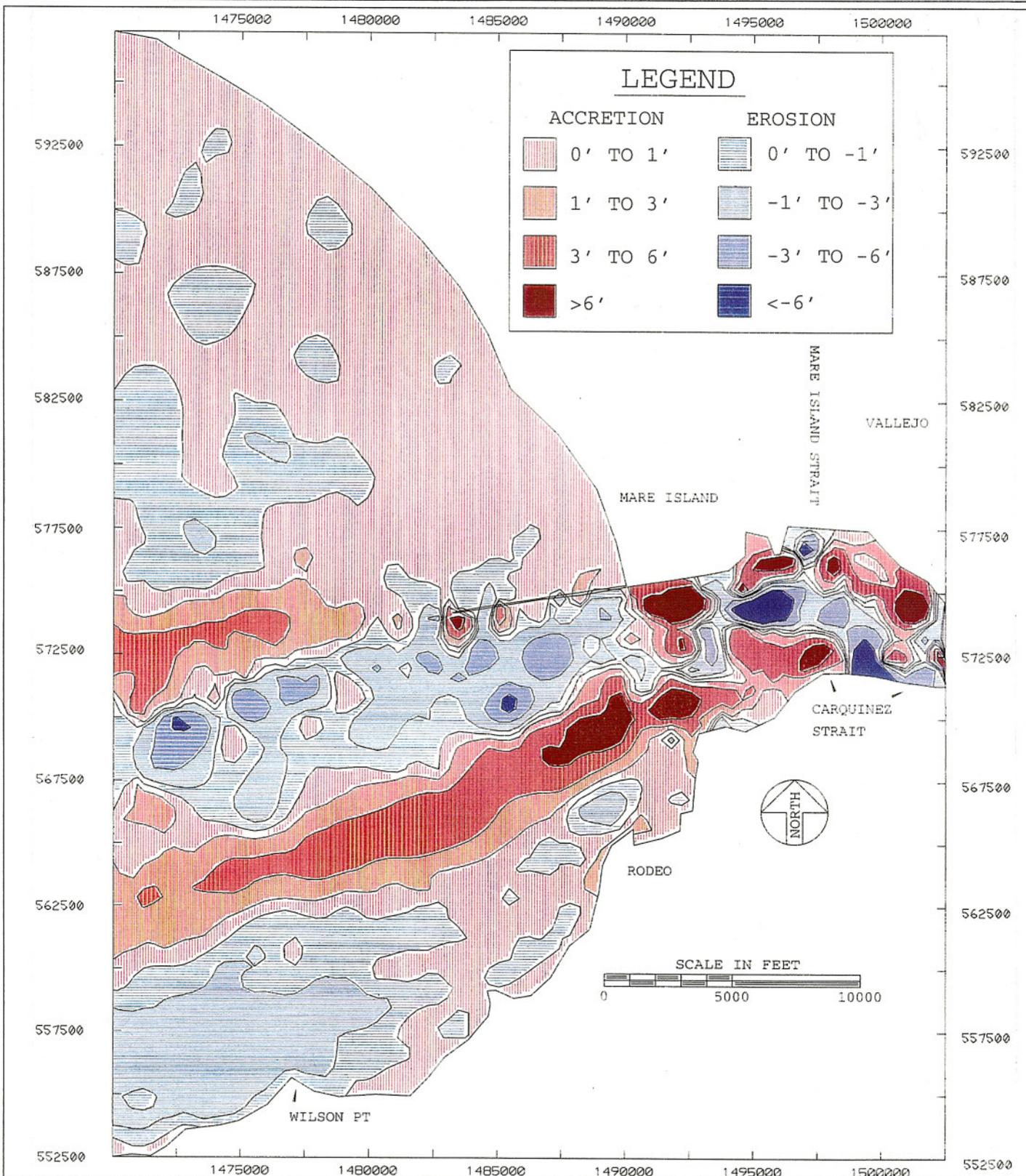


Figure 3.2-16. Net Bathymetric Changes in San Francisco Bay from 1955 to 1990 — San Pablo Bay, Section C (Plate 12)

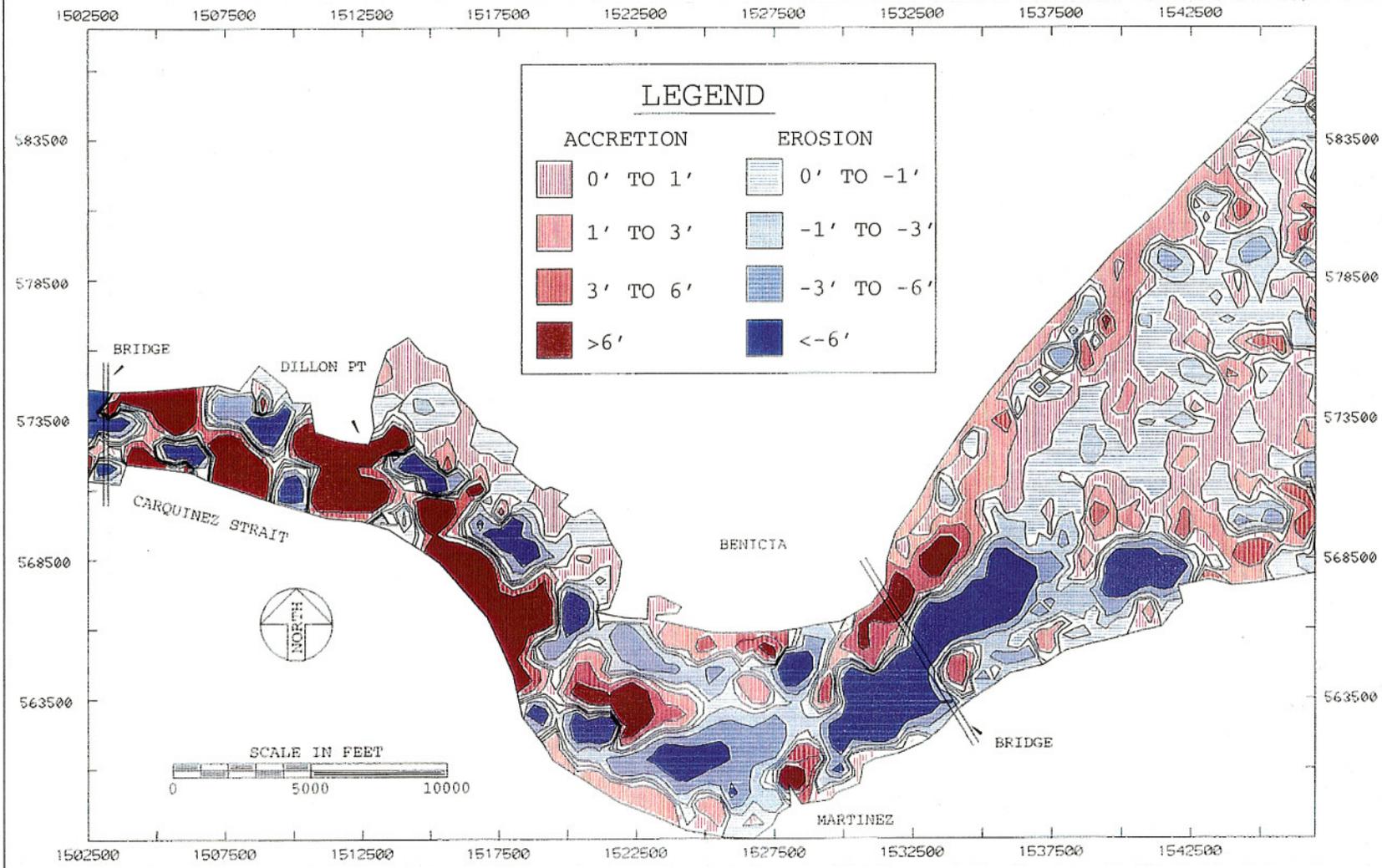


Figure 3.2-17. Net Bathymetric Changes in San Francisco Bay from 1955 to 1990 — Suisun Bay, Section A (Plate 13)

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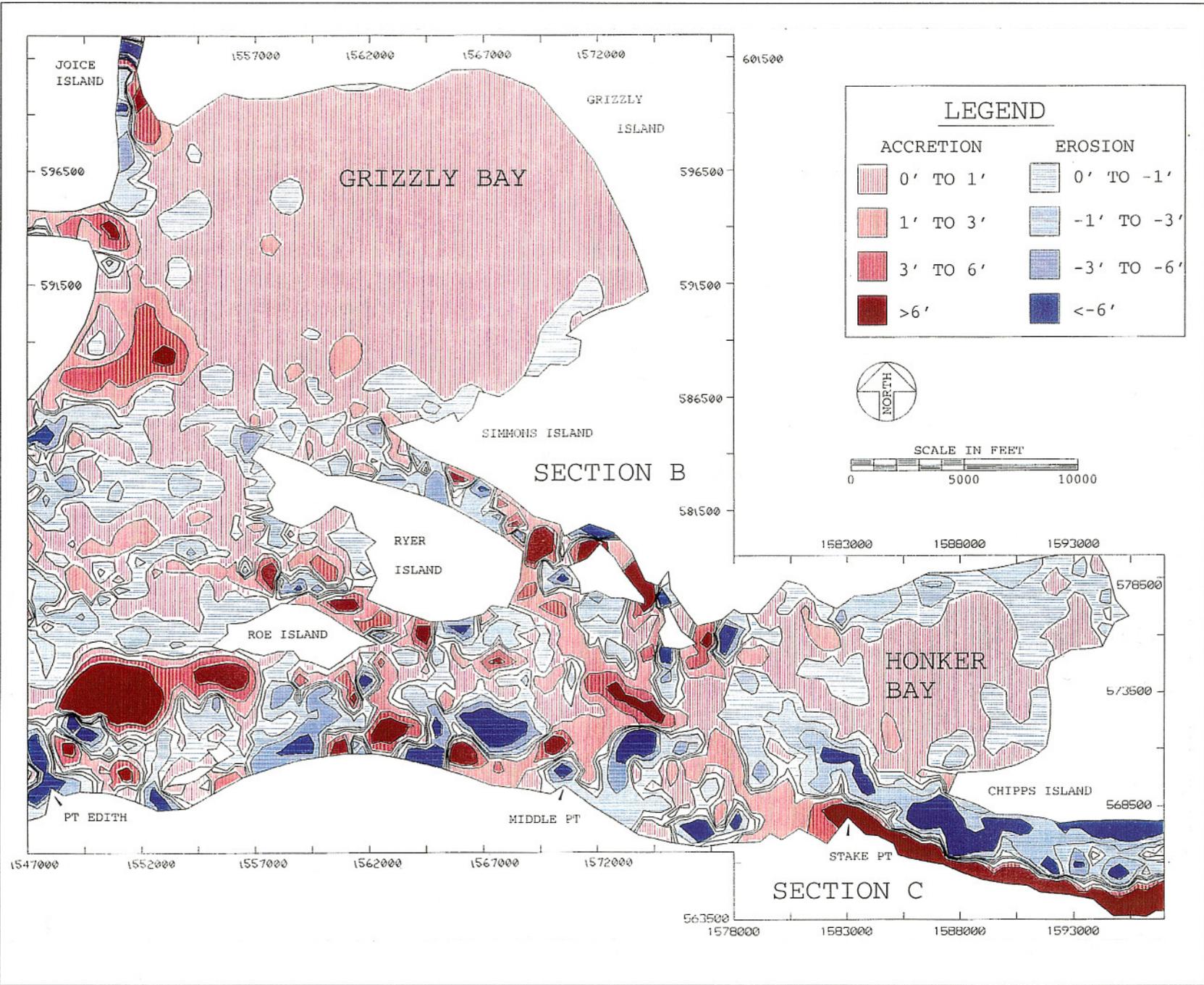


Figure 3.2-18. Net Bathymetric Changes in San Francisco Bay from 1955 to 1990 — Suisun Bay, Sections B & C (Plate 14)

Long-Term Management Strategy for Bay Area Dredged Material
Final Environmental Impact Statement/Environmental Impact Report

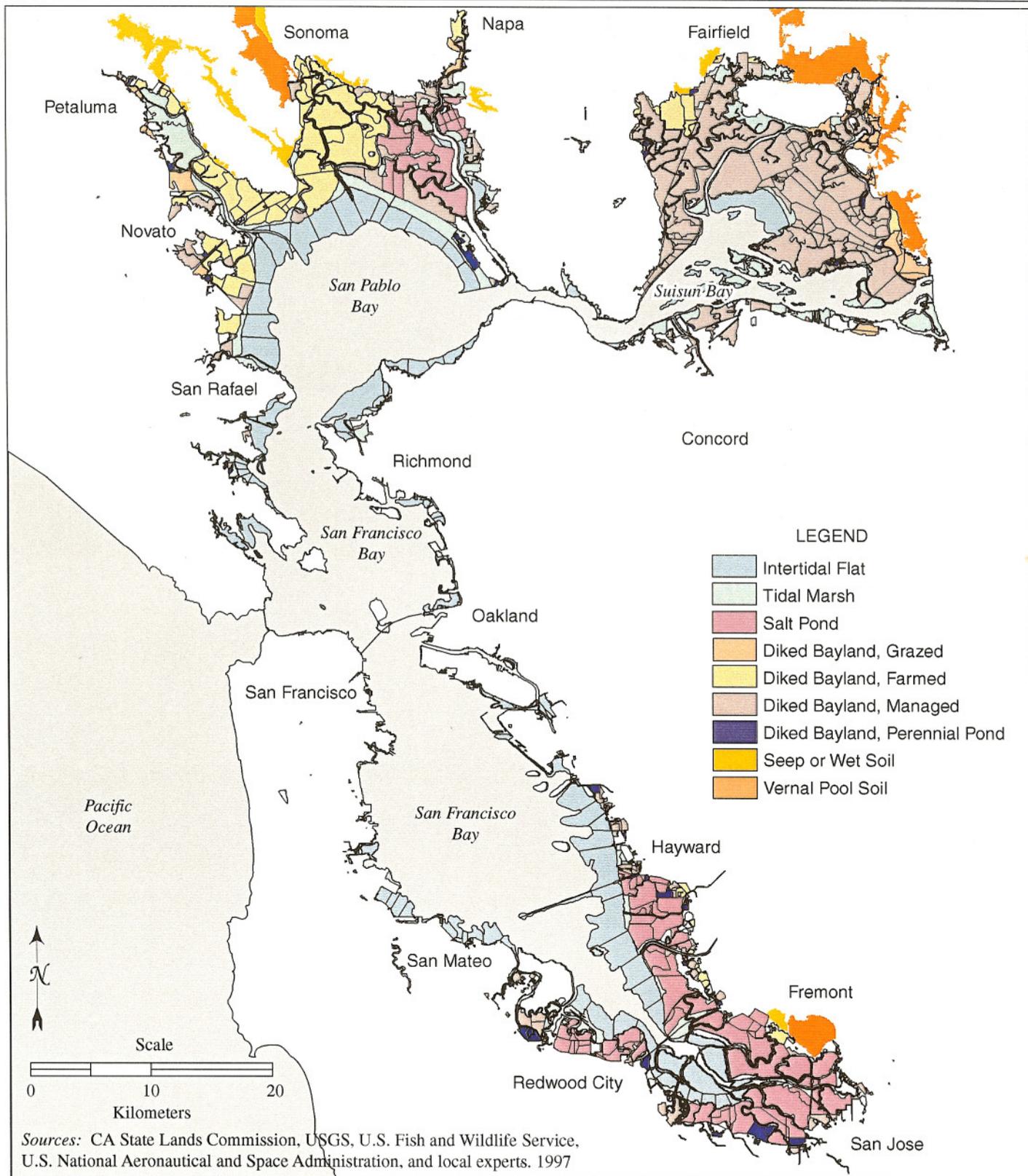


Figure 4.4-1. Modern View of Baylands (ca. 1985-1996)

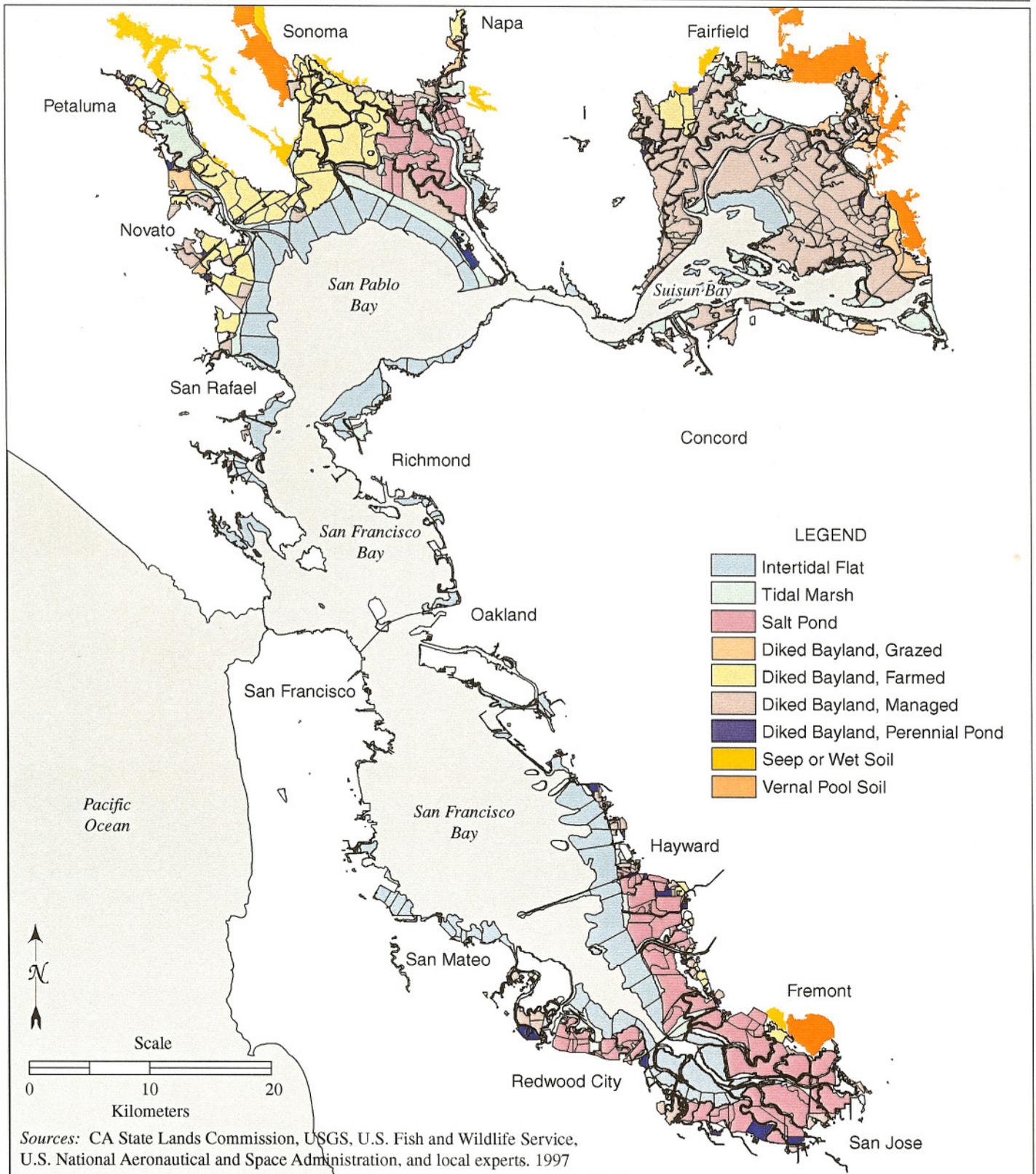


Figure 4.4-1. Modern View of Baylands (ca. 1985-1996)

“new” sediment loads are high and winds are generally weak, sediments tend to be deposited on the mudflats of northern San Pablo Bay and other quiescent locations. In the summer when river flows and “new” sediment loads decrease dramatically, strong, frequent westerly winds over the shallow mudflats resuspend the sediments and, in conjunction with tidal currents, transport them throughout the system. In addition, although most new sediment input occurs in San Pablo Bay, and although there is less overall water circulation in south San Francisco Bay, the information available today supports the presumption that sediments from any of the major sub-basins of the Estuary can be resuspended, and soon spread widely throughout the Estuary. Some sediments leave the Estuary system by being transported out the Golden Gate; however, the quantity leaving the system during a typical year is thought to be relatively small (on average, less than the input of new sediment from rivers and other sources) compared to the total quantity cycling within the Estuary (see Figure 3.2-3).

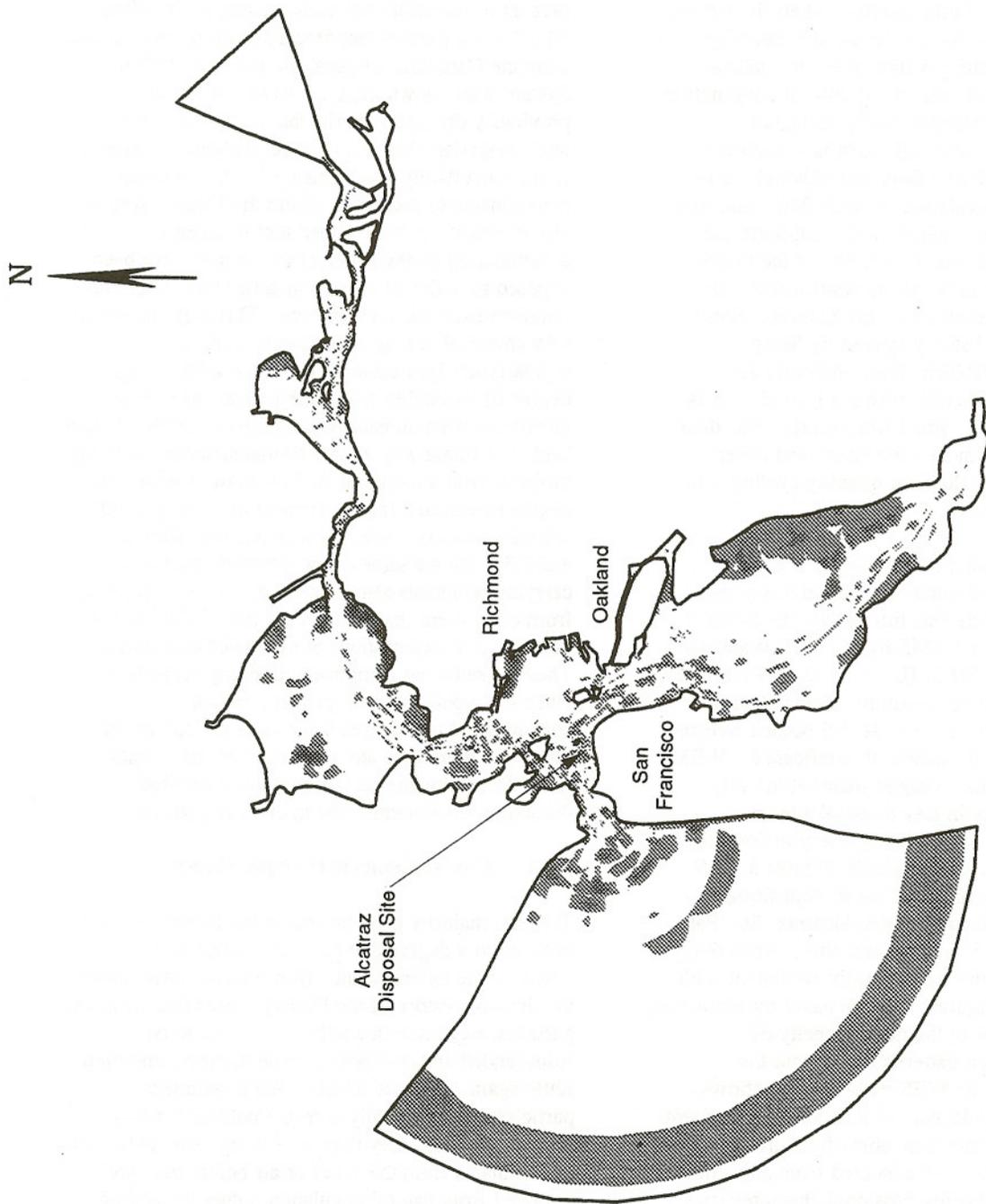
Preliminary mathematical modeling of dredged material transport and initial deposition following disposal at several locations throughout the Estuary was conducted for the LTMS by the COE Waterways Experiment Station (WES) (Letter et al. 1994). The results of this modeling remain preliminary, and substantial model development is still needed before any such results can be used with confidence. WES modeling indicates that dredged material initially discharged at existing in-Bay disposal sites may quickly find its way into virtually every major sub-basin of the Estuary. For example, figures 3.2-19 through 3.2-21 show modeled initial deposition patterns following disposal at the Alcatraz, San Pablo Bay, and Carquinez Strait disposal sites, respectively. These modeling results are generally consistent with the LTMS (1992e) figures, that are based on empirical information, in terms of the heterogeneity of deposition and erosion patterns throughout the Estuary. However, the WES model output shows only predicted *initial* deposition locations; subsequent resuspension and further transport of the dredged material particles would be expected from any initial deposition sites that exhibit erosional characteristics at times.

Because the majority of fine sediment particles are likely to settle and resuspend a number of times in the Estuary, at least a small percentage of the sediment accumulating in navigation channels is likely to include previously dredged material that was

discharged at an erosional in-Bay site, has resettled, and now has to be re-dredged. For example, tracer studies in the mid-1970s confirmed that as much as 10 percent of the sediments accumulating in the Mare Island Strait were in fact dredged material recirculated from the Carquinez disposal site (USACE 1976b). System-wide, however, the overall amount of previously dredged material that makes its way back into navigation channels to be re-dredged in this way is almost certainly much smaller.¹ The continual resuspension of sediments within the Estuary system also means it can be expected that sediments accumulating in navigation channels may have been exposed to pollutant sources in several locations, far removed from the dredging site. This helps to explain why chemical testing of sediments from some regularly dredged channels can show a fairly high degree of variability from year to year, even when there have been no nearby discharges or spills. It also helps to explain why almost all maintenance dredging projects from throughout the Bay show at least some degree of elevated (above ambient or “background”) concentrations of trace contaminants (see section 3.2.3.3). By the same token, however, particles carrying pollutants also may get diluted with particles from other areas that settle in the same location, that have lower concentrations of associated contaminants. Thus the sediment from many dredging projects, even when trace pollutants are present, are not contaminated to a degree that causes toxicity or that otherwise represents any significant environmental risk. The following section presents a detailed discussion of contamination in dredged material.

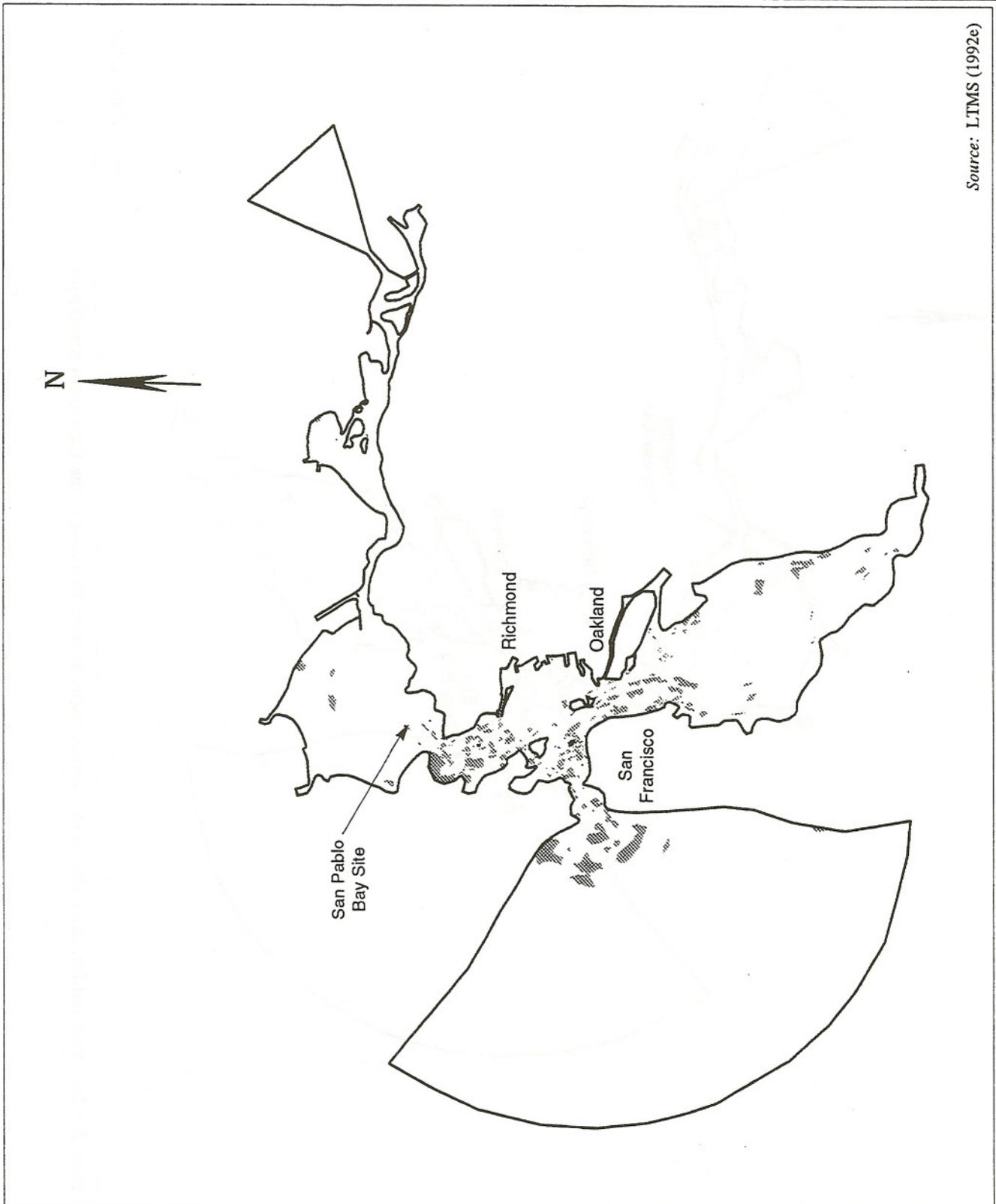
3.2.3 Contaminants in Dredged Material

The vast majority of sediments in the Estuary are not polluted to a degree that poses any threat to human health or the environment. However, as noted above, the dynamic nature of the Estuary means that sediment particles may settle in one location, later to be resuspended and transported some distance, and then settle again. Because of this, even if sediment particles are not initially carrying pollutants when entering the Bay, they may have many chances to pick up pollutants from the water or air before they are removed from natural circulation (either by settling into a depositional area and becoming buried, or being carried out the Golden Gate). This section briefly discusses the natural compounds and man-made (anthropogenic) pollutants that may become associated with sediments; when “contamination” is considered to be a problem in sediments; major



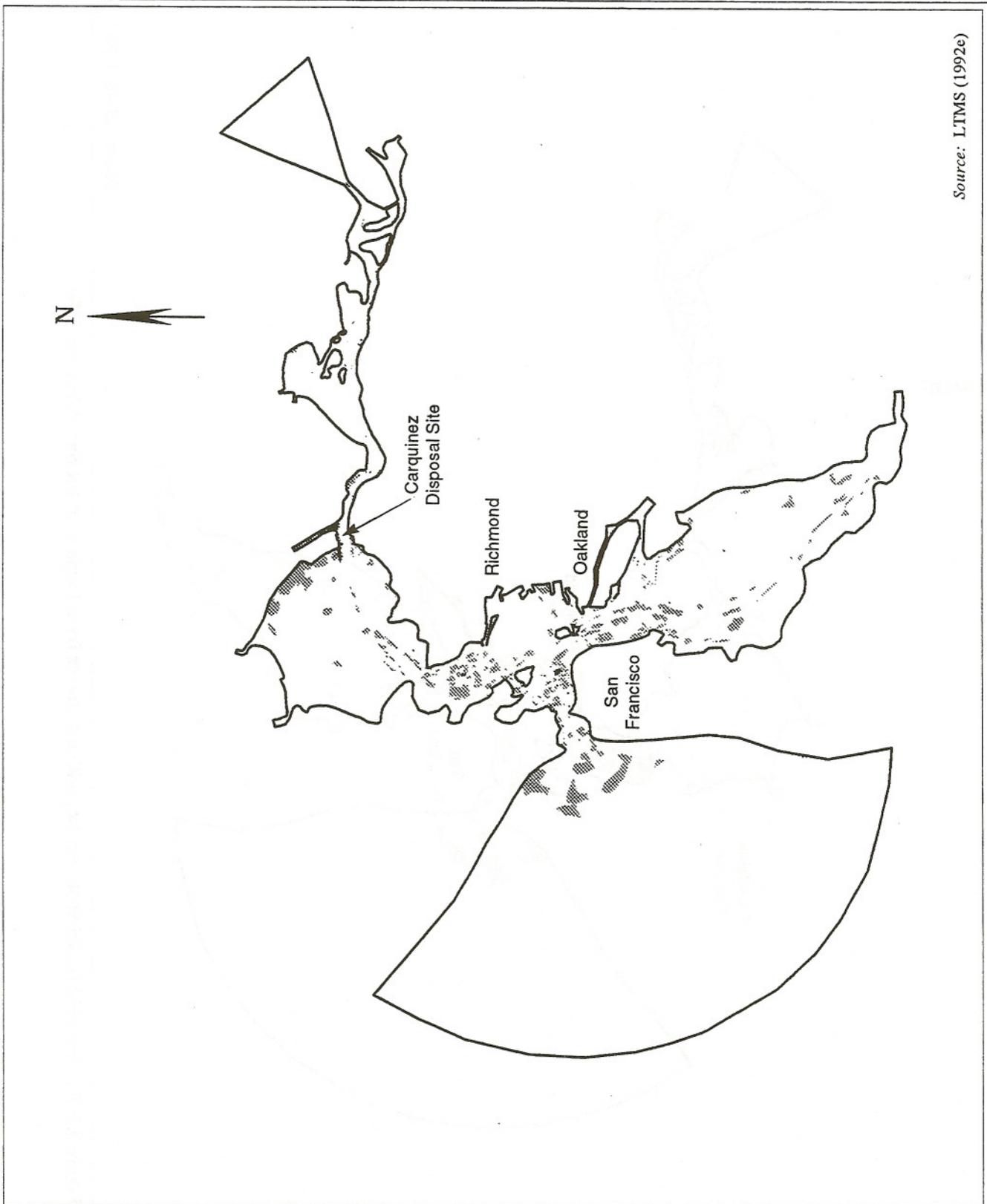
Source: LTMS (1992e)

Figure 3.2-19. Modeled Initial Sediment Deposition Patterns from Disposal at the Alcatraz Site



Source: LTMS (1992e)

Figure 3.2-20. Modeled Initial Sediment Deposition Patterns from Disposal at the San Pablo Bay Site



Source: LTMS (1992e)

Figure 3.2-21. Modeled Initial Sediment Deposition Patterns from Disposal at the Carquinez Strait Site

sources of sediment contamination; and locations of contaminated sediments in the Bay/Delta estuary.

3.2.3.1 Anthropogenic vs. Non-Anthropogenic Chemicals — What is “Contamination”?

Nationwide, the most frequently reported contaminants in sediments include heavy metals (e.g., cadmium, chromium, copper, lead, nickel, mercury, selenium, silver, and zinc), metalloids (e.g., arsenic), polychlorinated biphenyls (PCBs), pesticides (e.g., DDT compounds), and polynuclear aromatic hydrocarbons (PAHs) (USEPA 1994a; SFEP 1992b). A few of these can have natural origins. Heavy metals at varying concentrations are natural constituents of the crustal rock formations in different areas. As these formations erode and eventually contribute to the sediments, the crustal concentrations of these metals are reflected in the sediment chemistry. Even some PAHs can be found in otherwise “unpolluted” sediments. For example, some PAHs (such as pyrene and perylene) are combustion products that can make their way into sediments — from runoff (Hoffman et al. 1984) or via atmospheric deposition — as a result of natural forest fires as well as human causes. Other organic compounds (such as phenols) can be formed by decomposition of organic matter in marshes and elsewhere (Sims and Overcash 1983). Information about the “background” concentrations of chemicals in Estuary sediments is therefore helpful when determining whether the measured concentrations of a chemical are high enough to indicate that the sediment may be “contaminated” by an anthropogenic source. Further discussion of chemical concentrations typically encountered in the Estuary’s embayments is presented in section 3.2.3.3 and in Chapter 4.

Typically, the pollutant types noted above are the most highly concentrated types of anthropogenic contaminants in sediments because they are poorly soluble in water (hydrophobic) and have a high affinity (adsorption potential) for sediment particle surfaces or the organic matter associated with them.

These compounds are therefore readily removed from the water column by suspended particles, and are preferentially carried into the sediments as the particles settle out. The settling-out of suspended particulates is enhanced in estuaries, including the Bay/Delta Estuary, by the flocculation (aggregation of finer suspended particles into larger, more quickly settling groups) that naturally occurs where fresh and more saline waters mix. This is why sediments in

general, and particularly sediments in estuaries such as the Bay/Delta, are often thought of as “sinks” for contaminants that get into the water column from point or non-point sources.

But from whatever source, a sediment is considered to be “contaminated” when it contains deleterious chemical substances at concentrations that pose a known or potential threat of adverse impact to aquatic life, wildlife, or human health (USEPA 1994a). The degree of the threat by the contaminants in a particular sediment can change depending on how the sediment is handled (e.g., buried contamination left in place may not pose a threat of ecological impact, but if that material is disturbed, such as by dredging and disposal, the contaminants may become available again and have the potential to cause adverse effects). As discussed in the sections that follow, determining whether contaminants in dredged material may pose a threat of adverse impacts is a function of determining the following: (1) the potential for the contaminants to cause adverse effects at the placement site; and (2) the practicability of control measures that may be effective in reducing or eliminating the potential adverse effects at the placement site.

3.2.3.2 Major Sources of Sediment Contamination

In general, the surficial sediments in San Francisco Bay have been deposited since industrialization began in California, and therefore may have been exposed to anthropogenic sources of pollutants. These “industrial age” sediments can be encountered in both new work and maintenance dredging. (However, the more highly contaminated sediments are usually encountered by new work projects in industrialized areas of the Bay; such dredging commonly encounters sediments that became contaminated in decades past, before today’s stricter regulations on discharges were in effect.) Recent sand deposits — either riverine sand in portions of San Pablo and Suisun bays and the lower Sacramento River, or sand bars maintained by strong currents in central San Francisco Bay and the San Francisco Bar — also may be exposed to anthropogenic sources of pollutants, but typically do not accumulate significant concentrations of them, for the reasons noted above.

Existing permits authorize hundreds of millions of gallons of treated industrial and municipal effluents to be discharged into the Estuary each day. While these effluents are carefully regulated to ensure that they are not directly toxic to Estuary organisms, trace levels of various contaminants are associated with these

discharges, and some of these contaminants can end up concentrating in the Estuary's sediments. For example, Figure 3.2-22 shows the locations of the largest municipal discharges (Publicly-Owned Treatment Works, or POTWs), and their mean discharge volumes as of 1995. Similarly, a variety of industries discharge pollutants associated with sediment contamination. Table 3.2-2 lists over 40 of these classes of industries, along with the typically associated contaminants. The majority of these types of industries have historically been in operation around the Estuary. Some of the major industrial facilities still in operation as of 1995 are shown in Figure 3.2-23.

Even though industries and municipalities discharge major volumes of effluent each year, they are not the primary sources of pollutants that contribute to contamination of the Estuary's sediments today. Figure 3.2-24, from SFRWQCB (1994), shows the combined annual loadings to the Estuary of several heavy metals (arsenic, cadmium, chromium, copper, lead, and zinc) from six major sources. The sources shown are municipal and industrial effluents, riverine input, urban runoff, non-urban runoff, atmospheric deposition, and dredged material. Other sources may be important on a local level (e.g., groundwater). It can be seen from this figure that non-point pollution (especially nonurban runoff) is the source for the vast majority of these pollutants. This pattern generally holds true for other categories of chemicals, as well. It is because of these patterns that sediments near the urbanized shorelines, and especially in enclosed nearshore waters in the vicinity of storm drains and other input locations for nonpoint source pollutants, often continue to become contaminated even though permitted point sources have largely been brought under control in recent years.

It is useful to keep in mind that not all contaminants that may be associated with point and nonpoint discharges into the Estuary are necessarily contaminants of concern in the sediments. Highly water-soluble compounds will not tend to concentrate onto sediment particles in the first place. Similarly, affinity (adsorption potential) for sediment particle surfaces or the organic matter associated with them. Lower molecular weight organic compounds that are highly volatile will tend to dissipate before being

incorporated into the sediments. For example, "BTEX" (a mixture of benzene, toluene, ethylbenzene, and xylene) is often a concern in upland soils excavated from around leaking underground storage tanks; hence landfills typically require information about BTEX concentrations before accepting contaminated soils for disposal. However, BTEX would rarely be found in estuarine sediments (see discussion on Current Upland Testing Practice in section 3.2.5.2). Overall, although there are limited areas of highly contaminated sediments associated with specific sources, the majority of sediments in the Estuary are characterized by low concentrations of contaminants spread through large volumes of material. In contrast, cleanup projects addressing contaminated upland soils typically encounter small volumes of highly contaminated material (and the contaminants themselves are often different).

Dredged sediments that are determined to be not suitable for unconfined aquatic disposal are very rarely classified as "hazardous." The following section gives an overview of contaminants that are typically found in Estuary sediments.

3.2.3.3 Contamination Levels in San Francisco Bay/Delta Estuary Sediments

There have been several programs in San Francisco Bay that have monitored concentrations of contaminants in sediments from various embayments. Historical sediment chemistry data collected from numerous Bay surveys performed between 1971 and 1986 have been summarized by Long and Markel (1992). Data from these surveys are presented in Table 3.2-3. This table compares mean chemical concentrations in sediments from the central areas of San Pablo Bay, central San Francisco Bay, and the south Bay with chemical concentrations in sediments from peripheral areas of these basins (marinas, harbors, ship channels, and industrial waterways) that would be expected to be more directly influenced by pollutant sources. These data indicate that, overall, the peripheral industrialized areas indeed have higher mean contaminant concentrations than do the central basins. For most compounds, the range of contaminant concentrations is also greater in the peripheral industrial areas than in central basin samples (Long et al. 1988).

Publicly-Owned Treatment Works Discharge Sites

- | | |
|--|--|
| <ol style="list-style-type: none"> 1. City of Benicia 2. City of Burlingame 3. City of Calistoga 4. Central Contra Costa S.D. 5. Central Marin Sanitation A.G. 6. Contra Costa Co. S.D. No. 5 7. Delta Diablo S.D. 8. EBDA, East Bay Dischargers Authority: <ul style="list-style-type: none"> - City of Hayward - Oro Loma S.D. - City of San Leandro - Union S.D. 9. East Bay MUD 10. Fairfield-Suisun Sewer District 11. City of Hercules 12. Las Gallinas Valley S.D. <ul style="list-style-type: none"> LAVWMA, Livermore-Amador Valley - Dublin/San Ramon S.D. - City of Livermore 13. Marin Co. S.D. No. 5 14. City of Millbrae 15. Mountain View S.D. 16. Napa S.D. 17. N. San Mateo Co. S.D. 18. Novato S.D. 19. City of Pacifica 20. City of Palo Alto 21. City of Petaluma 22. City of Pinole 23. Rodeo S.D. 24. City & Co. of S.F., Southeast 25. City & Co. of S.F., Oceanside 26. City & Co. of S.F., Int'l Airport | <ol style="list-style-type: none"> 27. San Jose/Santa Clara WPCP 28. City of San Mateo 29. Sausalito – Marin City S.D. 30. Sewer Authority Mid-Coastside 31. Sewerage Agency of So. Marin 32. Sonoma Valley County S.D. 33. South Bayside System Authority 34. South S.F./San Bruno WQCP 35. City of St. Helena 36. City of Sunnyvale 37. Vallejo Sanitation & Flood Control 38. West County Agency 39. West County Wastewater District 40. Town of Yountville <p>SD = Sanitation District</p> |
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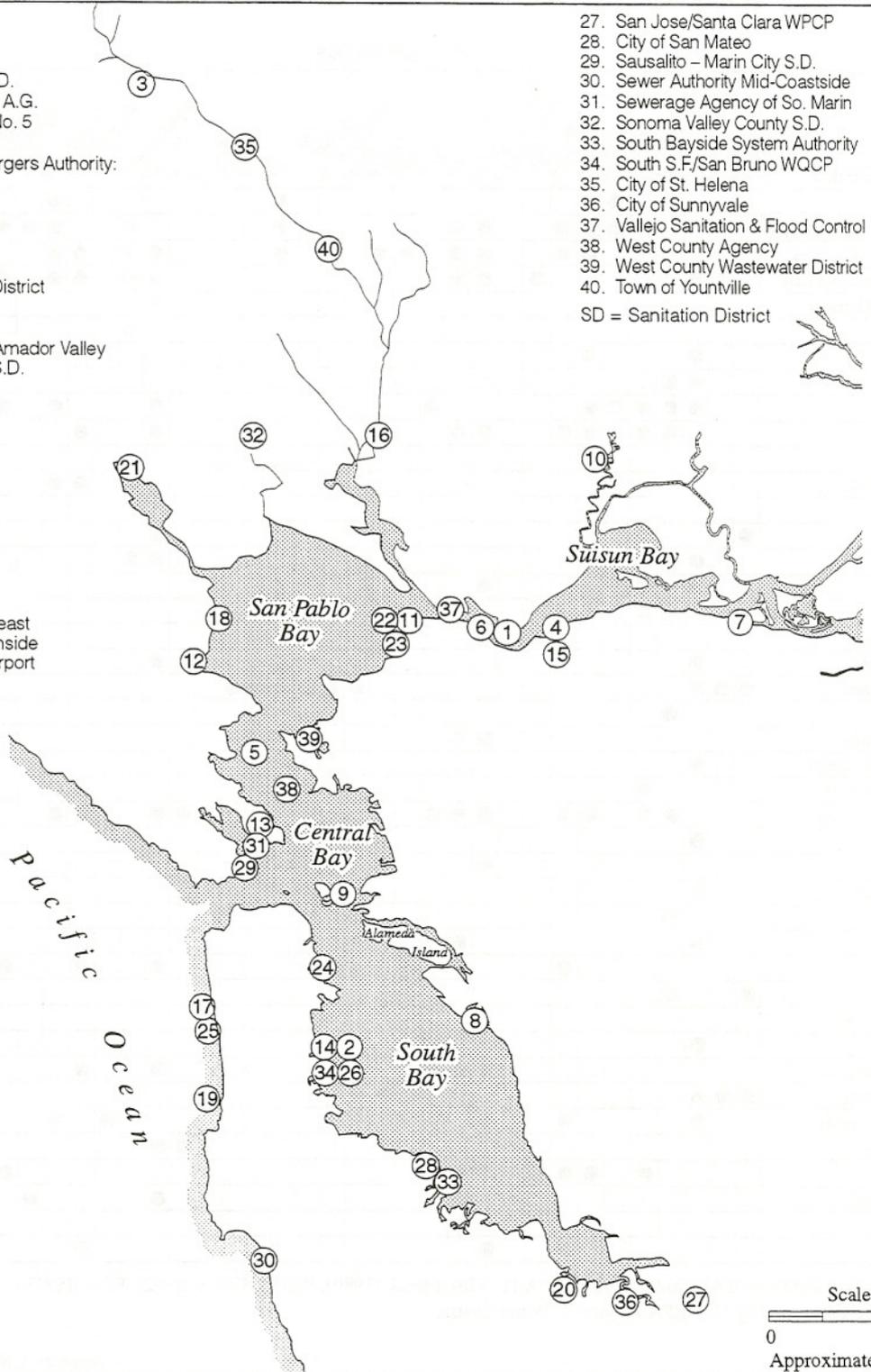


Figure 3.2-22. Location of Publicly-Owned Treatment Works (POTWs) in the Bay Area

Table 3.2-2. Industries Associated with Sediment Contamination

INDUSTRIES	CONTAMINANTS																																					
	Acenaphthene	Aldrin	Ammonia	Aniline	Benzo(a)anthracene	Benzo(a)pyrene	Cadmium	Chlordane	Chlorpyrifos	Chromium	Copper	Cyanide	DDE	DDT	Diethyl Parathion	Endrin	Fluoranthene	Heptachlor	HCB	HCCPD	Lead	Mercury	2-Methylnaphthalene	Oil and Grease	Nickel	Organotin/Tin	Phenanthrene	PCBs	Phosphorus	Pyrene	Selenium	TCDD	Toxaphene	Zinc				
Boat Refueling						•	•												•							•			•									
Boat Manufacturing/Boat Repair						•	•	•			•	•							•						•	•	•	•	•	•	•	•				•		
Potential Non-Point Sources					•		•	•			•	•		•	•									•	•	•	•	•	•	•	•	•				•		
Waste Water Treatment Plants				•							•	•												•	•	•	•	•	•	•	•	•				•		
Valuable Mineral Mining																								•												•		
Utilities																									•							•				•		
Textiles				•			•																		•												•	
Sulfuric Acid				•	•																																	
Steel/Iron				•	•	•	•	•						•										•			•		•	•	•	•	•				•	
Steam Power					•	•		•	•			•	•											•		•												
Rubber																																		•		•		
Pulp and Paper Mills																									•		•	•							•	•		•
Printing Plates																									•		•	•								•	•	
Plastics	•																							•													•	
Pigments/Inks				•	•																			•	•													
Photographic						•						•													•	•											•	
Phosphorus						•																															•	
Phosphate Mining																																					•	
Petroleum Refining					•																				•													•
Pesticides/Fertilizers	•	•	•																																		•	
Perfume					•																																•	
Oxide Manufacturing											•	•																									•	
Nitric Acid Manufacturing				•																																		
Metallurgical Processes					•																					•	•										•	
Metal Finishing Refining				•	•		•	•			•	•	•											•	•		•	•									•	
Meat Products				•																																	•	
Leather/Tanning											•																										•	
Fruits and Vegetables				•																																	•	
Flat Glass					•																																•	
Explosives				•								•																									•	
Electrical							•				•													•		•		•									•	
Dye	•			•																																		
Detergents/Surfactants																																					•	
Dairy				•																																	•	
Corrosion Metallurgy											•	•	•											•		•											•	
Commercial Farming	•	•	•																																		•	
Chemical Manufacturing				•							•																										•	
Batteries																								•	•												•	
Automobile					•		•	•			•	•																									•	
Anti-Fouling Paints											•													•				•										•
Ammunitions											•																										•	
Aluminum							•				•																•											•

Data derived from Eckenfelder (1980), EPA (1987a), Merck (1989), WDNR/USGS (1992), EPA (1987b), NOAA (1991).
 Table developed by U.S. EPA Region 5, Water District.

Source: USEPA and USACE (1992)