2.079 The most plausible explanation of preconsolidation is the sequence of Pleistocene glaciations and inter-glacial periods. Sediments comprising this formation deposited during the inter-glacial period prior to the advent of the first Wisconsin glaciation (late Pleistocene) when the Bay valley was flooded as a result of eustatic rise of sea level. The first advance of the Wisconsion ice sheet lowered the sea level (as much as 335 feet) exposing the Bay floor to sub-aerial desiccation and this drying out of the Older Bay Mud appears to have caused its preconsolidation and comparatively low moisture content.

2.080 (c) <u>Sand Deposits</u>. Sand Deposits form an additional stratigraphic unit interfingering with underlying Older Bay Mud and with Younger Bay Mud. The sand is generally classified as fine, mixed with considerable clay and silt. Its distribution and thickness is not uniform throughout but is thicker along the margins of the Bay (up to 50 feet thick) and occur in greater quantity in South Bay than in the other sub-bays.

2.081 These buried sand formations are belived to represent alluvial fans formed by fluviatile current action. The scattered distribution of these sand lenses presumably resulted from deposition during the shoreline fluctuation occurring in the Pleistocene.

2.082 (d) <u>Younger Bay Mud</u>. The Younger Bay Mud Formation overlies the Sand Deposits and the Older Bay Mud which forms an extensive sediment blanket covering most of the Bay floor. This stratigraphic unit reaches a maximum thickness of 130 feet and is characterized by black-gray silty clays and clayey silts with minor amounts of organic materials, fine sand and shell fragments. Younger Bay Mud stratum is made up of 45 to 90 percent clays and five percent carbonaceous material.

2.083 Younger Bay Mud is subdivided into a Soft Bay Mud member overlying a Semi-consolidated member based on degree of consolidation, wet weight density and moisture content. The Soft Bay Mud member becomes gradually firmer with depth until there is a sudden increase in strength and preconsolidated to a degree greater than would result from the weight of the overlying strata. This level represents the breakpoint which differentiates Soft Bay Mud (with an average wet weight density of 97 pounds per cubic foot and more than 40 percent moisture) and the Semi-consolidated member (with an average wet weight density of 110 pounds per cubic foot and drecrease in moisture to near 40 percent). The horizon separating these two stratigraphic units represents a major erosional surface interval (See Plate II-19).

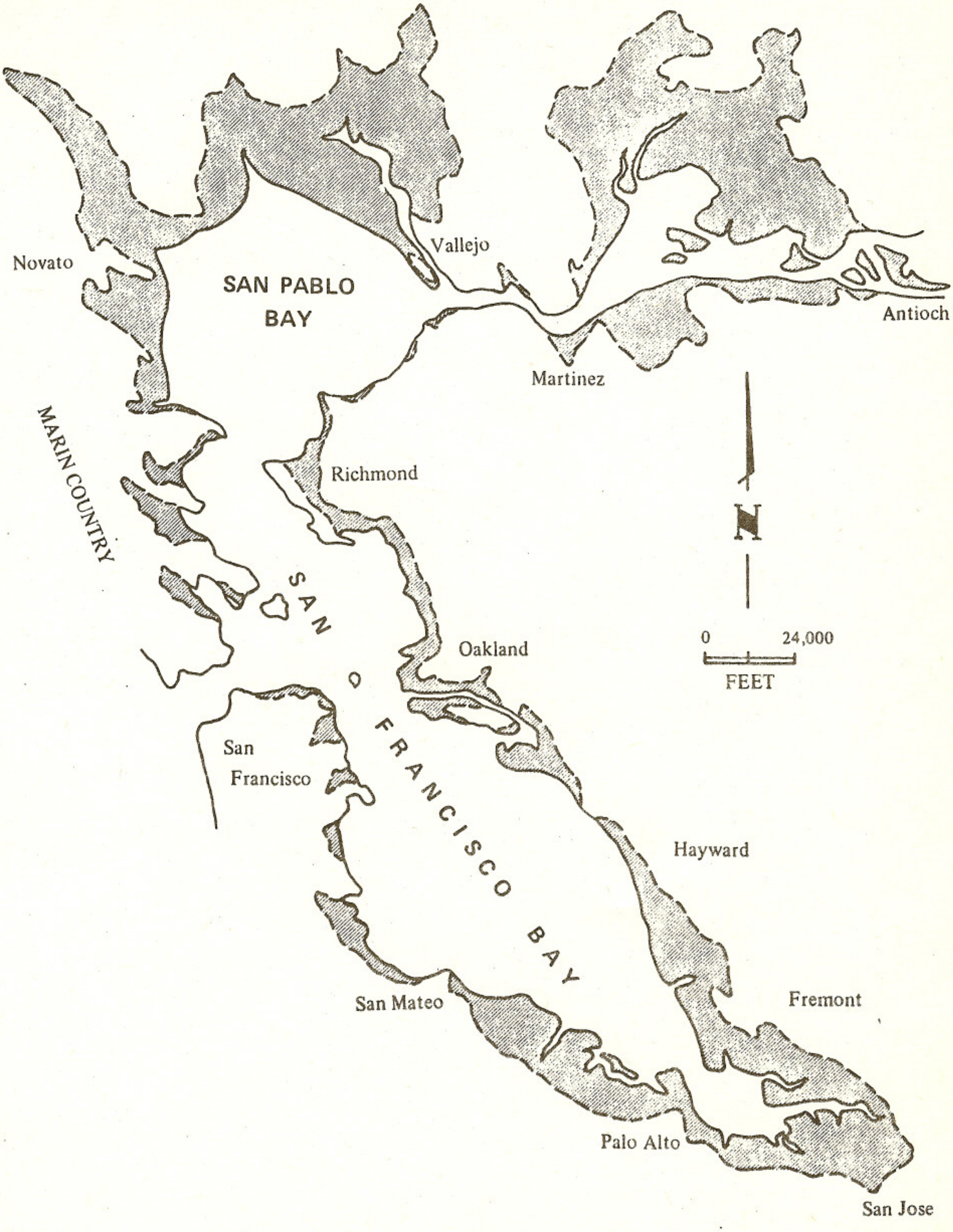
2.084 The most acceptable hypothesis explaining the deposition of Younger Bay Mud and separation of the Soft Bay Mud from the Semi-consolidated member, is the alternating eustatic rise and fall of sea level associated with the fluctuating advances and retreats of the Wisconsin ice (218). This theory states the Semi-consolidated member was deposited during the first retreat of the Wisconsin ice. The subsequent advance of the Wisconsin ice lowered the sea level exposing these deposits to preconsolidation and as a result, to the desiccating effects of sub-aerial exposure. The melting and retreat of the Wisonsin ice again flooded the Bay during which time the present Soft Bay Mud member was and still is being formed as a result of deposition of fine-grained sands, silts and clays, and flocculation and deposition of colloidal clays, transported to the Bay by fluvial current action.

2.085 It is this Younger Bay Mud (mostly the Soft Bay Mud member) and the surficial sand deposits that are dredged from the Bay and often disposed on land. The characteristics of bay sediments become important in the consideration of future land use at the upland disposal sites. Freshly deposited material is subject to settlement as it consolidates and dries. The impacts of using this material, is discussed in the land disposal Alternative Section.

2.086 Younger Bay Mud is not confined below mean higher high water of the Bay but extends considerable distance inland (Plate II-20). All the saltmarshes and most of the Bay Area shoreline are situated on Younger Bay Mud.

2.087 (e) Sedimentation. Sedimentation is the natural process of filling up the Bay; a phenomenon that occurs in all estuaries. For this reason, in order to provide and maintain safe navigation, dredging is required in certain areas. Appendix B of the Dredge Disposal Study provides a good summary of sedimentation in the Bay (222). It discusses the process, sources, estimated quantities and effects of sedimentation and for these reasons, the section on sedimentation from Appendix B is included, essentially intact, below.

2.088 Sediment inflow-outflow and distribution volumes within the San Francisco Bay System have been variously estimated by Gilbert of the U.S.G.S. in 1917 (61); Grimm of the Corps of Engineers in 1930 (67); the Soil Conservation Service of the U.S. Department of Agriculture in 1947; the Corps of Engineers in 1954 and 1967 (200, 215); State of California Department of Water Resources in 1955; Porterfield, Hawley and Dunnam of the U.S. Geological Survey (U.S.G.S.) in 1961 (137); Smith of the Corps of Engineers



Inshore extent of Bay sediments (after Schlocker, Goldman, and others).

Source: Wigginton, W.B. 1969. IN: E.A. Danehy (ed.), Urban Environmental Geology in the San Francisco Bay Region. Assn. of Engr. Geol.

in 1963 (178); and Krone in 1966 (94). These studies vary enormously in their estimates of inflow-outflow and distribution volumes in the Bay system. The variance can be attributed to paucity of data available to investigators at the time of each study.

2.089 Smith, using U.S.C. and G.S. surveys of the Bay at periodic intervals between 1855 and 1956 and logs of borings, estimated the total deposit of Bay sediments to be 16 billion cubic yards. The deposits were lightest in Suisun Bay, heaviest in Central Bay and roughly equal for the remaining areas. The ratio of deposition per acre is respectively, 1:3:2 for Suisun Bay. Generally, these areas have experienced cycles of depostion and erosion, with the greatest deposition taking place during the hydraulic mining era in the Sierra Nevadas. Gilbert estimated that just during the period of 1850-1914, one and one-half billion cubic yards of sediment were deposited in the Bay system.

2.090 Estimated annual inflow volumes before 1961 reflect the limited amount of data available at the time. These volumes range from 8.0 million cubic yards predicted by Gilbert to 1.97 million cubic yards estimated by the Corps of Engineers in 1954. The U.S.G.S. in 1961 were the first to use direct measurements of suspended loads being transported into the Bay system by all sources. From these measurements U.S.G.S. calculated the annual sediment inflow to the Bay system between the years 1957-1959 to be 8.8 million cubic yards. From this value they estimated the present annual inflow volume to be 8.0 million cubic yards. Smith in 1963 estimated that 8.325 million cubic yards per annum was the inflow rate to the Bay system. He derived his estimate from tonnages and daily sediment inflows by geographical areas for the years 1909-1959 and adjusted to 1957-1959 conditions. Smith considered these volumes valid for the period 1960-2011. The Corps of Engineers in 1967 used the basic data developed by U.S.G.S. for the period 1957-1959 to arrive at the average annual sediment inflow value of 9.56 million cubic yards. The difference in the Corps 1967 value and U.S.G.S. 1961 value reflect different in-place density values used to convert weight of sediment to volume of shoal. Krone in 1966 estimated the average annual sediment inflows for the Bay systems to be 10.5 million cubic yards, based on hydrologic data from 1922-1933 and U.S.G.S. measurements of suspended sediment for the years 1957-1965. Krone also estimated the projected 1990 and 2020 sediment inflows.

2.091 Of the sediment entering the Bay system from natural sources (new fluvial sediments) or from overboard dredge disposal practices, a portion is conveyed to the ocean via the Golden Gate and a portion is retained in the Bay system. The Corps of Engineers in 1967 used two methods for determining sediment outflow. The first method, "Historical Shoaling Method," estimated the volume of sediment leaving the Bay as the difference between the sum of the new sediment inflow (10.0 million cubic yards) and dredge material released in the Bay (9.6 million cubic yards) and the sum of shoaling within and outside navigation channels and facilities (15.4 million cubic yards). The estimated average annual sediment outflow volume derived from the "Historical Shoaling Method" was 4.2 million cubic yards. The second method, "River Discharge Method," used an estimate of the net water discharge through the Golden Gate and an assumed average turbidity for Bay water. The product of turbidity and net water discharge gave the net sediment outflow. Analysis of numerous suspended sediment samples throughout the Bay system for conditions of low, average and flood flows, indicated that the average turbidity in Carquinez Strait and easterly San Pablo Bay was about 70-80 parts per million, and at Golden Gate, about 40-50 parts per million. Assuming a turbidity of 50 parts per million for an average monthly discharge of 29,000 cubic feet per second, the Corps of Engineers using the "River Discharge Method," estimated the average annual outflow to be 3.3 million cubic yards. In addition, model studies indicated that an additional 1.4 million cubic yards would leave the Bay annually from overboard dredge disposal practices, totaling 4.7 million cubic yards.

2.092 The Corps of Engineers in 1967 studied the historical sedimentation patterns in the Bay system using hydrographic surveys for a 101-year period from 1855 to 1956. The results of the study showed that there was an average annual net deposition of 5.2 million cubic yards.

2.093 Krone, in his sedimentation studies of San Francisco Bay in 1966 and 1974 (94), estimated that 8.1 million cubic yards of sediment annually leaves the Bay, while 2.4 million cubic yards are retained. Krone estimated that a steady state situation was reached in the Bay-Delta system in about 1957. The annual retention of 2.4 million cubic yards of sediment in the system is compensated for by an average annual rise in sea-level of .00577 feet per year and gradual subsidence of the Bay bottom, over geologic time (61). The State of California Department of Water Resources (137) estimated annual net deposition

TABLE II - 5

ANNUAL SEDIMENT INFLOW-OUTFLOW AND
DEPOSITION VOLUMES
FOR
SAN FRANCISCO BAY SYSTEM

Investigator	Inflow From Delta	Inflow From Other Tributaries	Total Inflow	Sediment Outflow	Sediment Deposition
	Millions of Cubic Yards				
Gilbert (1917) predicted					
Prior to 1850	2.0				
1850-1914	23.0				
Present	8.0				
Grimm (1931)	5.75				-5.4*
Corps of Engineers (1954)					
Existing	3.36				
Future w/controls	1.97				
(1955)					
Existing	4.0				
Future w/controls	3.0				
U.S.G.S. (1961)					
From 1957-1959	7.2	1.6	8.8		
Present	6.9	1.1	8.0		
Smith (1963)	7.04	1.195	8.235		5.2
Corps of Engineers (1965)	8.13	1.43	9.56	4.2 4.7	5.2
Krone (1966)					
By year 1960	8.1	2.4	10.5	8.1	2.4
By year 1990	4.3	2.4	6.7		
By year 2020	3.0	2.4	5.4		

*Considers only North Bay.

Source: Dredge Disposal Study, Appendix B (in preparation).

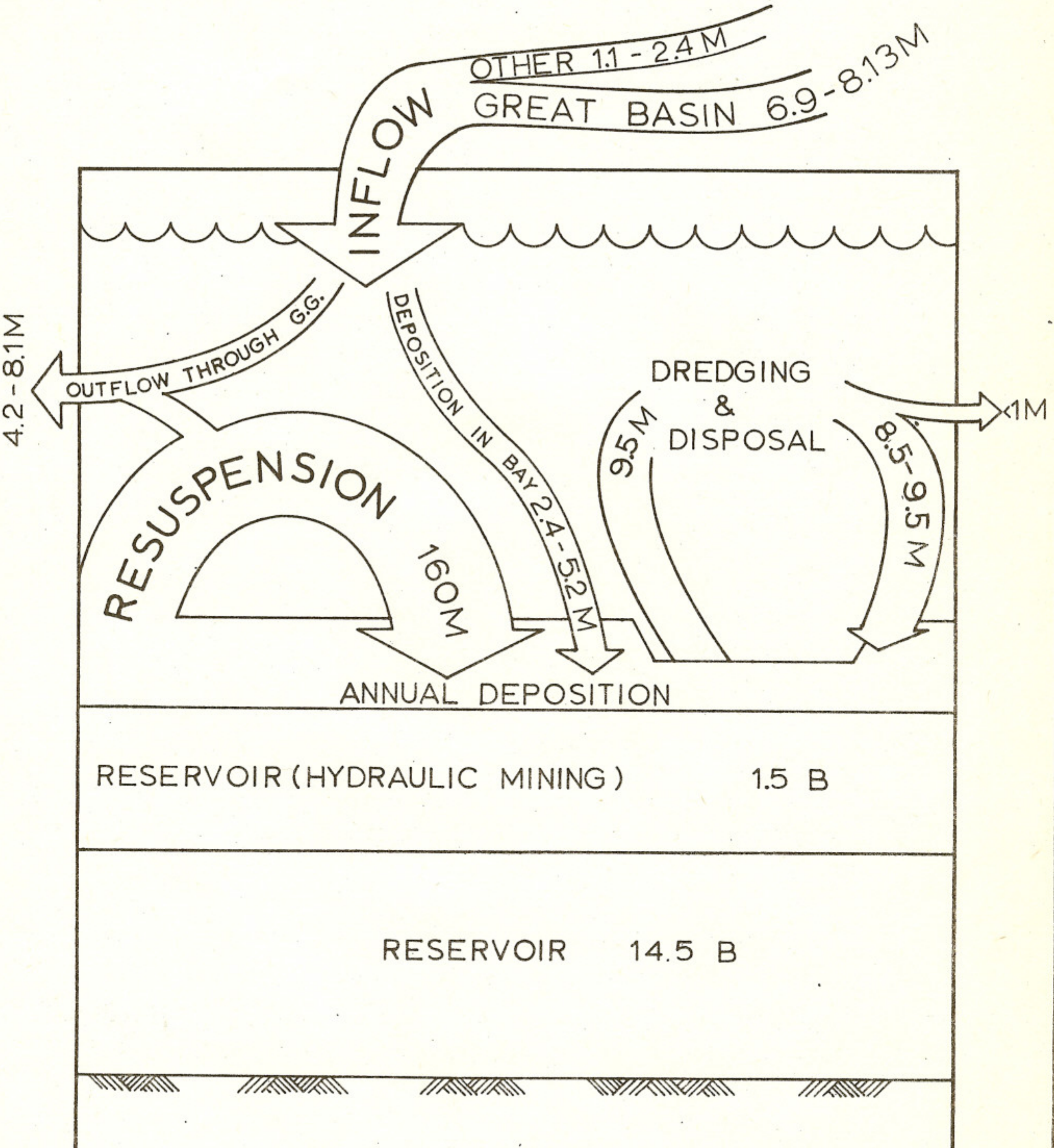
in the Bay to be 2.1 million cubic yards. Table II-5 is a summary of the average annual inflow-outflow and deposition volumes from the above investigations.

2.094 Two other factors affecting the annual sedimentation in the Bay system are annual dredging and disposal operations, and resuspension of bottom sediments due to wind-generated turbulence and tidal currents. Approximately 10.5 million cubic yards of Bay sediment are dredged annually by the Federal Government and private concerns in the Bay System. The majority of this material is disposed of in the Bay waters at one of three disposal sites. Assuming that these sites received dredged sediments over a 250-day period and that the material disperses over a 100-square-mile area, 400 cubic yards of dredge material would be placed in suspension per square mile per day of dredging. In contrast, Krone estimated the amount of material suspended by wave action in a square mile of shallow area by conservatively using an average suspended sediment concentration of .5 grams per liter over a five-foot water depth when the wind blows over 10 knots. Using the value of 220 days per year when the wind velocity is 10 knots or greater, Krone estimated that each square mile of shallow area suspends 2,200 tons of sediments per day. Using the specific gravity of 25 pounds per cubic foot for sediments brought into suspension by wind and wave forces, the 2,200 tons may be converted to cubic yards, giving a total of 6,500 cubic yards per square mile per day as the volume of sediment resuspended by wind driven waves. This is 16 times the amount calculated for dredging. It should be noted, however, that sediments resuspended by waves usually resettle over the same general area, whereas dredged sediments are derived from harbor areas and shipping lanes, where concentrations of heavy metals and other "pollutants" are frequently higher than in the disposal area. Plate II-21 is a summary of sedimentation in the San Francisco Bay System.

2.095 (f) <u>Physical estuarine processes affecting sedimentation</u>. Currents were briefly alluded to earlier as mechanisms affecting sediment transport. These included tidal currents, freshwater inflow, salinity-density currents and wind which will be expanded upon below. Other physical factors affecting sedimentation will be mentioned, and the mode of sediment deposition in the Bay will also be discussed.

2.096 Because tidal currents are such a dominating force in San Francisco Bay, they erode, resuspend (turbulent mixing) and transport sediments from the up-current sediment reservoirs of Suisun and San Pablo Bays. The sediments moved in suspension and as bedload through Carquinez and San Pablo Straits into

SEDIMENT MOVEMENT
IN SAN FRANCISCO BAY SYSTEM
(CUBIC YARDS)



M = MILLION
B = BILLION

PLATE II-21

Source: U.S. Army Engr. Dist., San Francisco. Dredge Disposal Study, Appendix B (to be published).

Central San Francisco Bay. Once the sediment-laden waters arrive in the broad expanse of Central Bay their velocity and ability to carry sediment become diminished. At the same time, these brackish waters are mixed with more saline ocean waters and suspended sediments settles to the bottom. These newly arrived sediments are subject to movement by additional estuarine processes.

2.097 Eddy and hydraulic currents, which are forms of tidal currents, can also cause shoaling. Hydraulic currents are caused by differences in head (surface level) elevation between contiguous masses. Eddy currents are surface gyres (whirls) where water next to the major current moves forward and parallel to the main stream while the water on the opposite side of the gyre flows in the opposite direction. Coves and land points along the Bay shore set off eddy currents which deposit material in sheltered, low energy areas down-current of these landforms.

2.098 Freshwater inflow is a non-tidal current that affects sedimentation in the Bay. During winter storm runoff, high freshwater inflow (primarily from the Delta) transports sediment into Central Bay and through the Golden Gate into the Gulf of the Farallones. The sediment is transported in suspension and dragged along the bottom as bedload, and it is during this wet season that high volume/velocity river currents are especially effective in eroding, resuspending and flushing unconsolidated sediments from the Bay floor.

2.099 Freshwater inflow dilutes and mixes with saline waters in the Bay which results in horizontal and vertical salinity gradients and these gradients are greatest during winter freshets. This difference in salinity and therefore density is the driving force of another type of non-tidal current found in the Bay system. Density-salinity currents move upstream along the Bay floor displacing less saline waters moving towards the Golden Gate in the upper water column. The predominant direction of this current is upstream. This salt-water wedge (vertical salinity stratification) is most developed during wet season storm runoff and is strong enough to erode and transport sediments in the near bottom strata of the water column. Average speed of this near bottom current between the Gulf of the Farallones and San Pablo Bay has been calcualted to be 2.2 nautical miles per day (37). Because this current is density driven, it is most competent in transporting sediments in the deeper parts of natural and dredged channels. Density driven salinity currents supplement floodtide bottom filling in tranquil, maintained waterways such as Mare Island Strait and Alameda NAS. These currents reinforce the tidal regimen in San Francisco Bay by generating a pattern of bottom strata filling and upper strata emptying of the tidal prism in this estuary.

2.100 The interface between the fresh and salt water masses is a zone of vertical mixing and flocculation of colloidal sediments which results in sediment deposition along the bottom beneath this shifting salt water wedge interface (167). This deposition process occurs in the San Pablo Bay and Carquinez Strait region of the Bay.

2.101 The fourth major physical factor affecting sedimentation is wind induced current. Wind force over the surface of the Bay generate wind-drift currents which attain velocities two to five per cent of the wind force (79). There is a seasonal pattern of prevailing winds and resultant wind-drift currents peculiar to each of the component bays forming the San Francisco Bay system. During the summer, prevailing NW winds blow onshore at the outer coast. However, once these winds reach the Golden Gate, direction and velocity are altered by the channeling effects of the rugged, landforms surrounding the Bay. In Central Bay, strong westerly summer are funneled through the Golden Gate and produce east setting wind-drift currents. These currents drive sediment bearing surface waters across the Bay, piling it up along the downwind, eastern shore (wind set-up). The same winds are redirected by San Pablo Strait and blow from S and SW over San Pablo Bay and into Carquinez Strait (114) generating N and NE wind-drift currents. During the winter, prevailing winds blow from N and NE. These winds produce wind-drift currents flowing through Carquinez, San Pablo and Golden Gate Straits. These currents increase the competency of freshet and tidal flows to flush unconsolidated sediment from North and Central Bays. This offshore wind pattern is frequently interrupted by violent SE gales associated with winter storms passing from west to east over the Bay Area. These SE winds are generally of short duration and produce very temporary north setting currents.

2.102 Other factors affecting local sedimentation are prop wash, coriolis force, and shoreline structures. Prop wash turbulence generated by propeller driven vessels, navigating in shallow harbor and channels, erode, mix and resuspend sediment in the same manner shallow subtidal and intertidal flats are worked upon by wave action. This suspended sediment is susceptible to movement by other types of currents flowing into these relatively tranquil areas. Prop wash is probably a significant factor in redistributing bottom sediments in these areas. Coriolis force concentrates current flows to the right of their setting direction in the northern hemisphere. In the confined area of the Bay the effect of this force is not great. However, it still reinforces or modifies the other more important current forces flowing within the estuary. Man-made shoreline structures (piers, walls, groins, and other structures) can affect local sedimentation by creating zones of stagnant waters and entrap sediments.

2.103 Sediment deposition in the Bay system not only depends on tidal and non-tidal circulation conditions described above but also on the type of accumulation process, physical characteristics of sediment particles, and concentration and availability of suspended and bedload material. Sediment deposition patterns reflect the energy gradient formed by the dynamic estuarine forces within the Bay. Suspended and bedload material is transported from high energy areas to low energy areas and if the available sediment supply is not a limiting factor, suspended and bedload concentration is directly proportional to transportation energy. Thus, deposition or accumulation zones are situated in tranquil areas where the energy of these forces is dissipated or nonexistent.

2.104 Postma has shown that on submerged tidal flats, wave action predominates over current velocity as a distributary force (138). Horizontal variation in sediment grain size across the surface of the submerged flats correlates directly with wave energy distribution. Wave action over submerged deposition flats is determined by the force of waves arriving from adjacent deepwater and channel areas, and waves generated over the flats themselves.

2.105 In the deepwater and channel areas of the Bay current velocity is the predominate estuarine force. Current force reaches a maximum velocity above the central portions of the channel and diminishes towards the channel banks. This energy gradient is reflected in the decreased sediment grain size away from the channel axis. Areas showing the highest sediment deposition rate in San Francisco Bay are the channel bank zones. These accumulation zones are too deep to be affected by wave action and too far away from the channel axis to be affected by strong current velocities; thus, grain size sediments found in the channel bank zones are smaller than sediments situated on the contiguous flats shoreward and on the adjacent channel floor towards deep water. The historical patterns of sediment deposition and erosion rate for Central San Francisco Bay and San Pablo Bay are shown in Plates II-22 and II-23. The depositional patterns in San Francisco Bay generally reflect the hydrodynamic accumulation patterns present in the estuary.

2.106 g. <u>Fate of Dredged Material Disposal in the Bay</u>. An estuary such as San Francisco Bay is a sink or holding area for fluvial sediment in transit to the ocean from soil erosion in the Bay's extensive drainage system. Sediment enters the Bay system from the land (via the drainage system), circulates, accumulates, and eventually a portion leaves the system by entering the ocean. Sediment entering the Bay system, then, is either temporarily or permanently held in residence, depending on the dynamic state of the estuary. Twenhofel (289) has described the dynamic state of an estuary as changes in bottom surface elevations or profile of equilibrium. The profile of equilibrium is a condition where the bottom surface has temporarily adjusted to the prevailing physical forces such as wind-wave action and currents which tend to alter the bottom elevation. Since these forces are responsible for maintaining a profile of equilibrium, the profile of equilibrium persists only so long as the conditions to which it is due exist. Surficial bottom sediments quickly respond to changes in these distributing forces. The nature and energy of the forces responsible for development of a profile of equilibrium fluctuate from moment to moment. However, there are seasonal patterns manifested by these forces (e.g. river inflow, wind characteristics, wave climate, tidal action, and sediment availability) that will result in seasonal trends of deposition and erosion. Deposition and erosion in an estuary ultimately depends upon whether or not the bottom surface level has attained a profile of equilibrium with the prevailing forces operating on it.

2.107 Inflowing sediment, however, is not, for the most part, carried directly to the ocean. A large percentage of the inflowing sediment remains in residence in the Bay for a number of years, being deposited, then resuspended, recirculated, and redeposited elsewhere, with the net effect of being transported (toward the mouth of the estuary) out of the Bay system into the ocean as suspended load and bedload. This complex process occurs many times before the sediment is either semi-permanently deposited in the Bay or transported as suspended load into the ocean and deposited on the continental shelf.

2.108 Before discussing the fate of dredged material released into the Bay, a description of the process of deposition and resuspension of new sediment entering the Bay system is necessary. Most new sediment entering the Bay system occurs during the months of maximum runoff (winter). Eighty percent of the total sediment inflow into the Bay enters from the Central Valley drainage basin, so it first enters the Bay system via Suisun and San Pablo Bays.

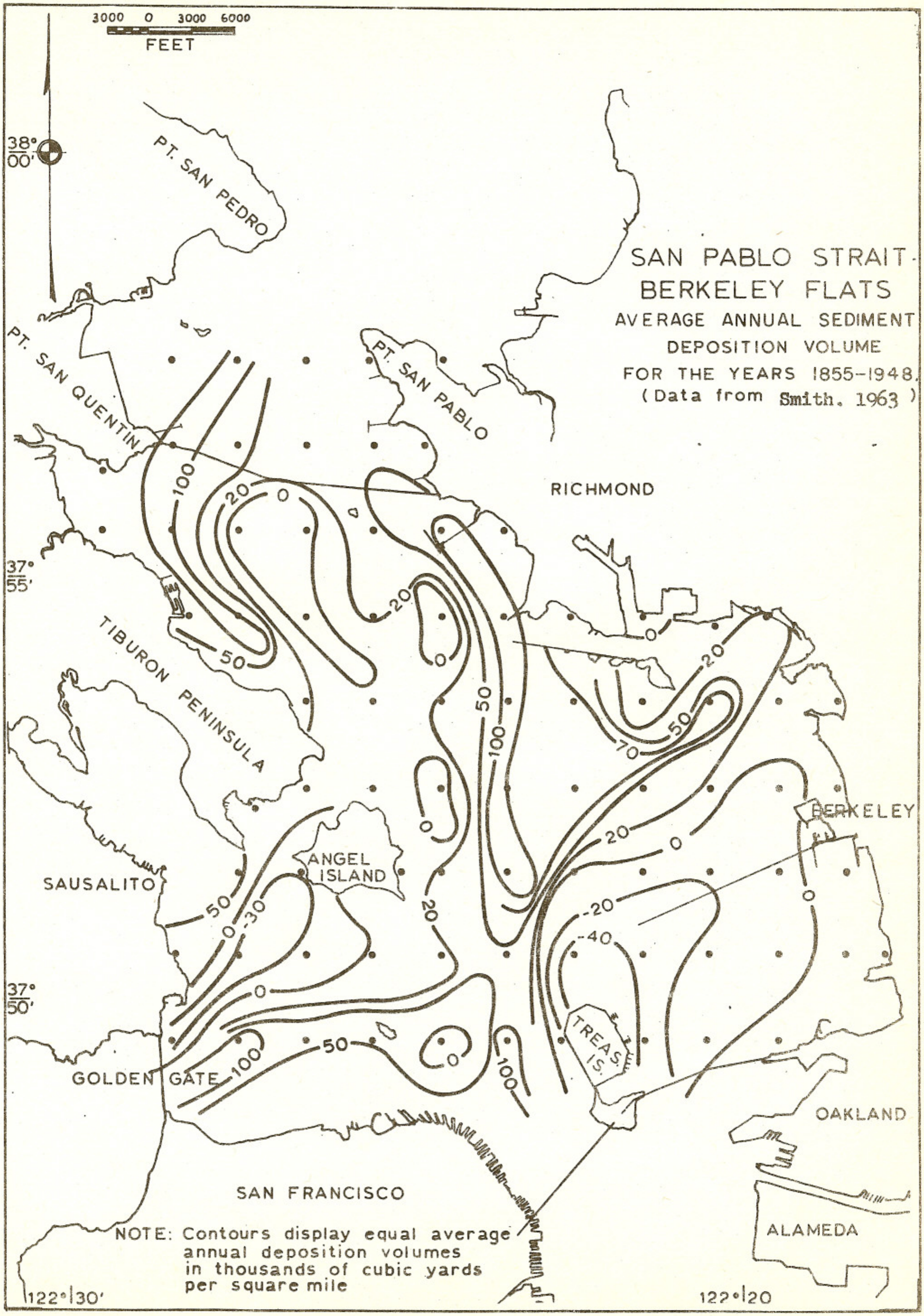
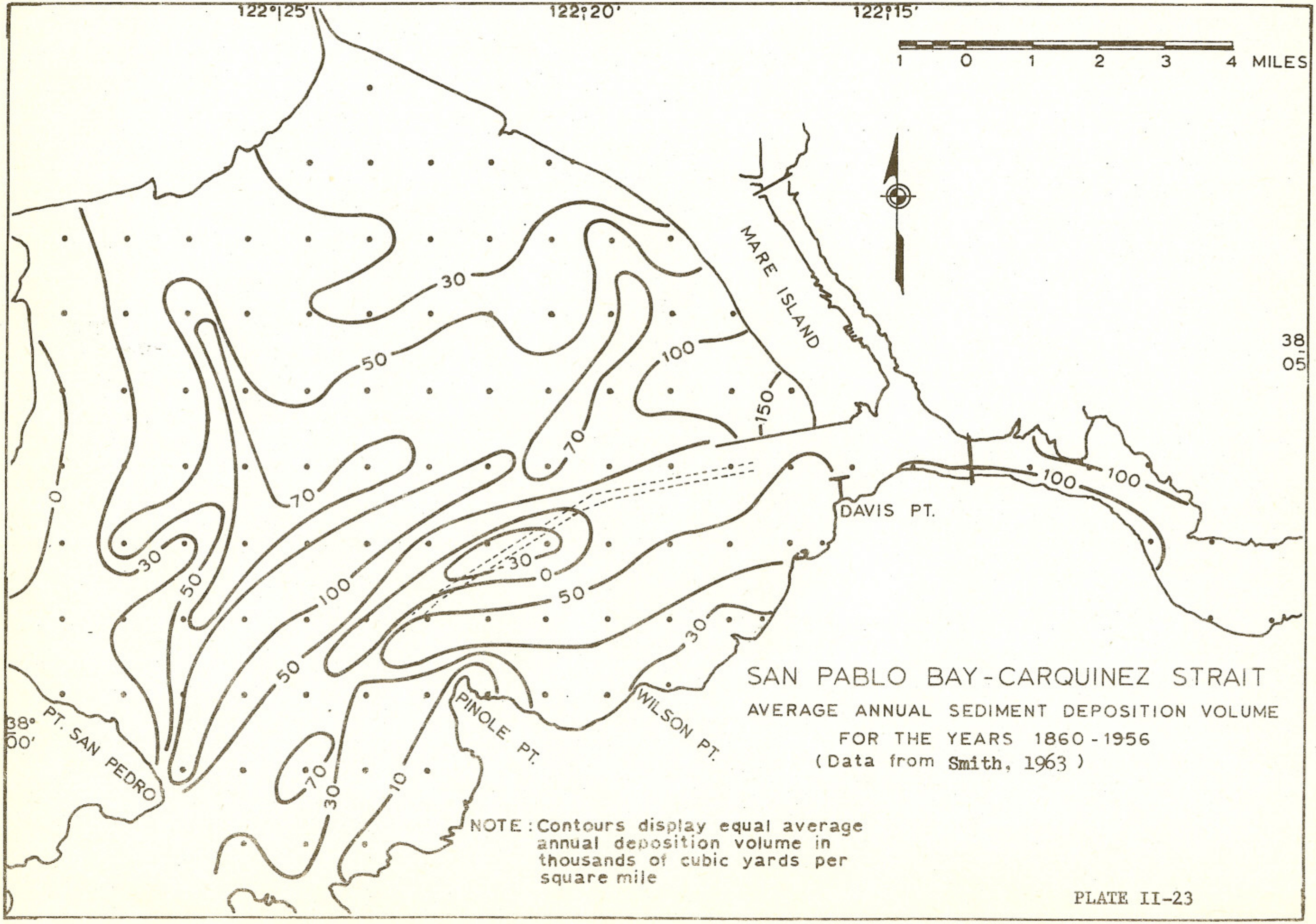

3000 0 3000 6000
FEET
38° 00'
37° 55'
37° 50'
122° 30'
122° 20
PT. SAN PEDRO
PT. SAN QUENTIN
PT. SAN PABLO
RICHMOND
TIBURON PENINSULA
SAUSALITO
ANGEL ISLAND
BERKELEY
GOLDEN GATE
TREAS. IS.
OAKLAND
SAN FRANCISCO
ALAMEDA
SAN PABLO STRAIT-
BERKELEY FLATS
AVERAGE ANNUAL SEDIMENT
DEPOSITION VOLUME
FOR THE YEARS 1855-1948.
(Data from Smith. 1963)
NOTE: Contours display equal average
annual deposition volumes
in thousands of cubic yards
per square mile

PLATE-II-22



SAN PABLO BAY - CARQUINEZ STRAIT
AVERAGE ANNUAL SEDIMENT DEPOSITION VOLUME
FOR THE YEARS 1860 - 1956
(Data from Smith, 1963)

PLATE II-23

When the sediment-laden waters reach the region where ocean and stream waters mix, the suspended particles become cohesive, causing aggregation and settling. The broad expanse of the shallow bays in the system where tidal velocities are low are the repository areas for the aggregated sediments. During the winter months wave suspension of sediment is at a minimum, allowing the sediment to accumulate in these shallow areas, making these areas shallower. In the spring and summer months, daily onshore breezes generate waves over the shallow areas, resuspending recently deposited sediments and maintaining them in suspension, while tidal and wind-generated currents circulate them throughout the Bay. The suspended sediment is repeatedly deposited and resuspended in the shallow areas until they are finally deposited in deeper water below the effective depth of wave influence. In spring and summer there is a net movement of sediment from the shallow repository areas, bringing the shallows back to a profile of equilibrium where wave action is no longer influential in resuspending the sediment. Once the sediment reaches deeper water, usually in natural channels or along the margin of these channels, tidal currents become the primary transporting mechanisms. Like the shallow areas (the depths of which are in equilibrium with the depth of effective wave action), the depth of the natural channels are in equilibrium with the flow volume and velocity in the channel. When resuspended sediments from the shallows are transported into the natural channels, the sediment has a tendency to be transported along the channel in the direction of net flow. In San Francisco Bay the direction of net water flow is towards the ocean, allowing the sediment to have a net seaward component. Sediments may be transported by tidal currents back into shallow areas, especially after the sediment has been transported through a constricted strait into a broad bay, such as through San Pablo Strait into Central Bay, and the whole recirculation process is repeated.

2.109 Some sediment is permanently retained in the system. This sediment is deposited and accumulated in low energy areas where wind-wave action and water flow volumes and velocities are not great enough to transport sediments. These areas may be found along the margins of the Bay such as intertidal flats, marshes and inlets, as well as around man-made structures and dredged channels. Marshes trap sediments much in the same manner as man-made structures by decreasing flow velocities and wind-wave action to the extent where the sediments may no longer be flushed out. In this case, the water depths decrease until a profile of equilibrium is reached. Inlets and sloughs provide sheltered areas with very low current velocities. When suspended sediment enters the inlets the flow velocities and wave action are normally insufficient to remove the sediments, and deposition will occur. Southampton Bay (in Carquinez Strait) near Benicia is such an example. Between 1857 and 1886 the Bay had experienced heavy shoaling at the rate of 300,000 cubic yards per year. Since that time the shoaling rate has been continuously decreasing until between 1922 and 1940 the annual shoaling rate was 43,500 cubic yards. A profile of equilibrium was reached sometime between 1940 and 1950 so that today no net deposition or erosion occurs in the bay (217).

2.110 Dredged navigation channels are out of equilibrium with the system in that the channels are maintained to a depth greater than the natural depth. Maintenance of dredged channels is required since the channels, with few exceptions, will attempt to regain the equilibrium depth of their surroundings. Flow velocities in these dredged channels are not great enough to remove deposited sediments. For this reason, sediment that accumulates in dredged channels will remain there until the channels are redredged.

2.111 The source of shoal material in dredged channels has been discussed previously (see Submarine Geology of the Bay, Section II). Shoal material may be derived directly from sediment inflow to the Bay delivered by the rivers and streams, or it may be derived from some part of the resuspension-recirculation-redeposition cycle. Shoaling rates in the dredged channels are not constant but vary from year to year, depending on the variable sediments inflow volume, wind-wave action and flow velocities. During a season of exceptionally high sediment inflow into the Bay, for example, dredged channels will normally experience higher sedimentation rates than usual, both in winter and spring-summer seasons. In the winter higher rates of shoaling are due principally to the higher flux of new suspended sediment load being carried through the channels, directly from the dredging area, resulting in greater deposition and accumulation. The same process occurs in the shallow areas where the depth of accumulation will be greater, thus reducing water depths. In the spring-summer season the higher rates of shoaling in the dredged channels are due to greater accumulation of sediment in the shallow areas during the winter. Since the water depth in the shallow areas is less than the profile of equilibrium, and assuming the effective depth of wave-action remains about the same, more sediment from the shallow areas will be resuspended by wind-wave action in the process of reestablishing the equilibrium depth. As in the winter, this results in a greater flux of suspended sediment through the dredged channels and therefore, a higher shoaling rate. High sediment inflow years are characterized by increased suspended solids (turbidity) in